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The Development of Memory for Actions

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"*The suggested intention slumbers on in the person concerned until the time for its execution approaches. Then it awakes and impels him to perform the action.*"

Sigmund Freud (1991)

Psychopathology of Everyday Life

Declaration of Original Authorship

'I confirm that this is my own work and the use of all material from other sources has been properly and fully acknowledged.'

Signature.

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Thank you to you all. Remember, in a world that is getting smaller with daily advances in communication; remember that some intentions are more important than others…

ABSTRACT

Adult studies have revealed superior retention for action words and phrases that are performed at encoding versus verbally encoded: the Subject-Performed-Task or SPT effect (e.g., Cohen 1981). Other studies demonstrate that information related to to-be-performed actions is more accessible from memory than other types of information: the Intention Superiority Effect or ISE (e.g. Goschke & Kuhl 1993; Marsh, Hicks & Bink 1998). Recent research suggests some degree of similarity between the processes underlying these effects (Freeman & Ellis 2003b). **Experiments 1-3** explore this proposal by examining the developmental trajectory of these phenomena across young adults, 9- and 11-year-old participants. Interestingly while the SPT effect was observed in all age groups, the ISE was only present in the young adults, indicating some differences between the processing underlying these phenomena.

Experiments 4-6 focused on another aspect of memory for actions, Prospective Memory or memory for delayed intentions. Related research includes an investigation into the effects of encoding modality on children's prospective memory by Passolunghi, Brandimonte and Cornoldi (1995) who found that younger (7-8 years) children benefited from visual encoding of a prospective memory task instruction while older children (10-11 years) benefited from motoric encoding.

Experiments 4-5 assigned children from different age groups to one of three encoding conditions (visual, verbal, motoric) and presented prospective instructions for target items. Experiment 4 revealed no encoding modality benefits between 7-, 9- and 11-year-olds, although there was a developmental trend, particularly between the 7- and 11-year-olds. Experiment 5 failed to reveal any age-related improvement between 9- and 11-year-olds. Experiment 6 examined whether prospective remembering in Experiment 5 was related to executive functioning and identified predictors following motoric and visual encoding.

The overall findings are discussed with reference to the deployment of attentional resources and to current theories of the development of executive functioning.

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CHAPTER 1

LITERATURE REVIEW 1:

Subject-Performed Tasks, Intention Superiority, and attentional resources

This thesis examines the development of memory for action-related information, enacted and to-be-enacted, in children aged from 7 to 11 years. In so doing it addresses issues and phenomena in memory, attention and executive processing. This topic is of practical and theoretical interest because children are expected to become more dependent, over time, on their own memory rather than relying on older siblings or parents; for example, remembering to bring a PE kit into school or return a signed parental-consent letter. It is important, therefore, to investigate how children's memory for actions develops and to identify any strategies that might enhance their memory performance.

This first review chapter examines the relevant literature on automatic / controlled processing and action memory. This then leads to the first research aim of the thesis.

The Subject-Performed Task and Intention Superiority Effect paradigms employ a common distinction between strategic (or controlled or attentional) and non-strategic (or automatic) processing. Therefore, it is important to discuss this distinction before defining the two paradigms.

1.1 STRATEGIC VS. AUTOMATIC PROCESSING

Over the last twenty-five years, much research has focused on a continuum, proposed by Hasher and Zacks (1979), concerning the attentional requirements of different mental operations. This section addresses some of this research with particular reference to the opposing ends of the hypothetical continuum –

controlled (Schneider & Shiffrin 1977; Shiffrin & Schneider 1977) or effortful (Hasher & Zacks 1979) and automatic processes. These will first be discussed separately and then together towards with reference to attentional and memorial processing.

1.1.1 Controlled processes

Posner and Snyder (1975) described non-automatic tasks as those that require explicit attention in order to be successfully completed. Schneider and Shiffrin (1977; Shiffrin & Schneider 1977) expanded on this idea and suggested that controlled processes have a limited capacity whereby one's ability to engage in numerous simultaneous, effortful processes is restricted. Consistent with this capacity view, Hasher and Zacks (1979) suggest that we can think of attention as a "*non-specific resource for cognitive processing*" (pp. 363). Attentional demands have been studied using two different paradigms. In the *selective attention* method, participants are presented with two or more inputs and asked to only respond to one. In the *divided attention* method, on the other hand, participants are also presented with two (or sometimes more) inputs but asked to attend and respond to all of them. Here, I focus on the divided attention paradigm only as this is more relevant for this thesis.

1.1.1.1 Divided Attention

Three factors are thought to affect performance on divided attention tasks: *Task similarity*, *task difficulty* and *practice*.

Circumstances in everyday life where one is required to perform two tasks concurrently usually involve two dissimilar tasks (e.g. walking and talking). Outlined here is some evidence indicating that the degree of similarity between tasks is of great importance. Wickens (1984), for example, identified three kinds of task similarity that can influence conflict between two tasks: stimulus modality, stages of processing, and related memory codes. McLeod (1977) identified a fourth, response similarity. For example, he found that if participants used two manual responses for different targets, their performance is affected more than when a manual response is used for one set of targets and a vocal response for the second. Similarly, Duncan (1979) asked participants to respond to closely successive stimuli using either their left- or right-hand. The stimulus-response relationship called for either a corresponding (i.e. a leftmost stimulus required a left-hand response), or a crossed response (e.g. a rightmost stimulus required a left-hand response). Duncan found performance to be poor when the stimulus-response relationship was corresponding for one stimulus but crossed for the other. Under these circumstances, participants appeared confused as to which response to make to each stimulus. This confusion added an obstacle to successful performance and introduces the second dual-task influencing factor; task difficulty.

Several lines of research have investigated the role of task difficulty. Sullivan (1976), for example, presented participants with a shadowing task in which the target words were delivered in the non-shadowed (to-be-ignored information stream presented to one ear) rather than the shadowed (to-be-attended stream presented to the second ear) message. When Sullivan made the shadowing task more difficult by using a less redundant message, she found that participants identified fewer targets on the non-shadowed message. Therefore, this research together with that of Duncan indicates that adding complexity to the two concurrent tasks can significantly affect performance.

The third factor that can determine performance on dual-tasks is practice. In addressing this factor, Spelke (1976) gave two students training for a variety of tasks over four months. Although Spelke *et al* found improvement over time on all of the dual-tasks in both participants, it has been argued that some of the tasks may not have been entirely effortful, but rather partially automatic (see 1.1.2). Nevertheless, it appears that practice can facilitate dual-task performance in at least three ways. First, new strategies could be employed to minimise task interference. Second, through practice the attentional demands made by the task may be reduced. Third, with more practice new, more efficient cognitive routes may be uncovered that rely on fewer resources than when first carried out. The topic of practice will be returned to later with respect to memory operations.

1.1.2 Automatic processes

In studies of divided attention there is a considerable evidence for a dramatic improvement in performance through practice. The most common explanation for this observation is that through prolonged practice, some of the processing activities become automatic i.e., some complex operations can occur with minimal involvement of conscious, attentional capacity. There are three major theories of automaticity proposed by Posner and Snyder (1975), Shiffrin and Schneider (1977; Schneider & Shiffrin 1977) and, more recently, Norman and Shallice (1986). Although some features vary, there are also similarities between these theories.

Although it is relatively easy to identify the criteria for automatic processes, the difficulty comes when one attempts to nail them down empirically (Hampson 1989). Thus various researchers have been able to summarise the criteria that are generally accepted for automatic processes (Hasher & Zacks 1979; Norman & Shallice 1986; Posner & Snyder 1975; Schneider & Shiffrin 1977; Shiffrin & Schneider 1977). Here, I focus on the most often cited criteria, supplied by Hasher and Zacks (1979). First, any process deemed as automatic tends to be fast and operate continuously. Second, compared to effortful processes, automatic operations demand zero attention. Third, there is no explicit awareness or knowledge of an automatic process occurring – it is therefore unconscious. Importantly, however, the knowledge gained by the process is thought to be accessible to consciousness. Finally, automatic processes are always engaged upon the presentation of a suitable stimulus, and are thus unavoidable. For example, in the Stroop task participants are asked to name the colours in which words are printed (e.g. the word RED printed in blue). Because participants find this task so difficult, as indicated by slower latencies when compared to just reading black print words, it is thought to involve unavoidable automatic responses (although see Kahneman and Henik 1979 for an alternative finding).

Although there is considerable agreement on the criteria for automatic processes a significant problem arises when one attempts to identify purely automatic processes. As Hasher and Zacks (1979) point out, there are many more processes that are only partially automatic or controlled. Consistent with this, Hasher and Zacks (1979) proposed a continuum in the attention requirements of mental operations based on research by Posner and Snyder (1975) and, in particular, Schneider and Shiffrin (1977; Shiffrin & Schneider 1977). On this continuum automatic and effortful processes lie at opposing poles with partially automatic operations somewhere in between.

In keeping with this, Norman and Shallice (1986) described three different levels of functioning as *fully automatic*, *partially automatic* and *deliberate control*. They suggested that the first of these occurs with very little conscious processing during the operation of the schema (action plans). In order to prevent these processes from disrupting behaviour, Norman and Shallice suggested that an automatic process known as “contention scheduling” is built into the system. This process has access to coexisting priorities and resolves conflicts between processes. This resolution is based on priority information together with current environmental information. Partially automatic processes, on the other hand, generally occur with more conscious awareness, although there is no conscious control. Rather, contention scheduling resolves inconsistencies between schemas with no deliberate control. The final higher level of functioning, deliberate control, is better known as the Supervisory Attentional System (SAS).

This flexible system can be likened to the operation of the will: it is involved in decision-making and responding to novel situations.

As Baddeley (1997) points out, the Norman and Shallice model "*…although it is not worked out in the degree of detail, or empirically tested as extensively as the Schneider and Shiffrin model, it nevertheless does appear to provide a very useful basis for conceptualising the central executive component of working memory*" (pp. 91). The central executive is the most important and versatile element of Baddeley's (Baddeley 1986; Baddeley & Hitch 1974) working memory model. Like the SAS, the central executive has a limited capacity and, working alongside two slave systems (the phonological loop and the visuo-spatial sketch pad) it deals with cognitively demanding tasks, such as driving. It was this similarity, together with observations from patients with frontal lobe deficits (e.g. Baddeley 1986; Baddeley & Wilson 1988; Saver & Damasio 1991), that led Baddeley to adopt the SAS as a model of his central executive.

Consistent with Luria's (1966) proposition that the frontal lobes are responsible for programming and regulating behaviour, it appears that the frontal lobes are linked to executive functioning. Shallice (1988) has suggested that damage to the frontal lobes is associated with two types of behavioural difficulty linked to the SAS / central executive: behavioural rigidity (or perseveration), inertia, and being easily distractible. Indeed there is a great deal of evidence that these behaviours are evident in frontal lobe patients although these data will not be discussed in detail here (see Parkin 1996 for a more detailed discussion). Essentially, findings from performance on a number of different cognitive tests including the Wisconsin Card Sorting Test, the Mental Fluency test and the Stroop task, indicate that many patients with frontal lobe deficits behave as if they lacked a control system that provided an efficient supervision over processing resources (e.g. Milner 1963; Bench, Frith, Grasby, Friston, Paulesu, Frackowiak, & Dolan 1993): Although the resources appeared intact, there is no overall direction over them.

1.1.2.1 Automatic and controlled encoding processes

Engelkamp (1998) has observed that, for a long time, the distinction between automatic and controlled processes was not applied to memory phenomena. In a notable exception, Hasher and Zacks (1979) studied the differentiation of the two operations with respect to encoding processes and, in so doing, devised a framework based on two principles. The first assumes a continuum of attentional processes, mentioned earlier, with automatic and effortful processes lying at opposing ends. The second assumes that attention has a variable but limited capacity and that this interacts with the demands made by encoding processes. They reviewed work on two states thought to influence cognitive capacity and studied these, together with different age groups, in four experiments.

The first state that Hasher and Zacks refer to is depression. Hasher and Zacks suggest that depression can produce reductions in cognitive capacity (e.g. deficits in serial learning, free recall and intelligence scores). The second state is arousal where cognitive capacity appears to increase with low levels of arousal and decrease with high levels of arousal (e.g. Kahneman 1973; Mandler 1975). Hasher and Zacks cite various studies to support the conclusion that under high levels of arousal only automatic and/or unconscious operations that require little or no cognitive capacity are able to function effectively. Other operations appear to be hindered under such conditions.

The two age groups that Hasher and Zacks use to further support to their arguments were young children and older adults. They point out that memory skills that place more demands on capacity (e.g. rehearsal) seem to show the most significant changes during childhood whereas those abilities described as "*basic*" (e.g. Flavell 1977; Flavell 1985) or non-strategic (e.g. Brown 1975) show few developmental trends. Examples include the encoding of space, time and recognition information (Hasher and Zacks 1979). Conversely, in older adults, Hasher and Zacks report research suggesting a decrement in memory function, indicated by poor performance in free recall tasks, mnemonics, imagery and rehearsal etc. Since all can be described as effortful, it would appear that ageing is often accompanied by a reduction in cognitive capacity.

Hasher and Zacks proposed five characteristics that they considered to be central to their framework and, more importantly, should influence automatic and effortful encoding processes: a) intentional versus incidental learning, b) instructions and practice, c) interference among operations, d) states that alter attentional capacity and e) developmental trends. In four experiments, Hasher and Zacks investigated these five determining factors together with frequency of occurrence[1]. In the first experiment, they compared the effects of word frequency on the performance of children from the first three grades of kindergarten and found no developmental differences in performance. In the second, they compared the effects on memory of differences in word frequency in forty college students and forty elderly subjects. They found that performance did not alter with age and concluded that, "*…this evidence is generally in support of the assumption that frequency processing is a skill relatively invulnerable to changes in cognitive performance…*" (pp. 372).

In their third experiment, Hasher and Zacks examined whether automatic frequency processing would be affected by stress states, measured by whether or not the participant was classed as depressed using the Beck Depression Inventory (Beck 1967). Again they found no differences between the two sample groups: depressed adults performed as well as nondepressed adults. In their final experiment, Hasher and Zacks examined performance by depressed and nondepressed adults on effortful processing tasks that involved rehearsal, elaboration, recognition and false recognition. They found that although the two samples were equivalent in their ability to recognise old items accurately, they

[1] This is a component thought to be encoded automatically with the stimulus. Second-grade children, for example, have been shown, experimentally, to be as sensitive to differences in the frequencies of the occurrences of words as college students (Hasher & Chromiak 1977)

differed in the kinds of recognition errors made, probably due to the differences in use of rehearsal processes.

Overall, Hasher and Zacks found that frequency occurrence performance is carried out as accurately by kindergartners as by college students and that even the elderly perform well, suggesting no developmental trends across the lifespan and thus indicating that it is an automatic, unconscious process requiring little or no cognitive capacity. This was further supported by findings from a sample of depressed college students who did as well as a control sample of nondepressed college students. Hasher and Zacks also found that effortful processes differ from automatic processes in a number of ways: they require an intention to be employed, benefit from training or practice, and show profound developmental changes between childhood and old age.

Engelkamp (1998) has challenged Hasher and Zacks' conclusions, citing evidence that suggests that these claims might be too presumptuous. Indeed, despite the experimental support provided by Hasher and Zacks, other researchers have failed to replicate their findings (e.g. McDaniel, Einstein & Lollis 1988; Naveh-Benjamin 1987). Furthermore, Baddeley (1997) reports that there have been a number of failed attempts to observe automaticity effects in encoding frequency tasks (e.g. Ellis, Palmer & Reeves 1988; Fisk 1986; Naveh-Benjamin & Jonides 1985; Sanders, Gonzalez, Murphy & Liddle 1987).

1.1.2.2 Automatic and controlled processes at test

The distinction between automatic and controlled processes at retrieval has also been made and has tended to concentrate on recognition memory (Engelkamp 1998). Mandler, Goodman and Wilkes-Gibbs (1982), for example, suggested that a combination of two alternate processes leads to recognition performance due to the additive effects of two components: frequency of occurrence and depth of processing. Indeed, Mandler (1967) has suggested that occurrence frequency leads to automatic recognition and processing depth to controlled recognition[2]. In one experiment, Graf and Mandler (1984) presented two groups of participants with words that were categorised semantically by one group while a second made a visual feature judgement. At test, all were presented with word stems and asked to either complete the word with the first word that came to mind or to use the stem as a cue. Graf and Mandler found that while semantic categorisation enhanced cued recollection, visual processing enhanced free recall. Thus, participants appeared to base their recognition judgements on either familiarity (i.e. based on a pre-experimental representation) or the learning episode (i.e. a controlled process where the person searches for information encoded during study). A similar proposal, put forward by Jacoby (1983; Jacoby & Dallas 1981), suggested that automatic and controlled processes could influence whether an item is recognised as old or new. However, as Engelkamp (1998) points out, it is often difficult to determine whether automatic or controlled recognition has taken place (see Gardiner 1988; Jacoby 1991 for alternative suggestions).

1.1.3 Summary: Controlled versus Automatic Processes

Over the past quarter of a century, research has begun to focus on controlled and automatic processes, in relation to both attention and memory. From this review, we can conclude that at the extremes of a continuum, controlled processing requires explicit attention from a limited capacity mechanism that hinders simultaneous multi- (effortful) tasking. Automatic processing, on the other hand, is fast, demands little attentional capacity, occurs without conscious awareness and is usually unavoidable.

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[2] Mandler referred to “automatic processing” as “familiarity-based” and “controlled processing” as “elaboration-based”.

Research into controlled and automatic memory processing by Hasher and Zacks (1979) focused on encoding processes. Their framework integrates studies on memory performance in young children, the elderly and individuals suffering from depression, and strongly suggests that the absence of developmental differences imply that a specific encoding operation is automatically applied.

With respect to this thesis, the work outlined above provides an excellent foundation for understanding the sort of cognitive processes that contribute to performance in memory tasks by young children. It is generally accepted that two opposing processes are involved in cognitive operations, controlled and automatic, although they may in fact represent two ends of a continuum (c.f. McDaniel & Einstein, 2000). What follows is a review of the literature associated with two memory paradigms central to this thesis: The Subject-Performed Task and the Intention Superiority Effect.

1.2 THE SUBJECT-PERFORMED TASK

Two groups instigated laboratory research on action memory over twenty years ago. In Saarbrücken, Germany, Engelkamp and Krumnacker (1980 cited in Zimmer & Cohen 2001) asked participants to either perform, passively listen to or imagine a series of mini-tasks. At test, participants were asked to recall as many of these descriptive action phrases as they could remember. Engelkamp and Krumnacker discovered that recall memory for the action phrases after performing was superior to that following listening to or imagining the action phrases. They referred to this finding as the *enactment effect*.

In separate work, Cohen and colleagues (Cohen 1981, 1983, 1985; Cohen & Bean 1983) used a similar methodology to investigate memory for actions. In the first study (Cohen 1981) Cohen tested participants' free recall of fifteen action phrases (e.g. "break the match" or "pick up the pencil") that had been studied either by standard learning instructions or by self-performance (Cohen referred to the latter encoding condition as a *subject-performed task*[3]). His results were consistent with those of Engelkamp and Krumnacker: Recall was higher after acting the phrases than after standard learning. Cohen named this effect the *Subject-Performed Task* or *SPT effect*.

Although the SPT or enactment effect is a very robust phenomenon that has been extensively replicated (for reviews see Cohen 1989; Engelkamp 1998; Engelkamp & Zimmer 1994; Zimmer & Cohen 2001), the means by which enactment enhances recall remains a matter of debate (Zimmer, Helstrup and Engelkamp 2000). What follows is a discussion of four alternate theoretical accounts that each attempt to explain the superior retention of self-performed tasks. The first two are based on the distinction between automatic and controlled processes. The third subscribes to the idea of an interaction between modality-specific systems and encoding processes and the final theory places memory for actions in the broader context of activity memory.

1.2.1 Cohen's Theory: Enactment Based On Strategy-Free Encoding

Cohen and colleagues' (Cohen 1981, 1983, 1985) early research into the enactment effect investigated whether variables known to affect retention following verbal learning have similar effects on the retention of SPTs. They paid particular attention to two variables: serial position and levels of processing.

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[3] In this thesis, when referring to the *subject-performed task* paradigm, the abbreviation **SPT** will be used. Similarly, for those conditions where participants study phrases under standard learning instructions – *verbal tasks* – the abbreviation **VT** will be substituted.

Serial Position Curve Studies

The serial position effect describes a robust observation in the free recall literature that first and last study list items are better recalled than those situated in the middle (Murdock 1962). These findings are more commonly referred to as the *primacy effect* (early list items) and the *recency effect* (later list items). It has been suggested that the primacy effect is a consequence of the rehearsal of early items during learning thereby increasing the likelihood of generation and recognition of these items compared to subsequent ones (e.g. Rundus 1971). The recency effect, on the other hand, has been said to originate from the properties of acoustic short-term memory, which is able to temporarily store latter items from a study list allowing easier retrieval Glanzer and Schwartz 1971).

A number of researchers have focused on serial recall research with respect to SPTs. Olofsson (1996) and Zimmer, Helstrup and Engelkamp (1993 cited in Zimmer & Cohen 2001), for example, asked participants to recall previously studied items from SPT and verbal task (VT) conditions either in serial order or to free recall and then rearrange the recalled items into serial order. They found no reliable differences between the latter two conditions. However, the type of task engaged in at encoding (SPT, VT) did influence serial position effects. Typically, in free recall, items encoded via SPT show strong recency but no primacy effects whilst those items encoded via a VT show both recency and primacy effects (Bäckman and Nilsson 1984, 1985; Cohen 1981; Helstrup 1986). However, in serial recall, similar recency and primacy effects were observed in both the SPT and VT conditions (Helstrup 1987; Olofsson 1996; Zimmer, Helstrup and Engelkamp 1993).

Zimmer and Cohen (2001) suggest that, based on the available experimental evidence, positional cues in serial recall paradigms are not enhanced by enactment. However, other studies have observed a primacy effect when the number of items in a list is increased. Zimmer, Engelkamp, Mohr and Mohr (1988 cited in Engelkamp 1998) and Mohr, Engelkamp and Zimmer (1989), for example, used 48 and 80 items in VT and SPT conditions, respectively. In both studies, primacy and recency effects were observed following both encoding conditions in a free recall test. Interestingly though, the recency effect was more pronounced after enactment than after hearing. Zimmer, Helstrup, Engelkamp and Saathoff (1997, Experiment 1 cited in Engelkamp 1998) investigated this further by manipulating list length (12, 24 or 36 phrases) under VT and SPT conditions. A comparison of the serial position curves revealed, once again, a stronger recency effect after enactment than after hearing. However, although a stronger primacy effect was shown after VT, the difference with SPT was nonsignificant. In a second experiment, when list length was increased to 80 items, similar results were observed with a small primacy effect after both VT and SPT.

Depth of Processing Studies

Craik and Lockhart (1972) proposed that the depth or level of processing a stimulus receives at study has a key effect on how memorable that stimulus is: Deeper (richer, semantic) processing leads to stronger, more elaborate memory traces than shallow (physical, superficial). In addition to the idea of levels of processing influencing long-term memory, Craik and colleagues also uncovered evidence to suggest that elaboration of processing (i.e. processing of a particular kind) is also important (e.g. Craik and Tulving 1975). Elaboration is a process that helps to increase the depth at which an item is encoded. For example, in one experiment, cued recall was found to be twice as high for words encoded using complex rather than simple sentences (Craik and Tulving 1975). Obviously, such elaboration requires conscious, effortful processing in order to be effective. Because of this, it has been described as *strategic* or *controlled* encoding.

Effects of levels of processing and elaboration have been repeatedly found for verbally encoded information on standard recognition and recall tests (Craik and

Tulving 1975; Hyde and Jenkins 1969, 1973). In contrast, they appear to have little impact on retrieval following SPT encoding. Cohen (1981), for example, investigated the recall of action phrases after VTs / SPTs and also manipulated the degree of encoding. Under the *shallow* encoding condition, Cohen asked participants to judge actions according to either bodily involvement or the degree of noise for each action phrase. Under the *deep* encoding condition, participants were asked to make self-performance frequency judgements and recall the last time when they had carried out the task. Although Cohen observed the usual effect of depth of processing following VTs, it was absent after SPTs. Similarly, Nilsson and Craik (1990) reported marginal level of processing effects following motoric encoding in contrast to large effects following verbal encoding (this manipulation did not, however, affect the enactment effect observed with free recall). In two other studies, Helstrup (1987) and Zimmer (1984, cited in Engelkamp 1998) manipulated encoding elaboration by asking participants to do preparation tasks for SPT encoding. Engelkamp (1998) points out that because neither study found any difference in retention between the instruction to perform the goal task directly and the instruction to also perform the preparatory tasks, it would seem that elaboration had little influence on learning through enactment.

More recent research from Zimmer and Engelkamp (1999) manipulated list length (range between 12 and 96 items) and orientation. Orientation or processing focus was either conceptual (how probable is action X in the situation Y: e.g. spreading something on bread – at the breakfast table?) or perceptual (a judgement of the occurrence of a series of letters appearing in the phrase). When 48 or more items were studied, they observed an effect of levels of processing under both encoding conditions, although this effect tended to be smaller after SPT encoding. Moreover, the enactment effect was only observed after “shallow” perceptual processing. At first glance, this finding indicates that the enactment effect is hindered by additional encoding demands, which contrasts with numerous observations that elaboration *benefits* verbal material (Craik and Tulving 1975; Lockhart and Craik 1990) and previous observations of enactment effects after both shallow and deep encoding by Cohen (1981) and Nilsson and Craik (1988). Engelkamp (1998), however, points out differences in design between the Zimmer and Engelkamp study and earlier experiments, such as the instructions used for the "shallow" processing manipulation.

Other research has also uncovered findings with SPTs that contrast with those of verbal learning. Study time (Cohen 1985), items of a bizarre nature (Einstein & McDaniel 1987; Engelkamp, Zimmer & Biegelmann 1993; Knopf 1991), presentation rate (Cohen 1985) and item importance (Cohen 1985) were all found to have no influence on SPT material. Zimmer and Cohen's (2001) summary of this research claims that such findings are "compatible with the assumption that *pure performance is an optimal type of encoding for actions*." (p.12; italics by Zimmer & Cohen).

Research into the SPT paradigm has revealed a number of important dissociations from verbal learning. One such, important for this thesis, is that SPT recall appears not to exhibit characteristics that typically denote the use of effortful encoding strategies in verbal learning.

Cohen's Theory: Controlled and Automatic Processes

Failures to observe either a primacy or a levels of processing effect led Cohen (1981; 1983) to suggest that, in contrast to verbal encoding, factors such as rehearsal and depth of processing have little if any effect on SPTs. Thus he proposed that SPT encoding processes are non-strategic or automatic (see 1.1) and conducted a series of studies to explore this proposal. In one, participants were asked to allocate more attention to some items than to others in a list. In contrast to research with verbally encoded items (e.g. Bjork 1972; Harley 1965), this manipulation had very little effect on retrieval following enactment at study. In another study, Cohen asked participants to predict their retention by indicating which actions they were more likely to remember. He found that in the enactment conditions participants experienced difficulty in making these judgements. For items in the listening condition, judgements were far more accurate. Cohen argues that these findings support his proposal that strategic encoding processes have a limited effect on information acquired through enactment.

Research on the effects of self-generation and study time manipulations lend further support to Cohen's proposal. The generation effect has been described as a form of conceptual elaboration by Gardiner, Gregg and Hampton (1988) in which extended study time for each item is thought to provide more opportunity for active encoding of that item. Nilsson and Cohen (1988), for example, contrasted performance where participants were asked to generate, name and execute a task related to a presented object (generate + SPT encoding) with performance in a control condition where participants were told to perform the task (SPT only). In the comparable VT conditions, participants had to either generate action phrases for object words (generate + VT) or to listen to predetermined phrases (VT only). As predicted, they observed a reliable generation effect following VT at study but no effect following SPT. Similar findings have been reported by Zimmer and Engelkamp (1999).

With respect to study time, a number of studies have revealed the benefits for retention of extending study time per verbal item (e.g. Glanzer & Cunitz 1966; Murdock 1960). In contrast, no such benefits have been observed for items enacted at study (Cohen 1985; Kausler, Lichty & Davis 1985; Kausler, Lichty & Freund 1985; Kausler, Lichty, Hakami & Freund 1986). Cohen, for example, found that varying study time had more of an influence on VTs than on SPTs. Kausler and his colleagues obtained a similar finding when they asked participants to perform various activities, the duration of which ranged from 45 to 180 seconds. Some activities were motor-based (e.g. cutting out shapes) and others more cognitive (e.g. word completion). Retention (measured by recall) was found to be unaffected by study time.

An alternative means of investigating the proposal that enactment at study leads to a non-strategic encoding process is to examine performance in individuals thought to experience difficulties in engaging active processes at encoding. Craik and Jennings (1992), for example, argue that one's ability to engage in active encoding increases through childhood and early adulthood and declines in later years. Consistent with this claim, age-related decrements in healthy older adults following verbal learning have been observed (Hasher & Zacks 1979) while, in contrast, neither older adults nor young children show memory differences (in comparison to a young adult control group) following enactment at study (Bäckman & Nilsson 1984, 1985; Cohen & Stewart 1982). Despite these findings, it is also important to note some contrasting evidence that, after SPT encoding, younger adults recalled *more* than older adults (Brooks & Gardiner 1994; Knopf 1991; Norris & West 1991). Moreover, using a modified procedure, Kausler and colleagues also reported significant age effects (Kausler 1989; Kausler, Lichty *et al* 1985; Kausler, Lichty *et al* 1986). In an attempt to explain these inconsistencies, Cohen, Sandler and Schroeder (1987) conducted a series of studies in which they identified a further contentious factor: list length. Thus their studies revealed that age differences only occurred with longer lists. However Kausler (1989), using short lists, observed a small age-related effect in recall and no effect in recognition with SPTs. Furthermore, Engelkamp (1998) points out that very short lists may be too easy, allowing "weaker" older adults to achieve performance on par with younger ones.

1.2.1.1 Evaluation of Cohen's Theory

Despite the contentious issues that are commonly raised by a controlled / automatic claim such as that proposed by Cohen, this claim is particularly important for this thesis as it could help to explain potential differences in young children's performance. Although all of the research outlined above is consistent with Cohen's (1983, 1985) proposal, Engelkamp (1998) points out that he fails to explain why (automatic) encoding through enactment is so beneficial to retention. From the observation that enactment supports memory without any additional encoding mechanisms (indicated by no age effect, no elaboration effect, no effect of presentation rate and no primacy effect, all of which occur in learning verbal material), Cohen suggested that the SPT was a nonstrategic form of encoding. If this is the case, then the inclusion of a secondary task designed to interfere with controlled processes should have a negligible effect on SPT retention (as suggested by Shiffrin & Schneider, 1977; Schneider & Shiffrin, 1977). But, as we shall see, this is not the case. Furthermore, Engelkamp (1998) argues that controlled encoding processes are more efficient than automatic processes (although he fails to support this argument) and should lead to better retention. However, it could be argued that because automatic processes require no effort they are a more efficient form of processing. In an attempt to resolve these dilemmas, Bäckman and Nilsson presented their own theory of the benefits of SPT encoding.

1.2.2 Bäckman and Nilsson’s Theory: Multimodal Encoding

One of the principal notions put forward by Bäckman and Nilsson (Bäckman & Nilsson 1984, 1985; Bäckman, Nilsson & Chalom 1986) is that SPT encoding is multimodal. The instruction to enact the phrase “*read a book*”, for example, involves auditory (hearing the instruction), visual (where the participant sees him/herself enacting the phrase) and motoric information (the actual performance). If this is the case, then additional (secondary task) interference should disrupt the SPT effect.

In a series of studies of memory retention in older and younger adults, Bäckman and Nilsson found an improvement with age after verbal encoding but no such improvement after non-verbal, SPT encoding (Bäckman, 1985; Bäckman & Nilsson, 1984, 1985; see also Cohen & Stewart, 1982). A retrospective examination of these experiments, however, revealed that some of the phrases contained an object (e.g. “*lift up the pen*”) whilst others did not (e.g. “*nod your* *head*"). When the recall data were re-analysed, using the Adjusted Ratio of Clustering (ARC: Roenker, Thompson & Brown 1971) method, it was found that phrases tended to be clustered according to whether or not they involved an external object. Moreover, higher ARC scores (indicating more of a categorical structure) were more evident following enactment than following listening.

Following this discovery, Bäckman, Nilsson and Chalom (1986) conducted three experiments that compared free recall of SPT and VT action phrases for organisable and non-organisable items (object-based versus related to the body), under full or divided attention at encoding, using a cognitively-demanding subtraction secondary task in the divided attention conditions.

Five principle findings were emerged from Bäckman, Nilsson and Chalom's (1986) experiments. First, consistent with previous experiments including those conducted by Cohen, recall for SPTs was superior to that for bimodally presented VTs[4]. Second, the effect of divided attention was greater on VT recall (M = 0.45 without interference, M = 0.16 with interference) than SPT recall (M = 0.78, without interference, M = 0.61, with interference). As the authors noted, however, there was a significant reduction in recall when attention was divided for both SPT and VT material. Third, following analysis of the ARC scores, clustering was found to occur more after enactment (ARC score without interference: 0.48, with interference: 0.46) than after listening (ARC score without interference: 0.33, with interference: -0.10), consistent with their previous experiments (Bäckman 1985; Bäckman & Nilsson 1984, 1985). This, they suggest, indicates that organisational information is easier to use after motoric than after verbal encoding. Fourth, when the items could not be organised, SPT recall was found to reduce more than VT recall compared to when items could be organised. (Again, however, both types of material showed a significant decline in recall.) Finally, under

[4] VT sentences were presented both in the visual (they appeared consecutively on a slide projector screen) and auditory (each sentence was read aloud by the experimenter) modalities.

conditions of divided attention for non-organisable items, recall was equally impaired for SPTs and VTs.

From these findings, Bäckman *et al* drew a number of conclusions concerning why participants should profit from SPT encoding. First, the contextually rich and automatic multimodal encoding of an action benefits retention. More importantly, though, this encoding includes a strategic, effortful component. This comes from the second finding in which, although SPTs were less affected by interference, a significant decline in recall performance was nevertheless observed, suggesting that a feature of the SPT encoding process was being disrupted. Therefore, in contrast to Cohen, Bäckman *et al* propose that the learning of SPTs requires some strategic, attention-demanding encoding (the verbal component) and some nonstrategic, more automatic encoding (the action component; see also Bäckman, Nilsson, Herlitz, Nyberg & Stigsdotter 1991; Bäckman, Nilsson & Nouri 1993). This latter component encompasses object features and originates from Bäckman *et al*'s emphasis on the importance of these qualities[5]. The verbal component, on the other hand, is comprised of the essential elements of the phrase – the words.

Bäckman *et al* also suggested that the multimodal and contextually rich features of SPTs allow easier access to information about a list's categorical structure. This permits the use of organisational strategies, which benefit retention. This was supported by analysis of the ARC scores, mentioned above, where clustering was found to occur more after enactment than after listening. This suggestion is consistent with Bäckman *et al*'s assertion that performance also enhances relational processing (Mandler 1967, 1968) - a view contested by Zimmer and Engelkamp (1989a, 1989b). These notions were left largely

[5] The majority of their experiments were conducted with real objects and features such as colour, smell, texture and weight were deemed particularly significant (e.g. Bäckman, Nilsson & Chalom, 1986).

unconsidered by Cohen but formed the core of Bäckman *et al*'s theory. Nevertheless, there are some concerns with their model.

1.2.2.1 Evaluation of Bäckman et al's Theory

Bäckman and Nilsson's theory differs from Cohen's (1985) in several ways. First, they suggest that encoding by enactment is comprised of two components: a verbal and a non-verbal (motoric) element. Second, motoric, non-verbal information requires both strategic and nonstrategic processing, while verbal information requires strategic processing exclusively for proficient encoding. The third difference highlights Bäckman and Nilsson's emphasis on the rich, multi-modal characteristics of non-verbal encoding; characteristics that they view as key to explaining better retention after enactment. This final point led Bäckman and Nilsson (1984) to contest Cohen's (1983, 1985) explanation for the absence of an age effect. As mentioned above, Bäckman and Nilsson suggested that controlled, strategic processes play an important role in motoric encoding by exerting an influence on the verbal component of each phrase. Therefore, they argue that the absence of an age effect cannot be solely based on automatic, non-strategic encoding processes: There must also be some strategic processing taking place. To account for this, they proposed that *spontaneous recoding* explains the retention advantage for enactment across age groups. This model suggests that while younger adults might use organisational strategies, older adults can exploit the multimodal and contextually rich encoding environment in compensation for deficient organisational strategies.

Although Bäckman and his colleagues' explanation is plausible, there are a number of contentious issues. First, they do not make it clear how the two processes (i.e. automatic and controlled) thought to be involved in encoding by enactment differ. In line with Hasher and Zacks (1979), they describe automatic processes as those that allow concurrent use of a finite number of controlled processes without themselves being influenced. With reference to controlled processes, they describe them as attention-demanding and open to disruption from other controlled processes and, consistent with Schneider and Shiffrin (1977; Shiffrin & Schneider 1977), these processes compete with each other for attention (Engelkamp 1998). However, Bäckman *et al* fail to establish the boundary between the two processes. It could be argued that the authors fail to explain where the automatic processes end and the controlled processes begin. The evidence is further weakened by research from Foley and colleagues showing an SPT effect in the absence of corresponding verbal material (e.g. Foley, Bouffard, Raag & Disanto-Rose 1991).

A second problem arises from methodological concerns highlighted by three anomalous findings: a) an unforeseen extended recency effect; b) interference effects following listening and enactment and c) observation of the SPT effect with and without objects. Concerning the first of these, the authors note that they did not score the final five "*recency items*" to ensure that, "*…the influence of short-term memory was minimized.*" (pp. 341). However, when Zimmer, Helstrup and Engelkamp (2000) included all of the recalled items in their experiments, they found an extended recency effect, indicating that the SPT free-recall advantage could be essentially due to superior recall of the last few items within a recall list. Thus it could be argued that if Bäckman *et al* had not removed the last five items, they might also have found an extended recency effect, similar to that of Zimmer *et al*. The second methodological problem relates to the backward-counting task employed as an interference task during each experiment. Bäckman, Nilsson and Chalom found that this task had a greater effect after listening than after enactment at encoding. However, they failed to explain why this occurred. Engelkamp (1998) suggests that one reason could be structural interference, where two tasks that use the same modal processing system interfere, reciprocally, with each other by over writing. Thus because the twenty-five stimuli in each of the conditions were presented bimodally (auditory and visual) the interference task also utilised the auditory system. Therefore, greater interference would be expected due to the increased load on the auditory system (but see Kormi-Nouri, Nilsson & Bäckman, 1994). Finally, Bäckman and

Nilsson's premise is dependent on the idea that the retention advantage is reliant on rich, multimodal features, they cannot explain why the effect has been observed both with real objects (Bäckman & Nilsson 1984, 1985) and when no objects are used (e.g. Engelkamp & Krumnacker 1980). However, Engelkamp (1998) is quick to point out that no research has been conducted to explicitly compare conditions with and without objects.

A third concern with Bäckman *et al's* theory relates to their emphasis on relational encoding. Zimmer, Helstrup and Engelkamp (2000) claim that Bäckman, Nilsson and Chalom's (1986) experiment is the only one to reveal better relational encoding with SPT than with VT encoding. In an attempted replication Engelkamp and Zimmer (1996) failed to find this effect. Other similar research by Engelkamp and colleagues has generally found that relational information is not influenced by enactment and, if anything, the importance of relational information is reduced when SPT encoding is employed (see Zimmer, Helstrup & Engelkamp, 2000 for further discussion). Instead several experiments that indicate that the SPT effect is due to item-specific, rather than relational encoding (e.g. Engelkamp & Zimmer 1994; Nyberg 1993 cited in Zimmer, Helstrup & Engelkamp 2000; Zimmer & Engelkamp 1989a, 1989b). Nevertheless, other research is consistent with Bäckman, Nilsson and Chalom's position (e.g. see Kormi-Nouri & Nilsson 1999).

Overall, although the theory put forward by Bäckman and his colleagues provides some interesting new ideas, in particular the importance of both strategic and non-strategic processing as the basis for the SPT effect, they failed to address a number of concerns. The third theory to be considered here, proposed by Engelkamp and Zimmer, moves away from the restrictions imposed by a contrast between strategic and non-strategic processes and instead focuses on modality-specific systems and encoding processes.

1.2.3 Engelkamp and Zimmer's Theory: Enactment Based On Motor Processes

In line with Bäckman and colleagues, (Bäckman & Nilsson 1984, 1985; Bäckman, Nilsson & Chalom 1986), Engelkamp and Zimmer (e.g. 1985) drew a distinction between modality-specific, verbal and nonverbal encoding systems and processes. However, whereas Bäckman and Nilsson suggest that multimodal encoding processes contribute to the enactment effect, Engelkamp and Zimmer concentrate exclusively on motor encoding processes.

Engelkamp and Zimmer outline three phases that they believe make up the encoding process. The first, **sensory encoding**, is dependent on different sensory modalities. Verbal stimuli, for example, induce verbal-sensory encoding processes and activate *word nodes* or *word marks* (Engelkamp & Zimmer 1985) in the verbal system. Pictorial stimuli, on the other hand, induce visual-sensory encoding processes and activate *picture nodes* or *picture marks* (Engelkamp & Zimmer 1985). The second phase, the **conceptual system**, represents semantics. This system activates the meaning from word and/or picture marks upon presentation. For example, when an action phrase (e.g. "*read a book*") is recited to a participant, the appropriate word marks are activated which in turn activate concepts in the system for the phrase. The third, **motor phase** occurs when the participant performs the action. For this to happen, Engelkamp and Zimmer argue that the action must be intentional and that a *motor programme* must be triggered to allow performance (Engelkamp & Zimmer 1985). Thus the principle motor components required for successful encoding are planned, programmed and finally carried out.

Because Engelkamp and Zimmer exclusively attribute the enactment effect to motor encoding and disregard the influence of other sensory information, they did not use real objects in their initial experiments. Instead, participants were asked to carry out the actions using imaginary objects (e.g. Engelkamp & Zimmer 1984;

Zimmer & Engelkamp 1985). These experiments also used a selective structural interference paradigm to investigate whether or not motor processes were the basis for the enactment effect. In one such experiment (Zimmer, Engelkamp & Sieloff 1984, Experiment 1, cited in Engelkamp 1998) found a crossover interaction between encoding conditions (SPTs and Experimenter Performed Tasks or EPTs) and the type of interference task (motor and visual) employed. Moreover, participants in the EPT condition appeared to stop watching the experimenter perform the actions and instead imagined a third person carrying out the actions. Although subsequent studies failed to replicate this unusual pattern of results, this was likely due to differences in the designs. For example, in both Zimmer *et al*'s (1984) second experiment and also in Saltz and Donnenwerth-Nolan's (1981) study, participants learned action phrases in one of two conditions. The first was a standard SPT condition and the second a visual-imagery condition in which participants were asked to visualise a third party performing the task (e.g. "*The quiz-master draws the lottery ticket*"). They were interested in whether the selective interference effects observed in Zimmer, Engelkamp and Sieloff's experiment would be found in this second condition. Thus, in both experiments, an interference task was included that was either motor (e.g. performance of a body-related task) or visual (e.g. remembering video images).

Although the results (for sentences recalled) from both studies revealed an interaction between learning and interference conditions, there was some disagreement: While Saltz and Donnenwerth-Nolan observed a crossover interaction, Zimmer *et al* only found an effect under motor learning indicating that performance after visual-imaginal learning was not disrupted by either motor or visual interference. Interestingly, when separate scores for the recall of the verbs and object words from each of the task sentences were calculated, Zimmer and colleagues found that the interaction reported above only occurred for verbs.

Zimmer and Engelkamp (1985) conducted two follow up experiments in an attempt to demonstrate that visual-imaginal (or kinematic as described in the studies) and motor components can be ascribed to independent processing systems. Although the experiments differed in the distraction tasks used, the results were indistinguishable: Recall of material encoded by enactment was more strongly interfered with by a secondary motor task than recall of visual-imaginary learning material and the latter was again recalled equally well after both visual and motor interference. Consistent with Zimmer *et al* (1984), an interaction was observed for verbs only.

From these experiments, it would seem that motor components can be distinguished from both verbal (Saltz & Donnenwerth-Nolan 1981) and visual-imaginary components (Zimmer & Engelkamp 1985). Further, Zimmer and Engelkamp (1985) suggest that, unlike sensory components, motor components contain a performance programme (or *motor programme*, c.f. Engelkamp & Zimmer, 1985) for actions. These programmes can be triggered in one of two ways: either by explicit motor activities or by an internal representation of motor activities.

In another study, Engelkamp and Zimmer (1984) investigated the movements involved in performance, comparing tasks such as "*stir the ingredients*" and "*turn the handle*". They reasoned that in certain tasks, the motor programme should be activated without the requirement of enactment instructions. Also, the motor information thus obtained should be transferred into the conceptual system from which the information can then be outputted. In one experiment, participants were presented with two consecutive action phrases and asked to judge if the movement patterns in each phrase were similar (50%) or dissimilar (50%). Presentation was also manipulated where the first phrase was either performed by the participant or verbally repeated, while the second phrase was always presented visually.

Engelkamp and Zimmer reasoned that judgement time should be reduced when the motor programme was activated early (i.e. by performance of the first phrase). In addition to this prediction being supported, they also found that when the two movement patterns corresponded, judgement was quicker than when they did not. From these results, Engelkamp and Zimmer suggested that tasks requiring motor information activate motor programmes, regardless of whether or not the action is executed. Moreover, they claimed that performance of an action makes movement information more available, as revealed by shorter judgement times following explicit performance of the first task compared to verbal repetition.

To confirm that the judgement is based specifically on motor information and not visual-imagery information, Engelkamp (1985, cited in Engelkamp 1998) conducted a replication. In the first study, actions from the first phrase had to be either visually imagined or enacted. In the second, they had to be either verbally repeated or visually imagined. Because Engelkamp found a shorter judgement time only after enactment and not under any of the visual-imagery conditions, he suggested that motor information was therefore more readily available after enactment.

1.2.3.1 Evaluation of Engelkamp and Zimmer's Theory

Foley and Ratner (2001) have suggested that, "*Zimmer and Engelkamp's emphasis on motoric codes in the enactment effect represents an important step forward*" (pp.119). Indeed, as we have seen, Engelkamp and Zimmer suggest that the enactment effect is due to motor processes via the activation of motor programmes – similar to picture and word nodes. Thus their explanation highlights the features of actions in preference to the features of words in the enactment effect.

To support this conclusion, Engelkamp *et al* used the motor interference task in several experiments, reporting that the enactment effect was reduced (though not entirely removed). However, Engelkamp (1998) himself is quick to point out the shortcomings of not including an interference-free control condition. He goes on to point out that due to this oversight and because they failed to consider central interference, interpretation of the data should remain preliminary for the time being.

More recently, Foley and Ratner (2001) have argued that Engelkamp and Zimmer's theory fails to emphasise the features of activities that are composed of goal-directed actions. Therefore, while Zimmer and Engelkamp (1985) conclude that the enactment effect cannot be reduced to planning, Foley and Ratner suggest that because this feature is related to a person's goal, it should not be ignored, particularly when underlining the importance of actions in the enactment effect and present their own *Activity Memory Framework* (Foley & Ratner 2001; Ratner & Foley 1994) to account for the enactment effect.

1.2.4 Foley and Ratner's Theory: The Activity Memory Framework

Based on action descriptions from a number of behavioural and cognitive theories, including a range of European perspectives (see Ratner & Foley, 1994), Ratner and Foley identified four memory-influencing features of activities that are specified by the goal(s) of the actor(s). The first concerns the **outcome(s)** of actions and activities and suggests that outcomes will be well retained and that their characteristics will influence the other aspects of an activity that are remembered (Ratner & Foley 1994). Ratner and Foley highlight two type of activity that differ in outcome. Activities such as exercise or motor play usually produce only kinaesthetic, internal feedback whereas other activities may produce external feedback in the form of a new product or a change of state in an object, thereby affecting how the activity is remembered. Smyth (1991, cited in Foley & Ratner, 2001), for example, found that movements that lead to an observable outcome (e.g. pick up a ball) show better retention than those that involve no outcome (e.g. point to a ball). Similarly, Ratner & Hill (1991) found that children were able to recall more actions when the outcome was observable at encoding.

For their second feature, **relational structure**, Ratner and Foley point out that acts are related to each other to create an interconnected sequence. Such a sequence can usually be organised in one of two ways: linear or hierarchical. In the first, (e.g. stimulus → response), time can play a major role (where order is determined by temporal position: early, late) irrespective of whether or not there are any goal- or outcome-related connections. For a sequence organised using a hierarchical structure, culture and individual goals play a key role. Thus, young children, like adults, tend to remember acts that have a greater causal relationship to the goal of a script (Nelson & Gruendel 1981) or an episode (Smith, Ratner & Hobart 1987).

Ratner and Foley discuss a number of Soviet activity theories (e.g. Leont'ev 1978; Wertsch 1985 cited in Ratner & Foley 1994) and review developmental research consistent with their suggestion that relational structure can affect both memory for an activity and the agent of the activity. Ratner and Foley also point out that the first, superordinate goals that emerge in children are those that are causally related to the outcome of an activity (e.g. Ratner, Smith & Padgett 1990). Ratner *et al* found that younger children were able to produce a simple hierarchical structure of a repeated event. With more experience, this structure became more complex.

The third feature focuses on **prospective processes**. Ratner and Foley state that when an act is carried out an outcome is usually anticipated: plans are often consciously and intentionally generated to bring about this anticipated result. Ratner and Foley argue that in order to produce such outcomes and anticipations of outcomes, prospective processes must include both complex and deliberate plans. Furthermore, both anticipations and plans relating to goals may occur before or during the activity. Indeed in SPT studies, the plans have typically been concurrent with the act. However, in many of the Foley and Ratner's studies, the actions were performed in the context of goal-directed activities that guided requests to perform the actions (e.g. Foley, Passalacqua & Ratner 1993). Nevertheless, irrespective of temporal relationships between plan formation and enacting, the framework proposed by Ratner and Foley predicts that three qualities should influence memory: The goal that guides the activity, the degree of effortful involvement of the actor, and the presence and type of symbolic indicators. In support of the importance of goals, Foley and Ratner (2001) highlighted a recent developmental study. In this study, preschoolers were asked to trace and imagine tracing pictures of objects. When these activities also involved listening to a story that involved the objects, Ratner, Foley and Gimpert (2000) found that children were more confused about which pictures they traced compared to those pictures they imagined tracing. This misattribution error is not, however, limited to children: Work into cryptomnesia effects by Marsh and colleagues, for example, has found that adults will sometimes claim responsibility for responses actually generated by others (e.g. Marsh & Bower 1993; Marsh & Landau 1995).

The final feature concentrates on **retrospective processes** that involve the activation of any aspect of a past instantiation of a present act (Foley & Ratner 2001; Ratner & Foley 1994). Because of their frequent association with the process of memory itself, these processes are included in all models of memory and learning (e.g. associative, connectionist, information processing) although the terminology may differ (e.g. inter-item associations, knowledge effects, script-based associations). Ratner and Foley (1994) argue that by focusing on the role of retrospective processing during the execution of an act, distinctions can be drawn between processes related to the experience of an act and those that are generally more typical of the cognitive system. With respect to how retrospective processes contribute to activity memory, they postulate two possibilities: First, activation of previously represented information may enhance the representation of the current act. For example, in a recent study that asked children to imagine their parents performing actions that involve the use of two objects, such as scissors and a newspaper, they found that children often cite occasions where their parents used the objects at home. Furthermore, retention of words was better using this kind of retrospective processing (Foley, Belch, Mann & MacLean 1999). The second possibility suggests that retrospectively activated material could become more related to an activity's goal if embedded in the prospective processes of an actor. Thus, when an event has been previously experienced, inputs can be provided from outcomes, relational information and both prospective and retrospective processes. For example, if the outcome from a previous event (arriving at a post box to post a letter) was successful, this could have a significant influence on an existing plan for a similar event (arriving at another post box) compared to if it was unsuccessful (i.e. not posting the letter).

1.2.5 Theories of the Enactment Effect: A comparison

Research has been conducted on the enactment effect for over twenty years and in that time, a series of theories have been put forward to account for the phenomenon. Although it is generally agreed that memory for motorically-encoded action phrases is retained better than that for phrases passively encoded by verbal task, the basis for this finding remains a contentious issue. From his experimental findings, Cohen (1981, 1983, 1985) stated that the enactment effect was independent of serial position cues in free recall and independent of the depth of processing effects. Because these effects were contrary to findings with effortful verbal tasks, Cohen proposed that the encoding of SPTs was nonstrategic. Bäckman and colleagues (Bäckman & Nilsson 1984, 1985; Bäckman *et al* 1986) agreed with Cohen that the encoding of SPTs involved some automatic processing (see 1.1), but argued for a dual conception of both automatic (for nonverbal components) and controlled (for verbal components) encoding. However, they later abandoned this theory in favour of a new position that described encoding by enactment as entirely attention-demanding (Kormi-Nouri, Nilsson & Bäckman 1994). However, this position also faces criticism, particularly with respect to Cohen's failure to observe age effects in young children.

Engelkamp and Zimmer (e.g. Engelkamp & Zimmer 1984; 1985; Zimmer & Engelkamp 1985), on the other hand, argue that the enactment effect has very little to do with controlled or automatic processes and instead can be explained by the involvement of motor processes, and in particular the activation of motor programmes. A range of experiments using visual-imaginal conditions, interference tasks and imaginary objects supported these ideas. Nevertheless, Foley and Ratner (2001) identify a gap in the vast majority of the SPT literature: Previous to their *Activity Memory Framework* (Ratner & Foley 1994), no one had accounted for the four features of activities that are composed of goal-directed actions. They outlined and discussed these in their paper, in an attempt to embed the SPT literature within the broader context of activity memory. This idea will be revisited later with respect to both prospective and source memory.

Before moving onto the next section, I should first like to return to the question of whether encoding during enactment of action phrases is automatic or controlled. Two alternative positions are evident: Cohen's (1983, 1985) standpoint that motor encoding is relatively strategy-free versus Bäckman and Nilsson's (Bäckman & Nilsson 1984, 1985; Bäckman *et al* 1986) dual-conception, encompassing both controlled and automatic encoding. The idea that there is at least some automatic processing involved in the encoding of SPT material, stems from the findings from both Bäckman's (Bäckman 1985; Bäckman & Nilsson 1984, 1985) and Cohen's (Cohen & Bean 1983; Cohen & Stewart 1982) research. Typically no age effects were observed between material that was acted at study compared to verbal task material. More importantly to this thesis, Cohen and Stewart (1982) were the first to address the subject-performed task paradigm in a developmental context. They presented children (9-, 11- and 13-

years-old) with two lists of lexical stimuli to remember for later free recall. The first list was made up of 2-syllable words and the second, simple task phrases (e.g. "*Hop on one foot*"). Immediate and free recall was tested in all three age groups and although the expected developmental effect was found in the recall of words, there was no evidence of such an effect following the recall of the tasks. However, it is important to note that this task did not specifically compare SPT versus VT procedures. Because of this methodological oversight, it sets the scene for one main area of focus of this thesis: A comparison of SPT and VT performance in children aged between 7- and 11-years-old. At this stage, we could speculate that if the effect is observed in younger children, then perhaps it is as automatic as suggested by Cohen and colleagues. If, on the other hand, the effect is only seen in older children, then we would need to re-evaluate the role and contribution of automatic processes in the enactment effect and perhaps focus more on Bäckman and Nilsson's dual-conception view.

Overall, from these studies we have begun to establish that encoding an action through enactment has tremendous benefits for memory. However, research has focused only on the benefits of enactment on retrospective memory: memory for past actions and events. Another aspect of memory is prospective memory; here the action cannot be carried out immediately but, at encoding, is intended for future performance. The status of this future intended action is addressed in another recent area of research: the Intention Superiority Effect.

1.3 THE INTENTION-SUPERIORITY EFFECT

Prospective memory is complex form of human memory that refers to a class of cognitive tasks related by one grouping feature – the generation of plans in memory that should be carried out at a later time (Marsh, Hicks & Bryan 1999) – delayed intentions. Following a series of four experiments, Goschke and Kuhl

(1993) were the first to suggest that intentions are represented in declarative memory with a heightened state of activation. They predicted that this heightened activation should be observed in faster recognition responses for words from an execution (to-be-performed) script than to those words from a neutral (to-be-remembered) script. In four separate experiments, they found this to be the case and thus the *Intention Superiority Effect* (henceforth the ISE) was born. Goschke and Kuhl instructed participants to memorise two scripts describing different activities (e.g. "*setting the table*" and "*clearing a messy desk*"). After learning both scripts, participants were told that they would later have to either act out one of the scripts (the execution condition) or observe one of the activities being carried out by the experimenter and note any mistakes (the observe condition). For the second script, they were told that they did not have to perform or observe it but just remember the details. Immediately following these instructions, participants were presented with a recognition test for words from both scripts, along with distractors. This was followed by the performance phase where participants were asked to execute the appropriate script or observe the experimenter execute their script, depending on the condition. They named this procedure the *postponed-intention paradigm*.

Goschke and Kuhl predicted that persisting activation - or more sustained activation – of an intention representation should be reflected in faster recognition responses for words from the execution (to-be-performed) script compared to those words from the neutral (to-be-remembered) script. They also predicted that in the observation condition no such difference would be found. Consistent with these predictions, participants were faster and more accurate with items from to-be-performed scripts compared to those from the paired to-be-remembered scripts. Furthermore, on examination of the observation condition, Goschke and Kuhl found no heightened activation compared to the neutral script. Therefore, not all intentions have such a privileged status in memory – only to-be-performed intentions (Marsh, Hicks & Bryan 1999). The superiority of a to-be-performed intention (the ISE) was replicated over all four of their experiments.

Goschke and Kuhl explain the ISE with reference to a model of memory that has been applied to other fields of research including the learning of geometry (Anderson, Greeno, Kline & Neves 1981) and computer programming (e.g. Anderson, Boyle & Reiser 1985). This model is called the Adaptive Control of Thought (ACT* Anderson 1983: see also the more recent ACT-R model; Anderson 1993) and consists of three memory components: declarative memory, procedural memory and working memory. The ACT* model suggests that in order to activate a goal a hierarchical system must be accessed consisting of a number of sub-goals beneath a top, superordinate goal. Although this superordinate goal receives activation exclusively, this activation is distributed amongst the subgoals. With this idea in mind, a prospective instruction only makes contact with the top goal, providing activation. The top goal then allows the activation to spread to the subgoals, which make up subordinate representations of the intended action. In this model, goals in working memory that control an immediate action are called source nodes. These sustain activation without rehearsal, unlike delayed intentions that have no special dynamic properties. However, in Goschke and Kuhl's findings, memory nodes that represented delayed intentions were seen to decay more slowly than neutral contents in long-term memory. They suggested, therefore, that intentions could be conceived as subthreshold source nodes in long-term memory.

Despite empirical support for the proposal that intentions have a heightened and persistent activation (e.g. Mäntylä 1993, 1996), there has also been some criticism. For example, Marsh, Hicks and colleagues (Marsh, Hicks & Bink 1998; Marsh, Hicks & Bryan 1999) argue that this proposal is insensitive to the reality that one has to deal with an assortment of goals during an average day. If Goschke and Kuhl's (1993) model is accepted then these goals would have to be continually activated and inhibited throughout the day. Marsh, Hicks and Bink (1998), therefore, suggested a more practical idea focusing on the rapid reprocessing of information through an intentional marker. This idea was based on three principles. The first concerned theories of action control suggesting that people need to be able to deactivate information in working memory in order to direct attention to a current task. The second principle stipulated that working memory contents are paired with previously stored conditions that, when fired, guide appropriate behavioural responses (c.f. Anderson 1983; Norman & Shallice 1986; Shallice & Burgess 1991). After successful execution, these conditions are then inhibited to prevent repetition. This is supported by the phenomenon of inhibition of return, the third principle, where slower latencies are seen for processing a stimulus located in the same position as on a previous trial compared with a new stimulus position (c.f. Kwak & Egeth 1992; Tipper, Driver & Weaver 1991).

Marsh and his colleagues' subsequent research on the ISE has both replicated and extended the work of Goschke and Kuhl. For example, Marsh, Hicks and Bink (1998) used a Lexical Decision Task (LDT) paradigm and a rudimentary Zeigarnik manipulation[6] (see Butterfield 1964; Mäntylä 1996) to discover the effect of completing the action on memory availability. They argued that the LDT, as well as being a more indirect measure of recognition, could extract purer measures of memory activation than the traditional recognition latency test employed by Goschke and Kuhl (see also Marsh & Landau 1995 for further discussion). Across four experiments, Marsh *et al* found evidence that information from uncompleted or partially completed intentions were more accessible from memory (indicated by shorter lexical decision latencies) than information from both their neutrally paired script and intentions that had been completed. The latter, in turn, exhibited much longer lexical decision latencies than their neutral partners. Therefore, Marsh *et al* found that when a to-be-performed script is uncompleted, the components appear more activated than

[6] An empirical phenomenon usually associated with retrospective memory where participants are presented with a series of tasks, some completed, some interrupted. Immediately after the study phase, participants are given instructions to recall the names of the tasks.

the components from a paired neutral script. The reverse is true following successful performance of the prospective script (Marsh, Hicks & Bryan 1999).

Over two experiments, Marsh, Hicks and Bryan (1999) attempted to extend the ISE to more real world manipulations of prospective remembering: Following on from their finding of heightened activation preceding completion and of inhibition following completion in groups of related activities (Marsh, Hicks & Bink 1998), Marsh, Hicks and Bryan questioned whether the same observation could be seen in clusters of unrelated activities (Experiment 1). During an average day people generate several unrelated activities (e.g. pick up a parcel, buy a newspaper, get the car washed) and may categorise them under an umbrella term such as "things to do on the way home". Clearly it is of interest to explore the ISE for these types of intentions.

In Experiment 2, they provided an extension of the ISE paradigm based on results from a previous everyday prospective memory experiment (Marsh, Hicks & Landau 1998) in which participants were asked to document goals for the week ahead, then return at the end of it to specify which goals had and had not been achieved and if not, why not. They found that around 26% of everyday intended activities are either cancelled or are impossible to complete due to numerous reasons. Marsh, Hicks and Bryan wanted to find out more about these cancelled intentions. First, they queried whether they would retain or lose their heightened activation. Second, they asked whether the cancelled intentions would become deactivated shortly after cancellation – as seen in completed intentions.

In line with their predictions, Marsh, Hicks and Bryan (1998) found that unrelated intentions exhibited heightened activation prior to completion and, following completion, showed signs of inhibition (Experiment 1). Similarly, in Experiment 2, cancelling an intention also resulted in inhibition being displayed. Therefore, the findings of Marsh, Hicks and Bink were replicated in a more naturalistic setting. Nevertheless, we should be cautious when interpreting these results: as Dockree and Ellis (2001) point out, although the everyday intention scripts used in the above experiments were goal-oriented, they were lacking in any self-reference or purpose. Moreover, despite Goschke and Kuhl's (1993) argument that activities lacking in self-reference allow for a purer measure of the ISE due to motivational influences, Kuhl (1985) points out that the suggested representation of an intention should encompass a self-referential component which may have significant encoding and retention consequences (Dockree & Ellis 2001).

Although not examining the ISE explicitly, Schaefer, Kozak and Sagness (1998) studied the contribution of self-referent and self-initiated intentions to prospective remembering using a novel paradigm. Participants were asked to complete prospective preparatory tasks for subsequent participants in addition to partaking in a cover task, understood to be the main experimental task. Because the experimenter explained that s/he would be unavailable during execution of the preparatory tasks, performance was reliant on self-initiation with respect to the participant. Interestingly, and in contrast to other research, Schaefer *et al* found that participants who enacted prospective tasks at study were less likely to perform them than participants who either watched them being demonstrated (EPTs) or had them verbally described (VTs).

Dockree and Ellis (2001) adapted Schaefer, Kozak, and Sagness' (1998) design to investigate the relative activation of maintained and cancelled intentions that have self-relevance and that require self-initiated retrieval processing. In line with the method of Schaefer *et al*, participants were asked to encode two preparatory tasks for subsequent participants. Immediately after this, participants were asked to complete the first of three Culture Fair Tests (CFT) while the experimenter attended a second (nonexistent) concurrent experiment. Once the CFT was completed, the experimenter returned and informed the participant that due to time constraints, one of the preparatory tasks was no longer required, thus setting up an intention cancellation. The experimenter left once more and the participant followed instructions for a lexical decision task - in order to measure activation - followed by the second and third CFT tasks. After the participant had undertaken some “finishing tasks”, the participant then had to remember to complete the uninhibited preparatory task before leaving the testing room.

Dockree and Ellis found that lexical decision responses to task words linked to the intact to-be-performed intention were faster than those to task words associated with the cancelled intention. This provides a valuable extension to the work of Goschke and Kuhl (1993), Marsh, Hicks and Bink (1998) and Marsh, Hicks and Bryan (1999). Furthermore, it is consistent with Marsh, Hicks and Bink’s suggestion that heightened activation of intentional constructs might be particularly effective in the absence of external cues to trigger recall and performance. More importantly, it again replicated the ISE in a more naturalistic domain.

It would appear that the role of the ISE in prospective remembering is theoretically important. Nevertheless, research to date allows us to claim only that this effect is a primed representation, relative to other memory contents. We cannot claim that this priming enhances the retrieval of a delayed intention at an appropriate moment (Dockree & Ellis 2001). Furthermore, on the basis of their findings, Goschke and Kuhl (1993) have proposed that the ISE is not mediated by controlled processing (Freeman 1999). For example, when Goschke and Kuhl added an imagery-blocking condition to assess whether such interference could hinder processing, they still found higher activation for intended than for non-intended action material indicating that the ISE does not require controlled processing. Following on from this, we can propose that if the effect is indeed automatic then it should appear in both children and older adults.

To date, although no research has investigated the ISE in children, it has been examined in older adults (e.g. Dockree 2002; Dockree and Ellis 2001; Freeman and Ellis 2003a; Maylor, Darby and Della Sala 2000) and an attenuation of the effect has been observed. Dockree and Ellis (2002) speculated that this could be due to reduced attentional resources in older adults. With respect to children, one could hypothesise that due to the gradual development of attentional processes in children we would observe a similar pattern of results. The development of attentional processes in children is addressed in the following chapter. Before the development of attentional processes in children is addressed (Chapter 2), a review of the literature relating to children's memory for actions is presented.

1.4 CHILDREN'S MEMORY FOR ACTIONS

Returning to the subject-performed task paradigm, Cohen and Stewart's (1982) paper is the only one to study the immediate/free recall of words and task list items in children (see section 1.2.5). Although there is come confusion as to whether or not children's *action* memory improves with age (see Foley & Ratner, 2001 for a discussion), there is no doubt that self-performance is of some benefit to children's memory. Indeed one study found that children aged between 6- and 9-years-old showed better recall for their own actions than for those of others (Baker-Ward, Hess & Flannagan 1990). Yet, while a handful of studies have examined the SPT in children, none have investigated the intention superiority effect in children. Notwithstanding, there is a growing body of research, from Foley, Ratner and colleagues that indirectly links these two phenomena.

In a discussion of Zimmer and Engelkamp's (e.g. Engelkamp & Zimmer 1985) theory behind the enactment effect, Foley and Ratner (2001) point out that they fail to address the features of activities and, more importantly, that activities are composed of goal-directed actions. Two particularly important features are planning, which contributes to activity memory, and the anticipation of actions. With respect to planning, Foley and Ratner cited a study by Bender and Levin (1976) in which kindergarten children (4- and 6-year-olds) were asked to either i) play with one pair of toys and plan to play with another pair (*Motor Plan* condition), ii) play with one pair of toys and resist playing with another pair (*Motor Stop* condition), iii) plan to play with one pair of toys (*Plan* condition) or iv) imagine playing with a pair of toys (*Imagery* condition). These conditions were manipulated by instructing the children to observe and/or manipulate pairs of toys under an incidental-learning format. Thus, children in the *Motor Stop* condition were asked to place their hands over the toys and wait for an instruction from the experimenter to either “Go” (for the motor element whereby the children could play with the toys) or “Stop” (where the children were not allowed to play with the toys). For children in the *Motor Plan* condition, the play activity was delayed until after an instruction was made by the experimenter, stating that the child would either have to play with the toys or to plan an activity that s/he would be asked to perform after a short delay. In a further manipulation, for both the *Motor Stop* and for the *Motor Plan* conditions, participants only played with half of the pairs. This manipulation was not applied to the other two conditions where children were either told to plan to make each pair of toys play together (*Plan* condition) or to just imagine pairs of toys playing together (*Imagery* condition). For this last condition, no reference to future motor activities was made. Two further, small-scale experiments contributed further findings using additional planning, imagery and control conditions.

The results indicated that learning (and therefore memory) was enhanced when participants simply planned an activity (by generating an image of the toys interacting), independent of execution at test. This, together with the finding that imagery alone could also support memory, prompted the suggestion that planning and imagination are two quite distinct cognitive operations.

With respect to the anticipation of actions, Foley and colleagues (Foley, Passalacqua & Ratner 1993; Foley & Ratner 1998b) conducted a series of collage-making experiments with young children to see whether collaborative learning could influence (source) memory for who contributed specific pieces to the collage. For example, in four experiments Foley, Passalacqua and Ratner

(1993) asked children (4- and 9-years-old) to make simple collages with an adult. A surprise reality-monitoring task was given in which each child was asked to recall who placed particular pieces on the collage. The children frequently demonstrated misattribution errors where they falsely claimed to have added pieces to the collage. Interestingly, they seldom stated that the adult had contributed pieces that they themselves had placed. Foley and colleagues interpreted these results as an indication of appropriation: a process embedded in shared circumstances where one can take on the role or perspective of another. This process was partly implicated as a reason for anticipations about actions made by another conflicting with one's own actions and thus influencing memory for actions. A number of other studies also support the role of planning and anticipation in memory (e.g. Foley & Ratner 1998a; Ratner, Foley & Gimpert 2000).

In typical SPT research, it is unusual to provide a goal to guide the performance of action phrases. However, in the studies above, each performed action had a purpose. In source-monitoring studies also, the effects of goal-related processing are apparent. Johnson, Hashtroudi and Lindsay (1993) describe source monitoring as referring, "…*to the set of processes involved in making attributions about the origins of memories, knowledge and beliefs*." (pp.3). They differentiated their framework from the *reality-monitoring* framework by Johnson and Raye (1981). Reality monitoring is a process that discriminates memories created from internally generated information (e.g. memories for thoughts) from those memories that consist of externally derived information (e.g. memories for perceived events). Source monitoring builds on this *internal-external* discrimination by adding two additional discriminatory situations: (a) *External source monitoring*, where externally derived sources are themselves discriminated (e.g. distinguishing memories of statements made from two different people) and (b) *Internal source monitoring*, where internally generated sources are discriminated (e.g. distinguishing between memories of what one has said versus what one has thought).

Evidence for the three types of source monitoring comes from studies with older adults (Hashtroudi, Johnson & Chrosniak 1989), thought-disordered manics (Harvey 1985) and studies with young children (Foley & Johnson 1985; Foley, Johnson & Raye 1983). In all of these studies, performance between situations was found to be inconsistent. For example, Hashtroudi *et al* found that older adults showed good performance in reality monitoring but were impaired in both internal and external source monitoring. Young children, on the other hand, had difficulty with internal, but not external source monitoring (Foley & Johnson 1985; Foley *et al* 1983). Interestingly, depending on the context, children's performance on source monitoring was comparable to that of adults (Foley, Aman & Gutch 1987; Foley, Durso, Wilder & Freidman 1991; Foley & Johnson 1985; Foley *et al* 1983; Lindsay, Johnson & Kwon 1991). Foley and Johnson, for example, compared the performance of adults with 6- and 9-year-old children in their memories for actions. Using a paradigm not entirely dissimilar to that of the SPT, Foley and Johnson found that although young children were as good as adults at discriminating what they did (self-performed task) from what they saw someone else do (experimenter-performed task), confusion arose, particularly in the 6-year-old children, when they had to remember whether actions were actually performed or merely imagined. Similarly, Foley *et al* (1983) found that young children showed a similar advantage to that of adults when remembering self-generated compared to passively presented words. However, the youngest children (6-years-old) did show difficulty in deciding whether or not thoughts had been vocalised. Therefore, it would appear that source monitoring does consist of different components, some of which young children can grasp, and some of which they have difficulty with. In order to try to understand why this should be, we return to the automatic-controlled process distinction.

Johnson, Hashtroudi and Lindsay (1993) point out that many source-monitoring decisions are typically made quickly, based on qualitative characteristics of activated memories, such as the amount of perceptual detail. However, on occasion, source-monitoring might also involve more controlled or strategic processing. An example would be when one questions the source of a memory based on previous knowledge. Such instances are likely to be more time-consuming and involve more conscious processing and reasoning. Could it be, therefore, that the first of these judgement processes is automatic, whilst the second is more controlled[7]? This would certainly help to explain the age-related findings of Foley and colleagues, described above, perhaps indicating that children might be more impaired on judgements that are more attentionally-demanding due to the requirement for accessing previous knowledge. Foley, Johnson and Raye (1983), for example, point out that children aged 6-years might not be able to use memory-related cues, citing consistent evidence from other research suggesting a discrepancy between young children's acquisition of knowledge and the use of this knowledge for the purpose of monitoring their own memory performance (Brown 1975; Brown & De Loache 1978; Flavell & Wellman 1977; Ornstein 1978).

To relate these studies back to the SPT and ISE effect, we return to the activity theory put forward by Ratner and Foley (1994), which describes people as goal-directed processors who carry out actions within the context of larger activities in an attempt to satisfy a purpose (Foley and Ratner 2001). Such actions are said to consist of at least two features: the anticipation (goal-directed nature) of actions and, more importantly, planning, which contributes to activity memory. Foley and Ratner (2001) suggest that the actions involved in typical SPT studies are not usually goal-directed. For example, when a participant is asked to "Peel the banana" in Engelkamp and Zimmer's (1996) study, s/he is not offered any reason or goal for such an act, only that it was part of the experimental requirement and should therefore be carried out. Therefore, Foley and Ratner

[7] It should be noted that Johnson *et al* (1993) subscribe to an alternative contrast first proposed by Chaiken, Lieberman and Eagly (1989). This distinction contrasts *heuristic* processes (i.e. based on a set of inferential rules or schemata) with *systematic* processes (i.e. a slow analytic process involving accessing all information relevant to the circumstances). However, this distinction has little relevance to this thesis and is therefore withheld from further discussion.

suggest that the action is stripped of its most crucial component (although see Zimmer and Engelkamp 1984, cited in Foley & Ratner 2001). Support for this notion comes from the aforementioned study by Bender and Levin (1976) and also from Ratner, Bazzy & Smith (1987). In the latter study, children (5-year-olds) and adults were asked to make clay together. Sometimes this clay making was planned and at other times performed. Similar to Bender and Levin, Ratner *et al* found the planning aspect to be critical to recall performance such that actions that were self-planned were better retained than those planned by the other clay maker.

Foley and Ratner (2001) argue that planning is not crucial to the SPT effect because planning is relatively irrelevant to the procedure. Conversely, planning has a crucial status in the delayed-intention ISE paradigm. Here actions are more goal-directed in nature because they are to-be-performed. With respect to the ISE, and as mentioned in 1.3, Goschke and Kuhl (1993) suggested that the phenomenon could be underpinned by relatively automatic processing. Similarly, Cohen (1981, 1983) suggested that the SPT effect is also reliant on automatic processing. If both statements are true, then we would not expect to observe any age-related differences in children’s performance on either the ISE or the SPT. If, however, more strategic processes are involved in one or both of these effects then we would expect to observe a developmental trend in that effect. This leads us to the first research question:

1.4.1 Is there a link between the development of the Subject-Performed Task and Intention Superiority Effects in nine- and eleven-year-old children?

Cohen and Stewart (1982) were the first to use an SPT-like paradigm to compare immediate and free recall of words and task lists in children. In a group of 9-, 11- and 13-year-olds, they found an expected developmental effect for the recall of words but no such effect was found for the recall of task lists. However, in their results Cohen and Stewart never actually directly compared words with task lists, in line with the traditional SPT paradigm (e.g. see Engelkamp 1998). The following chapters describe six experiments that attempt to address this by testing the SPT effect in 7-year olds (Chapter 4), 9-year olds (Chapter 3, Experiment 2; Chapters 4-5) and 11-year-olds (Chapter 3, Experiment 3; Chapters 4-5). These experiments go further by testing each child's recognition accuracy and recognition latency in addition to their free recall of performed (SPT) and verbalised (VT) material. If, as has been suggested (Cohen 1983), the SPT is an automatic effect, then it is expected that all age groups will show better performance – with respect to recognition accuracy – for SPT than for VT material.

Another phenomenon thought to be automatic in nature is the Intention-Superiority Effect. Using a recognition latency-based paradigm, Goschke and Kuhl (1993) investigated the dynamic properties of to-be-performed material compared to that intended for verbal recall. The results from their four experiments strongly indicated an automatic effect (see 1.3 for discussion). If this is indeed the case, then the effect should also appear in children. However, to date, no research has attempted to test such an idea. In order to rectify this gap in the literature, a modified ISE paradigm was also presented to the groups of 9- (Chapter 3, Experiment 2) and 11-year-old (Chapter 3, Experiment 3) children. If the ISE is indeed automatic, then children of both ages should show a reliable difference in recognition latencies of material intended for performance compared to that intended for verbal recall. If the ISE is not automatic, then two possibilities remain: The effect will not be present in either age group or the effect will show a developmental trend where the older 11-year-olds show better performance than the younger 9-year-olds. The development of attentional and executive skills and their possible role in the ISE and prospective memory is explored in the following chapter.

CHAPTER 2

LITERATURE REVIEW 2:

Executive Functions, ISE and Prospective Memory

2.1 EXECUTIVE FUNCTION

In 2002, Welsh noted that, "*The cognitive construct of executive function has been the subject of intense research interest over the last several years.*" (p. 140). The term 'executive function' originates from a rich history of neuropsychological research into the functions of the frontal lobes (see, for example, Benton 1991) in which various researchers have attributed different behaviours and functions to the region (e.g. Luria 1966; 1973). What follows is a review of existing work into three principle areas: theories of executive functioning (2.1.1), the development of the frontal lobes (2.1.2) and neuropsychological tasks thought to tap executive functioning in young populations (2.1.3).

2.1.1 Theories and components of Executive Function

Welsh and Pennington (1988) suggest that the concept of executive function describes the ability to adopt and maintain an appropriate problem-solving set in order to achieve a future goal. This set is typically comprised of one or more characteristics including i) an intention to inhibit a reaction or to defer it to a later, more reasonable time, ii) a strategic plan of action sequences, and iii) a mental representation of the task, comprised of information associated with the stimulus encoded in memory plus the intended end-state. With respect to where these processes take place in the brain, the prefrontal cortex is regularly cited as an area that underpins the integration of intentional behaviour (Welsh & Pennington

1988), following from behavioural investigations of adults with frontal damage (e.g. Luria 1966; Stuss & Benson 1984) and studies of animals with experimental lesions (e.g. Goldman-Rakic 1987). Indeed Fuster (1985) suggested that executive function could be split into three interactive areas of the prefrontal cortex, which closely resemble Welsh and Pennington's three characteristics, described above. First, he suggested an interference-control mechanism that is able to inhibit behaviour incompatible with the intended goal (related to the inhibition function), second, a temporally prospective function of anticipatory set (similar to the plan of action sequences) and third, a temporally retrospective function of working memory (closely linked to the mental representation idea).

Two other influential theories of executive function have been proposed by Stuss and Benson and by Norman and Shallice. Stuss and Benson (1984, 1986, 1987), for example, argue that a great deal of explicit behaviour is directed by systems that are both localised and function independently of the frontal lobes. In support of this, there exists much neuroanatomical evidence that the prefrontal cortex is bidirectionally linked with various systems including the limbic, diencephalic, mesencephalic and the reticular activating systems (Teuber 1972) in addition to the posterior cortex and, more importantly to this thesis, motor regions within the frontal lobes themselves (c.f. Welsh & Pennington 1988). The extent to which these systems are thought to employ the frontal lobes depends on whether the circumstances are familiar and routine (in which case the frontal lobes are redundant) or novel and nonroutine (where the frontal lobes play a significant role in coordinating these systems). Stuss and Benson (1987) suggested these latter situations reflect executive functioning in the form of anticipation, goal selection, planning and monitoring (Welsh 2002). The distinction between routine and nonroutine contexts was also included in Norman and Shallice's (1986; Shallice & Burgess 1991) theory in which contention scheduling (see 1.1.2) is required for familiar situations. The supervisory attentional system, on the other hand, takes over when executive functions such as planning and inhibition are required in novel situations.

In addition to these components, the umbrella term executive function also refers to other abilities including set maintenance, impulse control, working memory, attentional control, monitoring and flexibility (Roberts & Pennington 1996; Welsh 2002). These processes employ a range of fundamental cognitive mechanisms including attention, language, perception and, most importantly, (working) memory that together underlie efficient, future-oriented behaviours (Duncan 1986). What follows is a discussion on the development of these processes.

2.1.2 The development of Frontal Lobe (Executive) Functioning

Although Benton's (1991) historical review of frontal lobe investigations neatly addresses the plethora of research since the late 19th century, there is a surprising lack of developmental studies. Indeed, as Welsh (2002) points out, "*The current excitement surrounding the development of frontal lobe function is a phenomenon that is, at most, two decades old.*" (pp. 147). Nevertheless, the last two decades have added a significant amount to our understanding of both the developing frontal lobes and their relationship to executive function.

Perhaps the most influential contribution to this understanding comes from Luria (1966; 1973) who divided the frontal cortex into two key areas, the *orbitomedial* and the *dorsolateral* areas, and assigned different behaviours, linked to executive functioning, to each area. However, there are two main problems with Luria's theory. First, subsequent research has revealed inconsistent findings with respect to the localisation of executive behaviours to these subdivisions (Passler, Isaac & Hynd 1985) and second, whilst Luria proposed that these areas become functional between 4- and 7-years- old, there exists a great deal of support for the suggestion by Golden (1981) that they do not develop fully until preadolescence. Welsh (2002), for example, outlines three threads of reasoning in support of this assertion.

First, work looking at synaptogenesis (the creation of new synapses) by Huttenlocher (1979; 1990; 1994; Huttenlocher, de Courten, Garey & van der Loos 1982) and other researchers (Chugani, Phelps & Mazziotta 1996; Johnson 1999; Schade & van Groenigen 1961; Yakolev & Lecours 1967) has indicated that this brain region is the last to develop. Johnson (1999), for example, points out that although synaptogenesis in the prefrontal cortex commences simultaneously with that in other regions (e.g. primary visual and primary auditory cortices), increases in synapse density are much slower to develop and do not peak until after twelve months postpartum (see also Casey, Giedd and Thomas 2000). However, more recent research with non-human primates suggests that this might not be the case. Rakic, Bourgeois, Zecevic, Eckenhoff, and Goldman-Rakic (1986), for example, reported that all cortex areas in rhesus monkeys peak in synaptic density between two and four months (roughly 7-12 months in human infants).

The second line of reasoning stems from several studies that measured children's performance on the perseveration element of the Wisconsin Card Sorting Test (WCST). This task, originally used by Milner (1963; 1964) with adult clinical populations, requires a child to sort a pack of cards that conform to various features including form, colour and number. The child is initially asked to sort the cards according to one category for a series of consecutive trials (e.g. colour) before being asked to adopt a new sorting rule (e.g. number) and refrain from returning to the first rule (see Heaton 1981 for full details). This task therefore requires simultaneous deployment of flexible set-shifting, inhibition and working memory which could explain why "adult" performance has not been observed in children until around age 10 (Boucugnani & Jones 1989; Chelune & Baer 1986; Chelune, Ferguson, Koon & Dickey 1986; Welsh, Pennington & Grossier 1991). From these results, Welsh (2002) suggested that frontal lobe function must emerge in preadolescence.

For the third line of reasoning, Welsh refers to Piaget's (1962) fourth stage of cognitive development - formal operational thought – which has remarkably similar characteristics to those of frontal lobe functioning. Thus, it has been argued that behaviour relating to the frontal cortex, together with formal operational thought, emerges between age 10 and age 12 years. Overall, therefore, it would appear that executive function processes might not be evident in very young children. Evidence to suggest otherwise, using various tests thought to measure these processes, is discussed in 2.1.3.

A series of non-human primate studies have attempted to discover when the frontal lobes are able to support even basic executive function processes, with contradictory results. Some of this research has shown that infant monkeys with prefrontal lesions are still able to show adequate delayed-response behaviour (e.g. Goldman & Rosvold 1970) whilst other research (e.g. Diamond & Goldman-Rakic 1985) found that performance on a similar task is impaired. Such work has contributed to the idea of "*silent lesions*" to describe the lack of functioning of the frontal lobes in young children (Golden 1981).

Although this research, together with that from neuropsychological examinations of adults with frontal damage, has contributed significantly to our understanding of behaviours associated with the frontal lobes, it cannot substitute more direct research with children. This work has three potential methods for establishing the what and when of executive functioning: developmental neuropsychological examinations, neuroimaging techniques and performance on tasks selected from either neuropsychology or cognitive psychology due to their (presumed) close association with one or more executive function processes. It is generally agreed that the last method is the best because unlike neuropsychological and neuroimaging techniques, it is non-invasive. Therefore, this method is discussed in detail here (for discussion on the others, see Welsh, 2002).

2.1.3 Tests of Executive Function For Children: A Guide

As previously mentioned, research focusing on tracking the developmental trajectory of executive functioning is a relatively recent phenomenon (Welsh 2002). Authors have tended to start with a cognitive concept gleaned from the adult clinical neuropsychological literature and then adapted it so as to create a child-friendly task, sensitive to executive function abilities such as planning, set maintenance, impulse control, working memory and attentional control (Roberts & Pennington 1996). Age groups tested tend to range from seven- to twelve-years, although some studies have tested children as young as age three (Diamond & Taylor 1996; Klenberg, Korkman & Lahti-Nuuttila 2001; Welsh, Pennington & Grossier 1991) and as old as age fifteen (Levin, Culhane, Hartmann, Evankovich, Mattson, Harward, Ringholz, Ewingcobbs & Fletcher 1991).

In discussing the creation of a finite list of executive function measures, Denckla (1994) argues that, "*…it is not intended that every characteristic be incorporated into every proposed measure, especially because measures are chosen on the basis of literature already accumulated… and brain affiliation proposed/purported.*" (pp. 123). She also advises that measures should be ordered in a "*hierarchically conceived fashion*" where tests at one polar extreme challenge a participant's "*boredom tolerance*", whilst those at the opposite pole contest the participant's more advanced problem-solving skills.

Using these ideas, Denckla constructed a table of twelve executive function measures that have been used with children in the past two decades. These included (in ascending order in her table) the **Wisconsin Card Sort Test** (WCST), **Verbal Fluency**, **Figural Fluency**, **Disc/Ring Transfer Tasks** (Tower of Hanoi/London/Toronto), **Multitrial Verbal (Word List) Learning Tasks** (California Verbal Learning Test, CVLT), **Go/No-Go**, **Motor sequencing**, **Motor Overflow**, **Rey-Osterreith Complex Figure**, (Modified) **Stroop**, **Matching**

Familiar Figures Test and the **20 Questions Task**. Welsh and Pennington (1988) also mention the **Hooper Test of Visual Organisation**, **Porteus Mazes** and **Thurstone Word Fluency** tasks as ones hypothesised to be sensitive to frontal functioning in children (p. 200). Rather than discuss all fifteen measures, I have decided to focus on three of the most regularly used tasks.

2.1.3.1 The Wisconsin Card Sort Test (WCST)

Denckla suggested that nearly every paper that has addressed the development of executive function has included the Wisconsin Card Sort Test (1994). With the advent of a computerised version of the test, administration and scoring has become easier and inter-experimenter reliability is no longer an issue. Scores from the task consist of number of categories successfully completed (0-6), conceptual level of responses, ability to maintain set within the "right" feedback series and perseveration errors (where the child fails to shift set). Interestingly, the majority of the developmental work using the WCST only reports the perseveration score. Chelune and Baer (1986), together with Welsh, Pennington and Grossier (1991), used this score to explore performance in school-aged children. Chelune and Baer found a substantial increase in performance (indicated by fewer perseveration errors) between 6 and 10 years. They also found that children aged 6-7 years behaved like adults with frontal damage, whilst a mature, healthy adult level was reached at around age 10.

Similar results were found in a separate study that reported all of the WCST variables. Levin *et al* (1991) tested 52 children (three age groups: 7-8 years, 9-12 years and 13-15 years) using a battery of tests including the WCST. With respect to perseverative errors, they found a significant decline between 7-8 years and between 9-12 years. When analysing the measures of concept formation, set-shifting and inhibiting inappropriate responses, Levin *et al* found adult-level performance at age 12 years.

2.1.3.2 The Tower of London / Hanoi (ToL / ToH)

The Wisconsin Card Sorting Test requires participants to mentally manipulate or transform information but at the same time keep a cognitive record of the results (Roberts & Pennington 1996). The Tower of London (ToL[8]) task also demands this logic as a frontal task thought to the tap the executive functions of monitoring, self-regulation, problem-solving and in particular planning. In order to study deficits in this last cognitive function, Shallice (1982, 1988) developed the ToL measure. The task requires participants to solve a puzzle involving the arrangement of three coloured beads on a set of three pegs (of different heights) from an initial-state to a goal-state. The difficulty of the task stems from the rule that the goal state must be achieved within a constrained number of moves. The easiest problem requires only two moves, the hardest, five. For each of twelve problems, the participant must attain the goal state within three trials after which the problem is discontinued. P. Anderson, V. Anderson and Lajoie (1996) suggest three reasons why this task is applicable to young populations. First, it can be administered quickly and without the need for extensive attentional demands. Second, because the task is quite challenging, it is attractive to children of various ages and third, because the task incorporates a number of difficulty levels, even young children can complete at least some of the problems. Owen (1997) suggests a series of stages that must be abided by in order for such problems to be completed. From these he introduces a sequence of cognitive processes: (1) The general requirements of the problem are assessed, by comparing the initial and goal states; (2) A finite series of subgoals is established; (3) A sequence of moves is mentally generated that would fulfil the subgoals; (4) Using mental rehearsal, this sequence is revised and finally; (5) The correct sequence is executed (see Phillips, Wynn, McPherson & Gilhooly 2001 for further discussion). To score a participant's performance, a number of

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[8] The Tower of London task was based on the Tower of Hanoi (ToH) measure. See Welsh (2002) for examples of some studies that have been conducted using this measure with children. See also Welsh and Pennington (1992) for a discussion on the differences between the ToL and the ToH.

measures are used including initial planning time (the sum total of the time taken to make the first move for each problem), number of trials to solution, number of problems solved on the first trial and the average number of trials to solution.

As mentioned in the footnote earlier, the ToL and ToH tasks are very similar, yet a brief look at developmental research that has used the ToL and ToH measures (separately) indicates that more researchers seem to prefer employing the ToL (e.g. Anderson, Anderson & Lajoie 1996; Klenberg, Korkman & Lahti-Nuuttila 2001; Levin *et al* 1991; Luciana & Nelson 1999) rather than the ToH (e.g. Welsh 1991; Welsh, Pennington & Grossier 1991). Nonetheless, the data that has been gleaned from all of these studies suggests that both tasks are developmentally sensitive and neuropsychologically valid planning measures (Denckla 1994). Levin *et al* (1991), for example, investigated ToL performance amongst three groups of children aged 7-8, 9-12 and 13-15 years. Using the percentage solved and average number of trials to solution measures, they found a significant difference between the oldest and youngest groups, particularly in both the medium (four moves) and high (five moves) complexity conditions where more planning was required. Similarly, P. Anderson, V. Anderson and Lajoie (1996) observed that number correct and solution latencies showed striking improvements between children aged 7- and 9-years and also those between 11- and 12-years. A related finding was uncovered by Luciana and Nelson (1999) who found that 8-year-old children showed improved performance on a variety of tasks including more complex ToL problems, compared to younger children. This evidence, together with other research, indicates that two developmental improvements in executive function performance occur: an early shift between 7- and 9-years and a later one between 12- and 13-years (Welsh 2002). However, research that has focused on the ToH, indicates a slightly different developmental shift where Welsh and her colleagues (Welsh 1991; Welsh, Pennington & Grossier 1991) found that whereas relatively mature performance on the simple 3-disc version is shown by age 6 years, complex planning (i.e. as demonstrated on the 4-disc version) continues to develop past age 12. This discrepancy ties in with Welsh and Pennington's warning of inconsistencies between both the ToL and the ToH measures (1992).

2.1.3.3 The Stroop

Both the Tower of London / Tower of Hanoi and the Wisconsin Card Sorting Tests are thought to place high demands on working memory to determine the correct response (Phillips, Wynn, McPherson & Gilhooly 2001; Roberts & Pennington 1996). The Stroop task, and its many derivatives, (such as the Sun-Moon and Fruit Stroop by Archibald, 1999, and the Day-Night Stroop (Gerstadt, Hong & Diamond 1994; Diamond, Kirkham & Amso 2002), are thought to make much lighter demands on working memory but unlike the WCST and ToL / ToH tests require the inhibition of strong prepotent responses (Roberts & Pennington 1996). The adult version of the task (see 1.1.2) has been described as involving selective attention, interference control or inhibition (Denckla 1994) and is thought to be directly linked to frontal lobe function following a series of experimental (Perret 1974) and brain-imaging investigations (e.g. see Bench, *et al* 1993; Diamond, Kirkham & Amso 2002). Over the past two decades, some researchers have modified the adult Stroop for use with children by substituting the reading element. Perhaps the most well known adaptation is that by Diamond and colleagues (Diamond *et al* 2002; Gerstadt, Hong & Diamond 1994), based on Passler, Isaac and Hynd's (1985) verbal conflict task. Similar to the adult Stroop, the Day-Night version required participants to inhibit a natural tendency to give a different verbal response (i.e. say "*Night*" when presented with a white card depicting a bright sun and say "*Day*" when presented with a black card depicting a moon and stars). However, unlike the adult Stroop, the Day-Night version requires both inhibition and memory (i.e. to retain the rules for the alternative responses to the Day and Night cards).

Passler *et al*'s (Passler, Isaac & Hynd 1985) study with children aged 6-12 years found that the performance of the youngest children was at ceiling. In their modification, Gerstadt, Hong and Diamond (1994) looked at the performance of younger children (3 ½-7 years), predicting that the younger children would show worse performance with the task due to having to remember two rules whilst inhibiting the natural tendency (e.g. saying "*Day*" when presented with a day card instead of "*Night*"). This prediction was found to be the case as younger children (3 ½-4 years) performed more poorly (with respect to both percentage correct and response latencies) than the older children (5-7 years), some of whom performed at ceiling.

In a separate study, Diamond and Taylor (1996) focused on children from an identical age range (3 ½ - 7 years) and compared their performance on the Day-Night task (using the procedure described by Gerstadt *et al*) with that on Luria's Tapping test (Luria 1966). Similar to the Day-Night Stroop alternative, this task requires the participant to remember two rules (i.e. tap once when the experimenter taps twice and tape twice when the experimenter taps once) and inhibit a natural response (i.e. duplicate the experimenter's tapping). Diamond and Taylor found that over the age range tested, children improved on the tapping task in both accuracy and speed although the most striking improvement was around age 6. When comparing the tapping task with the Day-Night task, at roughly 4-4 ½ years, the children were beginning to perform better on the tapping task. After this period, performance on both tasks appeared to continue autonomously. Overall, the ability to retain two rules and inhibit a strong natural response tendency seemed to improve dramatically between 3-6 years, which is consistent with the results of Passler *et al* (1985), amongst others.

Diamond was intrigued by the weak performance of younger children on the Day-Night task and decided to rework the inhibition element of the design. In a new study, she presented ninety-six children, aged between 4-4 ½ years, with this revised Day-Night Stroop-like task (Diamond *et al* 2002). The revision was simple; instead of saying "Day" to the moon card and "Night" to the sun card, the children were asked to say, for example, "Pig" to the moon and "Dog" to the sun card. From this, the authors predicted that decrements in both interference and the strength of the semantic relationship between the prepotent responses ("Day" and "Night" or "Sun" and "Moon") and the correct responses ("Dog" and "Pig") would show increased successful performance by the children. Consistent with similar adult Stroop studies (e.g. Dalrymple-Alford 1972; Klein 1964; Klopfer 1996; Stirling 1979), performance improved. Although 4 ½-year-olds showed superior performance, the 4-year-olds were also able to supply correct responses, given more time. In their discussion, Diamond *et al* suggest that even young children can perform adequately on the Day-Night task so long as they are given sufficient time to recall the correct responses, based on the knowledge they have. However, it could be argued that this version is not testing prepotent response inhibition. Instead, it is a simple test of memory where the child must just remember the appropriate response for each stimulus.

Other research that also employed an alternative Stroop task, very similar to that used by Diamond and colleagues, was a study by Archibald and Kerns (1999). Amongst the battery of executive function measures, they presented three Stroop alternatives, the **Golden**, **Sun-Moon** and the **Fruit Stroop**, to a group of eighty-nine children aged between 7-12 years. The first of these alternatives was based on Golden's (1978) Stroop consisting of 45-second trials of naming either words, coloured X's (XXXX) or the ink of coloured words. The **Sun-Moon Stroop** was based on Gerstadt *et al*'s (Gerstadt, Hong & Diamond 1994) Day-Night Stroop but modified so as to closely resemble the format of the traditional Stroop. This modification was implemented by presenting each participant with two pages consisting of rows of pseudo-randomly arranged coloured sun and moon pictures. In the control condition, participants were instructed to respond "Sun" to sun pictures and "Moon" to moon pictures. In the interference condition, however, participants were told to reverse these responses (i.e. say "Sun" to moon pictures and vice versa). Therefore, unlike the stimuli responses of "Day" and "Night" used by Gerstadt *et al* (Gerstadt *et al* 1994), Archibald and Kerns substituted "Sun" and "Moon" because they argued that these were less abstract and more prepotent. Finally, for the **Fruit Stroop**, Archibald and Kerns modified the Fruit

Distraction Task from the Cognitive Control Battery (Santostefano 1988) and produced four pages of stimuli. The first page was comprised of rows of rectangle blocks of colour (blue, green, red and yellow), arranged pseudorandomly. Each participant was asked to name the colour of as many rectangles as they could in 45 seconds. The second page consisted of rows of fruits, coloured appropriately (e.g. yellow bananas, red apples, green grapes). Similar to the page one, the children were instructed to name the colour of each fruit, as quickly as possible. On page three the stimuli were identical to those on page two except that they were devoid of colour. Based on the stimuli from page two, the children were required to name the colour that each fruit should be, again as quickly as possible. Finally, page four displayed the same stimuli from pages two and three but the fruits were coloured incorrectly. As for page three, participants were required to name the colours that each of the fruits should be, as quickly as possible.

Consistent with previous Stroop research, Archibald and Kerns found that all the tasks were sensitive to developmental trends in one aspect of executive functioning, inhibition. Moreover, based on high correlations with the Golden Stroop, the Sun-Moon Stroop and Fruit Stroop tasks were highlighted as appropriate measures of inhibition for children who are non-readers or who are not yet proficient readers. This is particularly important, because it means that younger children's inhibition can also be measured, allowing a more thorough developmental trajectory to be investigated.

Returning to the adult literature, and under different task conditions, performance on the Stroop task has been related to the ability to realise delayed intentions (Dockree 2002). For example, Martin, Kliegel and McDaniel (2003) found that the Stroop task was the only significant predictor of performance on an event-based prospective memory task. Martin *et al* suggested that inhibitory processes, implicated by the Stroop task, could play a key role in helping to reduce ongoing task distraction, thereby freeing resources available for the prospective task. In a similar vein, Dockree (2002) found a relationship between Stroop performance and the intention superiority effect (ISE) in adults. In Experiment 3, Dockree investigated the relationship between everyday memory performance and attentional capabilities using the Stroop as the measure of attention. He observed that participants classified as showing high interference (i.e. those who found difficulty in naming the ink colour) on the Stroop task failed to show a reliable ISE, yet those participants who exhibited low Stroop interference (i.e. those who were more able to identify the ink colour) showed a statistically significant ISE. However, Dockree points out that the interaction between Stroop interference group (High vs. Low) and task status (Maintained vs. Cancelled task items) was unreliable, possibly due to insufficient statistical power. To address this concern, Experiment 5 increased the sample size using two groups of adults (younger and older). These participants were also subdivided into three categories (low, medium and high), depending on their Stroop performance. Consistent with the results from Experiment 3, participants in the low interference group showed a reliable ISE while those participants in the medium and high interference groups failed to exhibit an ISE. Therefore, it is possible that the processes that mediate the Stroop task may share a common relationship with the processes that serve the representation of intentional information. Dockree (2002) suggests three reasons to support this notion. First, controlled attentional processing might be required by both tasks to resolve conflict. In the Stroop, this conflict originates from the parallel processes that compete for a single response. In the ISE task, the conflict is between the maintained and cancelled representations where the former might require attention for later retrieval and the latter might require attention to prevent a competing response. This leads us to the second reason where suppression of irrelevant information might be a requirement for both the Stroop and ISE tasks. Finally, both tasks show an (adult) age-related decline in performance, which might be a consequence of fewer processing resources or fluctuations in controlled attentional ability as age increases.

If an inhibitory mechanism, such as that associated with the Stroop, is indeed linked to the ISE, Dockree argues that Bjork's (1989) strategic control process of attentional suppression provides a more satisfactory model than the more automatic lateral inhibition process. Irrespective of whether automatic or strategic processes underpin the ISE together with the SPT effect (considered in Chapter 1), it is also of interest to examine the overlap, in terms of the underlying processes, between these two effects. This is discussed in the next section.

2.2 THE ISE AND THE SPT

Two components are thought to be required to produce the rich item-specific information following enactment: planning and execution (c.f. Engelkamp 1998). Koriat, Ben-Zur and Nussbaum (1990) focused on this hypothesis and in particular the underlying representation of material intended for future enactment compared to that for material intended for verbal report. In their experimental paradigm, participants were asked to learn a list of unrelated, written verb-noun action phrases (e.g. "*Touch the stone*", "*Lift the ashtray*"). Each phrase was paired with an instruction to either recall the item verbally, or perform them at test.

Koriat *et al* hypothesised that recall would be superior when verbal report is expected than when phrases must be executed. Interestingly, the results revealed that free recall was enhanced for material intended for enactment, regardless of whether or not performance actually took place. Furthermore, participants commented that they found it easier to remember these phrases compared with the phrases intended for verbal report. Koriat *et al* concluded that although both tasks share the same underlying representational code, the process of encoding a future action could involve extra information in the form of, "*…an internal, symbolic enactment of the tasks…*" (p.577), that enhances memory for these items. From this, Koriat *et al* proposed that intended enactment could be a prospective SPT effect. Further support for this supposition was provided by Norris and West (1993) – who found that both young and older adults show better recall performance for items that are performed at retrieval compared to items that are verbally recalled – and by Engelkamp (1997). However, as Freeman and Ellis (Freeman 1999; Freeman & Ellis 2003b) point out, the findings are not entirely straightforward: Brooks and Gardiner (1994), for example, noted that Koriat and his colleagues failed to include a condition that could account for both planning *and* execution of study items. To address this, they directly compared Koriat *et al*'s planning condition with an enactment-at-study condition and a verbal control condition. Contrary to the findings of Koriat *et al*, Brooks and Gardiner failed to find a difference in the recall of phrases intended to-be-enacted versus those to-be-reported across younger and older adult age groups. More interestingly, memory performance in older adults only seemed to be enhanced by those items encoded by performance (i.e. SPT).

Although suggestions from both Kormi-Nouri, Nyberg and Nilsson (1994) and Engelkamp (1997) offer explanations for the differences between the Koriat *et al* (1990) and Brooks and Gardiner (1994) studies, a common discrepancy remains concerning the dynamic properties (i.e. level of activation) of the representation. During the retention interval, prior to test, these properties are not considered. SPT research, for example, has tended to focus on recall and recognition measures, whereas ISE research has looked at activation using either recognition latencies or lexical decisions (c.f. Freeman & Ellis 2003a). In a more recent study comparing young (mean age = 22-years-old) with older adults (mean age = 71-years-old), Freeman and Ellis (2003a) addressed this deficit, to establish whether, similar to young adults, older adults display increased accessibility (demonstrated by faster recognition latencies) for both executed and planned action representations. Tested individually, participants were exposed to two blocks of tests, each involving the presentation of two lists of eight unrelated action words (verbs). In the first block, participants were asked to learn two study lists, one by verbally reading each word and the second by performing an action for each word. Participants were also informed which modality to recall the lists in. Half of the participants were told to perform each of the retained words and half were asked to verbally recall any retained words[9]. For the second block, the same procedure was repeated except that at recall, the two lists were to-be-enacted if they had been reported verbally in the first block and vice versa. In addition to the data obtained from the two recall tests, each participant was also subjected to a recognition test for each block, where they were asked to distinguish novel verbs from those learnt during the encoding phase.

In line with their predictions, Freeman and Ellis found that both the younger and the older age groups showed an increase in accessibility (with respect to recognition latencies) for items they expected to be performed at recall, as compared to those items they expected to verbally recall. Overall, therefore, both young and older adults showed an intended enactment effect (IEE), a similar phenomenon to Goschke and Kuhl's (1993) intention superiority effect (ISE). Furthermore, consistent with findings from both Zimmer (1984 cited in Zimmer 1986) and Freeman and Ellis (2003b), a reliable SPT encoding effect was also found in both age groups, with respect to recognition latency, but only when verbal report was expected at retrieval. Items enacted during encoding were correctly recognised faster than those items verbally encoded. Of particular interest to this study, when comparing items intended for verbal report at retrieval, no advantage was found for those items overtly enacted at encoding compared to those verbally encoded.

Freeman and Ellis (2003a) speculate that, in line with their earlier findings (Freeman & Ellis 2003b), there is an overlap between the SPT and intended enactment effects with respect to item accessibility during the retention interval. Moreover, they suggest that the correspondence between the two effects could

[9] This recall instruction was relayed to the participants prior to encoding.

lie in similarities in these representations. For example, Engelkamp and Zimmer (Engelkamp & Zimmer 1995; Zimmer, Helstrup & Engelkamp 2000) suggested that enactment at encoding makes additional item-specific, sensori-motor information available that becomes integrated into the memorial representation, making it more accessible from memory. With respect to the heightened accessibility of to-be-enacted items, Freeman and Ellis (2003a) suggest a similar mechanism that is beneficial to both young and older adults: both the ISE and the SPT effects activate or access motoric information. Thus the ISE is an intended enactment effect due to similarity in the information activated at encoding and therefore, this advantage is due to action-based (rather than intention-based as Goschke and Kuhl suggested) representations: an *Action Superiority Effect* (ASE, see Freeman & Ellis 2003).

As mentioned earlier, as well as focusing on the effects of overt and intended enactment, Freeman and Ellis (2003a) also compared performance in young and older adults to see whether the ASE concept could aid understanding of the ISE in older adults, particularly when research has indicated that the SPT effect is beneficial for older adults (Bäckman 1985), with respect to recall and recognition accuracy. More importantly to this thesis, if older adults performed at the same level as younger adults, it would suggest the employment of at least some automatic memorial processing (Hasher & Zacks 1979). Freeman and Ellis found younger and older adults showed an ISE roughly equivalent, in addition to a reliable SPT effect, using recognition latencies.

To account for their findings, Freeman and Ellis suggested that the nature of the encoded stimulus (i.e. action verbs) is so closely associated with motoric processing that initiation of performance requires relatively little attention. From this, they propose that the type of stimulus dictates the deployment of strategies associated with preparing items for subsequent enactment. This process could theoretically compensate for age-related deficits seen in the (controlled) self-initiation of encoding operations. Although some evidence contests these findings (e.g. Maylor, Darby & Della Sala 2000), overall it would seem that the motoric advantage associated with to-be-enacted and SPT material involves at least some automatic processing. If this proposal is correct we would expect to observe a broadly similar developmental trajectory for both the subject-performed task and the intention superiority effects. Thus one would expect to observe parallel age-related performance (if both effects are *attentional*) or the absence of an age effect on performance (if both effects are *automatic*) in both memory phenomena, as described in Chapter 1.

2.3 THE ISE AND PROSPECTIVE MEMORY

The representation and accessibility of to-be-enacted actions is of particular interest to researchers in prospective memory as the latter are concerned with identifying the processes that underlie the realisation of delayed intended actions. This final section considers the rapidly developing area of prospective memory and describes and evaluates the small section of this research that focuses on the development of prospective memory in children. I also discuss how the intention superiority effect could influence the execution of delayed intentions, although to date, this link has not been directly investigated (Ellis & Kvavilashvili 2000; Maylor *et al* 2000).

2.3.1 Prospective Memory or the Realisation of Delayed Intentions

With reference to prospective memory (PM), Kvavilashvili and Ellis (1996) observed that, "*It is difficult to describe an area of research as boiling with ideas and findings when approximately only 45 papers were published over the past 20 years.*" (p. 23). Since 1996, however, over 100 extra articles have been added to the area (Ellis & Kvavilashvili 2000) that cover a range of themes including the effects of adult aging (e.g. Cockburn & Smith 1994; Craik & Kerr 1996; Einstein &

McDaniel 1990; Einstein, McDaniel, Smith & Shaw 1998; Einstein, Smith, McDaniel & Shaw 1997; Kliegel, Martin, McDaniel & Einstein Submitted; Kliegel, McDaniel & Einstein 2000; Martin, Kliegel & McDaniel 2003; Maylor 1990, 1996; Maylor 1996, 1998; Park, Hertzog, Kidder, Morrell & Mayhorn 1997; Reese & Cherry 2002; West & Craik 1999; West 1988), issues concerning everyday intentions (e.g. Ellis & Nimmo-Smith 1993; Kliegel, McDaniel & Einstein 2000; Marsh, Hicks & Landau 1998; Maylor 1990), the effects of (non-) cognitive and attentional influences (e.g. Kliegel, Martin, McDaniel & Einstein In Press; Marsh & Hicks 1998; Martin, Kliegel & McDaniel 2003; Otani, Landau, Libkuman, StLouis, Kazen & Throne 1997), contributions from neuropsychology (e.g. Bisiacchi 1996; Burgess & Shallice 1997b; Cockburn 1996a, 1996b; Cohen & O'Reilly 1996; Glisky 1996; Leynes, Marsh, Hicks, Allen & Mayhorn 2003; McDaniel, Glisky, Rubin, Guynn & Routhieaux 1999) and, most salient to this thesis, issues relating to the development of prospective memory (e.g. Beal 1988; Ceci & Bronfenbrenner 1985; Guajardo & Best 2000; Kerns 2000; Kerns & Price 2001; Kvavilashvili, Messer & Ebdon 2001; Meacham & Colombo 1980; Meltzoff 1995; Passolunghi, Brandimonte & Cornoldi 1995; Somerville, Wellman & Cultice 1983). This last topic is addressed in more detail a little later (2.4.1). First we should address the definition of prospective memory and two frameworks that address this research area.

2.3.1.1 Definition and Frameworks

It is generally agreed that prospective memory refers to remembering to carry out a delayed intention at some point in the future. Common examples include appointments, posting a letter and taking medicines at the appropriate time. Most researchers would also generally agree on three principle characteristics (c.f. Ellis & Kvavilashvili 2000): 1) A retention interval between the encoding of the intention and the performance window, 2) the absence of an obvious cue to execute the intention and 3) the requirement to interrupt the ongoing task[10] to perform the intention. Using these, several researchers have proposed frameworks for prospective memory including Brandimonte (1991 cited in Brandimonte & Passolunghi 1994) and Ellis (1996) who suggested a similar series of stages that typify the whole process. For example, using the delayed intention of posting a letter, the process can be broken down into the following phases:

Phase A: ***Formation and Encoding of an intention*** – This is concerned with the retention of the content of the intention itself, consisting of the *intent* (the fact that you have to do something in the future), the *action* (what that intent is, i.e. post the letter) and the *retrieval context* (the circumstances under which one can execute the intention, i.e. when one sees a post box).

Phase B: ***The Retention Interval*** – This is the delay between the formation / encoding of the intention and the commencement of a *performance interval* (**Phase C**) during which the intention can be executed. During this interval, we are typically engaged in various activities, often unrelated to our intention.

Phase C: ***The Performance Interval*** – This is the period during which the intention should be retrieved (i.e. passing a letter box). Thus, success in **Phase C** is dependent both on recognition of the appropriate circumstances and recall of the intended action.

Phase D: ***Initiation and Execution of the Intended action*** – In **Phase C**, the intended action must be retrieved from memory and executed (i.e. Posting the letter in the box).

Phase E: ***Evaluation of the Outcome*** – The reason for an evaluation phase is two-fold: Firstly, if the intention has been completed (i.e. the letter is posted), then it can be cancelled to prevent erroneous repetition. If, on the other hand, the intention has not been completed (e.g. the post box is no longer in use), then it

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[10] Burgess (2000) noted that the activity that participants are engaged in during the performance interval has been called the background, ongoing or cover task/activity. Delegates to the conference agreed on the term “ongoing” in all future publications.

must be re-encoded for retrieval upon presentation of another appropriate performance interval.

Although these five phases are typically involved in all prospective memory tasks, it is important to note that PM tasks may vary considerably. Einstein and McDaniel (1990) suggested that, similar to retrospective memory (RM) tasks, prospective memory tasks differ in terms of their retrieval dynamics. This led them to make a distinction between *event-* and *time-based* prospective memory tasks (see Kvavilashvili 1990, cited in Kvavilashvili & Ellis 1996, for a third type of task). Event-based tasks refer to circumstances where the intention is dependent on the occurrence of a specific, external event. Thus using the example of posting a letter, the intention cannot be carried out unless one comes across an appropriate event (the post box). Time-based tasks, on the other hand, refer to intentions that can only be performed during, at or after a specific time period. Baking cupcakes (c.f. Ceci & Bronfenbrenner 1985) is a good example, where the cakes should not be removed from the oven until a predefined amount of time has passed. Using evidence from event-based task paradigms, Einstein and McDaniel (1996) developed two theoretical models to explain how environmental cues can support the execution of delayed intentions. Both models (a *Simple Activation model* and a *Notice + Search model*) also help to explain the spontaneous remembering processes thought to be involved in prospective memory (Einstein & McDaniel 1996).

The Simple Activation Model

This framework suggests that a cue-action pairing is automatically encoded when a participant is assigned a prospective memory task. During the retention interval and ongoing task, the activation level of this representation decreases. This can be prevented or ameliorated either by external exposure to the target cue or through internal thoughts that refer to the pairing (e.g. "*When I see* 'car', *I must press the key*"). On presentation of the target event, the intention is then executed provided its activation is sufficient. Einstein and McDaniel argue that processing of the target event can also influence intention activation. For example, when participants are given instructions about a general target (e.g. vehicle = press key), the cue-action activation is likely to be less than that for a specific target (e.g. car = press key) where the activation is thought to link directly to the item's node in an associative network (e.g. Anderson 1983). This activation then spreads out to associated items, although this spread is dependent on the number of items associated with the target cue. Because an infrequent word such as "*mitten*", is likely to have very few associations it is more likely that the intended action associated with an unfamiliar word would be sufficient to bring the intention into awareness than one associated with a familiar word. Indirect support comes from research by McDaniel and Einstein (1993) and Brandimonte and Passolunghi (1994) who found that decreases in cue-familiarity resulted in superior prospective memory performance.

The Notice + Search Model

This alternative framework assumes that two separate processes are involved in the retrieval of prospective memories. Einstein and McDaniel (1996) suggest that prospective memory cues can automatically elicit internal responses (e.g. feelings of familiarity) that cause the cue to be noticed. This can then lead to a directed search to determine what the cue signifies i.e., an intention. Einstein and McDaniel cite evidence from other research that invokes similar processes or ideas including that by Mandler (1980) who proposed a hypothetical context-free recognition whereby if one sees a person out of context, they then attempt to search for information that is contextually-related to establish a link. For example, seeing a person in a shop and then linking them to your office. Here, there are two processes: familiarity and directed retrieval. Similarly, Einstein and McDaniel suggest that the *Noticing + Search* framework also involves two stages. The initial (noticing) stage being relatively automatic and the second (directed search) being reliant more on controlled processes. They also argue that effective prospective memory is dependent on a successful directed search process although this process is itself dependent on internal responses being elicited by the target cue.

This model can account for findings that prospective memory performance is influenced by instruction specificity and the familiarity and distinctiveness of the cue. When participants are presented with *specific* instructions (e.g. car = press key), they are more likely to experience familiarity feelings upon presentation of the cue compared to when *general* instructions (e.g. vehicle = press key) are used. Similarly, when one is presented with an *unfamiliar* cue, shown during encoding of the prospective instruction, there is likely to be more "noticing" than when a *familiar* cue is employed. Finally, when a cue is *distinctive*, prospective memory performance is usually improved due to increased attention being associated with distinctive cue presentations. This is thought to help participants notice the familiarity of the target event and search for its source.

Clearly, there are a number of variables that can influence prospective memory performance, particularly with reference to the processing of the cue. Both models that Einstein and McDaniel propose can accommodate many of the findings on these variables. However, the models differ in one important respect: the degree to which they rely on automatic versus controlled retrieval processes. The *Simple Activation model* relies exclusively on automatic processes whereas the *Notice + Search model* uses both automatic and controlled processes. Therefore, the models have slightly different implications for understanding the influence of age on prospective memory. If the Simple Activation model is a more accurate explanation of intention retrieval there should be minimal effects of aging (child-adult or young versus older adult) on prospective memory performance. If, on the other hand the Noticing + Search view is correct then while there should be no age effects for the relatively automatic "Noticing" stage, because the second "Search" stage uses controlled processes thought to decline with age, poorer performance should be evident in older compared to younger participants.

Notwithstanding this distinction, Einstein and McDaniel (1996) argue that, depending on the circumstances, "*…it is possible that both models are correct*." (p. 126) For example, in some situations when there is a salient association between the target event and the target action, participants might be able to perform the intended action without any need for the controlled search stage. This would be consistent with instances where intentions spontaneously "pop" into the mind (Einstein & McDaniel 1990; Zimmer, Helstrup & Engelkamp 2000), a common everyday phenomenon (Zimmer and Cohen 2001). However, there are other instances where recruiting the two-stage process would be more beneficial such as frequent visits to a local convenience shop where one must remember what one needs for each visit and avoid buying the same item twice.

The Multiprocess Model

A more recent model proposed by McDaniel and Einstein (2000) builds on the above suggestion, arguing that discrepancies in findings from the prospective memory literature can be explained using a multiprocess view, supported by both attention-demanding monitoring *and* automatic processes (similar to the Notice + Search framework, described above). Central to this model is the proposal that there are a handful of relatively automatic processes involved in the retrieval of a delayed intention. At least one of these processes is mediated by an attentional system, similar to Shallice's Supervisory Attention System (Norman & Shallice 1986; Shallice & Burgess 1991). This system accounts for when an individual is less engaged in an ongoing task and more resources are diverted to monitoring for the prospective memory cue. Other processes involved rely on memory systems, comparable to those suggested by Mandler (1980), Guynn, McDaniel and Einstein (2001) and McDaniel, Robinson-Riegler and Einstein (1998). Similar to the Simple Activation model, these processes can account for situations where intentions spontaneously "pop" into the mind (Einstein & McDaniel 1990; Zimmer, Helstrup & Engelkamp 2000).

McDaniel and Einstein (2000) describe some critical factors that they argue determine the extent to which prospective memory is dependent on either of the two aforementioned processes. These factors are: the importance of the prospective memory task, characteristics of the prospective memory cues, properties of the ongoing task, planning and individual differences.

Kliegel, Martin, McDaniel and Einstein (2001) cite a handful of studies that have focused on the influence of importance on prospective memory performance. These include two retrospective questionnaire or diary studies (Andrzejewski, Moore, Corvette & Herrmann 1991; Ellis 1988), two experimental field studies (Meacham & Singer 1977; Somerville, Wellman & Cultice 1983) and two empirical studies in the laboratory (Goschke & Kuhl 1996; Kvavilashvili 1987). In general, intentions encoded with an element of importance or incentive are more likely to be successfully remembered or performed compared to intentions encoded with no such incentive (for an exception see Goschke & Kuhl 1996).

Kliegel *et al* (2001) used both a time-based (experiment 1) and an event-based (experiment 2) prospective memory task to explore further the role of importance. They observed that manipulating importance had an effect on time-based tasks only and that the degree to which importance improves prospective memory performance is dependent on the amount of strategic allocation of attentional resources in the ongoing task. For example, in experiment 2, the combination of a taxing digit-monitoring task with a highly important intention significantly increased error rates on the ongoing task, suggesting that more resources were being assigned to monitoring for the prospective memory cue.

The nature of the cue, particularly in event-based prospective memory tasks, is important for determining the processes that support prospective memory retrieval (McDaniel and Einstein 2000). McDaniel and Einstein highlight two factors that have been investigated: the distinctiveness of the cue or target and the degree to which the cue is associated with the intention itself. With respect to the first, several studies have manipulated distinctiveness using a number of techniques such as presenting targets as low-frequency words in a set of highly familiar ones (Einstein & McDaniel 1990; McDaniel & Einstein 1993) or in an upper-case font (Brandimonte & Passolunghi 1994; Einstein, McDaniel, Manzi, Cochran & Baker 2000) within a set of words in lower case. Their findings reveal that when the target cue is salient, compared to other items in the ongoing task, prospective memory performance is improved. For example, Brandimonte and Passolunghi (1994) manipulated the semantic and perceptual distinctiveness of a cue and found that prospective memory performance was improved when the cue was both semantically (experiment 1) and perceptually (experiment 2) distinctive.

When considering the association between the cue and the intended action, McDaniel and Einstein (2000) cite data from two presentations made at the First International Conference on Prospective Memory (e.g. Wilson; McDaniel & Einstein). In an event-based task study, for example, Wilson (2000 cited in McDaniel & Einstein 2000) found that performance was significantly improved when target events were related (e.g. remembering to remove a bookmark from a book when presented with a depiction of a book and bookmark) rather than unrelated (e.g. remembering to remove a floppy disk from a box when shown an image of a University entrance gate) to the intended action.

In a typical prospective memory paradigm target events are traditionally embedded within an ongoing task. McDaniel and Einstein (2000) suggest two factors of this task that can determine the degree to which strategic, attentional processes versus less strategic processes will be involved in prospective memory: focal processing and task absorption. If focal processing of the cue is required for performance of the ongoing task, then the cue should be sufficiently processed to trigger involuntary or automatic retrieval of the intended action (McDaniel & Einstein 2000). Laboratory studies where the prospective memory cue is focally processed have reported very small (usually nonsignificant) or no age-related decrements (e.g. Einstein & McDaniel 1990; Einstein, Smith, McDaniel & Shaw 1997), indicating an automatic retrieval process. However, for those situations where the prospective memory cue is not a focal component, monitoring of the cue is thought to require more strategic, attentional resources. This is supported by significant age-related declines in prospective memory performance (e.g. Maylor 1993, 1996; Park, Hertzog, Kidder, Morrell & Mayhorn 1997) in such situations.

With respect to the second aspect of ongoing tasks, McDaniel and Einstein (2000) postulate that when an ongoing task is very engaging, fewer attentional resources are likely to be made available for deployment towards prospective memory performance. They further divide this factor into four contributory elements that determine level of absorption: the design of the ongoing task, presentation speed of task stimuli, how much interest the individual has in the task and the physiological state of the participant. An early study by Kvavilashvili (1987, experiment 2), for example, sought to investigate whether increases in ongoing task absorption could affect thinking about the intended activity. Kvavilashvili tested ongoing task absorption by manipulating the character of the intervening activity (c.f. Meacham and Colombo 1980) through either having an interesting task (deciding whether people in various photographs were murderers or not), an uninteresting task (Bourdon's test, monotonous) or no task at all during the retention interval. Although Meacham and Colombo failed to find an effect of varying the difficulty of the intervening activity, Kvavilashvili found that as the task became more engaging, the proportion of participants who reported thinking about the intended action decreased. This finding is consistent with the suggestion that fewer attentional resources are available for intention retrieval when the ongoing task becomes more absorbing.

McDaniel, Einstein and Finstad (2000, cited in McDaniel & Einstein 2000) reported findings consistent with Kvavilashvili's observations. They presented participants with either one or four different ongoing word activities, hypothesising that a single activity presented repeatedly in a task would become less absorbing to the participant compared to four novel tasks, which would require more strategic processing. Their findings supported this proposal with participants in the single-ongoing task condition displaying significantly higher performance on the prospective memory task than those in the second condition[11]. Other research that has found consistent results includes recent work by Rendell and colleagues (Rendell & Craik 2000; Rendell & Forbes 2000 cited in McDaniel & Einstein 2000). Thus it would seem that ongoing tasks that are very engaging or complex to a participant can have a negative effect on prospective memory performance when strategic processing is required (e.g. when the cue is not distinctive). This may also be the case for participants who choose to employ an *action-oriented* approach to prospective memory (Goschke & Kuhl 1993; see below).

In their *Activity Memory Framework* (see 1.2.4), Foley and Ratner (2001; Ratner & Foley 1994) highlighted planning as a crucial component of the enactment effect. This factor is relevant also to prospective memory where a number of researchers have suggested that the type and degree of planning that a person employs for a delayed intention can have a significant influence on performance (Burgess & Shallice 1997b; Mäntylä 1996 although see Bisiacchi 1996 for a conflicting result). Mäntylä, for example, suggested that the planning of activities could improve prospective memory in one of two ways: by automatically increasing the activation level of the prospective memory representation or by creating a more intricate representation that could boost the number of potential retrieval routes and thus benefit prospective memory performance. Research

[11] Contrasting results come from a similar study by Hicks, Marsh and Russell (2000) who used a similar paradigm but focused on the retention interval rather than the ongoing task.

with neuropsychological patients with planning deficits indicates that planning ability might indeed benefit prospective memory performance (Cockburn 1996b but see Bisiacchi 1996 for an alternative perspective).

A study with younger and older adults, cited by McDaniel and Einstein (2000), attempted to focus more closely on the issue of planning. Participants were presented with a distinctive target (a CAPITALISED word that appeared in a sentence containing otherwise non-capitalised words). Contrary to traditional prospective memory tasks, this target acted as a cue to *plan* to perform an action (press a predetermined key on the keyboard) when they received a series of trivia items, ten seconds later. Furthermore, some of the participants were given an additional, divided attention task (a taxing digit-detection task) to observe its influence on performance. Conflicting with findings from a previous study that employed a more traditional prospective memory task (Einstein, McDaniel, Manzi, Cochran & Baker 2000), the results indicated that the divided attention task had a negative effect on performance only when the target word was presented in the planning phase and not when it was presented during the delay or execution phase, especially for older than for younger adults. Thus, it would appear that dividing attention during presentation of the target encroaches on resources necessary for planning: when attention was not divided during presentation of the target, more resources were available for forming an intention and prospective memory performance benefited. Similarly, in a study that focused on a basic element of planning rather than planning per se, Mäntylä (1993) discovered that priming target events before carrying out a prospective memory task improved performance for both younger and older adults. McDaniel and Einstein (2000) suggest this could be due to the increased familiarity involuntarily capturing attention.

Another study linked to this area is one by Guynn, McDaniel and Einstein (1998) who, in a series of four experiments, focused on the effectiveness of different kinds of reminders: frequent versus no reminders (Experiments 1A and 1B) and reminders that referenced the prospective memory target and the intended action (Experiment 2-3). Guynn *et al* found reminders that referred to both the prospective memory target events and the intended activity were more effective than those that only referred to the target events or the intended action. This finding is consistent with the research, stated earlier, concerning activation of the association between the cue and the intended action. This activation has the effect of increasing the likelihood that the intended activity is executed, potentially through an automatic associative system (McDaniel & Einstein 2000) similar to the idea proposed by Mäntylä (1996). Moreover, some circumstances require more planning than others. Goschke and Kuhl (1996), for example, make the distinction between *procedural* and *declarative intentions*, where the former are those that are dependent on preformed intentions. Because a memory trace has already been formed, the intention can be executed more quickly, more automatically and therefore, with fewer resources. The execution of declarative intentions, on the other hand, is dependent on the details of concrete actions being specified by further (strategic) planning or problem solving. In addition to making this distinction, Goschke and Kuhl (1993, 1996) also ask whether there are individual differences with respect to the activation and persistence of intentions.

McDaniel and Einstein (2000) suggest that the degree to which automatic versus strategic processes are involved in a prospective memory task is likely to depend also on *individual differences*. Goschke and Kuhl (1993, 1996) examined one particular personality temperament, *state versus action orientation*. They describe state orientation "*…as a tendency to experience involuntary intrusions concerning past failures or future goals.*" (p.1221). Moreover, they suggested that individuals with a state orientation are more likely to ponder over current concerns and therefore maintain unfulfilled intentions in a more activated state than individuals who are *action orientated*. The latter are thought to reduce activation for the declarative representation of a postponed intention when external cues are available. Goschke and Kuhl investigated whether there are any differences between these two personality types, with respect to the intention superiority effect (ISE), using their postponed-intention paradigm (see 1.3). In all three experiments, the difference between neutral and prospective material in the execution condition was reliable only for those participants described as state-oriented. Thus Goschke and Kuhl suggested that while action-oriented participants appear to deactivate intention-related items and focus instead on the ongoing task, state-oriented participants persist in keeping the intended items active. In experiment 3, where the intended activity had to be self-initiated without external cues, both groups showed a similar intention superiority effect. Overall, these results indicate that individuals with specific personality types are more sensitive to specific task demands and will adjust their approach to prospective memory tasks depending on the circumstances.

2.4 AGE EFFECTS ON PROSPECTIVE MEMORY PERFORMANCE

In Hasher and Zacks' (1979) attentional framework (see 1.1) for automatic and effortful memory processes, they suggest that one criterion for a process to be automatic is that it should be minimally influenced by differences in age i.e., developmental trends should be limited. Consistent with this, a number of studies have focused on the issue of aging and prospective memory: an issue that, as Ellis and Kvavilashvili (2000) point out, is of both theoretical and practical concern due to the impact that failures in prospective memory can have on everyday life such as forgetting appointments (e.g. Kvavilashvili 1987) or taking medicine (Park and Kidder 1996). Findings in this area are equivocal as some experiments have suggested that there are significant age differences (e.g. Maylor 1996, 1998; Park, Hertzog, Kidder, Morrell & Mayhorn 1997; Reese & Cherry 2002) while results from other studies (e.g. Cherry & LeCompte 1999; Cherry, Martin, Simmons-D'Gerolamo, Pinkston, Griffing & Gouvier 2001; Einstein & McDaniel 1990; Einstein, McDaniel, Richardson, Guynn & Cunfer 1995; Einstein, Smith, McDaniel & Shaw 1997) suggest the opposite (Maylor

1998). Closer inspection of these studies reveals that methodological differences may typically be responsible for these contrasting findings. For example, Einstein, McDaniel *et al* (1995) compared time- with event-based prospective memory tasks (Einstein & McDaniel 1990) and found that while self-initiated time-based tasks produced age differences, more cue-driven tasks showed an inverse set of results. The first finding is analogous to a suggestion by Craik (1986) who argued that prospective memory tasks are substantially dependent on self-initiated retrieval cues and should, therefore, be especially difficult for older adults. More evidence stems from an early study by Maylor (1990) who looked at performance by participants aged 52- to 95-years-old on a simple prospective memory task: making a daily telephone call either at a particular time or during a period of time using either internal (self-initiated) or external (cue-driven) memory aids. She found age effects such that internal cues significantly reduced performance for older compared to younger participants. However, we should note that the “younger” participants were aged 52+ years.

Maylor later focused on questionnaire-based studies. Evidence from a subset of items from a Cognitive Failures Questionnaire found that elderly people appear to complain more about *retrospective* than *prospective* memory failures compared to young people (Maylor 1993). In a more recent study, Smith *et al* (2000) asked five groups of adults (n=862) to rate prospective and retrospective memory failures on a sixteen-item questionnaire. The five groups were comprised of Alzheimer Disease patients, their carers (usually a parent or spouse; also rated the patients), an elderly group (aged 60 years and over), a young control group (under 60 years) and a group of married couples, matched to the elderly group in terms of age and education. Half of the sixteen questionnaire items were related to retrospective memory and half to prospective memory (unlike the original Cognitive Failures Questionnaire (Broadbent, Cooper, Fitzgerald and Parkes 1982), which addressed prospective memory in only 2 out of 25 items). Smith *et al* found that reported memory failures (both retrospective and prospective) were highest for the patients and lowest for the carers. A comparison of the young and elderly controls indicated no reported differences in memory failures for either type (although some experimental evidence has found the opposite). A closer inspection revealed not only that prospective memory errors were reported more frequently than retrospective errors, but also that self-cued (internal) retrieval apparently led to more frequent errors than environmentally-cued (external) retrieval. This again conforms to Craik's (1986) proposal, mentioned above, although in this particular study no significant age differences were reported.

Other, experimental studies by Cherry and colleagues have also failed to reveal significant age differences in prospective memory. Cherry and LeCompte (1999), for example, subdivided young and older adult groups into higher and lower ability (using educational attainment) and focused on how much they thought about an event-based prospective memory task. They found that both higher and lower ability older adults thought about the task less often than younger adults. Moreover, the higher ability group of older adults were more successful than lower ability adults although there was no reliable difference in performance between the two age groups. However, a drawback with this study was that prospective memory monitoring was measured post-test. To overcome this, a recent replication by Reese and Cherry (2002) included both a four-item post-test questionnaire and an online measure that periodically probed participants' thoughts throughout the ongoing activity (a short-term memory task). Again young and older adults were subdivided into high and low ability, using educational history. The results again found analogous prospective memory performance for the age/ability groups (see also Cherry, Martin, Simmons-D'Gerolamo, Pinkston, Griffing & Gouvier 2001). The older adults were also found to think more about the STM task – either the presentation stimuli or a self-evaluation on their performance (e.g. "I'm getting better at this") – although the younger adults had a higher frequency of task-irrelevant thoughts[12]. This last

[12] This is in contrast to Einstein and McDaniel (1996) who found that older and younger adults are equally guilty of mind wanderin

finding is of particular interest because although participants did not rehearse the intention, their performance was generally very good. Therefore, using the McDaniel and Einstein (2000) framework, it could be argued that automatic processing underlies performance in this particular event-based task (Reese and Cherry 2002) due to necessary focal processing on the target cue.

Thus far, then, it would seem that age differences in prospective memory are dependent on the paradigm used (time- or event-based). Another possibility comes from research conducted by Martin, Kliegel and McDaniel (2003) who focused on the relationship between age, prospective memory performance and frontally-mediated executive functions. This follows from strong indications that frontal functioning declines with age (e.g. West 1996) and the possible relationship between prospective memory and frontal processes (e.g. McDaniel, Glisky, Rubin, Guynn & Routhieaux 1999; Wecker, Kramer, Wisniewski, Delis & Kaplan 2000). In their study, Martin, Kliegel and McDaniel (2003) presented a group of young (n=40) and old (n=40) adults a battery of prospective memory and executive function measures. They reported that a range of executive functions is involved in prospective memory although the importance of any particular one is dependent on aspects of the task (e.g. complexity of the task and retention interval). They also found that age-related differences in prospective memory performance are evident only in tasks associated with frontal/executive functions. From this, Martin *et al* present a viable explanation for the disparate findings with relation to age differences (or lack thereof) in prospective memory performance. They suggest that these could be due to the requirement of executive functions (e.g. planning, attention-switching or inhibition). Therefore, those studies where no age effects have been uncovered (typically event-based) could employ tasks that have very little need for executive functions. On the other hand, studies that have found age effects (usually time-based) might have used tasks with a predisposition for executive functions. If this is indeed the case, then it would seem prudent to test the theory with a younger population: children.

2.4.1 The Development of Prospective Memory

As pointed out at the beginning of this section, only a handful of studies have focused specifically on prospective memory in children. Moreover, as Kvavilashvili, Messer and Ebdon (2001) point out, these studies vary considerably in the method employed, area of focus and ages tested. Nevertheless, it has been frequently argued that prospective memory should be studied in the developmental domain (e.g. Kvavilashvili *et al* 2001; Meacham & Colombo 1980; Winograd 1988) to investigate any developmental trajectory and whether factors that affect adults' prospective memory (e.g. cue-familiarity, cue-distinctiveness, retention interval, task interruption/complexity) exert a similar influence on children's performance.

In a recent series of experiments, Kvavilashvili, Messer and Ebdon (2001) investigated the effects of age and task interruption on prospective memory performance and the relationship between prospective and retrospective memory in children aged 4-, 5- and 7-years-old. Using an innovative event-based task, Kvavilashvili *et al* engrossed the children in a picture-naming game (ongoing task) and asked them to remember to hide any pictures of animals (prospective task). To manipulate task interruption, the authors placed the target cards either in the middle of the pack of cards (task interruption) or at the end of the pack (no task interruption). Although they observed significant differences between the age groups, these differences were small and age was found to account for only a small amount of variance (about 7 – 10% in prospective memory). Task interruption, on the other hand, accounted for a significant amount of the variance, although the authors are cautious in their explanations for this due to lack of previous research. In line with their hypotheses, children who had to execute the prospective memory task at the end of the pack performed significantly better than those who had to interrupt the game in the middle of the pack in order to perform it. Finally, when using regression analyses to address the relationship between retrospective and prospective memory, the authors found no such correlation, indicating a difference in the developmental trajectory of these two cognitive constructs.

But what about the relationship between the development of executive processes and prospective memory performance? Indeed as Kerns (2000) points out that, "*Increased interest in the phenomena of prospective memory has coincided with the exponential growth of research addressing executive functions*" (p. 62). With this in mind, Kerns focused on seeing whether or not there was a relationship between prospective memory and four measures of executive function in a sample of children aged 6-12 years. She used a computerised, time-based measure of prospective memory, the CyberCruiser: a five-minute computer game divided into two principle tasks. The first, ongoing task involved driving along a road, using a joystick. The children were required to score as many points as possible by manoeuvring around other vehicles on the road. Their real-time score was displayed onscreen, together with the names and scores of the three top-scoring previous participants to act as an incentive to score as highly as possible. The second, prospective task involved monitoring the fuel level. If this level ever reached zero (fuel would last approximately one minute), the children were warned that they would lose all their accumulated points. To prevent this, the children were informed that they could check the fuel level by pressing one of the joystick buttons. This would reveal the gauge although it would only remain onscreen for three seconds. This procedure could be checked as often as required, although refuelling (carried out by pressing another button) could be done only when 25% of the fuel was remaining.

The four executive tasks were two tasks of visuospatial working memory (delayed alternation-nonalternation and a self-ordered pointing task) and two measures of inhibition (go-no-go and a Stroop task). The findings revealed a significant developmental trend on prospective memory performance with the younger children making more prospective memory errors than the older children. The children also demonstrated an anticipated *Test-Wait-Test-Exit* (TWTE) checking behaviour, previously shown by Harris and Wilkins (1982). This pattern describes a strategy whereby participants test the time (e.g. in Kern's study, checking the fuel gauge), then wait for a period of time until a second test seems appropriate. This test-wait behaviour continues until the performance interval arrives at which point the intended activity (i.e. refuel) is carried out and the loop is exited. In their experiment, Harris and Wilkins reported that participants produced a *J*-shaped pattern of clock checking (although see Ceci and Bronfenbrenner 1985, below, for a different finding). The pattern shown by participants in Kerns' (2000) study was also *J*-shaped, suggesting that 7-12-year-old children tend to check the time more as the performance interval approaches. Kerns also discovered that failures on the prospective memory task were highly correlated with three of the four executive measures: Stroop interference, errors on the self-ordered pointing task and errors on the nonalternation component of the delayed alternation task, even after controlling for chronological age. Overall, this novel measure of prospective memory is as an excellent time-based task for use with children of a variety of ages.

An earlier study, conducted by Ceci and Bronfenbrenner (1985), also used a time-based measure of prospective memory. They focused on the influence of age (10- versus 14-years) and gender on what they described as *strategic time-monitoring*. In describing this phenomenon, they outlined three phases: 1) A *calibration phase*, where participants supposedly synchronise their psychological clocks with real-time, 2) an *intermediate phase* where they reduce clock-watching and concentrate more on the ongoing task or other unrelated activities and 3) a *scalloping phase*, where a sharp increase in clock-watching is observed as the performance time approaches. Using this framework, Ceci and Bronfenbrenner predicted a U-shaped distribution of clock-watching behaviour. In their experiment, children (equal numbers of girls and boys) were asked either to bake some cupcakes or to charge a motorcycle battery whilst playing on a Pac Man video machine located in an adjoining room. The game was carefully positioned so that the children's backs faced a wall clock. Depending on the condition, children were told either to remove the cupcakes from the oven to avoid them burning or to remove the battery cables to avoid over-charging. In both, the retention interval was thirty minutes. The experimenters also manipulated context in their experiment with half of the children carrying out the task in their own homes and half in a laboratory.

Ceci and Bronfenbrenner (1985) found that children as young as 10-years-old, when tested in a familiar home setting, exhibited a similar TWTE pattern to that observed by Harris and Wilkins (1982), although it was more *U*- than *J*-shaped. This pattern contrasted with children who were tested in the unfamiliar laboratory setting. These children exhibited an ascending linear pattern of checks, steadily increasing until the target time occurred. Therefore, very little strategic monitoring was employed, perhaps, as the authors suggest, because the children deemed the laboratory task more important than the home-based tasks. Moreover, Ceci and Bronfenbrenner point out that, "*… had our experiment been conducted only in the laboratory, we would have reached rather different conclusions*" (p. 161).

Another, more recent study focused on the effects of incentive and external cues whilst also comparing naturalistic and laboratory-based prospective memory tasks in children aged 3-5-years-old. Guajardo and Best (2000) also sought to address the development of the relationship, if any, between retrospective and prospective memory following pilot work that revealed a positive relationship in young children (Ruther & Best 1993 cited in Guajardo & Best 2000). 48 3-year-olds and 48 5-year-olds participated in both computer-based and naturalistic prospective memory tasks, split over two sessions. The computer task, based on Einstein and McDaniel's (1990) task, involved the presentation of sixty simple pictures, which the children were told to remember for a later recall test. A target picture appeared amongst these pictures on six occasions and the children were told to press the space bar whenever this occurred. Children in the external cue condition were allowed to select an appropriate picture and place it somewhere where it could remind them to press the key upon presentation of the target. Children in the incentive condition were offered a reward on every occasion where they remembered to press the space bar at the appropriate time.

For the naturalistic tasks, Guajardo and Best opted to use tasks that were familiar to preschool-aged children. These were divided into two *short-delay* (roughly 20 minutes; remember to ask for a sticker and close the door after they completed the computer task) and two *long-delay* tasks (between 24 and 72 hours; remember to return a picture that they received at the end of the first session and ask for a pencil to take home).

For the laboratory tasks, the authors found that although older, 5-year-olds showed better prospective memory performance than the younger, 3-year-olds, neither incentive nor external cuing improved overall performance. Focusing on the naturalistic tasks, again an effect of age was uncovered where more 5- than 3-year-olds remembered to perform the tasks, regardless of retention interval and without a prompt. This latter point indicates that younger children may rely more on external support to successfully fulfil delayed intentions than older children.

Consistent with previous work (c.f. Gathercole 1998), when Guajardo and Best looked at retrospective memory performance they found that older children outperformed younger children in recall of the ongoing task stimuli[13]. When they collapsed across age and included children’s target response (i.e. prospective memory) scores to evaluate the relationship between the prospective and retrospective memory, a significant and positive correlation was uncovered. However, separate correlations conducted on each age group revealed that this

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[13] Interestingly, more pictures were recalled during the first than the second session, perhaps indicating boredom or some other extraneous factor.

correlation was significant only for the 3-year-olds. In their discussion, Guajardo and Best cite Einstein and McDaniel (1990) to attempt to explain this, suggesting that perhaps if the prospective memory task were made more difficult, particularly for the older age group, these differences would be eliminated. Nevertheless, it is a very interesting finding. I would also argue that perhaps the retrospective task might have been a little easy; adding an extra element to the task such as identifying a stimuli-related colour would have increased the difficulty and have the potential to distract a little more from the prospective memory targets.

Overall, the positive findings from this study are consistent with other studies (e.g. Kreutzer, Leonard & Flavell 1975; Somerville *et al* 1983) in suggesting that preschool children are able to demonstrate prospective memory. However, this research went one step further and focused on prospective memory both in laboratory *and* naturalistic contexts and found developmental effects in both. Although the authors failed to find a significant influence of incentive or external cues on prospective memory performance, despite contradictory evidence from both adult and developmental research (e.g. Ceci & Bronfenbrenner 1985; Einstein & McDaniel 1990; Meacham & Singer 1977; Somerville, *et al* 1983; West 1988), they did discover evidence for the employment of strategies in nearly a third of the younger children. This is in line with Beal (1988) who suggested that children overestimate their memory ability and that although they might discover efficient strategies for employment with prospective memory, they tend not to utilise them appropriately. On this point, Passolunghi, Brandimonte and Cornoldi (1995) observed that children "*… because they overestimate the informativeness of the cue … do not construct an effective link between the cue and the action*" (p. 633). Consistent with this, Ellis and Milne (1996) suggested that varying the nature of the cue has a significant effect on prospective memory performance. But what if the encoding of the cue is varied? Using a paradigm similar to that of Einstein and McDaniel (1990), Passolunghi *et al* crafted their own series of three experiments to address this in younger (7-8-year-olds) and older (10-11-year-olds) children.

In Passolunghi *et al*'s first experiment, sixty 7-8 year old children and sixty 10-11 year old children were assigned to one of three experimental conditions where encoding of the prospective instruction was either visual (a line-drawing), verbal (a printed word) or motoric (enactment of the response). In all conditions, participants were informed that the objective behind the task was to verify reading skills by reading a series of words (grouped into sets of five) as quickly and accurately as possible. This established the ongoing task. Similar to Guajardo and Best's (2000) study, the prospective task was to press a response key whenever a target word (e.g. *boat*) occurred within a word set. Participants in the visual-encoding condition were shown a line drawing depicting the target word and told to press the key whenever they saw the word. Participants in the verbal-encoding condition were shown a printed version of the word and told to press the key whenever they saw this word. Finally, participants in the motor-encoding condition were told to press the key whenever they saw the word and asked to practice this procedure, by actually pressing the response key.

The experimental phase was divided into four blocks of ten trials in which the target word appeared eight times, twice per block, although participants were not made aware of this. Before the experimental phase was presented, participants were given a practice block of ten trials in which the target word never occurred. The results from this first experiment revealed that, in general, prospective memory improved with age. However, the authors were more interested in which encoding condition appeared to benefit each age group: For the younger children (7-8-year-olds), performance was particularly enhanced when the prospective instruction was presented *visually* (i.e. a picture). The older children, on the other hand, seemed to benefit more from *motoric* encoding of the prospective instruction. To try to account for this apparent performance disadvantage in young children, Passolunghi *et al*'s (1995) second experiment orthogonally crossed encoding modality with the presence / absence of motoric encoding. Therefore, participants were assigned to one of four experimental conditions:

Visual, Verbal (both identical to those in experiment 1), Visual-Motoric (line-drawing + enactment of the response) and Verbal-Motoric (written word + enactment of the response). Using these conditions, the authors found that older children once again benefited from the motor component in both the visual-motoric and verbal-motoric conditions. Interestingly, although younger participant's performance again improved with visual encoding, when visual / verbal was paired with motoric encoding, performance was not reliably facilitated. From these results, the authors suggested that enhancing the encoding of both stimulus *and* response does not necessarily increase the strength of the intention. Moreover, although perhaps a weaker integration between cue and response might increase prospective forgetting, a stronger integration might also make significantly greater demands on younger children's attentional resources. To focus on this more closely, the author's third experiment attempted to manipulate the strength of the association between the cue and the action to see the effect on prospective memory performance in younger children.

In experiment 3 the strength of the association was manipulated either by making it more meaningful and naturalistic (*Natural Association*) or by assisting in the strengthening of the cue-response association by presenting the cue to participants and asking them to respond accordingly, separate from the experiment (*Constructed Association*). Thus in the experiment, four conditions were compared that all used motoric encoding. The *Standard, no association* condition was identical to the motoric condition from Experiment 1. In the *Natural Association* condition, the prospective task of pressing the key was compared to a game of *battle ships* where presentation of the target word, boat, would be "sunk" by pressing the response key. In the *Constructed Association* condition the target word appeared in the training block three times and participants had to react accordingly, aided by reminders if necessary. Finally, the *Constructed Association plus delay* condition was identical to the Constructed Association condition except that an additional 3-minute trial (containing no target words) preceded the experimental blocks. As a post-experimental measure of prospective memory, the authors also included a two-item questionnaire, presented after the four experimental blocks. The first item asked whether the participant had to do something during the game. They were then asked if they could remember the target and the response.

Data from the forty 7-8-year old children in this experiment revealed a number of interesting discussion points. First, under appropriate conditions, motoric encoding *can* enhance young children's prospective memory performance. Second, for successful prospective recall, a strong link between the cue and the response must be established. Third, once such a link is established, it must be learned through direct experience; not simply verbalised.

Overall in their three studies, therefore, Passolunghi *et al* (1995) observed significant differences in prospective memory performance between 7- and 11-years, although this may be dependent upon encoding modality. Indeed the results from experiments 1 and 2 are partially consistent with retrospective memory work by Hitch, Woodin and Baker (1989) who discovered that younger participants' performance benefited from visually presented cues while older participants showed no reliable performance benefit when the cue was presented verbally. Notwithstanding this, prospective memory researchers are beginning to appreciate that an efficient strategy for successful performance may be to encode a delayed intention as an imaginal / action-schema (e.g. Brandimonte & Passolunghi 1994; Koriat, Ben-Zur & Nussbaum 1990). However, although children as young as three years of age might begin to build up an understanding of planning skills, attention and strategy use (Nelson & Gruendel 1981), this understanding is still quite basic, perhaps because of a relative lack of attentional or other cognitive resources. This reasoning could also explain why the younger children in the Passolunghi *et al* study have difficulty with motor encoding but the older children seem quite capable of employing enactment as a tool for remembering to execute the appropriate response at the appropriate time. Either way, this study provides an excellent insight into the development of prospective memory in children by focusing on encoding strategies.

In summary, the research mentioned in this section has made a significant contribution to the developmental area of the prospective memory literature. Kvavilashvili, Messer and Ebdon's (2001) paper focused on task interruption and age effects with a young age range; Kern's (2000) used a novel, time-based prospective memory task with children aged 6-12-years and looked at the relationship with executive functioning[14]; Ceci and Bronfenbrenner (1985) also used the time-based prospective memory paradigm to focus on strategy use by children to aid prospective memory; Guajardo and Best (2000) focused on incentive, external cue use and age effects whilst comparing naturalistic with laboratory tasks; and finally, Passolunghi, Brandimonte and Cornoldi (1995) addressed the encoding of the prospective instruction and the strength of the cue-response association using three modalities. One crucial aim of this thesis is to contribute something to the literature in an attempt to discover how prospective memory develops in children.

2.5 FURTHER RESEARCH QUESTIONS AND PREDICTIONS

In addition to the research question described at the end of Chapter 1, there are two further research questions.

2.5.1 What effect does encoding modality have on prospective memory performance in seven-, nine- and eleven-year-olds?

[14] She later went on to use the task with children diagnosed with attention-deficit disorder with hyperactivity (ADHD) to see whether these children experienced prospective memory difficulties (Kerns & Price 2001).

Research has revealed that the manipulation of the prospective memory cue can influence adult's prospective remembering (e.g. Brandimonte & Passolunghi 1994; Cherry *et al* 2001; Ellis & Milne 1996; McDaniel & Einstein 1993, 1991). Passolunghi, Brandimonte and Cornoldi (1995) were the first to investigate the effect of manipulating prospective memory target / cue encoding modality on prospective performance in children. They discovered that younger children's (7-8-years) performance seemed to benefit from a visually encoded prospective memory instruction. Older children's (10-11-years) performance, on the other, hand appeared to benefit more when the instruction was learnt using motoric encoding. However, in their experiments Passolunghi *et al* did not make a meaningful link between the cue (boat) and the intended response (pressing a button) – although their Natural Association condition in experiment 3 could be argued to address this, but only for 7-8-year-old children. Chapters 4 and 5 in this thesis describe attempts to explore and extend the findings of Passolunghi *et al* by increasing the strength of the association between the cue and the response while at the same time manipulating the encoding modality (either verbal, visual or motoric) of the prospective memory cue instruction. Based on the findings of Passolunghi *et al*, it was predicted that the younger children would benefit from visual encoding and the older children from motoric encoding of the prospective instruction. The SPT paradigm was also included in the experimental session to examine whether performance on this task had any links to prospective memory performance due to the motoric nature of the task.

2.5.2 To what extent do attentional measures support prospective memory performance in seven-, nine- and eleven-year-olds?

In her novel time-based prospective memory experiment, Kerns (2000) compared performance on the prospective memory task with measures of executive functioning (visuospatial working memory and inhibitory capacity). She speculated that because time-based tasks require monitoring, there should be a correlation between accuracy on the prospective memory task and the executive measures. Kerns reported such a correlation with three of the executive function measures, including performance on the Stroop task. In the prospective memory task from Chapter 4, four items from the Test of Everyday Attention for Children (TEA-Ch; Manly, Robertson, Anderson, & Nimmo-Smith 1999) were also included together with the British Picture Vocabulary Scale (BPVS; Dunn, Dunn, Whetton & Burley 1997). These tests were included to provide measures of executive functioning (selective attention, attentional switching and working memory) and a verbal comprehension score (BPVS) for each participant. Using these and additional data from Chapter 5, the relationship between executive skills and prospective remembering is explored in the final experiment in Chapter 6. The main aim of Chapter 6 is to investigate the relationship between executive functioning and memory for actions in young children.

CHAPTER 3:

THE SPT & ISE EFFECTS IN CHILDREN

3.1 INTRODUCTION

In Chapters 1 and 2 I attempted to draw together research from the subject-performed task (SPT) and intention-superiority effect (ISE) paradigms with developmental research on executive functioning and prospective memory. The three experiments reported in this chapter were designed to explore the foundations for these associations by focusing on memory for actions in adults and, more importantly to this thesis, children.

Zimmer and Cohen (2001) argue that everyday memory situations can largely be characterised by at least three aspects. First, this form of memory is usually applied to situations where a person is active. Second, the encoding of memory traces for these situations is typically unintentional i.e., everyday memory is regarded as involuntary and perhaps even automatic. Finally, everyday memory includes both input and output elements: a record is kept of an environmental stimulus and the subsequent response. Zimmer and Cohen also point out that memory research has largely ignored the motor modality, tending to concentrate more on visual and verbal stimuli. This is a striking bias given that there are a number of unusual aspects of memory for actions. For example, during the retrieval stage, intended actions can spontaneously “pop” into conscious memory, particularly when presented with an environmental stimulus (Mandler 1994; McDaniel, Robinson-Riegler & Einstein 1998; Zimmer, Helstrup & Engelkamp 2000). Furthermore, during a complex task that involves a number of stages, the individual has to monitor the stages that have been completed and those that remain to be completed. Similarly, actions that are intended for future performance need to be planned. This relates to a distinguishing characteristic of action memory: its goal-directed nature (Foley & Ratner 2001).

As mentioned in Chapter 1, over the last two decades research into memory for actions has investigated the SPT effect under a number of different circumstances. The advantage for information enacted at encoding has been demonstrated with a variety of materials (e.g. verb-noun phrases, verbs alone, phrases with and without real objects, bizarre phrases), on different retrieval tests (free and cued recall, recognition) and with various population samples (e.g. students, elderly, Alzheimer patients).

Despite this plethora of research into memory for actions, to date very few studies have focused on the development of memory for actions in children. This is unusual, particularly when one considers a popular, yet controversial explanation for the SPT that suggests that action memory is non-strategic and relies on more automatic processes compared to verbal memory (e.g. Cohen 1989). In line with this contentious notion, Cohen and Stewart (1982) cite a suggestion by Brown (1975) that if a mnemonic strategy is required for efficient performance of a memory task, then age effects should be observed. The reverse is true when such a strategy is redundant in a memory task. Similarly, Foley and Ratner (2001) note that children are known to have difficulty using mnemonic strategies and as a consequence, memory for verbal material increases with age. Therefore, if memory for actions is indeed reliant on automatic rather than attentional processes, developmental differences should not be observed or, at least, should be less marked for enacted than for verbally encoded information.

As noted in Chapter 1, the developmental SPT literature consists of just one seminal study by Cohen and Stewart (1982). In an attempt to investigate free recall of word and task lists in children, Cohen and Stewart presented three age groups (9-, 11- and 13-years old) with two blocks of four lists. In one block, children were asked to perform each item from four task lists (e.g. "*Clap hands*") as quickly as possible. If a task involved an object (e.g. "*Close a safety pin*"), this was presented to the child, together with the task. In the second block, children were asked to repeat each two-syllable item from four word lists, again as quickly as possible. After each list, immediate free recall was tested. A three-minute interval followed presentation of all four lists, followed by a final, free recall interval of two minutes where children had to recollect as many items as possible from all of the lists.

Consistent with a previous study with adults (Cohen 1981), post-test questioning revealed that almost all of the children had attempted to actively remember the two-syllable word items but had not employed such a strategy for the task items, notwithstanding the fact that more items were recalled from the task lists (both in immediate and in final free recall) than from the word lists. An even more pertinent finding concerned performance differences between the age groups: Free recall was found to improve with age but only for the word lists. When compared to the earlier adult study data (Cohen 1981), Cohen found two fundamental consistencies. First, both sets of participants actively tried to learn the words but not the tasks. Second, in comparing the data from both studies, Cohen and Stewart (1982) argue for a constancy of immediate and final task recall across the three age groups (Cohen & Stewart 1982) and then into adulthood (Cohen 1981) where immediate word recall continues to improve. Furthermore, examination of the serial position data revealed a pronounced primacy effect for word recall but not for the recall of task lists. From these results, Cohen and Stewart (1982) summed up, stating, "*…this study provides a further instance of memory for subject performed tasks failing to conform to laws of memory already established for word events.*" (pp. 15). These findings, however, are not without contention.

In introducing their *Activity Memory Framework*, Foley and Ratner (Foley & Ratner 2001; Ratner & Foley 1994) suggest that the developmental evidence comparing adults' and children's memory for actions is contradictory (see Foley & Ratner 2001, for discussion); in some cases developmental differences occur and in other cases, they are absent. However, it should be pointed out that some of this "contradictory" evidence comes from the source monitoring paradigm (e.g. Foley & Johnson 1985) while other studies only compare subject-performed task material with experimenter-performed (EPT) material (i.e. material that is performed by the experimenter not the participant and not directly verbally encoded). In defining the SPT advantage, researchers generally agree that material that is encoded by performance is remembered better compared to *verbally-encoded* material (e.g. Engelkamp 1998). Foley and Ratner make no mention of any developmental studies where SPT material is compared with EPT *and* VT material[15].

The *Activity Memory Framework* put forward by Foley and Ratner (2001; Ratner & Foley 1994) provides a very different explanation for the SPT effect to that proposed by others (Bäckman & Nilsson 1984, 1985; Bäckman, Nilsson & Chalom 1986; Cohen 1981, 1983, 1985; Cohen & Bean 1983; Engelkamp & Zimmer 1985) mainly due to its consideration of the goal-directed nature of action memory i.e., the observation that performance of an action is usually in pursuit of a goal. Seminal work by Goschke and Kuhl (1993) built on this with their finding that material intended for future performance is more accessible in memory than material with no such intentionality: the intention-superiority effect (or ISE).

In four similar experiments, Goschke and Kuhl instructed participants to learn and memorise two short descriptions – in each of two blocks – of different activities (e.g. "*setting the table*" and "*clearing a messy desk*"). Each script consisted of action phrases that followed an identical verb-noun structure (e.g.

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[15] Although see Engelkamp & Zimmer (1997) for a study where such a comparison is made with an adult population.

"*spread the tablecloth*"). After studying both scripts, participants were given a prospective instruction where they were informed that they would later have to either act out one of the scripts (the execution condition, in one block) or observe one of the activities being carried out by the experimenter (in the other block) and note any mistakes (the observe condition). For the second script, they were told that they did not have to perform or observe it but just remember the details. Immediately following these instructions, participants were presented with a recognition test composed of both script and non-script material. This was followed by the performance interval during which participants were asked either to execute the appropriate script or to observe the experimenter execute their script, depending on the experimental condition.

Goschke and Kuhl report that participants were faster and more accurate with items from to-be-performed scripts compared to those from the neutral, to-be-remembered scripts. In the observation condition, by contrast, there was no heightened activation, in terms of faster recognition latencies, compared to the neutral script. Therefore, only to-be-performed intentions appeared to have a privileged status in memory. This superiority for performance intention (the ISE) was replicated in all four experiments.

Goschke and Kuhl interpreted these results as reflecting persisting activation, or more sustained activation, of an intention representation for the words from the execution (to-be-performed) script compared to those words from the neutral (to-be-remembered) script. Marsh, Hicks and colleagues (Marsh, Hicks & Bink 1998; Marsh, Hicks & Bryan 1999), however, argue that this proposal cannot account for the reality that one often has to deal with a hotchpotch of unrelated goals during an average day. Marsh, Hicks & Bink (1998) proposed an alternative, more practical explanation that focuses on the rapid reprocessing of information, at retrieval, through an intentional marker. To investigate the effect of action completion on memory availability, Marsh and colleagues (Marsh, Hicks & Bink 1998) examined the ISE for related intentions together using a Lexical Decision

Task (LDT) paradigm. Across four experiments, they observed that uncompleted or partially completed intentions exhibited more availability in memory (indicated by shorter lexical decision latencies) compared to neutral intentions. Therefore, Marsh *et al* found that when a to-be-performed script is uncompleted, its components appear more activated than those from a paired neutral script. The reverse is true following successful performance of the prospective script (Marsh, Hicks & Bryan 1999).

Over two experiments, Marsh, Hicks and Bryan (1999) adapted the delayed intention paradigm to correspond to more naturalistic conditions in which we have to perform a series of unrelated tasks. They found that unrelated intentions exhibited heightened activation prior to completion and, following completion, showed signs of inhibition (Experiment 1). Moreover, cancelling an intention also resulted in inhibition being displayed (Experiment 2). Therefore, the findings of Marsh, Hicks & Bink (1998) were replicated within a more ecologically valid setting. Dockree and Ellis (2001), however, point out that while the materials used in the above experiments were undoubtedly goal-directed, the script material lacked self-reference. Kuhl (1985) argues that the propositional structure of an intention should establish a link between the intended action and the self, particularly because such a link could have important consequences for both encoding *and* retention (Dockree & Ellis 2001).

Dockree and Ellis (2001) conducted two experiments that incorporated features from three seminal studies in order to investigate the occurrence of the ISE for self-relevant intentions that require self-performance. The experiments incorporated the naturalistic design from Schaefer, Kozak and Sagness (1998)[16], the basic experimental design of Goschke and Kuhl's (1993) study together with experimental scripts similar to those used by Marsh, Hicks and Bink (1998). Participants were asked to encode two preparatory tasks that they were

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[16] This study is described in more detail in the next Chapter.

instructed to carry out before they left the room in preparation for subsequent participants (e.g. "*Prepare the computer for the next participant*"), in addition to completing a series of Culture Fair Tests (CFTs, the ongoing task). Once encoded, the experimenter set up an intention cancellation by informing the participant that due to time constraints, one of the preparatory tasks was no longer required. The participant then completed a lexical decision task (LDT) where response times were compared for intended and cancelled script materials. After finishing both the LDT and then the CFTs, participants then had to remember to complete the uninhibited preparatory task prior to leaving the testing room. A short, post-test questionnaire completed the experiment. For the control condition, participants followed the same procedure but here *both* prospective scripts were cancelled. This was included to assess the relative activation levels of both tasks after their intentional status was inhibited.

Dockree and Ellis found that lexical decisions to task words linked to the intact to-be-performed intention were faster than those to task words associated with the cancelled intention. These findings were consistent with the suggestion from Marsh, Hicks and Bink (1998) that heightened activation of intentional constructs might be particularly effective in the absence of external cues to trigger recall and performance. More importantly, it again extended the ISE paradigm to a more naturalistic domain.

From this and other research there is general support for Goschke and Kuhl's (1993) suggestion that, due to its intentional status, to-be-performed material is represented as verbal propositions that either have a heightened level of activation or are more easily reprocessed, relative to other memory contents. Freeman and Ellis (2003b), however, propose an alternative explanation whereby the effect reflects an advantage for the motor or sensorimotor information present in an intention that requires a motor response. They refer to this as the *action-superiority effect*. Freeman and Ellis also present converging evidence that intended actions may be represented motorically. Brandimonte and

Passolunghi (1994), for example, investigated the effects of manipulating the retention interval by comparing filled / unfilled retention interval conditions with a no-delay condition. They found that prospective memory performance was disrupted only when the interval was occupied by a demanding interpolated activity (practice at a short term memory task) or an undemanding motor task (repetitive hands movement). From these findings, they suggested that the representation of intended actions takes the form of an imagined action schema. The memory advantage demonstrated by intended actions, therefore, could be linked to the memory advantage demonstrated by actions enacted at encoding (i.e. SPT research).

One study that helps to establish a link between these ISE and SPT paradigms was conducted by Koriat, Ben-Zur and Nussbaum (1990, see 2.2) who looked at the underlying representation of material intended for future enactment, compared to that intended for verbal report. Their results revealed that recall was enhanced for to-be-enacted material, regardless of whether or not performance actually took place at encoding or retrieval (i.e., even when participants were lead to believe that performance would be required). From these findings, Koriat *et al* concluded that although both performed and to-be-performed tasks are similar in that they share the same underlying representational code, the process of encoding a future action could involve extra information in the form of, "*…an internal, symbolic enactment of the tasks…*" (p.577). This representation is thought to be responsible for the enhancement of memory for the items. Koriat *et al* described these benefits as a *prospective SPT effect*. Similarly, research from Engelkamp and Zimmer (1997) suggests that the motoric representations generated when an action is performed might have a significant role in the enhanced retention of enacted information.

Using two paradigms over four experiments, Freeman and Ellis (2003c) investigated the relationship between overt enactment effects (observed in SPT paradigms) and intended enactment effects (observed in ISE paradigms) using recognition latencies as a performance measure[17]. In one paradigm, participants were informed that the procedure would consist of two blocks, each block presenting two lists of verbs (e.g. "*Deal*", "*Sprinkle*", "*Fiddle*") to learn and remember for subsequent memory tests (recognition and recall). One list was learned by reading it out loud and the other by performing the action described by the word. A sixty-second filler task preceded the recognition task and was typically followed by a free recall test. To test for intended enactment effects, participants were informed that they would have to recall each list in different modalities. One block would require verbal report of all remembered items from both lists and for the other block, participants were asked to enact retained words from both lists. Also, in Experiment 4, an additional interference task (either a verbal or motor task) was included. Based on Brandimonte and Passolunghi's (1994) Experiment 5, these tasks were included to ascertain whether such activity could influence prospective remembering.

Overall, Freeman and Ellis (2003c) observed faster recognition latencies for both material enacted at encoding as well as material intended for enactment at test. Interestingly, recognition latencies for items enacted at encoding and intended for execution were no quicker than those for items intended for execution but verbally encoded. Further converging evidence for the role of motor information was demonstrated when the ISE was eliminated following motor interference for verbally encoded material. From these results, Freeman and Ellis speculated that the SPT and intention superiority effects might not be independent. There could be a processing overlap, linked to motoric information, between both tasks where motor information could also be activated for verbally encoded material intended for execution.

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[17] Only one previous study by Zimmer (1984, cited in Zimmer 1986) has examined the effects of SPT encoding using the recognition latency measure. He found shorter latencies for phrases enacted at study compared to those verbally encoded.

The primary motivation for the three studies reported in this Chapter is to investigate the development of memory for actions in young children (aged 9- and 11-years) using SPT and ISE paradigms. These actions are either performed (SPT paradigm) or to-be-performed (ISE paradigm) and are tested under similar conditions. The aims are 1) to investigate whether motoric encoding creates a more concrete memory trace compared to verbal encoding and 2) to examine whether to-be-performed intentions have the same heightened accessibility seen in adults compared to material intended for verbal recall. If motoric encoding and to-be-performed intentions have a privileged status in children's memory, this has enormous potential for unpicking the processes underlying these effects as well as a better understanding of developing memory strategies.

3.2 EXPERIMENT 1

The primary concern for this thesis is to investigate the development of action memory in children, building onto the research of Cohen and Stewart (1982) to explore further differences between verbal and motoric information. To date, however, there has been little research focusing on this area (none addressing the intention superiority effect in children) and therefore, there are few resources to draw upon to create material suitable for use with children. Conversely, there are a large number of studies with adults, each using a range of materials. However, these materials are designed to be relatively taxing for adults to avoid ceiling effects and are therefore unsuitable for use with children. It was decided, therefore, to establish a compromise by creating materials that would be suitable for children but could also be used with adults. This was the logic behind Experiment 1 in which materials and instructions were piloted with a sample of adult participants using both the subject-performed task (SPT) and the intention superiority effect (ISE) paradigms. In addition, information was collected on participants' verbal intelligence (National Adult Reading Test, NART, Nelson

1982) and their inhibitory ability (Hayling sentence completion task, Burgess & Shallice 1997a).

The general procedure for the SPT and ISE paradigms involved testing in a single session that included both practice and the main experimental tasks. The practice procedure matched the corresponding test condition and occurred before participants were presented with instructions to encode two lists of verb-noun phrases. For the SPT task, participants were instructed to act out all of the phrases from one list and repeat the phrases from the other list. For the ISE task, participants were asked to repeat both lists but also to encode an instruction that one list was to-be-executed and the other to-be-verbally-recalled at a later time (i.e. after the recognition test). This was followed by a reverse-counting filler task and a recognition test that included the encoded materials. Finally, for the recall phase, participants were asked to recall as much material from the study phase as possible, adhering to the task instructions. The two test battery measures were also randomly assigned to each task, taking place after each recall phase.

Following previous research in this area it was hypothesised that information acted out at study would be retained better than information verbally encoded (SPT task) and second, information intended for future enactment would be retained better than information intended for verbal report (ISE task). Verbal intelligence (measured by the NART) was included to see whether this plays a role in the performance of either task. A measure of inhibition (Hayling sentence completion task) was also included: Those participants who exhibit low inhibitory interference were expected to be more successful at the ISE task compared to those with high inhibitory interference. The reasoning for this is that those participants who are able to successfully inhibit a competing response in the Hayling test might also be more able to attenuate neutral material in the ISE task and thus support heightened activation for to-be-performed versus to-be-reported information.

In summary, this experiment was designed to investigate the effect of motoric encoding (SPT) and intended action (ISE) on memory performance in adults. As Zimmer and Cohen (2001) point out, "*Obviously remembering self-performed actions or remembering to-be-performed actions are both common, everyday memory tasks… highly important for humans to function successfully.*" (p. 5).

3.2.1 Method

3.2.1.1 Participants

Fifty-one undergraduates were recruited from various departments at the University of Reading. Each received either money or course credit for their participation in the experiment. Age was not formally recorded, although most participants were aged between 18- and 25-years. Of the fifty-one participants, fifteen adults were removed due to high numbers of false positives to either the SPT or the ISE tasks. Moreover, these participants showed unusually high false responses to the unseen recognition stimuli. As in all subsequent experiments, all participants were tested individually and undertook all of the experimental tasks.

3.2.1.2 Materials

ISE & SPT Materials: A set of fifty-six phrases (e.g. "*Crush an Acorn*": see Appendix 2) were compiled by initially obtaining fifty-six nouns, deemed appropriate for children as young as seven according to age of acquisition measures, from Masterson and Druks (1998) and Morrison, Chappell and Ellis (1997). These nouns were then paired with similarly defined verbs such that fundamental similarities (e.g. semantic and phonological) between phrases were avoided. The resulting fifty-six phrases were then divided into eight lists of seven verb-noun phrases. Each list was recorded onto a separate cassette tape, with inter-phrase intervals of about one second. The order of phrases in each of the eight lists was then revised and recorded onto another eight cassette tapes, labelled as set 2. In summary, the materials consisted of two sets of eight cassette tapes: set 1 contained the eight verb-noun phrases in one order, and set 2 the phrases in a second order. Half of the participants were exposed to four cassettes from set 1, and half to four cassettes from set 2. Two of these cassettes were presented in the SPT task and two in the ISE task. The phrases from the four unheard cassettes were used for the recognition test as novel stimuli.

Recognition test items were comprised of the twenty-eight nouns and twenty-eight verbs used on the cassettes. For each participant, half of these nouns and verbs were previously heard (from the presented cassettes) and the remainder were novel (from the unheard cassettes). At the beginning of each recognition test, three additional unheard buffer items were presented, making a total of fifty-nine test items.

In addition to these experimental items, a set of practice items (see Appendix 1) was constructed for presentation before the SPT and ISE tasks. These items were designed to be distinct from the experimental items but also to appeal to children. For the SPT task, there were ten medium imageable words (e.g. *Dragon*; *Volcano*) and for the ISE task, the ten practice items were names of characters from various television shows (e.g. *Bart*, *Pikachu*). A further sixteen verb-noun phrases (which did not appear in the main experimental phase) were also included for the participants to practice enacting or verbalising. Half of these were presented in the SPT task and half in the ISE task.

Test Battery Materials: Two tests were employed: an adapted version of the Hayling Sentence Completion task (Burgess & Shallice 1997a), thought to measure inhibition, and the National Adult Reading Test (NART), developed by Nelson (1982), a measure of verbal IQ. The Hayling task consisted of two lists of fifteen incomplete sentences (see Appendix 4). The NART consisted of fifty low-frequency words taken from an English dictionary (see Appendix 5).

3.2.1.3 Design

All participants undertook all of the following tasks: SPT, ISE, Hayling and NART in one testing session. Encoding (SPT) or retrieval (ISE) modality (verbal versus motoric) was manipulated within subjects in each task. The order of these tasks was counterbalanced across participants, as was presentation of the Hayling and NART tasks.

3.2.1.4 Procedure

Each testing session started with either the SPT or ISE task (for the verbal instructions, see Appendix 3) and was followed by either the Hayling or the NART task, which acted as filler tasks. After completion of the filler task, depending on which task had already been presented, the SPT or ISE was carried out. The session then finished with the second filler task. The total duration of testing was approximately one hour.

Testing took place in a small, quiet testing room. Auditory materials for the SPT and ISE tasks were presented using a conventional tape player, set to a comfortable volume. Each participant was asked for both verbal and written confirmation for participation in the experiment. As for all subsequent experiments, all of the participants endorsed both forms of consent. Each session began with practice tasks for the ISE or SPT experimental task, as appropriate. As for all subsequent experiments, a Toshiba Tecra 8000 laptop computer controlled presentation of the recognition test, response and reaction time measurements. Each participant responded to the task by pressing either “yes” or “no” on a labelled dual-button pad, attached to the laptop via a parallel port connection.

Practice Tasks: Participants were familiarised with the task of learning and being tested on sample lexical stimuli, using a procedure that matched the first experimental task: Each participant first heard then was asked to repeat a set of ten words, (see Appendix 1) that were not used subsequently in the experiment.

Immediately after the practice study phase, the participant was asked to count backwards for thirty seconds from a random three-digit number. This irrelevant mental arithmetic task, which acted as a filler task, is widely believed to require the involvement of the central executive (Baddeley and Hitch 1974) and block subvocal rehearsal (Gathercole 1998). The participant was then informed that they would be tested to see whether they could remember any of the words from the original list of ten practice items. They were told that a series of words would appear consecutively on the laptop screen to which they should respond by pressing either “yes” or “no”, depending on whether or not they remembered them from the original list. It was stressed that they should press the button as quickly as possible.

Once understanding of the instructions was confirmed, the participant was presented with the button pad and asked to watch the laptop screen. This presented the instruction, “*Press a button to start*” to which the participant was instructed to depress either button on the pad. This triggered presentation of the first test word. Immediately after this stimulus had been responded to, the next word was shown and so forth until the last word, which was followed by a dialogue box confirming the end of the practice test. Each word remained on the screen until a response was given at which point it disappeared and was immediately replaced with the subsequent word.

The next part of the procedure was dependent on the task being tested. In the ISE task, participants were asked to remember two, auditorily presented lists of four verb-noun phrases (e.g.: *Dig for treasure*) that were not used elsewhere in the experiment. One list they were asked to verbally recall after a short interval. For the other list, they were asked to repeat the phrases and act out as many as they could remember, again, after a short interval. Therefore, eight verb-noun phrases were presented, four of which were to-be-acted and four, to-be-verbally-recalled. After presentation of these eight phrases, participants were asked to recall each according to the appropriate instruction (i.e. act or verbal recall).

In the SPT task, participants were also presented with two lists of four verb-noun phrases (e.g. "*Knock on the door*", "*Lift a fork*" see Appendix 2). However, unlike in the ISE task, participants were given additional encoding instructions where, after hearing each phrase, they had to perform items from one list and repeat items from the other list. They were told that they would not have to remember either list just perform or repeat each one. These two procedures provided participants with some practice at encoding verb-noun phrases in their respective test conditions.

ISE and SPT Tasks: Immediately after the practice phase, participants were informed that they would hear two lists of (seven) verb-noun phrases from a cassette player, and that their memory for these phrases would be tested later. Subsequent instructions were dependent on the task: In the SPT task, participants were instructed to act out all of the phrases from one list and repeat the phrases from the other list. In the ISE task, participants were asked to repeat both lists but also to encode an instruction that identified the list to-be-acted out and the script to-be-verbally recalled at a later time (i.e. after the recognition test).

Immediately after this study phase, participants were given a (new) reverse-counting task for thirty seconds to prevent them from employing a rehearsal strategy. The recognition test was then presented. Each participant was instructed to respond as quickly and accurately as possible to each of fifty-nine words (50% seen and 50% unseen), including three buffer items (three salient words: *Iguana*, *Igloo*, *Spider*), using the button pad. Participants were asked to decide whether they recognised each word (or not) as having come from either of the two study lists by pressing the appropriate button. Once the participant was comfortable with the instructions, the experimenter started the programme that displayed the message, "*Press a button to start*". The participant was told to press either button that resulted in the first (buffer) word appearing in the centre of the computer screen. This triggered presentation of the next word and so on until all fifty-nine stimuli had been presented and responded to.

Following the recognition test, participants were asked to recall as many of the phrases from the study phase as possible. In the ISE task, they had to act out as many from the to-be-enacted list as they could remember and recite as many as they could remember from the to-be-reported list. It was pointed out that they could recall the phrases in any order. The experimenter noted down all of those correctly recalled phrases and, in the case of the ISE task, the modality in which they were recalled.

Test Battery Procedures: The adapted Hayling Sentence Completion Task was divided into two sections each consisting of fifteen incomplete sentences (see Appendix 4). For the first set, participants were instructed to listen carefully to each sentence (e.g.: "*The rich child attended a private…*") and then give an appropriate word (e.g.: "*School*") that completed each sentence. The experimenter read out two incomplete practice sentences before moving onto fifteen test sentences. After the experimenter had read each sentence, the participant was asked to respond as quickly as possible. The experimenter noted both the response and the latency to each test item. For the second set of sentences (Appendix 4), participants were again instructed to listen carefully to each of fifteen sentences but on this occasion to provide an inappropriate word (i.e. one that is completely unconnected to the sentence). Again participants were given two practice sentences (e.g.: "*London is a very busy…*") to ensure full understanding. Before reading out the fifteen test sentences, the experimenter reminded participants that their single-word responses should not be connected to the sentences and asked them to try not to make repeat responses. Again, the experimenter noted both the response and the time taken to respond to each test item.

The National Adult Reading Test (NART) consists of fifty low-frequency words (see Appendix 5). A white sheet of card on which these words were printed was presented to the participant who was asked to read them out loud, at their own pace. The experimenter recorded whether or not the pronunciation of each word was correct on a separate score sheet. Thus the maximum possible correct score was fifty.

3.2.2 Results and Discussion

As for all subsequent experiments that used either / both the SPT or ISE paradigms, three measures were obtained for each test: recognition accuracy, recognition latency and recall performance. These are reported separately for the two tasks. Before focusing on the results, some comments concerning data manipulation should be addressed.

With respect to recognition latency and in accordance with previous research (c.f. Freeman & Ellis 2003b, 2003c; Goschke & Kuhl 1993; Marsh, Hicks & Bink 1998; Marsh, Hicks & Bryan 1999), the mean time recorded for participants to correctly respond to test items was calculated in milliseconds for both tasks. Any trials with latencies greater than three seconds were removed together with any responses that exceeded two standard deviations of an individual participant's mean for the task. This pruning technique has been employed in previous research (Freeman 1999; Freeman & Ellis 2003b, 2003c; Goschke and Kuhl, 1993; Marsh, Hicks & Bryan, 1999). The number of responses discarded by using this method is addressed for each task, separately.

Another trimming technique involved looking at the number of false positives for each participant. If an individual's number of false positives was greater than two standard deviations of the group's mean number of false positives, the participant was replaced. This was used to account for participants thought to be guessing by continually pressing the "*Yes*" button. Details of participants replaced using this criterion is provided for each task separately. The reader should also note that as for each subsequent experiment, unless stated otherwise, all analyses were conducted using paired-sample t-tests with encoding or retrieval modality (verbal versus enactment) as the within-subjects factor.

3.2.2.1 SPT

Using the latency-pruning technique, described above, approximately 4.17% (n=42) of correct responses were removed from all analyses in this task. Note that removing these data did not produce any empty cells.

Recognition latency

No reliable difference was found between the two encoding conditions; t (35) = -0.427, p=0.672, although the general trend for recognition latencies was that correct responses for SPT material (M=962, SD=197) were faster than those made for VT material (M=977, SD=205). Although Freeman and Ellis (2003c) report a significant trend for this analysis in their experiments (see also Zimmer 1984 cited in Zimmer 1986), generally the SPT literature tends to concentrate on recognition accuracy and/or recall data. Therefore, the replicability of the SPT effect on recognition latency remains to be established.

Recognition accuracy and Free recall

For recognition accuracy, a reliable difference was found between the number of hits for the Motoric (SPT) and Verbal (VT) encoding conditions with SPT yielding a higher hit rate (M=10.97, SD=1.89) than VT encoding (M=8.81, SD=2.15); t (35) = 4.954, p<0.001, where the maximum possible score for each was 14. All participants were also included in the free recall analyses, including those who failed to correctly recall any of the targets. A reliable difference was found where more SPT items (M=8.92, SD=2.97) were recalled than VT (M=5.72, SD=2.98) items; t (35) = 4.768, p<0.001. Therefore, in line with previous research (c.f. Engelkamp 1998), for both recognition accuracy and recall measures, material enacted at encoding was better retained than verbally encoded material.

Order Effects

To address the concern that there could be some influence on performance depending on whether the participants were exposed to the SPT or the ISE task first, two 2 x 2 mixed ANOVAs were conducted (with first versus second order as a between-subjects factor). Both ANOVAs compared verbal encoding (VT) with motoric encoding (SPT) but the first used response times (a common measure for the ISE) as a performance measure and the second, recognition accuracy (a common measure for the SPT effect). 0 illustrates the mean and standard deviations for each set of data.

: Mean latency and accuracy data for presentation order and encoding modality

Order	Measure	Condition	Mean (sd)	n
SPT First	*Latency*	ME	962 (186)	18
		VE	992 (168)	18
	Accuracy	ME	10.50 (1.65)	18
		VE	8.33 (2.20)	18
ISE First	*Latency*	ME	962 (212)	18
		VE	964 (241)	18
	Accuracy	ME	11.44 (2.04)	18
		VE	9.28 (2.05)	18

NOTE: ME = Motoric encoding, VE = Verbal encoding

0 provides a summary of the analyses. There was a reliable difference between verbal and motoric encoding, with respect to recognition accuracy. This finding that significantly more motoric than verbal material accurately recognised was expected, in light of the previously reported analyses.

: SPT performance data compared with task presentation order

ANOVA	Description	Effect 1	Effect 2	Interaction
1	Verbal vs. Motoric encoding (latency)	p=.676	p=.807	p=.709
2	Verbal vs. Motoric encoding (accuracy)	p<.001	***p=.065***	p=1.00

(Effect 1 = Encoding modality (Verbal / Motoric), Effect 2 = Task presented first (SPT / ISE))

Looking at the difference between those groups exposed to the SPT versus the ISE task first, the difference was marginal and because of this is no considered further. Therefore, order effects did not play a significant role in performance on the SPT task.

3.2.2.2 ISE

A second aim of this experiment was to test material similar to that used in the SPT paradigm using the intention-superiority effect procedure. Previous adult-based research has frequently cited the ISE using recognition (Goschke & Kuhl 1993) and lexical decision latency (Marsh, Hicks & Bink 1998) paradigms. As for the SPT task, the measures recorded in this study included recall, recognition accuracy and recognition latency. Using the latency-pruning technique, described in 3.2.2, approximately 3.97% (n=40) of correct responses were removed from all analyses in this task. The same participants analysed in the SPT paradigm were also analysed here. The latency measure is of most interest and so is addressed first.

Recognition latency

A marginally significant difference was found between latencies for the to-be-performed (M=978ms, SD=220) versus to-be-reported (M=1016ms, SD=242) conditions; t (35) = -1.826, p=0.076. Thus, in line with expectation, this sample of adults showed marginally faster responses to material intended for enactment compared with material intended for verbal report. There are at least two possible reasons why this difference failed to reach a conventional level of significance. First, the presented material was intended for use with children and therefore, the phrases were relatively non-taxing (e.g. *squash a tomato*) and perhaps less appropriate for adults, compared to children. Therefore, it could be argued that the materials were not sufficiently engaging to elicit a reliable ISE for adults. Second, perhaps insufficient participants were tested and therefore the lack of a significant ISE could relate to power. Goschke and Kuhl (1993), for example, used a range of sample sizes (60 participants in Experiment 2) in their four experiments. Overall, however, the general trend (64% of the participants demonstrated faster response times for to-be-performed material) is consistent with previous research by Goschke and Kuhl (1993) in suggesting that material relating to action representation is more highly activated and accessible than material relating to verbal representation.

Recognition accuracy

Analysis of the mean number of hits (items correctly recognised as old, ceiling was 14) for each retrieval condition failed to reveal a reliable difference between the number of hits for the to-be-performed (M=9.67, SD=2.16) and the to-be-reported (M=9.69, SD=1.51) conditions; t (35) = -0.075, p=0.941. This finding is somewhat unexpected although previous ISE studies tend not to report recognition accuracy. Indeed as mentioned earlier (see section 3.1), previous research has reported either recognition (Goschke & Kuhl 1993) or lexical decision latency (Marsh, Hicks & Bink 1998) data rather than participants' accuracy performance (c.f. Freeman and Ellis 2003c) who also failed to find the ISE with recognition accuracy). Similarly, it is unusual for ISE studies to report recall data. Nevertheless, it is included here for additional information.

Free recall

No reliable difference was observed between the mean number of items correctly recalled in the to-be-performed (M=7.50, SD=3.40) and the to-be-reported (M=6.92, SD=3.08) conditions; t (35) = 0.918, p=0.365. Therefore, although overall more to-be-enacted material was recalled (closer inspection of the data reveals that 64% of the participants recalled more or the same number of items for to-be-performed than to-be-reported material) compared to that intended for verbal report, this difference was not reliable. This could be due to contamination of the material from the recognition test. During this test, participants are presented with all the 28 test items plus an additional 28 distractors. Such exposure could cue their memory for test items and this could enhance recall relative to the absence of a recognition test. Interestingly, some adult research that used an almost identical procedure for the same purpose has reported similar instances where an ISE is not always apparent with recall tests (e.g. Freeman & Ellis 2003b).

Order Effects

As with the SPT task, the possible influence of order effects, relating to task presentation, on ISE performance was investigated. Two 2 x 2 mixed ANOVAs were conducted (first versus second order as a between-subjects factor), both examining verbal retrieval (VR) versus motoric retrieval (MR). The first used response times as the dependent variable and the second recognition accuracy performance. 0 illustrates the mean and standard deviations for each set of data.

: Mean latency and accuracy data for presentation order and retrieval modality

Order	**Measure**	**Condition**	**Mean (sd)**	**n**
SPT First	*Latency*	VR	986 (176)	18
		MR	960 (160)	18
	Accuracy	VR	9.44 (1.34)	18
		MR	9.61 (2.20)	18
ISE First	*Latency*	VR	1046 (296)	18
		MR	997 (271)	18
	Accuracy	VR	9.94 (1.66)	18
		MR	9.72 (2.19)	18

NOTE: VR = Verbal Retrieval, MR = Motoric Retrieval

0 provides a summary of the four analyses. Amongst these analyses there are no significant differences, although there is one marginally significant difference relating to the recognition latency data.

: ISE performance data compared with task presentation order

ANOVA	Description	Effect 1	Effect 2	Interaction
1	Verbal vs. Motoric retrieval (latency)	*p=.080*	p=.518	p=.599
2	Verbal vs. Motoric retrieval (accuracy)	p=.941	p=.548	p=.607

(Effect 1 = Retrieval modality (Verbal / Motoric), Effect 2 = Task presented first (SPT / ISE))

Response times were marginally faster for material intended for performance than for material intended for verbal recall. However, we are more interested in the two interactions. In this instance, the interactions were found to be nonsignificant. Overall therefore, it appears that for this group of participants, order effects did not play a significant role in performance on the ISE task.

3.2.2.3 Test Battery Results

Participants' responses to both SPT and ISE task materials were examined as a function of both NART and Hayling performance. While it might be optimal to examine this using multiple regression, this was prohibited by the relatively small sample size. These analyses were therefore conducted using median splits (a similar method of analysis is also used for the same reason in Experiments 2-5). It was of interest to analyse only a subset of the recorded measures.

For the SPT task participants' responses were measured using recognition accuracy and free recall. For the ISE task, recognition accuracy and participants' response times were used. These measures were chosen for each task due to their frequent employment in other studies.

National Adult Reading Test

For this measure, the scores ranged from 23 to 45 with a sample mean of 32.39 (SD = 5.71) and a median of 33. A median split was performed on the NART data to derive groups of relatively low and high performance on this task. All participants were included in the analyses except for those whose score matched the median (three were removed). 0 shows how the groups differed with respect to mean NART scores.

: Mean NART performance for low (<33) and high (>33) groups.

	Low NART performance	**High NART performance**
Mean	27.35 (2.60)	37.63 (3.28)
N	17	16

(Standard deviations in parentheses)

For the SPT task two repeated measures ANOVA analyses were conducted both using NART performance (high versus low) as the between-subjects factor and encoding modality (SPT versus VT) for the within-subjects factors. The data for both of these analyses are illustrated in 0.

: Mean SPT recognition accuracy and recall performance for low and high NART performance groups

NART Performance	**SPT Performance Measure / Encoding Condition**			
	Recognition Accuracy		*Recall*	
	SPT	VT	SPT	VT
Low	10.82 (1.81)	9.29 (2.05)	8.53 (2.53)	5.41 (2.37)
High	11.13 (2.16)	8.38 (2.39)	9.75 (2.91)	6.25 (3.73)

(Standard deviations in parentheses)

For the first ANOVA, participants' recognition accuracy under both encoding conditions was used as the dependent variable and for the second, their recall performance was the dependent variable.

For the first analysis, no main effect of NART performance was apparent, $F\ (1,31) = 0.297$, $p=.589$, although a highly significant main effect of encoding condition was observed, as expected, $F\ (1,31) = 20.961$, $p=<.001$. This is consistent with the data from the main analyses. The interaction was not reliable; $F\ (1,31) = 1.705$, $p=.201$. This indicates that, irrespective of NART performance, items performed at encoding were remembered more accurately than those items learnt through verbal repetition.

A similar result was found in analyses of free recall performance where there was no reliable effect of NART performance, $F (1,31) = 1.959$, $p=.172$, but a highly significant main effect of encoding; $F (1,31) = 22.212$, $p<.001$. Once again there was no reliable interaction ($F < 1$). Therefore, items performed at encoding were better recalled than those items recited at encoding, regardless of NART performance. This result is consistent with the accuracy results, indicating something specific to the representation of enacted actions benefits memory performance.

0 compares participants' ISE performance (measured by accuracy and latency) with lower versus higher NART performance.

: Mean ISE response times / accuracy performance for low and high NART performance groups

	ISE Performance Measure / Encoding Condition			
	Latency		*Recognition Accuracy*	
NART Performance	To-be-performed	To-be-reported	To-be-performed	To-be-reported
Low	1047 (245)	1088 (270)	9.41 (2.53)	9.71 (1.90)
High	911 (194)	972 (202)	10.00 (1.83)	9.75 (1.13)

(Standard deviations in parentheses)

With respect to response accuracy, the data indicates little discrepancy between the two NART performance groups (both accurately identifying around 10 items). For response latencies however, the data suggest that adult participants in the low NART group exhibited slower response times compared to those in the high performance group. Two repeated measures ANOVA analyses were conducted, each using NART performance (low versus high) as the between-subjects factor and retrieval modality as the within-subjects factor. The dependent variable was either participants' accuracy performance (analysis 1) or their response latencies (analysis 2).

In the first analysis of accuracy there were no reliable effects of either NART performance or retrieval modality, and no interaction (all Fs <1). For the analysis of reaction time, a significant main effect of retrieval modality was revealed, $F(1,31) = 6.312$, $p=.17$, such that material intended for enactment (M=981ms) was responded to more quickly than information intended for verbal report (M=1032ms). However, neither the main effect of NART nor the interaction were reliable; $F(1,31) = 2.614$, $p=.116$, and $F<1$, respectively. Therefore, the first analysis suggests that verbal intelligence does not have an effect on the accuracy measure of the intention superiority effect. The second analysis is consistent with this observation, although information intended for performance was correctly identified faster than material intended for verbal report.

Hayling Sentence Completion Task

As mentioned in section 3.2.1, this task consists of two sets of incomplete sentences. The resulting data can be broken down into three principle scaled scores: The time taken to complete the *sensible completion* component (where participants were instructed to provide appropriate words that completed each sentence), the time taken to complete the *unconnected completion* component (where participants were instructed to provide unconnected words to complete each sentence) and errors made on this latter component. These three scores were then scaled into an overall score for each participant, ranging from 1 (denoting impairment on the task) to 10 (excellent performance).

For the adult participants in this experiment, the scaled scores ranged from 4 to 8 with a sample mean of 5.47 (SD = 0.91) and a median of 6. In order to examine participants' responses to both SPT and ISE task material as a function of performance on this task, it was initially decided to use this latter statistic. However, a closer inspection of participants' individual scores revealed that fifteen out of the thirty-six participants exhibited the median Hayling score. Because of this, it was decided to use a more sensitive score that directly measured participant's inhibitory performance. Therefore, the actual time taken to complete the unconnected completion component was used. For this latency measure, the adult participants' times ranged from 0 to 40 seconds, with a sample mean of 14.64 (SD = 11.06) and a median of 14.

Using this median score, the adult participant's scores were divided to derive low (n=18) and high (n=18) performance, where those with low times were quicker to respond, indicating better performance, compared to those with high times. All participants were included in the analyses as none of the times matched the median. 0 shows how the groups differed with respect to performance times on the Hayling task.

: Mean Hayling inhibitory component latencies for low (<14) and high (>14) groups.

	Low Hayling scores	**High Hayling scores**
Mean	5.22 (3.78)	24.06 (7.04)
N	18	18

(Standard deviations in parentheses)

As for the NART analyses, two mixed-design ANOVA analyses were conducted for the SPT task using Hayling performance as the between-subjects factor. For the first ANOVA, participants' recognition accuracy under both encoding conditions was used as the dependent variable and for the second, their recall performance was the dependent variable.

For the first analysis, the main effect of Hayling performance and the interaction were not reliable; $F < 1$ and $F(1,34) = 2.009$, $p=.165$, respectively. However, there was a highly significant main effect of encoding condition; $F(1,34) = 25.251$, $p<.001$. This finding suggests that latencies on the inhibitory component of the Hayling sentence completion task do not appear to influence either the retention of material or the size of the SPT effect, with respect to recognition accuracy. Closer inspection of the data (0) supports earlier SPT findings, indicating that information encoded by performance is more accurately recognised than that encoded through verbal repetition.

: Mean SPT accuracy and recall performance for low and high Hayling groups

	SPT Performance Measure / Encoding Condition			
	Recognition Accuracy		*Recall*	
Hayling group	SPT	VT	SPT	VT
Low	10.61 (1.88)	9.06 (1.83)	8.78 (2.58)	5.78 (2.90)
High	11.33 (1.88)	8.56 (2.45)	9.06 (3.39)	5.67 (3.14)

(Standard deviations in parentheses)

0 displays the recognition and recall data for the participants. Similar to the first analysis, only a significant main effect of encoding was revealed; $F(1,34) = 22.135$, $p<.001$. The effects of Hayling performance and the interaction were both unreliable ($Fs<1$). Therefore, as expected, this analysis confirms the findings from the main SPT analysis, described earlier (3.2.2.1). Taking into account the recognition accuracy analysis, it would also appear that Hayling performance (using the definition employed here) does not influence either 1) the retention of material encoded either through performance or by verbal repetition or 2) the size of the SPT effect. This point concerning the role of inhibition is returned to in 3.5 at the end of this Chapter.

Finally, for the ISE task two additional ANOVA analyses were conducted, examining Hayling performance (between-subjects) and retrieval modality (within-subjects). Participants' response times and their recognition accuracy were the dependent variables in analyses 1 and 2 respectively. These data are illustrated in 0.

: Mean ISE response times / accuracy performance for low and high Hayling performance groups

	ISE Performance Measure / Encoding Condition			
	Latency		*Recognition Accuracy*	
Hayling Performance	To-be-performed	To-be-reported	To-be-performed	To-be-reported
Low	970 (263)	989 (280)	9.89 (2.14)	9.56 (1.50)
High	987 (175)	1043 (201)	9.44 (2.23)	9.83 (1.54)

(Standard deviations in parentheses)

It is worth noting the latency data where, although the overall to-be-performed latencies are in the predicted direction (i.e. faster than the respective to-be-reported latencies), the low Hayling performance group appear to be exhibiting slower latencies than the high Hayling group. This is unusual and inconsistent with the prediction that people with better inhibitory performance should also perform better on the ISE task. Interestingly, the first analysis revealed only a marginally significant main effect of retrieval modality, consistent with the previously reported analysis (3.2.2.2); $F(1,34) = 3.320$, $p=.077$. Neither the main effect of Hayling group nor the interaction was significant (both $Fs<1$). Similarly, the second analysis failed to reveal any significant main effects or interaction indicating that Hayling performance does not have an effect on accuracy and that the accuracy scores did not differ between the two retrieval modality groups (all $Fs <1$). Together, these findings suggest that Hayling task performance did not affect ISE performance in this group of adults. This finding is therefore partially inconsistent with previous research that has reported a link between inhibition and ISE performance (e.g. Dockree 2002).

Overall, therefore, the data from Experiment 1 indicate three principle sets of findings relating to the SPT and ISE paradigms and links with the test battery measures. With respect to the SPT results, material encoded motorically is retained better (with respect to recognition accuracy and free recall performance) compared to material encoded through passive repetition. For the ISE data, material intended for future enactment was generally responded to more quickly than material intended for verbal recall, although only marginal.

The two test battery tasks were included to obtain measures of intelligence (the National Adult Reading Test, NART) and of inhibition (the Hayling Sentence Completion Task). Subsequent analyses revealed that the NART had no effect on SPT or ISE performance. Interestingly however, when participants whose scores matched the median were removed, the intention superiority effect was strengthened, with respect to recognition latency; a common measure for this task. The author can offer no explanation for this unusual finding. The findings for the Hayling inhibitory latency measure were very similar to those from the NART whereby latency did not reliably influence either SPT or ISE performance. This finding is somewhat inconsistent with a previous study using the ISE paradigm which reported that adults who have difficulties with inhibition are also less likely to show an ISE (Dockree 2002).

Overall, these findings are consistent with previous research with adults and indicate that these materials, suitable for use with children, might be expected to reveal the presence of either the ISE and/or the SPT effect in children. Experiments 2 and 3 use similar procedures and materials to those described here with two groups of children to investigate the development of motoric enacting and intended enactment.

3.3 EXPERIMENT 2

3.3.1 Introduction

This and the following experiment in this Chapter were designed to assess the performance of 9- and 11-year old children on the SPT and ISE tasks and to explore the relationship between performance on these tasks and that on a reputed test of inhibition, the Stroop task (Stroop 1935). In this experiment 9-

year children were studied while the performance of 11-year olds was examined in Experiment 3.

The procedures used for the SPT and ISE tasks in Experiment 1 were employed in Experiment 2. As in Experiment 1, the SPT procedure employed in these experiments resembled that used by Cohen and Stewart (1982). To reiterate, Cohen and Stewart tested recall of lists of words and tasks in children aged 9-, 11- and 13-years. They found an age effect in the recall of words but not in the recall of task lists. Cohen and Stewart used this finding to suggest that the processing of actions is relatively automatic compared to that of verbal material that requires more controlled processing. However, although this experiment is commonly cited as the original developmental Subject-Performed Task study, Cohen and Stewart failed to make a clear comparison between the material encoded by enactment (SPT) and that encoded by verbal repetition (VT). Moreover, they used a different set of stimuli in each condition: A list of words (the VT material) and a set of task lists (SPT). Because these lists were fundamentally different, it was not possible to perform a direct comparison of the two sets of materials. This (and the following) experiment was designed to address this disparity by comparing retention for both SPT and VT material by using the same materials for each condition. In addition, the same performance measures used in Experiment 1 were employed here: recognition accuracy, recognition latency and free recall. Similarly, for the ISE task, the procedure and materials matched those used in Experiment 1 to see whether or not the findings could be replicated with children, consistent with Goschke and Kuhl's (1993; 1996) suggestion that the ISE is an automatic process, unlikely to be hindered by age (Hasher & Zacks 1979).

The two test battery measures used in Experiment 1 were included to explore whether or not they might have an effect on SPT and ISE task performance. The Hayling Sentence Completion task was included to provide a measure of inhibitory performance. Similarly, the Stroop task was included as a related measure suitable for this age group[18]. This measure is arguably an executive measure of inhibitory control (Cohen, Dunbar & McClelland 1990 provide a critical review), in which participants are asked to name the colours of non-matching colour words (e.g. the word RED printed in blue). More importantly, recent evidence from the adult literature suggests that Stroop performance may be related to the realisation of intentions and the ISE (Dockree 2002; Martin, Kliegel & McDaniel 2003). Although this finding was not replicated in Experiment 1, it was judged of interest to investigate this relationship in children. Finally, the National Adult Reading Test was included in Experiment 1 as a measure of verbal intelligence. A developmental alternative is the British Picture Vocabulary Scale (BPVS). As with the NART in Experiment 1, the BPVS was included to explore any link between intelligence and performance on the SPT and ISE tasks.

Following on from the findings of Experiment 1, the expectations of this experiment remain relatively consistent. First, it was expected that information encoded through performance would be retained better than verbally encoded information (SPT task), consistent with Cohen and Stewart’s interpretation of their findings. Second, information intended for future performance should be retained better than information intended for verbal report (ISE task), consistent with Goschke and Kuhl’s assertion that this effect is not reliant on attentional or strategic resources. Third, verbal comprehension (measured using the British Picture Vocabulary Scale) should not affect performance on either the SPT or the ISE tasks. Finally, participants who exhibit low inhibitory interference on the Stroop task (i.e. those who are able to perform well at the task) should be more likely to show good performance on the ISE task (reflected by shorter recognition latencies on to-be-performed material) compared to those who exhibit high inhibitory interference who are less able to inhibit competing information.

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[18] An early pilot study using the Hayling Sentence Completion task with 9-year-olds revealed that the children had trouble understanding both the instructions and successfully completing the task. Therefore, this task was removed from the final procedure.

3.3.2 Method

3.3.2.1 Participants

Thirty-six participants, aged between 8 years 2 months and 10 years 1 month (mean age: 9 years 4 months, sixteen boys, twenty girls), were recruited from two primary schools in Reading (Katesgrove Primary and Whitley Park Junior). In addition to parental consent, verbal and written consent from the child was also required for participation in this and all subsequent experiments.

3.3.2.2 Materials

ISE & SPT Materials: The same set of fifty-six phrases (see Appendix 2) from Experiment 1 were used in this and the following experiment. The recognition test items were therefore also the same, as were the instructions (see Appendix 3).

Test Battery Materials: The British Picture Vocabulary Scale (Second Edition; BPVS henceforth (Dunn, Dunn, Whetton & Burley 1997) consists of a test book containing fourteen sets of twelve test stimuli. Each page presents a test item composed of four numbered line drawings.

For the Stroop task, a double-sided Stroop board and a reading-speed board (each roughly 52cm x 100cm) were used. One side of the Stroop board depicted the simple Stroop task consisting of 150 randomised, coloured (black, blue, green, red or yellow) dots, each approximately 2.5cm in diameter. The reverse side showed the interference Stroop task consisting of 150 randomised colour names (same colours as above, roughly 3-5cm in length and 1.5cm high) written in coloured inks. In this task, the name and ink colour were incongruent. The reading-speed board was used as a control measure and consisted of 150 colour names written in black capital letters (also roughly 1.5cm high). A stop clock was used to record response times.

3.3.2.3 Design

All participants undertook all of the following tasks: SPT, ISE, BPVS and Stroop across two testing sessions, one week apart. Encoding (SPT) or retrieval (ISE) modality (verbal versus motoric) was manipulated within subjects in each task. The order of these tasks was counterbalanced across participants as was presentation of the Stroop and BPVS tasks.

3.3.2.4 Procedure

Each testing session started with either the SPT or ISE task and was followed by either the BPVS or the Stroop task. The total duration of testing was approximately one hour.

As for all subsequent experiments in this thesis, the testing sessions took place in quiet conditions (usually the school library), free from distraction. Auditory materials were presented using a conventional cassette player, set to a comfortable volume.

As in Experiment 1, each session began with a practice task for the ISE / SPT experimental task. The same Toshiba Tecra 8000 laptop computer used in Experiment 1 controlled presentation of the recognition test, response and reaction time measurements.

SPT / ISE Tasks: The procedures for the practice and experimental SPT / ISE tasks were identical to those described in Experiment 1 whereby children were familiarised with the task of learning and being tested on sample lexical stimuli followed by testing with the experimental stimuli (see Appendix 3 for instructions).

Test Battery Procedures: The BPVS is split into fourteen sets each containing twelve trials, ordered such that the difficulty of the task increases across the sets. Following instructions for administration of this test, the children started on Set Four (the baseline condition for children aged 8 – 9 years). On each trial four numbered pictures were presented to the participant. The experimenter stated the name of one of the pictures and asked which picture corresponded to this word. This was repeated for each trial until the child made eight or more errors (the ceiling set).

The Stroop test consisted of three different sections. For the first (a practice reading task), each child was asked to read a list of 150 colour words, typed in black ink, as quickly as they could. The experimenter noted the time taken, using a stopwatch. Immediately after this the child was told that s/he would be given ninety seconds to name the colours of an array of 150 simple colour patches (the Simple Stroop condition). The experimenter noted how many were correctly identified in the ninety seconds. For the final section, each child was instructed to name the ink colour in which colour words were printed (the Interference Stroop condition). Once again, ninety seconds were allowed for this task and the experimenter noted how many items were (in)correctly identified in this time period.

3.3.3 Results and Discussion

The main purpose of this experiment was to investigate the occurrence of the subject-performed task and intention superiority effects in nine-year-old children, using a modification of the procedure described by Cohen and Stewart (1982) and Goschke and Kuhl (1993). As for Experiment 1, the three measures of recognition accuracy, recognition latency and recall performance were recorded for both the SPT and ISE paradigms. The latency pruning technique described in Experiment 1 was used here. Details of participants who were replaced using this technique are addressed for each task separately.

3.3.3.1 SPT

Using the latency-pruning technique, described in 3.2.2, approximately 3.8% (n=38) of correct responses were removed from all analyses in this task. Furthermore, fifteen participants had to be replaced due to high numbers of false positives (i.e. where false positives were greater than two standard deviations above the mean number of false positives for the group as a whole). Another child, who had been diagnosed with dyslexia, was also replaced due to problems in completing the recognition test.

Recognition latency

Data from two additional participants were excluded from the recognition latency analyses because they failed to correctly identify any items from either the SPT or VT encoding conditions.

There was no significant difference found between SPT (M=1210, SD=248) and VT (M=1275, SD=340) material; t (33) = -1.599, p=0.119. Nevertheless, taken with the results from Experiment 1 (3.2.2.1) it does indicate that an underlying trend for material encoded through performance being more accessible than material encoded by verbal repetition. It is possible that this is a relatively small effect and that the current studies lack the necessary power to reveal it. This finding is discussed in greater depth in the General Discussion (3.5).

Recognition accuracy

All participants were included in the recognition accuracy analyses. No significant difference was found between the two encoding conditions; t (35) = 1.476, p=0.149. This suggests that with this group of nine-year-olds motoric encoding (M=8.97, SD=2.86) did not benefit memory accuracy compared to verbal encoding (M=8.03, SD=2.63).

Free recall

All participants were included in the free recall analyses, including those who failed to correctly recall any of the targets. Interestingly, the t-test revealed a marginally reliable difference between motoric (M=5.03, SD=2.89) compared to verbal (M=3.83, SD=2.32) encoding.

Thus, these findings indicate that although the nine-year-old children's performance exhibited expected trends, such that material enacted at encoding enhanced recognition latency, recognition accuracy and free recall, the trends were unreliable. These findings indicate that the SPT effect might require more attentional resources than Cohen (Cohen & Bean 1983; Cohen & Stewart 1982) and others have suggested. These findings are explored further in Experiments 4 (Chapter 4) and 5 (Chapter 5).

Order Effects

As mentioned earlier (3.2.2.1), there was some concern that task presentation order might influence SPT performance. To address this concern, two 2 x 2 mixed ANOVAs were conducted (with first versus second order as a between-subjects factor). All analyses were identical to those outlined in 3.2.2.1. 0 illustrates the mean and standard deviations for each set of data.

: Mean latency and accuracy data for presentation order and encoding modality

Order	Measure	Condition	Mean (sd)	n
SPT First	*Latency*	ME	1314 (257)	16
		VE	1366 (355)	16
	Accuracy	ME	8.50 (2.98)	18
		VE	7.61 (2.73)	18
ISE First	*Latency*	ME	1118 (203)	18
		VE	1195 (314)	18
	Accuracy	ME	9.44 (2.75)	18
		VE	8.44 (2.55)	18

NOTE: ME = Motoric encoding, VE = Verbal encoding

0 provides a summary of the four analyses and illustrates only one significant difference, relating to the latency data.

: SPT performance data compared with task presentation order

ANOVA	Description	Effect 1	Effect 2	Interaction
1	Verbal vs. Motoric encoding (latency)	p=.129	p=.049	p=.765
2	Verbal vs. Motoric encoding (accuracy)	p=.155	p=.180	p=.932

(Effect 1 = Encoding modality (Verbal / Motoric), Effect 2 = Task presented first (SPT / ISE))

Overall latencies were shorter for participants who were exposed to the ISE task first (M=1156) than for participants who were exposed to the SPT task first (M=1352). However, it should be noted that this analysis refers to differences in overall latencies in the SPT paradigm (SPT + VT) and not for the size of the SPT effect. Also, as mentioned earlier, SPT research mainly focuses on recognition accuracy and recall performance. Finally, the findings here are not of great concern as there were no significant interactions. Moreover it can be argued that for this group of children, SPT task performance is not influenced by whether this task precedes or follows performance of the ISE.

3.3.3.2 ISE

The measures used to assess performance on this task were identical to those reported in Experiment 1: Recall, recognition accuracy and recognition latency. This last measure is of most interest and so is addressed first.

Using the latency-pruning technique, described in 3.2.2, approximately 3.8% (n=38) of correct responses were removed from all analyses in this task, although all participants were included in all analyses.

Recognition latency

For this measure, the difference between the two intended material types was not reliable; t (35) = 0.525, p=0.603. Interestingly, closer inspection of the mean latencies for each retrieval modality revealed an inverse ISE: responses were slightly slower for material intended for verbal (M=1246ms, SD=263) than for material intended for performance (M=1264ms, SD=240). However, because of the nonsignificant difference and the fact that the difference is less than 20 milliseconds, this result will not be discussed further.

Recognition accuracy

For the recognition accuracy data, the difference between the means was not reliable; t (35) = 0.249, p=.805, despite an apparent predicted trend where material intended for enactment (M=8.19, SD=2.36) was recognised slightly more accurately than that intended for verbal report (M=8.08, SD=2.16).

Free recall

Finally, for the free recall data, the difference between the two retention modalities was nonsignificant t (35) = 1.548, p=0.131, again despite an observed difference in the descriptive data where more items were recalled for material intended for enactment (M=4.81, SD=2.35) compared to that intended for verbal report (M=3.97, SD=2.54).

For the ISE task, data from both the latency and the accuracy measures fail to reveal any significant differences. However, the free recall data is more interesting: Although the overall difference was not significant, closer inspection of the data reveals that 58% of the participants show the expected trend. Thus, at least some of the 9 year olds appeared to show an advantage, in free recall, for to-be-enacted information. It should be remembered that this test takes place after the recognition test. It is possible that these children, unlike the adults in Experiment 1, are able to selectively benefit from this re-exposure to to-be-intended information. Overall, however, these findings suggest that the ISE effect might not be as automatic as Goschke and Kuhl (1993, 1996) suggest.

Order Effects

As in Experiment 1, a further 2 x 2 mixed ANOVAs were conducted (with first versus second order as a between-subjects factor) to examine whether task presentation order could influence ISE performance. These analyses were identical to those described in 3.2.2.2. 0 illustrates means and standard deviations for each set of data.

: Mean latency and accuracy data for presentation order and retrieval modality

Order	Measure	Condition	Mean (sd)	n
SPT First	*Latency*	VR	1247 (297)	18
		MR	1267 (258)	18
	Accuracy	VR	7.44 (2.20)	18
		MR	8.22 (2.56)	18
ISE First	*Latency*	VR	1245 (232)	18
		MR	1262 (228)	18
	Accuracy	VR	8.72 (1.96)	18
		MR	8.17 (2.23)	18

NOTE: VR = Verbal Retrieval, MR = Motoric Retrieval

: ISE performance data compared with task presentation order

ANOVA	Description	Effect 1	Effect 2	Interaction
1	Verbal vs. Motoric retrieval (latency)	p=.608	p=.964	p=.961
2	Verbal vs. Motoric retrieval (accuracy)	p=.802	p=.322	p=.138

(Effect 1 = Retrieval modality (Verbal / Motoric), Effect 2 = Task presented first (SPT / ISE))

0 provides a summary of the two analyses and shows there to be no significant differences for either effect. More importantly, the interactions were also nonsignificant. Taken together, these findings suggest that, for this group of children, ISE task performance was not influenced by whether the ISE was presented before or after the SPT.

3.3.3.3 Test Battery Results

Similar to Experiment 1, participants' responses to both SPT and ISE task materials were examined (using the same measures as in Experiment 1) as a function of both BPVS performance and Stroop interference. Again, given the small sample size, these analyses were conducted using median splits.

British Picture Vocabulary Score (BPVS)

For this measure, scores ranged from 88 to 118 with a sample mean of 97.7 (SD = 11.1) and a median of 98. A median split was performed on the BPVS data to derive low and high verbal comprehension groups. All but two participants were included in the analyses. The scores from the two excluded participants matched the median. 0 shows how the groups differed with respect to mean BPVS performance.

: Mean BPVS performance for low (<98) and high (>98) groups.

	Low BPVS performance	*High BPVS performance*
Mean	89.33 (7.11)	107.13 (7.26)
N	18	16

(Standard deviations in parentheses)

For the SPT task two 2 x 2 mixed ANOVA analyses were conducted, both using BPVS performance as the between-subjects factor and encoding modality was the within-subjects factor. Consistent with Experiment 1, the first ANOVA used participants' recognition accuracy and the second recall performance as the respective dependent variables.

Although the recognition accuracy data (see 0) look to have some interesting trends, the analyses did not reveal a main effect of BPVS, $F(1,32) = 2.568$, $p=.119$, or of encoding, $F(1,32) = 2.135$, $p=.154$, nor an interaction; $F < 1$. Thus these findings suggest that BPVS does not appear have any influence on these recognition accuracy measures in the SPT paradigm, nor does it mediate the SPT effect. For the second analysis with the recall data, a marginally significant main effect of BPVS performance was apparent, $F(1,32) = 4.064$, $p=.052$, together with a marginal main effect of encoding, $F(1,32) = 3.368$, $p=.076$, and a nonsignificant interaction; $F < 1$.

: Mean SPT recognition accuracy and recall performance
for low and high BPVS performance groups

BPVS Performance	**SPT Performance Measure / Encoding Condition**	
	Recognition Accuracy	*Recall*

	SPT	VT	SPT	VT
Low	8.22 (3.26)	7.67 (2.61)	4.22 (3.06)	3.28 (2.24)
High	9.75 (2.38)	8.31 (2.82)	5.69 (2.65)	4.19 (2.29)

(Standard deviations in parentheses)

Tentatively, therefore, these results hint at a link between verbal comprehension and recall of overall SPT/VT material and it would be interesting to analyse this relationship with more participants. However, it is important to stress that this is speculative.

For the ISE task, two 2 x 2 mixed ANOVA analyses were conducted using BPVS performance (high versus low) as the between-subjects factor and retrieval modality as the within-subjects factor. Consistent with the SPT analyses, participants' response latencies and recognition accuracy were the dependent variable for analyses1 and 2 respectively. 0 shows the data for both of these analyses.

: Mean ISE response times / accuracy performance for low and high BPVS performance groups

	ISE Performance Measure / Encoding Condition			
	Latency		*Recognition Accuracy*	
BPVS Performance	To-be-performed	To-be-reported	To-be-performed	To-be-reported
Low	1373 (236)	1318 (250)	8.22 (2.26)	7.94 (2.58)
High	1162 (197)	1174 (269)	8.06 (2.64)	8.13 (1.75)

(Standard deviations in parentheses)

With respect to recognition latencies, the data suggest that those children who demonstrated relatively poorer verbal comprehension were slower to respond to all test materials compared to those children with high verbal comprehension. This is apparent for both to-be-performed and for to-be-reported material. The accuracy data, on the other hand, is not as clear-cut. Looking at the group of participants classed as having low verbal comprehension, their mean for to-be-performed material (M=8.22) is higher than any of the corresponding cells.

Conversely, the same group appear to have struggled with accurately recognising material intended for verbal recall (M=7.94). For the high BPVS group, however, there does not appear to be any obvious difference between material intended for performance (M=8.06) compared to that intended for verbal recall (M=8.13). Subsequent ANOVA analyses shed more light on these observations.

An ANOVA conducted on recognition accuracy failed to reveal a reliable main effect of retrieval modality and the interaction between this and BPVS scores was not reliable (both Fs < 1). However there was a significant effect of BPVS performance indicating that, as noted above, children classed as having relatively high verbal comprehension showed faster performance times compared to those with lower verbal comprehension; $F(1,32) = 5.747$, $p=.023$.

A second ANOVA, conducted on the recognition accuracy data, failed to reveal any reliable main effects or an interaction (all Fs <1). Overall, therefore, the only reliable finding was that 9-year old children with relatively low BPVS scores were slower to correctly respond to test material compared to those with higher BPVS scores. Thus, although it would appear that BPVS performance has an effect on response times, it does not appear to influence recognition accuracy performance nor the size or presence of the ISE on either recognition latency or accuracy.

Stroop Test

Two principle scores were derived from performance on this test (simple and performance) and from this an overall score was calculated. Group mean scores for these are shown in 0. The Simple and Interference Stroop scores (from the Simple and Interference Stroop conditions respectively; see 3.3.2.4) were calculated by counting the number of items correctly responded to (the maximum for each was 150), including those items initially incorrectly identified and then changed to the correct response (e.g. for the Interference Stroop, they state the word instead of the ink colour and then change their answer to the ink colour).

Finally, the Overall score was computed by subtracting the Interference Stroop score from the Simple Stroop score and then dividing this by the Simple Stroop score. This takes account of individual differences in processing speed.

: Mean Stroop scores

Simple Stroop score	Interference Stroop score	Overall Score
91.42 (17.71)	***47.69 (14.47)***	***0.48 (0.12)***

(Standard deviations in parentheses)

Overall Stroop scores ranged from 0.25 to 0.97. A median split was performed on these data to derive low and high Stroop interference groups (c.f. Dockree 2002). 0 illustrates how the groups differed with respect to performance on the Stroop test and assignment to the two interference groups. All participants were included in the subsequent analyses.

: Mean Stroop Interference scores for Low (<0.46) and High (>0.46) interference groups

	Low interference group	High interference group
Mean	0.394 (0.054)	0.559 (0.118)
N	17	17

(Standard deviations in parentheses)

As for the BPVS analyses, using the data shown in 0 two 2 x 2 mixed ANOVA analyses were conducted for the SPT task using Stroop interference as the between-subjects factor and retrieval modality as the within-subjects factor. An ANOVA conducted on recognition accuracy failed to reveal any significant differences for either encoding, $F(1,32) = 2.766$, $p=.106$, Stroop interference, $F(1,32) = 1.690$, $p=.203$, or the interaction ($F < 1$). Therefore, performance on the Stroop test does not appear to influence these 9-year olds' VT or SPT recognition accuracy performance.

: Mean SPT accuracy and recall performance for low and high Stroop interference groups

	SPT Performance Measure / Encoding Condition			
	Recognition Accuracy		*Recall*	
Stroop Interference	SPT	VT	SPT	VT
Low	9.47 (2.29)	8.00 (2.06)	5.53 (2.76)	4.24 (2.36)
High	8.29 (3.37)	7.53 (2.85)	4.65 (3.10)	3.18 (2.24)

(Standard deviations in parentheses)

A second ANOVA conducted on the recall data also failed to reveal any reliable effects on either Stroop interference, F (1,32) = 2.353, p=.135, or the interaction (F < 1). However, a reliable main effect of encoding was obtained such that more material encoded by SPT was recalled compared to material encoded by VT; F (1,32) = 4.562, p=.040. Overall, these results indicate that ability to inhibit competing responses does not influence the SPT effect.

Finally, for the ISE task, a further two 2 x 2 mixed ANOVAs were conducted, examining Stroop interference (between-subjects factor) with retrieval modality (within-subjects) using participants' response latencies (analysis 1) and recognition accuracy (analysis 2) as dependent variables.

: Mean ISE response times / accuracy performance for low and high Stroop interference groups

	ISE Performance Measure / Encoding Condition			
	Latency		*Recognition Accuracy*	
Stroop Interference	To-be-performed	To-be-reported	To-be-performed	To-be-reported
Low	1169 (190)	1207 (272)	8.29 (2.59)	8.76 (2.11)
High	1344 (264)	1292 (268)	7.71 (1.96)	7.35 (2.15)

(Standard deviations in parentheses)

The first ANOVA failed to reveal any reliable differences for either Stroop interference, F (1,32) = 2.736, p=.108, retrieval modality, F (1,32) = 0.043, p=.837, or the interaction; F (1,32) = 1.652, p=.208. Similarly, no significant effects were revealed in the second ANOVA: Stroop interference, F (1,32) = 2.707, p=.110, retrieval modality and interaction Fs <1. Together the results from these two analyses results suggest that in this group of 9-year-old children, inhibition (as measured by Stroop performance) was not related to performance on the ISE task.

Overall, the results from Experiment 2 can be broken down into three parts. First, looking at the SPT results, it is evident that the 9-year-olds in this sample were able to retain marginally more items from phrases encoded through enactment than verbally encoded phrases, but only when retention was assessed by free recall performance. Interestingly, however, both the accuracy and the latency data exhibited trends in the expected direction. Second, the results from the ISE paradigm were not in the predicted direction: Material intended for verbal report was recognised slightly faster than material intended for performance. Although this difference was not reliable, it does raise the question of whether 9-year old children encode items intended for future enactment with heightened activation. As Goschke and Kuhl (1993, 1996) have already established this in adults, these findings suggest that the effect in adults may require some attentional resources.

The third set of findings concern the test battery results. First, the British Picture Vocabulary Scale task was found to have some relationship with the retention of different material. Those children in the SPT task with relatively low verbal comprehension scores were found to recall fewer items than those with higher verbal comprehension scores. Similarly, those children in the ISE task with relatively low verbal comprehension scores were slower to correctly respond to all material than those with higher verbal comprehension scores. Finally, the Stroop task was found to have no effect on either the SPT or the ISE tasks, indicating that inhibitory performance might not be associated with young children’s ability to retain enacted or intended information. Experiment 3 explores performance on these tasks further with an older group of children and also incorporates additional measures that focus on executive skills.

3.4 EXPERIMENT 3

3.4.1 Introduction

The findings from the previous experiment indicate that 9-year old children demonstrate some sensitivity to the benefits of enactment at encoding, as expressed in the SPT effect, when performance is assessed through free recall of action phrases. In contrast, there was little indication of an ISE in this group on any of the available measures. The current experiment was designed to explore these findings further in an older group of children drawn from the same general population. In addition, possible relationships between these effects and executive skill performance were investigated.

In addition to the tests used in Experiment 2, the 11-year-old children who participated in this experiment were tested on four measures from the Test for Everyday Attention for Children (TEA-Ch). This is a developmental test battery consisting of nine subtests, designed to make differential demands on sustained attention, selective attention, divided attention and attentional switching capabilities (see Manly *et al*, 2001 for a thorough description). For this experiment, four subtests, each measuring a different aspect of attention, were included: *Sky Search* (selective attention), *Score!* (sustained attention), *Sky Search Dual Task* (divided attention) and *Opposite Worlds* (attentional switching). These were integrated into the design to see whether there would be a relationship between any of these specific aspects of attentional / executive skill and ISE performance, given that the findings from Experiment 2 suggested that the emergence of the ISE may depend on some attentional resources.

3.4.2 Method

3.4.2.1 Participants

Twenty-four participants, aged between 10 years 1 month and 11 years 6 months (mean age: 11 years 1 month, nine boys and fifteen girls), were recruited from two primary schools in Reading (Katesgrove Primary and Whitley Park Junior). All participants were tested individually and undertook all of the experimental tasks.

3.4.2.2 Materials

ISE & SPT Material

As for Experiment 2, the set of fifty-six phrases (see Appendix 2) used in Experiment 1 were also used in the present study. The recognition test items and instructions were also identical (see Appendix 3).

Test Battery Materials

In Experiment 2, the BPVS (Dunn *et al* 1997) and the Stroop task were the only tests included in the battery. These were also included in Experiment 3, along with four measures of attentional skills. Thus, four tests from the TEA-Ch (Manly, Robertson, Anderson & Nimmo-Smith 1999) were included in the battery: *Sky Search*, *Score!*, *Sky Search Dual Task* and *Opposite Worlds*. For both the *Sky Search* and the *Sky Search Dual Task* tests, the children were presented with a double-sided blue A3 sheet (see Appendix 6 for diagrams). One side displayed an array of rows of 128 pairs of black space ships. Four distinctive types of spacecraft were presented, most pairs being of mixed type. The sheet also had a box in the lower right corner, which, upon being ticked, signalled to the experimenter that the child had finished the task. On the other side of the A3 sheet was a motor control version of the task. This was identical to the reverse side, except that all of the distracter items were removed leaving only the 20 target pairs seen on the first side. This was presented in the *Sky Search* task only.

For the *Score!* and *Sky Search Dual Tasks*, a cassette player and the TEA-Ch cassette tape were used to present auditory stimuli. A series of identical tones (between nine and fifteen identical tones each of 345 milliseconds duration) were presented, separated by silent interstimulus intervals of varying length. These variables were important to manipulate task difficulty.

Finally, for the *Opposite Worlds* test, there were four sheets showing a mixed, quasi-random array of the digits 1 and 2, following a non-linear path beginning with “Start” and ending with “Stop” (see Appendix 6).
A stop clock was used for recording response times in the TEA-Ch subtests.

3.4.2.3 Design

All participants undertook all of the following tasks: SPT, ISE, BPVS, Stroop and TEA-Ch across two testing sessions, one week apart. Encoding (SPT) or retrieval (ISE) modality (verbal versus motoric) was manipulated within subjects in each task. The order of these tasks was counterbalanced across participants, as was presentation of the BPVS, Stroop and TEA-Ch tasks.

3.4.2.4 Procedure

In line with Experiment 2, each child was seen individually for two sessions, separated by one week, in the school library. Each appointment started with either the SPT or ISE task and was followed by two other tasks selected from the battery. The total duration of testing was approximately one hour.
ISE and SPT Tasks
The procedures for the practice and experimental SPT / ISE tasks were identical to those described in Experiments 1 and 2 such that children were familiarised with the task of learning and being tested on sample lexical stimuli followed by testing with the experimental stimuli (see Appendix 3 for instructions).
Test Battery Procedures
The procedures for the BPVS and Stroop tasks were identical to those described in Experiment 2 (see 3.3.2.4). For the first TEA-Ch test, *Sky Search*, participants

were initially presented with a blue A4 practice sheet depicting rows of thirty paired spaceships (see Appendix 6), similar to those in the main task. Each participant was informed that the spaceships always travel in pairs (an explanation was given to those who were unsure what a pair meant). They were then told to find and circle all pairs of spaceships where the pair consisted of identical spaceships. The experimenter gave an example by circling the first pair with a coloured felt tip. Then, the pen was handed over to the child and s/he was asked to find the remainder of identical pairs (a further seven targets were hidden amongst the array). The child was also asked to tick a small rectangular box in the bottom right hand corner of the sheet once s/he was sure that s/he had completed the task.

After the child had finished the practice task, s/he was presented with the blue A3 sheet mentioned in 3.4.2.2. Again participants were asked to circle as many identical pairs of ships as they were able to find. Participants were also instructed that they should tick the box in the lower right hand corner of the sheet, to indicate completion of the task. To control for individual differences in motor speed, each participant also completed the motor control version of the test (see 3.4.2.2) where the child was asked to circle all of twenty targets as quickly as possible and tick the box to signal completion.

In the second TEA-Ch subtest, *Score!*, ten auditory trials were presented to each participant via a cassette tape. Each trial consisted of between nine and fifteen identical tones that the participant had to silently monitor and communicate the "score" (i.e. the number of identical tones) on hearing a distinct second sound. This sound signalled both the beginning and end of each trial. Two practice trials preceded the main task to ensure full understanding.

The third TEA-Ch subtest, *Sky Search DT*, combined the *Sky Search* and *Score!* tasks to form a dual task measure. In this measure, participants were asked to complete a second A3 *Sky Search* sheet, as described above, and at the same time to monitor tones presented within each trial of a second *Score!* task. This dual task was complete once the child indicated completion of the *Sky Search* component, by ticking the completion box. At this point, the experimenter stopped timing.

In the final TEA-Ch subtest, *Opposite Worlds*, participants were presented with four consecutive stimuli sheets, each showing a mixed quasi-random array of twenty-four digits (each digit was either 1 or 2; see Appendix 6 for an example). The first and last sheets were labelled “Same World” and the second and third, “Opposite World”. For the Same World sheets, participants were asked to read out the digits, as presented, as quickly as possible. In the Opposite World condition, they were asked to say the opposite for each digit (i.e. “*one*” for 2 and “*two*” for 1), again as quickly as possible, thus examining the ability to inhibit the pre-potent response. Although the overall speed of the task was controlled by a participant’s verbal responses, consistent with the standard instructions, the experimenter controlled the progress of stimuli responses by pointing to each individual number and only moving onto the next once the correct response was given. Thus any errors were instantly turned into time penalties. The experimenter noted the time taken for each test sheet. Instructions for all of the TEA-Ch measures are provided in Appendix 7.

3.4.3 Results and Discussion

In line with the two previous experiments, three measures of recognition accuracy, recognition latency and recall performance were recorded for both the SPT and ISE paradigms. The latency-pruning technique described in 3.2.2 was also used here. Details of participants replaced using this technique are addressed for each task separately.

3.4.3.1 SPT

Using the latency-pruning technique, approximately 3.9% (n=26) of correct responses were removed from all analyses in this task. Four participants also had to be replaced due to high numbers of false positives (same criterion as that reported in Experiment 2). Data from all of the participants are included in the following analyses.

Recognition latency

Although the trend for recognition latencies indicated that correct responses for SPT material (M=1248, SD=230) were shorter than those made for VT material (M=1269, SD=281), the t-test revealed that this difference was not reliable; $t(23) = -0.458$, $p=0.652$. This is consistent with previously reported findings in this thesis for both the adult and the nine-year-old groups.

Recognition accuracy

For recognition accuracy, a highly significant difference was found between the number of hits for the SPT versus VT encoding conditions with SPT yielding a higher hit rate (M=9.42, SD=1.91) than VT encoding (M=7.75, SD=1.87); $t(23) = 3.443$, $p=0.002$.

Free recall

Consistent with previous experiments in this thesis, all participants were included in the free recall analyses, including those who failed to correctly recall any of the targets. For this group of eleven-year-old children, a reliable difference was revealed where more SPT (M=4.92, SD=3.01) than VT items (M=2.71, SD=1.99) were correctly recalled; $t(23) = 2.892$, $p=0.008$.

The eleven-year-old children in this sample recognised material enacted at encoding more accurately than material from the verbally encoded lists. Similarly, more SPT than VT material was recalled. Therefore, these findings indicate that perhaps information studied by through enactment is better retained than information studied through verbal repetition and, more importantly, these findings suggest that children, like adults, demonstrate an SPT effect, consistent with the findings of Cohen and Stewart (1982).

Order Effects

Consistent with Experiments 1 (3.2.2.1) and 2 (3.3.3.1), two 2 x 2 mixed ANOVAs were conducted to investigate whether task order had affected performance on the SPT task. Both analyses were identical to those previously employed. 0 presents the means and standard deviations for each set of data.

: Mean latency and accuracy data for presentation order and encoding modality

Order	Measure	Condition	Mean (sd)	n
SPT First	*Latency*	ME	1266 (214)	12
		VE	1306 (234)	12
	Accuracy	ME	9.33 (1.72)	12
		VE	7.08 (1.88)	12
ISE First	*Latency*	ME	1229 (254)	12
		VE	1233 (328)	12
	Accuracy	ME	9.50 (2.15)	12
		VE	8.42 (1.68)	12

NOTE: ME = Motoric encoding, VE = Verbal encoding

0 provides a summary of both analyses and shows only one significant difference relating to the accuracy data.

: SPT performance data compared with task presentation order

ANOVA	Description	Effect 1	Effect 2	Interaction
1	Verbal vs. Motoric encoding (latency)	p=.658	p=.570	p=.715
2	Verbal vs. Motoric encoding (accuracy)	p=.002	p=.219	p=.236

(Effect 1 = Encoding modality (Verbal / Motoric), Effect 2 = Task presented first (SPT / ISE))

Consistent with an earlier analysis (see the Recognition accuracy part of this section), this significant difference reveals an SPT effect whereby more material encoded through enactment was accurately recognised than material encoded through verbal repetition.

Taken together with the nonsignificant interactions, analyses of the two effects revealed findings in partial agreement with those from Experiments 1 (3.2.2.1) and 2 (3.3.3.1) Moreover, it would appear that SPT performance, measured using latency and accuracy data, was not influenced by which task (ISE, SPT) was undertaken first.

3.4.3.2 ISE

The trimming technique resulted in the removal of approximately 3.1% (n=21) of correct responses from all analyses in this task. For this task, all participants were included in all analyses, apart from the four who were replaced due to a high number of false positives.

Recognition latency

Although response latencies for to-be-performed material (M=1263, SD=250) were slightly slower than those for to-be-reported material (M=1225, SD=230), this difference was not reliable; t (23) = 0.934, p=0.360. Therefore, although the response latencies for the two retention modalities were in the opposite direction to that predicted, the difference was not significant. Thus it is difficult to provide an accurate discussion of the data other than to say that there was no significant difference between response times for to-be-performed versus to-be-reported material.

Recognition accuracy

Initial inspection of the mean number of hits for each retrieval condition indicated little difference between to-be-performed (M=8.33, SD=2.30) versus to-be-reported (M=8.75, SD=1.87) material. The subsequent t-test analysis supported this observation (t (23) = -0.718, p=0.480). Taken with the previous experiments, this result suggested that recognition accuracy performance was very similar for both forms of retrieval, regardless of the age of the participants.

Free recall

Similar to the results for recognition accuracy, there was little difference between the free recall means for each retrieval condition. A t-test analysis confirmed this:

there was no reliable difference between to-be-performed (M=3.67, SD=2.32) and to-be-reported (M=3.38, SD=2.39) items; t (23) = 0.385, p=0.704.

The findings from this experiment revealed that although material intended for enactment was recognised less accurately than material intended for verbal report, this difference was not reliable. Conversely, although the recall measure indicated more material intended for enactment was recalled than material intended for verbal report, this difference was again not reliable. These data together with the latency measure, once again indicate that the ISE effect might not be automatic as Goschke and Kuhl (1993, 1996) propose.

Order Effects

Consistent with analyses reported in Experiments 1 (3.2.2.2) and 2 (3.3.3.2), two 2 x 2 mixed ANOVAs were employed to investigate whether task presentation order had influenced ISE performance. These analyses were identical to those previously described. 0 illustrates the mean and standard deviations for each set of data.

: Mean latency and accuracy data for presentation order and retrieval modality

Order	Measure	Condition	Mean (sd)	n
SPT First	*Latency*	VR	1164 (223)	12
		MR	1279 (312)	12
	Accuracy	VR	8.42 (2.23)	12
		MR	8.42 (2.81)	12
ISE First	*Latency*	VR	1288 (229)	12
		MR	1247 (181)	12
	Accuracy	VR	9.08 (1.44)	12
		MR	8.25 (1.76)	12

NOTE: VR = Verbal Retrieval, MR = Motoric Retrieval

0 provides a summary of both analyses and shows only one significant difference relating to the interaction with the latency data.

: ISE performance data compared with task presentation order

ANOVA	Description	Effect 1	Effect 2	Interaction
1	Verbal vs. Motoric retrieval (latency)	p=.327	p=.620	p=.046
2	Verbal vs. Motoric retrieval (accuracy)	p=.485	p=.700	p=.485

(Effect 1 = Retrieval modality (Verbal / Motoric), Effect 2 = Task presented first (SPT / ISE))

This significant interaction indicates that retrieval modality effects are influenced by the task that participants were exposed to first: Simple main effects revealed a marginally significant effect between to-be-performed (M=1164, SD=223) versus to-be-reported (M=1278, SD=312) material in participants who were exposed to the SPT task first; t(11) = -1.970, p=.075. In comparison, reaction times for participants who were exposed to the SPT task last showed less difference between to-be-performed (M=1247, SD=181) versus to-be-reported (M=1288, SD=229) material. Therefore, these data tentatively suggest that similar to the adults in the SPT condition in Experiment 1, there is a small effect of exposure to one task before the other although it is unclear which task hinders which and by how much.

3.4.3.3 Test Battery Results

Consistent with Experiment 2, participants' responses to both SPT and ISE task materials were examined as a function of both BPVS performance and Stroop interference. Measures for the SPT and ISE tasks were identical to those used in the analyses presented in Experiments 1 and 2. In addition, for this experiment TEA-Ch performance was included. All of these analyses were also conducted using median splits.

BPVS

On this measure, scores ranged from 80 to 133 with a sample mean of 99.07 (SD = 14.86). Using the BPVS median (94) the data for all the participants was split to derive relatively low and high verbal comprehension groups. All but four participants were included in the analyses. The scores from the four excluded participants matched the median. 0 illustrates how these two groups differed with respect to their BPVS scores.

: Mean BPVS performance for low (<94) and high (>94) groups.

	Low BPVS performance	*High BPVS performance*
Mean	94 (7)	107 (19)
N	10	10

(Standard deviations in parentheses)

Consistent with previous analyses that investigated similar data for SPT tasks, two 2 x 2 mixed ANOVAs were conducted, both using BPVS as the between-subjects factor and encoding modality as the within-subjects factor. Recognition accuracy (first analysis) and free recall performance (second analysis) were employed as dependent variables.

The first analysis focused on recognition accuracy. The means (0) seem to indicate that the low BPVS group performed less well compared to the high BPVS group. Similarly, for the SPT data, it would appear that those in the low BPVS group (M=8.40) recognised considerably less than those in the high BPVS group (M=9.90). This was not the case for the VT data however, where the means were very similar. The analyses revealed that there was no reliable main effect of BPVS performance (F < 1) nor an interaction; F (1,18) = 3.012, p=.100. As expected, there was a reliable main effect of encoding; F (1,18) = 8.368, p=.01. These findings, together with the data presented in 0 below, suggest that material encoded motorically was more accurately recognised than material encoded through verbal repetition and that this effect is not affected by verbal comprehension as measured by the BPVS.

: Mean SPT recognition accuracy and recall performance for low and high BPVS performance groups

BPVS Performance	**SPT Performance Measure / Encoding Condition**			
	Recognition Accuracy		*Recall*	
	SPT	VT	SPT	VT
Low	8.40 (1.43)	7.80 (1.99)	4.80 (2.57)	2.70 (1.70)
High	9.90 (1.85)	7.50 (2.07)	5.10 (3.35)	3.00 (2.40)

(Standard deviations in parentheses)

A similar finding was uncovered in the second analysis where only recall performance was found to differ significantly with respect to encoding condition; F (1,18) = 6.018, p=.025. Neither BPVS performance nor the interaction was reliable (both Fs <1). From these findings it would appear that, with respect to free recall performance, this group of 11-year-olds were able to retain material encoded through performance better than verbally encoded material, irrespective of their verbal comprehension.

Two ANOVAs were also conducted to investigate the effect of BPVS on ISE performance. From the first analysis, no significant main effects were uncovered for participants' response times (No main effect of encoding, no main effect of BPVS performance and no interaction (all Fs <1)).

: Mean ISE response times / accuracy performance for low and high BPVS performance groups

	ISE Performance Measure / Encoding Condition			
	Latency		*Recognition Accuracy*	
BPVS Performance	To-be-performed	To-be-reported	To-be-performed	To-be-reported
Low	1273 (219)	1285 (228)	8.80 (3.19)	9.10 (2.08)
High	1189 (262)	1185 (231)	8.00 (1.33)	8.70 (1.49)

(Standard deviations in parentheses)

Similarly, for the second analysis (participants' recognition accuracy), no significant main effects or interaction were uncovered (Fs <1).

Therefore, it would appear that verbal comprehension has no significant effect on ISE performance in this group of 11-year-old children.

Stroop

A full explanation of these scores is given in 3.3.3.3. The group mean scores for the Simple and Interference measures are shown in 0.

: Mean Stroop scores

Simple Stroop score	Interference Stroop score	Overall Score
99.58 (17.78)	*51.75 (12.10)*	*0.48 (0.09)*

(Standard deviations in parentheses)

Overall Stroop scores ranged from 0.30 to 0.75. Using the median for the Overall Stroop score (0.45), the data for all the participants was split to derive relatively low and high Stroop interference groups. 0 illustrates how these two groups differ. Two participants were removed because their scores matched the median.

: Mean Stroop interference for Low (<0.45) and High (>0.45) groups.

	Low Interference Group	**High Interference Group**
Mean	0.40 (0.04)	0.54 (0.08)

N	10	12

(Standard deviations in parentheses)

: Mean SPT accuracy and recall performance for low and high Stroop interference groups

	SPT Performance Measure / Encoding Condition			
	Recognition Accuracy		*Recall*	
Stroop Interference	SPT	VT	SPT	VT
Low	9.40 (1.96)	7.70 (1.64)	4.90 (3.70)	2.80 (2.30)
High	9.25 (1.76)	7.50 (2.02)	4.92 (2.39)	2.50 (1.93)

(Standard deviations in parentheses)

Two 2 x 2 mixed ANOVA analyses were conducted on the SPT accuracy and recall performance data (as summarised in 0) examining Stroop interference (between-subjects factor) with encoding condition (within-subjects condition). The only significant effect observed was the expected main effect of encoding condition. Thus for the accuracy data there was neither a reliable effect of Stroop interference nor an interaction (Fs <1) although there was a strong effect of encoding condition in the expected direction such that information encoded by performance was more accurately recognised compared to material encoded through verbal repetition; F (1,20) = 13.476, p=.002. Similarly, for the recall data there was no reliable effect of Stroop interference and no interaction (Fs <1). However, there was a reliable effect of encoding condition in the expected direction; F (1,20) = 7.732, p=.012.

For the ISE data, a further two 2 x 2 mixed ANOVA analyses were conducted examining Stroop interference (between-subjects factor) and retrieval condition (within-subjects factor) using recognition accuracy and latency performance data (summarised in 0) as dependent variables for the first and second analyses, respectively. However, no significant effects or interactions were observed although the interaction between retrieval condition and Stroop interference with respect to recognition latency data did approach significance; F (1,20) = 3.024, p=.097 (all other Fs < 1). Looking more closely at the data, the nature of this interaction suggests an inverse ISE for low Stroop children: participants who exhibited relatively low Stroop performance recognised more to-be-reported than to to-be-performed items and also more material overall compared to those with fewer problems with Stroop interference.

: Mean ISE response times / accuracy performance for low and high Stroop interference groups

	ISE Performance Measure / Encoding Condition			
	Recognition Latency (ms)		*Recognition Accuracy*	
Stroop Interference	**To-be-performed**	**To-be-reported**	**To-be-performed**	**To-be-reported**
Low	1286 (299)	1174 (277)	8.80 (2.25)	9.00 (1.49)
High	1267 (214)	1297 (177)	8.17 (2.52)	8.50 (2.15)

(Standard deviations in parentheses)

TEA-Ch

The mean and median age-scaled (standardised) scores for each subtest are summarised in 0. The Opposite Worlds score was calculated by subtracting the raw Same Worlds score from the raw Opposite Worlds score (i.e. OW – SW = OWs). In the TEA-Ch handbook (Manly *et al* 1999), the score traditionally used is the age-adjusted Opposite Worlds score. However, this does not account for data obtained from the Same Worlds task. Therefore, it was decided to obtain scores that accounted for both tasks by subtracting one from the other, as described above.

: Mean age-scaled (standardised) scores for each subtest

	Subtest Score	
	Mean	*Median*
Sky Search	*9.46 (2.45)*	9
Score!	*8.79 (2.25)*	9
Sky Search DT	*6.67 (3.03)*	8
Opposite Worlds	*-0.42 (1.95)*	-0.5

(Standard deviations in parentheses)

Median splits were carried out on these data to analyse whether these TEA-Ch derived attentional skills affected ISE performance, using recognition latencies as a measure of the ISE. It should be noted that this study was primarily concerned with exploring this relationship and not that between TEA-Ch and SPT performance. This relates back to previous research that has looked at the relationship between the ISE and executive functioning (c.f. Dockree 2002). It should also be noted that the Sky Search-DT measure was excluded from these analyses due to a high number of scores matching the median. This resulted in an uneven distribution of high (n=6) and low (n=11) scores.

Thus a series of three 2 x 2 mixed ANOVAs was conducted to examine each of the three remaining TEA-Ch measures (high vs. low: between-subjects factor) on the two retrieval conditions (MR vs. VR within-subjects) with respect to response times. 0 indicates how the groups on each measure differed and 0 illustrates the spread of response times across the three measures.

: Mean TEA-Ch measure scores for Low and High groups.

		Low Score Group	**High Score Group**
Sky Search	*Mean*	7.50 (0.90)	11.42 (1.83)
	N	12	12
Score!	*Mean*	6.60 (0.70)	10.90 (1.45)
	N	10	10
Opposite Worlds	*Mean*	-2.00 (1.04)	1.17 (1.19)
	N	12	12

(Standard deviations in parentheses)

: Mean ISE response times for low and high Sky Search, Score! And Opposite Worlds performance groups

		ISE Performance Measure / Encoding Condition	
		Recognition Latency (ms)	
TEA-Ch Measure	**Performance group**	To-be-performed	To-be-reported
Sky Search	*Low*	1328 (196)	1284 (238)
	High	1197 (287)	1168 (215)
Score!	*Low*	1243 (211)	1207 (179)
	High	1324 (293)	1239 (274)
Opposite Worlds	*Low*	1254 (259)	1229 (197)
	High	1272 (251)	1223 (267)

(Standard deviations in parentheses)

Interestingly no significant main effects or interactions were uncovered in any of these analyses (Fs < 2[19]) indicating that factors measured by TEA-Ch might not play a significant role in determining response times in the ISE task or the size of the ISE.

[19] **Sky Search**: Effect of Retrieval p=.371; effect of Sky Search p=.174; Interaction p=.846. **Score!**: Effect of Retrieval p=.181; effect of Score! p=.582; Interaction p=.578. **Opposite Worlds**: Effect of Retrieval p=.370; effect of OW p=.943; Interaction p=.771.

3.5 GENERAL DISCUSSION

In the three experiments described in this chapter, participants were asked to learn four lists of verb-noun task phrases. Two of these lists were encoded immediately (one performed and one repeated out loud: SPT task) and two were learned for delayed recall (one to-be-performed and one to-be-verbally reported: ISE task). Retention of both pairs of lists was measured by recognition accuracy, recognition latency and delayed free recall. Participants were also presented with a test battery consisting of a test of verbal comprehension, a test of inhibition and tests of executive functioning (the latter for Experiment 3 only). What follows is a discussion of the results obtained from these measures across the three experiments.

3.5.1 The effect of enacting material at encoding

3.5.1.1 Recognition accuracy and recall

A number of interesting findings emerged from the analysis of both the recognition accuracy and of the free recall data in the Subject-Performed Task paradigm. These measures, used in the vast majority of published SPT literature, were of primary importance when analysing these data. For adults (Experiment 1), items enacted at encoded were retained far better than those items encoded through repetition. This is consistent with similar research with adults that has used one or both of these measures (see Engelkamp 1998, for a summary). Interestingly, the results from children are less clear. For the 9-year-olds (Experiment 2), both recognition accuracy and free recall performance data produced no reliable differences although the trends were in the expected direction. Insufficient participants, small effect sizes and variations in development within this group were cited as potential reasons for these results.

For the 11-year-old group (Experiment 3), on the other hand, both measures revealed highly significant differences such that more SPT material was retained compared to VT material.

3.5.1.2 Recognition latency

Unlike the recognition accuracy and free recall data, which revealed some significant differences, the recognition latency analyses revealed no reliable differences across all three age groups. Particularly in the adult and 11-year-old groups, this highlights a potential dissociation between the ability to recognise items as old and the speed with which this judgement can be made. Moreover, while the two older groups (adults and 11 year olds) seem able to accurately recognise more items encoded through enactment, the time to make these judgements is no different to that for items encoded through verbal repetition. However, as noted in 3.2.2.1, the majority of SPT research has concentrated on recall and accuracy measures that tend to reveal more reliable SPT effects.

3.5.2 Intended enactment effects

3.5.2.1 Recognition latency

In Experiment 1, Goschke and Kuhl's (1993) observation of faster response times for material intended for enactment at retrieval (MR) compared to material not intended for enactment (VR) was only partially replicated. The trend was in line with Goschke and Kuhl's findings although the difference was marginal. A number of possible explanations for this finding have already been mentioned (see 3.2.2.2). This thesis, however, is more interested in the findings for the developmental groups where, perhaps unsurprisingly, the differences were not reliable. Therefore, it would appear that only adults demonstrated a higher level of activation for to-be-performed material compared to to-be-reported material suggesting a heightened accessibility in memory. This is consistent with previous adult research for both experimental (Dockree 2002; Goschke & Kuhl 1993;

Marsh, Hicks & Bink 1998) and naturalistic (Dockree & Ellis 2001; Marsh, Hicks & Bryan 1999) intended actions.

3.5.2.2 Recognition accuracy and recall

The findings from these measures were consistent across all three experiments where there were no differences between items to-be-enacted versus items to-be-reported. Therefore, it would appear from these results that, at least for these groups of participants, there was no additional benefit of the expected motoric modality of retrieval on retention, when measured using recognition accuracy and free recall. This is perhaps not surprising since, similar to the SPT research, the ISE paradigm has focused on a limited number of measures: either recognition (Goschke & Kuhl 1993) or lexical decision (Marsh, Hicks & Bink 1998) latencies. Nevertheless, both recognition accuracy and recall have been used with the ISE (e.g. Freeman 1999; Freeman & Ellis 2003b) and have elicited some contrasting findings to those observed here. Therefore, it remains to be seen whether or not to-be-performed material has an additional advantage over to-be-reported material in measures other than the traditional recognition and lexical decision latencies.

3.5.3 The effect of verbal intelligence / comprehension and inhibition on ISE and SPT effects

For these measures, a number of age-appropriate tests were employed to establish scores for each age group. Thus for adults the National Adult Reading Test (NART) was used to measure verbal intelligence whereas the British Picture Vocabulary Scale (BPVS) was used to measure verbal comprehension for the developmental groups. To provide a measure of inhibition, the Hayling Sentence Completion task was used in Experiment 1 and a modified version of the Stroop in Experiments 2-3. The outcome of the examination of the relationship between these and the SPT / ISE tasks in the three experiments is now discussed, starting with verbal comprehension.

3.5.3.1 Verbal intelligence / comprehension

For both the adult participants in Experiment 1 and the 11-year-olds in Experiment 3, verbal intelligence was found to have no effect on either the SPT or the ISE tasks. Moreover, those participants with low verbal intelligence performed as well as those with high verbal intelligence on both the SPT and the ISE tasks. The results from Experiment 2, however, were less clear. When examining verbal comprehension (BPVS) on recognition accuracy in both tasks, no clear differences were uncovered. However, for both free recall (in the SPT task) and recognition latency (in the ISE task) performance, those participants with low verbal comprehension performed less well than those with high verbal comprehension, irrespective of the encoding or retrieval modality.

Therefore, whereas performance on the SPT/ISE tasks in the two older groups was unaffected by verbal comprehension, this was not the case for the 9-year-olds. This finding could indicate that during this age verbal comprehension can help with the retention of verbal material (regardless of how it is learnt). It would be of interest to study this further by including a 10-year-old group to see whether a critical age could be discovered where verbal comprehension no longer has an effect on SPT / ISE performance.

3.5.3.2 Inhibition

Interestingly for all three groups across both tasks, inhibition did not appear to have a significant role in performance. This was true for all measures across both tasks. Notwithstanding this finding, there was one instance where inhibition seemed to contribute some effect: Closer inspection of the nonsignificant interaction relating to the inhibition with ISE latency data revealed an interesting trend. An inverse ISE (where latencies were slower for to-be-enacted than for to-be-reported items) was apparent for those participants classed as having low Stroop performance. Moreover, participants whose performance on the Stroop task indicated difficulty inhibiting competing information were quicker to respond to material intended for verbal recall compared to that intended for performance.

It is difficult to explain why this should be, particularly with reference to the adult literature surrounding the ISE-inhibition relationship. Dockree (2002), for example, found that participants who showed difficulties inhibiting competing responses (mid to high interference) on the Stroop task did not show an ISE. The opposite was true for those participants who exhibited low interference on the Stroop task. However, returning to earlier explanations for a lack of a significant ISE in the adult participants (3.2.2.2), we should treat these overall findings with caution.

3.5.4 The effect of executive functions on the Intention-Superiority Effect in 11-year-olds

Previous research has indicated links between executive functions and memory for future intentions (see 2.4). Sub-tests from the Test of Everyday Attention in Children (TEA-Ch) battery were included as an initial trial to see whether performance on the tasks could help to determine performance on the ISE task. However, the results indicated that performance on the sub-tests did not appear to determine recognition latencies in the ISE task or the size of the ISE. Moreover, those participants who performed poorly on each TEA-Ch measure responded to ISE task material at similar speeds to participants who showed superior executive function ability. Furthermore, these latencies were irrespective of retrieval modality. Although this finding is perhaps unexpected, it could follow from earlier analyses showing that this age group failed to show an ISE as a whole. Closer inspection of the data reveals that only 42% actually exhibited faster latencies for to-be-performed versus to-be-reported items.

3.5.5 Procedural and theoretical issues relating to the development of memory for actions in 9- and 11-year-old children

Overall, the studies reported here have revealed some interesting findings. They have also introduced some interesting points relating to methodology. For example, participants were informed from the very beginning that the project involved a “memory game”. Although this early insight into the task could have improved their overall performance at the task, it would be unlikely to effect one method of encoding / retrieval over another.

As described earlier, presentation of the ISE / SPT tasks was counterbalanced so as to ensure that half of the participants were exposed to the ISE task first and half to the SPT task first. As the reader will note, the Results section for each experiment includes separate analyses for each task to investigate whether this manipulation had any effect on task performance. However, because of no significant interactions this counterbalancing was seen to make no considerable influence on task performance.

Relating the ISE / SPT results from Experiments 1-3 to the theoretical models mentioned in Chapter 1, there are some interesting observations. For example, the reader will recall that four models were described to explain the SPT effect. Cohen and colleagues (Cohen 1981; 1983; 1985; Cohen & Stewart 1982; Cohen & Bean 1983) would predict no developmental trend for the SPT effect due to the nonstrategic nature of motoric encoding. Bäckman, Nilsson and colleagues (Backman & Nilsson 1984; 1985; Backman, Nilsson & Chalom 1986) would also predict the absence of age effects, but for slightly different reasons relating to both strategic *and* nonstrategic processing. Although Engelkamp and Zimmer (e.g. 1985) did not directly test age effects, because they argue that the SPT effect is exclusively due to (nonstrategic) motor processes, it could be argued that they also would not expect to observe performance differences between the younger and older participants. Finally, although Foley and Ratner’s (1994) Activity Framework model does not directly test age effects, some of the four features identified by Foley and Ratner arguably develop with age (e.g. *relational structure* and *retrospective processes*). Looking at the overall data from Experiments 2-3, only 11 year-old children seemed to benefit from the encoding of verb-noun phrases using motoric rather than verbal means. Relating this back to the four models, it would appear that the findings from these initial experiments do not provide unequivocal support for one particular model. Although it could be argued that the absence of a reliable SPT effect in 9-year-old children together with a reliable effect in 11-year-old children is inconsistent with the assertion that the effect does not rely on strategic processing, it should be noted that the data from the 9-year-old children was in the expected direction. Because the SPT paradigm is used in subsequent experiments in this thesis this issue will be returned to later in the thesis.

A second observation highlights the finding that the two groups of children did not show the expected advantage for items intended for future performance versus items intended for future report. In fact there was no difference between the two types of intended material. Interestingly, this conflicts with the aforementioned suggestion by Goschke and Kuhl (1993) that the Intention Superiority Effect is automatic and therefore free from age effects (see 1.3). Perhaps because of this finding, subsequent analyses using test-battery measures were also inconclusive. A decision was made at this point to focus on the SPT effect in 9- and 11-year-old children and to explore it further in a younger age group (7-year-olds) in order to examine further the role of strategic processes in this effect. The ISE was not included in the remaining studies in view of the failure to observe any strong indication of the presence of the effect in these age groups. The next chapter also introduces another area linked to memory for actions: Prospective memory.

CHAPTER 4:

ENCODING MODALITY, PROSPECTIVE MEMORY AND SUBJECT-PERFORMED TASKS IN CHILDREN

4.1 INTRODUCTION

The previous chapter focused on children's memory for enacted versus verbalised material (SPT paradigm) and material intended for enactment versus that intended for verbal recall (ISE paradigm). However, none of these experiments directly investigated the effects of variations in the modality in which intended actions are encoded on prospective memory performance. The study reported here was designed to address this question. In particular, the potential benefits of visual, verbal, and motoric encoding of an intended action, for younger and older children, on prospective remembering were investigated.

Schaefer, Kozak and Sagness (1998) used a novel task to investigate the contribution of self-enactment at encoding to prospective memory performance on adult participants. Forty-five young adults were asked to perform five tasks at retrieval after either having performed the tasks themselves, watched the experimenter perform them (EPTs) or had the tasks described to them (VTs) at encoding. This contrast followed previous research indicating, in tests of retrospective memory, that material that is self-referent (Rogers, Kuiper & Kirker 1977) or self-generated (Slamecka & Graf 1978) is better retained than material that is not. Similarly, as the review of the SPT literature presented in Chapter 1 illustrated, self-enactment at study generally leads to better recall than verbal encoding (SPT effect). The question that Schaeffer *et al* posed was whether self-enactment would benefit the timely performance of those intended actions (prospective memory). Interestingly, Schaefer *et al* found, contrary to their expectations, that participants who enacted prospective tasks at study were *less* likely to perform them at test compared to those who had watched them being demonstrated or had heard a verbal description of the tasks.

Schaeffer *et al*'s finding that enactment at study hinders prospective remembering is in direct contrast to previous research that has demonstrated the benefits of enactment in retrospective memory: the SPT effect. If, as described in Chapter 1, enactment facilitates automatic processing (Cohen 1981), or produces a richer trace as a consequence of either motoric coding (Engelkamp & Zimmer 1985) or greater self-involvement (Helstrup 1986), then one would expect it to enhance prospective remembering relative to verbal encoding.

Schaeffer *et al* suggest that the negative effects of enactment may be a consequence of people's beliefs or expectations about their prospective memory performance, a "*metacognitive-expectation hypothesis*" (p. 648). Thus they argue that people who enact the tasks at study may be more likely to expect that later performance of these tasks will be easier as a consequence and therefore allocate less time and effort to prospective remembering. Interestingly, increased confidence in one's memory skills has been associated with more memory failures in children (Beal 1988) and older adults (Moscovitch & Minde cited in Schaeffer *et al* 1998). Moreover, adults have been found to judge SPTs to be easier than other comparable recall tasks (Cohen 1983). Thus there is some support for Schaeffer *et al*'s metacognitive explanation of their findings.

Schaeffer *et al*'s metacognitive explanation of the negative effect of enactment at encoding suggests that it would be interesting to study the impact of different encoding instructions on children's prospective remembering, given the gradual development of metacognitive skills (e.g. Flavell 1970) and the previously reported findings on the emergence of the SPT effect in 9- and 11-year olds (Chapter 3). A particularly important study, in this regard, was conducted by Passolunghi, Brandimonte and Cornoldi (1995). They focused on the effects of prospective memory cue/target encoding modality on prospective memory performance in 7-8 and 10-11 year old children, as well as the influence of the strength of the association between the cue and the intended action.

Previous retrospective memory research has found that encoding modality can have differential effects on performance, depending on the age of the children. Hitch, Woodin and Baker (1989), for example, conducted three experiments to explore the processing strategies that children employ to encode visually presented materials. In the first experiment, Hitch *et al* compared performance on this task by young (5-year-olds) and older (11-year-olds) children by presenting three sets of eight line drawings that were either visually similar (e.g. a long bone and a broom), phonemically similar (e.g. rat and hat) or a control set (e.g. bell and chair). The procedure and design for both age groups were identical apart from two notable exceptions: First, the older group were presented with more stimuli and second, half of the older children were randomly assigned to an articulatory suppression group where they were instructed to say aloud, "*the*" continuously during presentation of the stimuli to prevent subvocal rehearsal.

Overall, young children's immediate recall was found to be poorer for visually similar materials indicating some dependence on visual processing. Because this younger group's performance was also found to be unaffected by phonological similarity, this led the researchers to suggest that these children had little dependence on phonological processing. For the older children, on the other hand, articulatory suppression was found to reduce overall recall performance in addition to removing an effect of phonemic similarity that was seen with those older children who were not subject to suppression. More interesting was the finding that suppression led to a reliable visual similarity effect where performance closely resembled that of the younger children. Therefore, it would appear that older, eleven-year-old children employ visual processing when phonological processing is blocked, but when it is available verbal processing is employed. Younger, five-year-old children, on the other hand, tend to use visual processing exclusively.

Hitch *et al*'s (1989) findings were a starting point for Passolunghi, Brandimonte and Cornoldi's (1995) study of children's prospective memory performance. In a series of three experiments, Passolunghi *et al* manipulated cue encoding modality with groups of young (7-8 years) and older (10-11 years) children to investigate whether prospective memory performance would be enhanced by the use of a specific encoding modality and whether the effectiveness of a particular modality would vary according to the age of the child. In the first experiment, thirty young and thirty older children were asked to read a series of words as quickly and accurately as possible. In addition, the children were asked to press a response key upon presentation of a target word: the prospective memory instruction. To distract from this instruction and thus reduce the possibility of ceiling effects, it was emphasised that the main purpose of the experiment was to investigate reading ability.

Encoding of the prospective instruction was manipulated in one of three ways: For children in the *visual* condition, a representative line-drawing was shown. For those in the *verbal* condition, a printed word was shown. Finally, for those participants in the *motoric* condition, the verbal instruction was presented but the children were also asked to practice the prospective task by pressing the response key. After encoding of these instructions, participants were given a training activity (a retention interval) in which they were asked to perform the same task as that used for the experimental task by reading a series of word sets, each comprised of five words. During this activity the target word did not appear. For the experimental task, four blocks of ten trials were presented. Within these trials, the target word appeared eight times (twice per block) within word sets of five items, although participants were not told this. Each word set appeared on a computer screen for six seconds, followed by a one second inter-stimulus interval. Therefore, when a target word was presented, participants had a total of seven seconds to read the words and make their response.

In addition to finding an improvement in prospective memory performance with age, Passolunghi *et al* also found a marked difference between the two age groups with respect to encoding modality. The younger children performed better following visual encoding of the prospective instruction and the older children performed better after motoric encoding. In line with the findings reported by Hitch, Woodin and Baker (1989), Passolunghi *et al* suggested that the older group had employed a strategy that involved a verbal recoding of the lexical target.

Passolunghi *et al* conducted a second experiment to investigate the role of motoric enactment after visual and verbal encoding of the prospective instruction. Thus the eighty participants were separated not only by age but also through assignment to one of four encoding modality conditions. For those in the *visual* or *verbal* conditions, the procedures were identical to those in the first experiment. Children assigned to the *visual-motoric* condition were shown a line drawing of the target but also requested to perform the intended action (pressing the response key). Similarly, participants in the *verbal-motoric* condition were shown a printed representation of the target and also requested to perform the intended action.

Passolunghi *et al* again found that motoric encoding benefited older children's prospective memory. In contrast, although the younger visual encoding group performed better than the younger verbal encoding group, the addition of motoric encoding was not found to enhance performance. Passolunghi *et al* suggested from this that enhancing the encoding of both stimulus and response does not increase the strength of the intended activity in younger children, perhaps due to overloading of their working memory capacity. The final experiment sought to investigate this integration theory further but only in the younger age group, where until this point only visual encoding appeared to enhance prospective memory performance.

Forty children (7-8 years) were assigned to one of four conditions. Participants in the *Standard*, no association condition undertook the motoric condition from the first experiment. Participants in the *Natural Association* condition were asked to form an association between the task and a video game whereby responding to the target word (boat) would "sink it" (c.f. the game Battle Ships). Participants in the *Constructed Association* condition were given verbal instructions and then given additional practice during the training phase in which the target appeared three times. Finally, participants in the *Constructed Association plus delay* condition were given the same procedure as for those in the Constructed Association condition with an additional training phase where the target word did not appear. Therefore, participants in this condition were subject to an additional time delay preceding the experimental phase. To obtain additional, post-experimental data on what each participant remembered from the task, they were each asked two questions: whether they remembered the prospective task and the identity of the target word and its associated response.

Overall, the results from this final experiment revealed that when a salient link is established between the target and the intended action (as in the two *Constructed Association* conditions), motoric encoding was seen to enhance performance compared to the other two conditions. From this finding, Passolunghi *et al* argue that the link must be learnt through direct experience, not simply acknowledged through verbal repetition. When direct experience is provided, participants as young as 7-years are able to benefit from motoric encoding. In an attempt to explain why this group had not previously shown a benefit from motoric encoding, Passolunghi *et al* suggest that in the first two experiments, the younger children required additional training (not required by the older group) to learn the intended action and thus create and strengthen the cue-action link.

Although this experiment provides a number of interesting findings and conclusions, it also raises some concerns. First, although Passolunghi and colleagues claim to have established a more concrete link between the cue and the action, it could be argued that the relationship remains weak. For example, what does pressing a computer button have to do with a boat? Even the explanation that pressing the button would sink the boat, although meaningful in the context of computer games, provides at best an indirect association. Surely a closer, more meaningful association would involve an action that is directly related to the target. For example, the action *tearing* is highly related to the target paper. A second concern is that, in all of their experiments, Passolunghi *et al* only used one target word: *Barca* (the Italian word for *boat*). This raises some doubt about the generalisability of the results: Could the findings be specific to the word *boat*? Finally, throughout the article, Passolunghi *et al* argue that the younger children's attentional resources are overloaded but never attempt to measure this.

The experiment reported in this chapter was designed to explore Passolunghi, Brandimonte and Cornoldi's (1995) findings further using a modified design. This design was adopted to rectify the concerns outlined above. In addition, a third group of 9-10 year olds was included to examine the transition, if any, between visual and verbal/motoric encoding benefits. Finally, performance on the prospective memory task was compared with performance on the Subject-Performed task and other measures. This permitted further investigation of the development of the SPT effect in younger children and an opportunity to replicate the findings for SPTs reported in Chapter 3.

Similar to Passolunghi *et al*'s first experiment, the present experiment included three encoding modality conditions: motoric, verbal and visual. However, the instructions and materials in each condition were slightly altered. Thus, each participant was presented with one pair of target words from a set of three and in each encoding condition the target-action link was made more meaningful by creating related activity phrases (responses) that involved the target. For example, participants who were told to look out for the word "*Chair*" were asked to pretend to "*Move the chair*" when the word appeared. Similarly, participants who were told to look out for "*Key*" were asked to pretend to "*Turn the key*". Each of the two targets presented to an individual child was presented on four occasions during the ongoing task. Finally, the visual condition in the present study differed from that used by Passolunghi *et al*. The latter used a picture of the target word, a decision that potentially confuses visual processing and pictorial stimuli. Thus the written target word was presented in this study in the visual condition to contrast with the heard word in the verbal condition.

Three age groups were included in this experiment. The youngest age group was aged 7-8 years, to complement the youngest age group used by Passolunghi *et al*. The middle group was aged 9-10 years and was included in part because of the interesting SPT results identified in the previous chapter and in part to investigate the nature of the transition, if any, between the benefits of visual and motoric encoding. Finally, the older group was aged between 10-11 years and included to complement the eldest group used by Passolunghi *et al*. Its inclusion permitted also replication of the SPT effect in this age group that was reported in Chapter 3. Following Passolunghi *et al*, it was expected that visual encoding would improve only younger children's prospective memory. Motoric encoding, on the other hand was expected to enhance older children's performance on the task. The middle group were expected to show mixed performance with no clear encoding modality advantage for either visually or motorically encoded prospective memory tasks.

Each participant was asked to carry out a range of additional tasks. These included the Subject-Performed Task, four measures from the Test of Everyday Attention for Children (TEA-Ch) battery and the British Picture Vocabulary Scale (BPVS). Justification for the inclusion of each of these measures is discussed separately.

The findings from Chapter 3 revealed that although both adults and the 11-year-old children showed strong SPT effects, with respect to recognition accuracy and recall performance, these effects were not apparent in the group of 9-year-olds. Nevertheless, closer inspection of the data revealed distinct trends. For example, in the recognition accuracy data, 21 of the 36 participants showed greater accuracy for those items enacted at encoding compared to those verbalised. A further 19 participants recalled more SPT than VT material suggesting that it would be interesting to examine the benefits of SPT encoding further, particularly in a larger sample. Because at least some of the 9-10 year-olds appeared to benefit from motoric encoding, the SPT was administered also to the 7-8 year old age group. The materials used for this task were selected initially to provide stimuli familiar to this younger age group. Thus all of the words used at study had appropriately low age of acquisition ratings (see 3.2.2).

This SPT task is also of interest because of the similar processing thought to occur in both prospective remembering, via the ISE, and enactment at encoding (Freeman & Ellis 2003c). However, Passolunghi, Brandimonte and Cornoldi (1995) point out one interesting distinction between the two memory phenomena: while to-be-recalled SPTs (retrospective memory) do not require motoric information to be integrated with visual/verbal information, to-be-performe*d* SPTs (prospective memory) necessitate integration of the visual/verbal with the intended action prior to execution of that action. Without this strong integration, prospective memory performance is hindered. The activity phrases selected for the current experiment were designed to facilitate this integration. However, while it is expected that all three age groups will show SPT effects (in line with Cohen and Stewart's 1982 hypothesis of automaticity) with respect to recognition accuracy and recall performance, the relationship between SPT and prospective memory performance is included as an exploratory measure.

Each of the three age groups in this Experiment was tested on three subtests from the TEA-Ch (Manly, Nimmo-Smith, Watson, Anderson, Turner & Robertson

2001) that measure a different aspect of attention: *Sky Search* (selective attention), *Sky Search Dual Task* (divided attention) and *Opposite Worlds* (attentional switching). These are integrated into the design as measures of executive functioning to see whether there is any correlation between performance on these tasks and prospective memory performance. This follows from research with adults indicating a relationship between executive function and prospective memory. Martin, Kliegel and McDaniel (2003), for example, reported that although a number of executive functions are involved in prospective memory, particular aspects of task design (e.g. retention interval and complexity of the task), as well as the specific phase of a prospective memory task (encoding, retrieval etc) may determine the contribution of a specific attentional/executive skill.

Returning to the TEA-Ch subtests employed in this experiment: *Sky Search* is a measure of selective attention or, "*…a capacity to enhance the processing of particular target characteristics regardless of spatial location*" (p.1066 Manly, Nimmo-Smith, Watson, Anderson, Turner & Robertson 2001). Within the prospective memory domain, this function is important to be able to distinguish target from distracter items in order to successfully complete the task. *Sky Search Dual Task*, on the other hand, is a measure of divided attention where the participant must divide his/her concentration between two concurrent tasks. Similarly, in a typical prospective memory task, the participant must attend to the ongoing task but also be primed to respond to the prospective element (i.e. making a response at the appropriate time). Finally, the *Opposite Worlds Task* is a measure of attentional switching. Similar in some respects to the Wisconsin Card Sorting Task (Milner 1963), it requires children to respond to numerical stimuli using two opposing rules over four trials (i.e. each rule is used twice). Therefore, the child must remember and apply each rule appropriately. Typical prospective memory tasks could be argued to require this function when switching between the ongoing and the prospective elements of the task.

Therefore, it is predicted that children with higher performance on these skills should also demonstrate good performance at the prospective memory task.

In summary, the experiment reported here investigates prospective memory performance and performance on the SPT in three age groups. Later on, in Chapter 6, this performance is related to other abilities including retrospective memory and executive functioning.

4.2 EXPERIMENT 4

4.2.1 Method

4.2.1.1 Participants

In each age condition (7-, 9- and 11-year-olds), forty-five participants were recruited from two primary schools (Katesgrove Primary and Whitley Park Junior) in Reading. (7-year-olds ranged between 6 years 8 months and 8 years 5 months; mean age: 8 years 0 months, sixteen boys and twenty-nine girls; 9-year-olds ranged between 8 years 3 months and 10 years 3 months; mean age: 9 years 6 months, twenty-two boys and twenty-three girls; 11-year-olds ranged between 10 years 1 month and 12 years 0 months; mean age: 10 years 8 months, twenty-two boys and twenty-three girls). All participants were tested individually and were assigned to one of three experimental conditions: *Motoric*, *Verbal* and *Visual* (N=15 for each).

4.2.1.2 Materials

Prospective Memory Task Materials

Participants were seated in front of the same Toshiba Tecra 8000 laptop computer used in the previous experiments. The “Reading Game” task involved presenting participants with a set of five words on each of forty trials. For each set, the child was asked to read the words out as quickly and accurately as possible. If a target word was presented within the set, they were asked to mime the prescribed action (see Appendix 8). In line with Passolunghi *et al* (1995) the trials consisted of four blocks of ten trials each with a rest between blocks. The word sets (see Appendix 8) were randomly selected from a pool of fifty one- or two-syllable English words matched for frequency, age-of-acquisition and imageability using the MRC Psycholinguistic Database.

For each encoding modality, a different instruction script was required. In the *Visual* condition, similar to the verbal condition in the Passolunghi *et al* (1995) paper, printed copies of the paired target words were also presented to participants. For the test phase, the experimenter used a score sheet (Appendix 10) on which notes and a pseudo-score were written to reinforce the reading game construct. At the end of the score sheet, a post-test questionnaire was also included to establish what each participant had remembered from the instructions.

SPT Materials

The materials for this task were identical to those mentioned in Experiments 1-3.

Test Battery Materials

Materials for both the BPVS and TEA-Ch measures were identical to those mentioned in Experiment 3. As mentioned in the Introduction, measures of Sky Search, Sky Search DT and Opposite Worlds from Experiment 3, were also used in this experiment.

4.2.1.3 Design

All participants undertook all of the experimental tasks. The tasks were spread out over two sessions, one week apart. In the first session the prospective memory (PM) and TEA-Ch tasks were presented and in the second, the SPT and BPVS tasks. For the PM task, presentation of the particular set of two target words was counterbalanced across participants, within an age group. Only one pair of target words was presented to each child. For the encoding condition manipulation (between-subjects), fifteen children in each age group were exposed to the Motoric condition, fifteen the Verbal condition and fifteen the Visual condition. Within each of these conditions, five children were presented with the words, "*Chair*" and "*Key*", five, "*Hat*" and "*Tree*" and five, "*Ship*" and "*Tie*". Each target word in a pair was presented on 4 occasions. Counterbalancing measures for the SPT task employed in Experiments 1 and 2 were also applied here.

4.2.1.4 Procedure

The total duration of testing was approximately 1 hour. Testing sessions usually took place in the school library where the conditions were quiet and free from distraction. Auditory materials were presented using a conventional tape player, set to a comfortable volume. As well as providing parental consent, each child was also asked for verbal and written confirmation for participation in the experiment. All participants provided all forms of consent.

PM Task Procedure

Participants were tested individually in a session lasting approximately ten minutes. All were given oral instructions (see Appendix 9 for a full set of instructions for each condition) explaining that the PM task was a game to look at reading ability. They were told that they would be presented with a series of words, five at a time, on the computer screen and that they should attempt to read these words as accurately and quickly as possible. This latter point was emphasised as exposure to each trial only lasted for five seconds (seven seconds for the younger participants). The task consisted of four blocks of ten trials, where each trial consisted of five words selected from the word pool mentioned in the *Materials* section. For each participant, the two target words appeared four times, one in each block, providing 8 opportunities for prospective remembering. Participants were not made aware of how often the targets would be presented.

Towards the end of the instructions, participants were informed about the prospective instruction; to respond to target words (e.g. *chair*, *key*) by performing an appropriate action (e.g. pretending to *move a chair* or *turning a key*). This instruction invoked the encoding modality manipulation: In the *Motoric* condition, the participant performed the associated actions. In the *Verbal* condition, children were only given oral instructions to perform the associated actions upon presentation of the words – no other cues were provided. In the *Visual* condition, participants were shown typed versions of the two target words and told to perform the associated actions when they saw these during the game. This design closely resembled the verbal condition used by Passolunghi *et al* (1995). For both the Visual and Verbal conditions, the participants were not given any opportunity to perform the associated actions once they had been given the instructions. An example of the instruction for the *Motoric* condition is as follows:

> *"Within this game there are a couple of words that I would like you to look out for. These are <u>CHAIR</u> and <u>KEY</u>. If you see these words, I would like you to do a little action for me: If you see the word <u>CHAIR</u>, then I would like you to <u>PRETEND TO LIFT THE CHAIR</u>. (Child acts out, appropriately). If you see the word <u>KEY</u>, then I would like you to <u>PRETEND TO TURN THE KEY</u>." (Child acts out, appropriately).*

After ensuring that each participant fully understood what was required of him or her, the experimenter presented a training activity, scoring performance on the scoresheet provided in Appendix 10. During this activity, a series of ten trials were shown to the participant, each of which the child had to read out loud. (Note that neither target word appeared during this task.) After the tenth trial, the sentence, "*End of block press space bar to continue*" was shown indicating to the experimenter that the practice task was over. At this point, the experimenter explained to the participant that the computer needed to do something before the reading game could continue and that whilst waiting, s/he would partake in a separate game. This game, the *Sky Search* task from the *TEA-Ch* battery (see below), formed the retention interval within the PM task, designed to induce prospective forgetting (Einstein & McDaniel 1990; McDaniel & Einstein 1993).

Before commencing the task, it was emphasised to the participants that they would return to the reading game within a few minutes. Thus, after the *Sky Search* task was completed, the participant's attention was redirected to the reading task, without any reminder of the prospective memory task. The experimenter checked that the participant was happy to continue and recommenced the ongoing task in which, on this occasion, the relevant two target words were embedded. When the target words were presented, the experimenter noted whether or not the child responded with the correct action during the performance interval. If the child performed after the performance window (i.e. during a subsequent word set), this was marked as a failure to perform.

After the participant had completed all forty trials in the reading game, a message appeared on the screen to indicate the end of the task. At this point the experimenter asked the post-test questionnaire items (see Appendix 10) to ascertain what the child had remembered from the reading game and, more importantly, whether or not they had remembered the prospective instruction. These items were designed to increase the amount of cue information that they provided to the participant. First of all, the experimenter simply asked, "*Can you remember what it was that you had to do in this game?*" If the participant correctly recalled the entire procedure including the target words and their respective actions, the experimenter noted down a maximum score of twelve. If, however, the participant failed to mention either of the target words or their actions or indeed to recall the overall PM task, the experimenter then asked, "*Do you remember that there were some special words that I asked you to look out for?*" Successful recall of both target words and their actions at this point resulted in a score of ten. Further cues were provided for the participant until the experimenter explained the whole procedure and simply asked whether or not s/he had performed the actions upon presentation. Thus it was possible for a participant to obtain a score of zero if they failed to recall any details of the PM task procedure.

After the PM task and questionnaire were completed, the experimenter moved onto presenting the child with the remainder of the *TEA-Ch* battery, following a procedure identical to that mentioned in Experiment 3. This was followed by presentation of the SPT task, using the procedure as that mentioned in Experiments 1-3. Finally, each child was given the BPVS task.

4.2.2 Results

4.2.2.1 PM Task Results

Before the PM performance data are addressed, the results from the post-test questionnaire are presented. The reason for this will become apparent when the analyses of the performance data are described.

For each of the six items in the questionnaire, a score out of 2 was given. Therefore, each individual was able to score a maximum of 12. These scores were then converted into a Likert scale (see 0 for a description). 0 provides a summary of what each age group remembered from the prospective memory instruction where ‘0’ depicts nothing remembered about the prospective memory task, ‘1’ that target words were remembered from the instruction but not the actions, ‘2**’** that the actions but not the target words were remembered from the instruction and ‘3**’** that the entire prospective instruction was remembered.

: Score attributed for post-test recall, based on questionnaire responses

Age Group	**What Remembered**	**N**
7-year-olds	0	2
	1	5
	2	9
	3	28
9-year-olds	0	4
	1	2
	2	1
	3	38
11-year-olds	0	1
	1	0
	2	0
	3	44

0 shows prospective memory performance for each age group in each encoding condition, where performance is expressed as the mean proportion of prospective memory targets correctly responded to.

A 3 x 3 between subjects ANOVA was performed on these performance data with encoding condition (motoric vs. verbal vs. visual) and each age group (7-, 9- and 11-year-olds) as between-subjects factors. This analysis revealed a reliable main effect of age group, $F(2,126)=6.595$, $p=.002$, but neither a main effect of condition nor a reliable interaction (both $Fs < 1$). Post hoc tests on the age group factor revealed no significant performance differences between the 7- and 9-year-old children; Tukey HSD = -0.078, $p=.647$, SE=0.087.

: Mean performance (proportional total targets responded to)

in each prospective memory condition and age group

Age Group	Encoding Condition	Mean	SD	N	
7-year-olds	*Motoric*	.3833	.3582	15	
	Verbal	.2917	.4190	15	
	Visual	.4000	.4412	15	
9-year-olds	*Motoric*	.5750	.4452	15	
	Verbal	.3583	.4142	15	
	Visual	.3750	.4278	15	
11-year-olds	*Motoric*	.5750	.4551	15	
	Verbal	.6333	.4393	15	
	Visual	.7833	.3115	15	

However, there was a reliable difference in performance between the 7- and 11-year-olds (Tukey HSD = -0.306, p=.001, SE=0.087) and between the 9- and 11-year-old age groups (Tukey HSD = -0.228, p=.025, SE=0.087). On both occasions, the 11-year-olds (M=0.6639) outperformed the younger groups of 7- (M=0.3583) and 9-year-olds (M=0.4361).

The above analysis included all participants, regardless of whether or not they remembered the words and actions from the prospective memory phrase. A second analysis focused on only those children who remembered both the words and the actions (i.e. the whole phrase) using the answers provided in the post-test questionnaire. This analysis removes the possibility that some children failed to carry out the prospective memory task because they had not remembered either the target words or their associated action i.e., failure to recall the content of the task rather than failure to carry out that task. As can be seen from the data in 0, below, this resulted in eight participants being removed from the analysis.

: Mean performance in each prospective memory condition and age group, excluding participants who failed to remember both the words and actions.

Age Group	**Encoding Condition**	**Mean**	**SD**	**N**	
7-year-olds	*Motoric*	.4423	.3484	13	
	Verbal	.3125	.4267	14	
	Visual	.4000	.4412	15	
9-year-olds	*Motoric*	.6161	.4315	14	
	Verbal	.4375	.4281	12	
	Visual	.3750	.4278	15	
11-year-olds	*Motoric*	.5536	.4644	14	
	Verbal	.6333	.4393	15	
	Visual	.7833	.3115	15	

A second 3 x 3 between-subjects ANOVA again revealed a main effect of age group, $F(2,118)=4.762$, $p=.010$, but neither a reliable main effect of encoding condition nor a reliable interaction ($F<1$ and $F(4,118)=1.204$, $p=.313$, respectively). Post hoc tests on the age group factor failed to reveal a reliable difference in PM performance between the 7- and 9-year-old children (Tukey HSD = -0.091, p=.576, SE=0.91). PM performance was again reliably different overall between the 7- and 11-year-olds (Tukey HSD = -0.275, p=.008, SE=0.090), with the 11-year-olds producing the higher performance. Interestingly, the difference between the 9- and 11-year-old age groups was not reliable (Tukey HSD = -0.184, p=.109, SE=0.090), although the trend was in the predicted direction.

A third analysis in this experiment focused on the PM data from a different perspective. This analysis sought to investigate how much each child remembered (using the post-test questionnaire data) rather than the total number of targets responded to in the PM task. These data are presented in 0. A 3 x 3 between-subjects ANOVA revealed a main effect of age group on PM task content recall; F(2,126)=5.504, p=.005. Interestingly, a marginally reliable main effect of encoding condition, F(2,126)=2.840, p=.062, was also revealed although the interaction was again not reliable; F(4,126)=0.982, p=.420. Because of these findings, two sets of Post hoc tests were conducted: one set for the age groups and one for the encoding conditions. For the age groups, only one significant difference was uncovered: when comparing the 7- (M = 2.38, SD = 0.94) and 11-year-old (M = 2.93, SD = 0.45) children, the 11-year-olds were seen to perform better; Tukey HSD = -0.56, p=.003, SE=0.17. Thus when comparing the 7- and 9- year-old (Tukey HSD = -0.24, p=.312, SE=0.17) as well as the 9- and 11-year-old children (Tukey HSD = -0.31, p=.152, SE=0.17), the differences were not significant, notwithstanding the fact that in both instances the trends were in the expected direction.

: Amount of information remembered for

each prospective memory condition and age group.

Age Group	**Encoding Condition**	**Mean**	**SD**	**N**	
7-year-olds	*Motoric*	2.40	1.06	15	
	Verbal	2.07	0.96	15	
	Visual	2.67	0.72	15	
9-year-olds	*Motoric*	2.73	0.80	15	
	Verbal	2.27	1.28	15	
	Visual	2.87	0.52	15	
11-year-olds	*Motoric*	2.80	0.77	15	
	Verbal	3.00	0.00	15	

	Visual	3.00	0.00	15	

Post hoc tests for the encoding condition revealed one significant difference relating to the verbal versus the visual conditions (Tukey HSD = -0.40, p=.045, SE=0.17) where performance following visual encoding (mean = 2.84, SD = 0.52) was better than that following verbal encoding (mean = 2.44, SD = 0.99) of the prospective memory instruction. There were no reliable differences between either the motoric and verbal (Tukey HSD = 0.20, p=.458, SE=0.17) or the motoric and visual encoding conditions (Tukey HSD = -0.20, p=.458, SE=0.17).

4.2.2.2 SPT Results

The trimming technique, described in Experiment 1, was applied to the SPT data in this experiment for all three age groups. For the 7-year-old group, approximately 3.9% (n=49) of correct responses were removed from all analyses. For the 9-year-old group, approximately 5.2% (n=65) of correct responses were removed and for the 11-year-old group approximately 5.4% (n=68) of correct responses were removed. Note that unlike in Experiments 1-3, no participants were replaced due to high numbers of false positives. For each of the three measures (recognition latency, accuracy and free recall) 2x3 mixed design ANOVAs were employed to include the encoding conditions (motoric vs. verbal) and the age groups (7-, 9- and 11-years).

Recognition latency

All participants from all age groups were included in the recognition latency analysis. The mean number of correct response times for each age group and condition is shown in 0.

: Mean recognition latencies (ms) for each encoding condition and age group

Age Group	**Method of encoding**	**Mean Recognition latency (ms)**
7-year-olds	*Motoric (SPT)*	*1336 (276)*
	Verbal (VT)	*1354 (225)*
9-year-olds	*Motoric (SPT)*	*1263 (283)*
	Verbal (VT)	*1286 (353)*
11-year-olds	*Motoric (SPT)*	*1196 (219)*
	Verbal (VT)	*1210 (263)*

(Standard deviations in parentheses)

An ANOVA conducted on these data failed to reveal either a significant main effect of encoding (F(1,132) = 1.10, p=.317) or a significant interaction (F(2,132) = 0.023, p=.977). There was, however, a significant effect of age (F(2,132) = 3.551, p=.031). Post hoc tests did not reveal a significant difference between the 7- and 9-year-old children; Tukey HSD = 70.24, p=.381, SE=53.03. This was the same when comparing the 9- and 11-year-olds Tukey HSD = 71.07, p=.373, SE=53.03. Perhaps unsurprisingly there was a significant age effect between the younger, 7-, and the older 11-year-old Tukey HSD = 141.31, p=.021, SE=53.03.

Recognition accuracy

All participants from all three age groups were included in the recognition accuracy analyses. The mean number of hits (items correctly recognised as old) for each condition and age group is shown in 0.

: Mean number of hits for each encoding condition and age group

Age Group	Method of encoding	Hits
7-year-olds	*Motoric (SPT)*	*8.11 (2.57)*
	Verbal (VT)	*6.91 (2.24)*
9-year-olds	*Motoric (SPT)*	*8.64 (2.28)*
	Verbal (VT)	*7.69 (2.64)*
11-year-olds	*Motoric (SPT)*	*9.22 (1.96)*
	Verbal (VT)	*7.82 (2.04)*

(Standard deviations in parentheses)

The ANOVA revealed a highly significant main effect of encoding where significantly more items encoded by performance were accurately recognised than those encoded by verbal repetition ($F(1,132) = 32.43$, $p<.001$). Although no significant interaction was found ($F(2,132) = 0.381$, $p=.684$), a significant main effect of age group was observed ($F(2,132) = 3.081$, $p=.049$).

Post hoc tests revealed no significant difference between the 7- and 9-year-old children; Tukey HSD = -0.66, p=.252, SE=0.41. Similarly, there was no significant difference between the 9- and 11-year-olds Tukey HSD = -0.36, p=.665, SE=0.41. There was, however, a significant difference between the younger and older children where the 11-year-olds performed better than the 7-year-olds (Tukey HSD = -1.01, p=.038, SE=0.41).

Free recall

All participants were included in the free recall analyses, including those who failed to correctly recall any of the targets. The mean number of items correctly recalled for each condition is shown in 0.

: Mean number of targets recalled for each encoding condition and age group

Age Group	Method of encoding	Targets Recalled
7-year-olds	*Motoric (SPT)*	*3.76 (2.65)*
	Verbal (VT)	*2.69 (1.68)*
9-year-olds	*Motoric (SPT)*	*5.02 (2.71)*
	Verbal (VT)	*3.20 (1.95)*
11-year-olds	*Motoric (SPT)*	*6.02 (2.73)*
	Verbal (VT)	*4.04 (2.58)*

(Standard deviations in parentheses)

The ANOVA for this data revealed a highly significant main effect of encoding where significantly more items encoded by performance were recalled than those encoded by verbal repetition ($F(1,132) = 33.45$, $p<.001$). Although there was no reliable interaction ($F(2,132) = 1.13$, $p=.325$), a highly significant main effect of age group was observed ($F(2,132) = 11.40$, $p<.001$).

Post hoc tests revealed either significant or marginally significant differences between the three age groups. First, the 7- and 9-year-old children were found to exhibit a marginally significant age effect; Tukey HSD = -0.89, p=.050, SE=0.38. This was also evident for the 9- and 11-year-olds; Tukey HSD = -0.92, p=.040, SE=0.38. Unsurprisingly, there was a reliable difference between the younger and older children where the 11-year-olds performed considerably better than the 7-year-olds (Tukey HSD = -1.81, p<.001, SE=0.38).

4.2.2.3 Test Battery Results

BPVS

For each of the age groups, the mean, range and median descriptive statistics for BPVS standardised scores are shown in 0. Median scores on the BPVS were used to analyse whether or not BPVS performance had any effect on SPT performance (c.f. Experiments 2 and 3) and prospective memory performance. As in the previous experiments, any participants whose mean score matched the median were removed from median split analyses. This involved the removal of two, two and three participants for the 7-, 9- and 11-year-old groups respectively.

: Standardised BPVS descriptive data for each age group

	7-year-olds	**9-year-olds**	**11-year-olds**
Mean	94.89 (9.27)	94.40 (11.24)	90.56 (14.03)
Range	76 - 114	71 - 119	60 - 126
Median	95	93	89

(Standard deviations in parentheses)

0 illustrates how the median split groups differed with respect to mean BPVS performance.

: Mean BPVS performance for low and high groups.

	High BPVS Score Group		**Low BPVS Score Group**	
Age group	*Mean*	*N*	*Mean*	*N*
7-year-olds	103.10 (6.11)	20	87.41 (4.86)	22
9-year-olds	104.40 (7.57)	20	85.50 (5.88)	22
11-year-olds	101.23 (9.89)	22	79.52 (8.77)	21

(Standard deviations in parentheses)

Two 2 x 3 mixed design ANOVAs were conducted for each age group, both using BPVS group and PM encoding condition as the between-subjects factors. Consistent with previous analyses from Experiments 2-3, the first ANOVA used participants' recognition accuracy and the second recall performance as the respective dependent variables. Recognition latency was not used because it has been found to be an uncommon and ineffective measure of the SPT effect.

SPT Data + BPVS

: 7-year-old mean SPT recognition accuracy and recall performance for low and high BPVS performance groups

BPVS Performance	**SPT Performance Measure / Encoding Condition**			
	Recognition Accuracy		*Recall*	
	SPT	VT	SPT	VT
Low	8.09 (2.16)	6.68 (2.06)	3.82 (2.42)	2.45 (1.97)
High	8.25 (2.77)	7.05 (2.61)	3.10 (2.51)	3.05 (1.23)

(Standard deviations in parentheses)

7-year-old age group

The data for the recognition accuracy measure (see 0) indicates that those with relatively higher BVPS appeared to accurately recognise more material than those with lower BPVS. Moreover, there also appears to be a trend for more accurate performance for material enacted at encoding (M=8.17) compared to that verbally encoded (M=6.86). However, the analysis revealed no main effect of BPVS and no interaction (both Fs<1) although an expected significant main effect of encoding was revealed; F (1,40) = 12.936, p=.001. Therefore, although there are some interesting trends, overall these analyses suggest that BPVS performance did not appear have any effect on the SPT recognition accuracy measure in this sample of 7-year-olds.

For the recall measure, the data are unclear because although overall more material was recalled when encoded by performance (M=3.48) than by verbal repetition (M=2.74) this difference was not reliable; F (1,40) = 2.553, p=.118. This is unexpected, particularly because only two participants were removed due to matching median scores. There was no reliable main effect of BPVS (F<1) and no interaction, F (1,40) = 2.204, p=.145, indicating very little relationship between recall performance and BPVS in this group of 7-year-olds. Interestingly, a marked trend was identified in the recall means for the SPT effect to be greater in children with lower than for children with relatively higher BPVS performance.

This is in contrast to trends observed in Experiments 1-3 in which participants exhibiting high verbal comprehension / intelligence tended to show better recall for SPT material.

: 9-year-old mean SPT recognition accuracy and recall performance for low and high BPVS performance groups

BPVS Performance	**SPT Performance Measure / Encoding Condition**			
	Recognition Accuracy		*Recall*	
	SPT	VT	SPT	VT
Low	8.32 (2.42)	7.14 (2.88)	4.91 (2.52)	3.09 (2.07)
High	9.15 (2.23)	8.25 (2.43)	5.30 (3.05)	3.55 (1.76)

(Standard deviations in parentheses)

9-year-old age group

Similar to the 7-year-old data, the accuracy data (0) indicate that children with relatively higher BVPS appeared to accurately recognise more material than those with low BPVS. Moreover, there also appears to be a trend for more accurate performance for material enacted at encoding (M=8.71) compared to that verbally encoded (M=7.67). The results of the analysis were also consistent with the 7-year-old data: a significant effect of encoding, $F(1,40) = 7.176$, $p=.011$, no reliable effect of BPVS, $F(1,40) = 2.103$, $p=.155$, and no interaction ($F<1$). Consistent with the previous analyses, this finding suggests that BPVS does not affect SPT performance.

For the recall measure, the data suggest two things. First that children classed as having relatively low BPVS recalled less material than those classed as having higher BPVS and second that, overall, material encoded through enactment (M=5.10) was recalled better than that encoded through verbal repetition (M=3.31). The ANOVA conducted on these data revealed a reliable main effect of encoding, $F(1,40) = 10.085$, $p=.003$, in the absence of a reliable effect of BPVS or interaction (both $Fs<1$), indicating little correspondence between recall performance and BPVS in this group of 9-year-olds.

: 11-year-old mean SPT recognition accuracy and recall performance for low and high BPVS performance groups

BPVS Performance	**SPT Performance Measure / Encoding Condition**			
	Recognition Accuracy		*Recall*	
	SPT	VT	SPT	VT
Low	9.00 (2.05)	8.14 (1.82)	5.33 (2.87)	3.43 (2.62)
High	9.23 (1.88)	7.64 (2.01)	6.68 (2.61)	4.68 (2.51)

(Standard deviations in parentheses)

11-year-old age group

As can be seen from 0 above, the 11-year-old accuracy data appears to be unclear when divided into higher and lower BPVS groups. If the data are examined irrespective of BPVS condition, however, the trend is identical to that found for the other age groups where material encoded through enactment (M=9.12) is more accurately recognised compared to information encoded through verbal repetition (M=7.88). This difference was confirmed by the ANOVA which revealed a reliable main effect of encoding, F (1,40) = 14.202, p=.001, in the absence of a reliable effect of BPVS, F (1,40) = 0.079, p=.780, or interaction, F (1,40) = 1.276, p=.265. This finding suggests once more that BPVS performance does not affect SPT performance.

Finally, for the recall measure, close inspection of the data suggests a difference between encoding methods (SPT M = 6.02; VT M = 4.07) and also between the BPVS groups (low M = 8.76; high M = 11.36). The ANOVA uncovered a highly significant main effect of encoding, F (1,40) = 16.551, p<.001, with superior SPT, and a marginally reliable effect of BPVS, F (1,40) = 3.982, p=.053, with high BPVS having better overall recall, but no interaction (F (1,40) = 0.010, p=.921). In slight contrast to the previous analyses with younger age groups, this finding indicates that there could be a relationship between overall recall performance and BPVS, certainly in this group of 11-year-olds, but not on the size of the SPT effect.

Prospective Memory Data + BPVS

Initially a 2 x 3 mixed design ANOVA analysis was conducted for each age group separately using BPVS group (high versus low) and PM encoding condition (motoric versus verbal versus visual) as the between-subjects factors and proportional PM performance (as used in analysis 2 from 4.2.2.1) as the dependent variable. However, these revealed only one significant difference with respect to BPVS groups in the 7-year-olds, $F(1,36) = 9.108$, $p=0.005$, where those classed as having high BPVS ($M = 0.52$) performed better on the prospective memory task (irrespective of encoding modality) compared to those classed as having low BPVS ($M = 0.16$).

Following this, an additional ANOVA was conducted that collapsed the data across all the age groups (see 0). Using these data, a significant effect of BPVS ability was revealed, $F(1, 121) = 3.981$, $p=.048$, but no main effect of prospective memory condition or an interaction ($Fs<1$). Looking more closely at the data, those children classed as having low BPVS appeared to perform more poorly ($M=0.4019$) than those classed as having high BPVS ($M=0.5544$).

: Prospective memory performance for low and high BPVS performance groups

BPVS Performance	**Prospective memory condition**		
	Motoric	Verbal	Visual
Low	0.51 (0.46)	0.34 (0.43)	0.40 (0.44)
High	0.53 (0.43)	0.50 (0.44)	0.65 (0.39)

(Standard deviations in parentheses)

This confirms the previous findings that across the age groups there was no effect of encoding modality and an effect of BPVS in the youngest group only, suggesting that verbal comprehension has little effect on prospective memory.

TEA-Ch

Mean age-scaled (standardised) scores for each subtest across age groups are summarised in 0. It should be noted that these data are not discussed further here but used later to investigate the effect of executive functions on prospective memory performance (see Chapter 6).

: Mean age-scaled (standardised) scores for each subtest by age group

	Age group		
	7-year-olds (n=45)	*9-year-olds (n=45)*	*11-year-olds (n=45)*
Sky Search	*8.12 (3.18)*	*9.02 (2.40)*	*9.07 (2.69)*
Sky Search DT	*4.93 (3.80)*	*6.66 (3.60)*	*6.41 (3.00)*
Opposite Worlds	*8.37 (2.27)*	*8.37 (2.45)*	*9.21 (2.81)*

(Standard deviations in parentheses)

4.2.3 Discussion

The main purpose of this Experiment was to explore the benefits of different prospective memory task encoding modalities for young children prospective remembering. Measures of verbal comprehension and executive functioning were also included to investigate whether or not they affect performance on the prospective memory task.

4.2.3.1 Memory for delayed intentions in children

The data from the prospective memory task was analysed in three ways. First, when recall of the instruction was analysed using the post-test questionnaire, an age effect was uncovered where the older 11-year-olds remembered to perform the prospective task more often than both the younger 7- and 9-year-old groups. This benefit was independent of encoding modalities which were found to have no significant effect across the three age groups.

The second analysis examined performance using a proportional measure for each encoding condition across the three age groups. Similar to the first analysis, an age effect was revealed which occurred irrespective of encoding condition. Moreover, the 11-year-old group exhibited the best PM performance compared to the two younger groups whose performance was found to be very similar. Tentatively, this might suggest that analogous mechanisms are employed by both of these age groups and that an improvement in prospective memory occurs at around age 11.

Following removal of those participants who failed to recall the target words and related actions in the post-test questionnaire, the final analysis (using the proportional measure of PM performance) revealed only that PM performance by the 7-year-old group substantially differed from that of the 11-year-old group, again irrespective of encoding condition. In conjunction with the previous findings, this suggests that although there is a difference in prospective memory performance between these groups, it is unclear how the 9-year-old performance fits in. On the one hand, it could be that their performance closely matches that of the 7-year-olds, indicating the employment of similar strategies or it could be that performance is closer to that of the 11-year-olds. Either way, it would be of benefit to explore prospective remembering in this age group further.

When analysing what each group remembered (post-test) from the prospective memory instruction, two main differences were apparent. First, the 7-year-olds remembered less about the task compared to the 11-year-olds. Moreover, those participants in the verbal encoding condition (i.e. participants who were not given any cues) remembered less than those participants in the visual encoding condition (i.e. participants who were shown written representations of the targets) for questionnaire analysis.

These results are particularly interesting in the context of Passolunghi, Brandimonte and Cornoldi's (1995) findings. In their first two experiments, Passolunghi *et al* found that children's prospective performance benefited from visual encoding but only in the younger age group (7-8-year-olds). The older age group (10-11-year-olds) showed better performance following motoric encoding. Notwithstanding this however, in Experiment 1 they failed to observe a reliable difference between the verbal (M = 3.50) and visual (M = 2.70) conditions. The reader is reminded of procedural differences between the Passolunghi *et al* experiment and the methodology employed here: Where Passolunghi *et al* used a line-drawing of the target word for the *visual* condition, Experiment 4 involved presentation of a printed word. Passolunghi *et al* employed this design for their *verbal* condition whereas the Experiment 4 *verbal* condition involved describing the procedure to the participant. (Recall that this change was made to avoid confusion between visual and pictorial encoding). With these differences in mind, it could be argued that it would be unfair to compare the two sets of data.

Nevertheless, although the current Experiment failed to reveal any differences in the benefits of specific encoding modalities for performance in any of the three age groups, it is interesting to note that a visual cue was shown to have some benefit for children's retention of the prospective memory instructions (when analysing the post-test questionnaire data), perhaps because the target presented at study is identical to that seen at test. This benefit, however, was present for all age groups and not specific to the younger children.

Although the instructions used here for motoric encoding were similar to those reported by Passolunghi *et al*, there was no support here for their observation of the benefits of motoric encoding in this group of 11-year-olds or, indeed, in any of the age groups. One possible reason for this finding could relate to motoric encoding as a strategy for prospective remembering. It is possible that the children in the current group of 11-year-olds had not yet developed the necessary cognitive or metacognitive skills to successfully utilise motoric encoding as a suitable strategy for remembering to perform an intended action. This is despite the fact that they do demonstrate the SPT effect i.e., an advantage for enacted over verbally encoded information in both recall and recognition accuracy. This possibility is investigated in greater detail in Chapter 6 where executive functioning is examined with respect to prospective memory performance. The stability of these findings is explored in the following chapter.

Another reason why this effect was not observed (particularly in the older 11-year-old group) could relate to the verbal materials, where participants in each encoding condition closely associated the target words with the ongoing "reading game" task. Moreover, the learning phase where the prospective memory instruction was encoded might not have made the target words distinct enough as targets. Nevertheless, the targets were responded to in each condition. Interestingly, closer inspection of each analysis from the three age groups, indicates that the verbal encoding condition was less effective (but not significantly so) than the other two. This is similar to the results from Passolunghi *et al* who essentially found the strongest benefits for visual and motoric encoding of the prospective instruction for the younger and older groups, respectively.

The next section deals with the results from the additional measures and their relationship to prospective memory performance.

4.2.3.2 The effect of enacting material at encoding and of verbal comprehension

The Subject-Performed Task

As in the previous three experiments, the recognition accuracy and recall results were of primary interest (although recognition latency was also measured at test). For both of these measures, material enacted at encoding was retained better than material encoded by verbal repetition. Interestingly, when overall material retained was collapsed across the two encoding conditions, post hoc analyses revealed some age effects where the older 11-year-olds were outperforming the younger 7-year-olds (with respect to recognition latency and accuracy) and the 11-year-olds were outperforming the 9-year-olds who showed better performance than the 7-year-olds (recall performance). This observation likely relates to the inclusion of the VT material but might also highlight what Bäckman, Nilsson and colleagues (Bäckman & Nilsson 1984; 1985; Bäckman, Nilsson & Chalom 1986) referred to as the strategic or effortful component of SPT encoding (see 1.2.2). Nevertheless, we should be cautious in subscribing to this concept as Bäckman, Nilsson and colleagues were never specific as to how the non-strategic and strategic processing components differed. However, it is interesting to uncover a developmental effect.

Returning to the original observation – a reliable SPT effect in each age group in the absence of a reliable interaction between age and encoding modality – it would appear that there is consistency with Cohen and Stewart's (1982) suggestion that the SPT effect is automatic in nature. Moreover, the finding here relates to two measures of retention (recognition accuracy and free recall), building on the free recall data from Cohen and Stewart's original experiment. Nevertheless, it is interesting to note that other research with adult participants has also uncovered the effect with recognition latency (e.g. Freeman & Ellis 2003a). One possible reason for this discrepancy could relate to Bäckman, Nilsson *et al*'s concept of spontaneous recoding (see 1.2.2.) whereby younger and older adults differ in their use of strategies to encode multimodal information. Perhaps the development of these strategies could relate to quicker accessibility of SPT compared to VT material.

The British Picture Vocabulary Scale Measure

The scores across the three age groups indicated a general improvement in age although this is unusual because each participant's score was adjusted depending on their age. In Experiments 2 and 3, analyses were conducted to investigate whether BPVS performance had any effect on SPT performance. Upon repeating this analysis with the three age groups, verbal comprehension was found to have no effect on any of the SPT performance measures, nor did it mediate the SPT effect in any of the age groups. This is consistent with the findings from Experiments 2-3 in suggesting that participants with low verbal comprehension performed no worse on the SPT paradigm than those with high verbal comprehension.

The current experiment also focused on the relationship between verbal comprehension and prospective memory performance. It was found that those 9- and 11-year-old participants with low verbal comprehension performed comparably to those with relatively high verbal comprehension. Interestingly, the 7-year-old children with high verbal comprehension appeared to perform better at the task compared to those with low verbal comprehension. It could be argued that those children with relatively high verbal comprehension have a greater vocabulary and therefore are able to recognise and comprehend more words. With this in mind, perhaps they are able to perform the ongoing reading task more efficiently than children with lower verbal comprehension who may struggle more with the task. If this is the case, then perhaps the children with lower verbal comprehension attribute more resources to the reading task, resources that could be used for identifying and responding to the prospective targets.

A possible reason why this pattern was not seen in the older age groups could relate to the words used for the ongoing task. The stimuli were specifically selected for use with young children i.e., early age of acquisition and within their reading competencies. The older children, therefore, may have experienced less difficulty reading the words and be able to attribute more resources to the prospective element of the task: Hence the performance differences between the younger and older groups.

With reference to other related research, Kerns (2000) carried out a number of correlations between prospective memory performance and executive function measures. Amongst these measures, Kerns included verbal and nonverbal components of the KBIT intelligence test. Her findings are in line with those found here – no significant correlations between the prospective memory measures and either the verbal or nonverbal components of the KBIT intelligence test. This was true for the whole sample of 80 participants, collapsed by age group. It would be interesting to see whether this correlation was true for her younger (~6 years) versus older participants.

4.2.3.3 Summary

The findings from this experiment have extended the investigation of the development of memory for actions by focusing on children aged 7-11-years-old and also examining whether the encoding modality of a prospective memory instruction could aid performance. Although a significant improvement in prospective memory performance over the three age groups was observed, this improvement was not influenced by the modality in which the instruction was encoded. Moreover, there did not appear to be any specific encoding modality benefit for any of the age groups. These findings therefore are in contrast to those obtained by Passolunghi, Brandimonte and Cornoldi (1995).

Focusing on the SPT results, the findings from the present experiment revealed a significant SPT effect, independent of age, consistent with Cohen and Stewart's (1982) proposal that the SPT effect is supported by automatic processes. Finally, verbal comprehension (measured using BPVS) did not generally appear to play a significant role in either PM or the SPT task performance.

At this stage, it would appear that young children's memory can benefit from action enactment at encoding, but only for retrospective memory performance – the SPT task. The next chapter leads directly on from this issue by using a modified design for the Prospective Memory task. First, a new set of materials was constructed – pictures rather than words – and second, only two instruction encoding conditions were examined: Visual and motoric. In addition to these changes, only two age groups were included: The 9- and the 11-year-olds. The reason for including just these two groups relates back to the findings of the current Experiment where, when all participants were included, the 11-year-olds performed better than the 9-year-olds. In contrast, when participants who failed to recall task instructions were excluded then this difference was marginal although the means were in the expected direction. It is therefore interesting to see whether these findings are replicated under different conditions, or if there are specific differences relating to the encoding modality of the prospective instruction. It also provides an opportunity to explore the SPT effect in 9-year-olds and examine the stability of the findings reported in this chapter, in view of the non-reliable difference reported in Chapter 3.

CHAPTER 5:

THE DEVELOPMENT OF PROSPECTIVE MEMORY IN 9- AND 11-YEAR-OLD CHILDREN

5.1 INTRODUCTION

The experiment reported in the previous chapter was designed to explore the effect of manipulating the encoding modality of the prospective memory instruction on prospective memory performance. This was investigated in three groups of young children aged 7-, 9- and 11-years-old. Although reliable age effects in prospective remembering were found between the younger 7- and the older 11-year-olds and between 9 and 11 year olds, there was no clear benefit of the encoding modality in which the PM instruction was presented for any of the three age groups. However, closer inspection of the mean data for each group indicated that the 7-year-olds appeared to benefit most from visual or motoric encoding, the 9-year-olds from motoric encoding and the 11-year-olds from visual encoding.

A measure of verbal comprehension, the British Picture Vocabulary Scale, was employed to investigate the potential influence of verbal comprehension on prospective memory performance. The results, however, were generally inconclusive. Only the youngest group of children showed a reliable effect such that children with relatively high verbal comprehension performed better on the PM task than those with low verbal comprehension[20]. Interestingly, this pattern was also observed, and found to be significant, when the data were collapsed across the three age groups. Therefore it would seem that for this group of

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[20] In the 9-year-old group, although this pattern was displayed in the mean data, the difference was unreliable. For the 11-year-old data, on the other hand, the means for the low and high BPVS groups differed by less than 0.05 indicating that verbal intelligence had very little influence on this group.

participants, prospective memory performance was related to verbal comprehension where those participants who remembered more intentions tended to have greater verbal comprehension.

Lexical stimuli, consistent with Passolunghi, Brandimonte and Cornoldi (1995), were used in Experiment 4. However, whereas Passolunghi *et al* used a line drawing of the target for their visual encoding condition, a printed word was used in the same condition in Experiment 4 (the verbal encoding condition used by Passolunghi *et al*). This manipulation was used in an attempt to avoid a cue-target mismatch where the cue and target are non-identical. One aim of the current experiment is to investigate whether using pictorial rather than lexical stimuli has any additional benefit on prospective memory performance. One potential drawback with applying this modification relates to the work of Hitch, Woodin and Baker (1989) who found that children around the age of 11 years tend to adopt a strategy of verbally recoding pictures (using the phonological loop). They argued that the younger, 5-year-old children in their study were unable to employ this strategy. Instead, they were forced to rely on purely visual characteristics. However, in the present experiment, two points are worth highlighting. First, the youngest children are aged 9 years and second, the design of the task is significantly different: a *prospective* rather than a *retrospective* memory task.

Passolunghi *et al* also found that younger (7-8 years) children benefited from visual encoding of the prospective memory cue i.e., being presented with an auditory instruction together with a visual representation of the target in the form of a line-drawing. The reader is reminded that the test stimuli were all lexical and therefore there was little correspondence between the pictorial target (line-drawing) and the actual item presented during the ongoing task (written word). This is overcome both in the previous experiment and in the current study where the target presented in the visual encoding condition matches that presented during the ongoing task: word-word in Experiment 4, picture-picture in the present experiment.

The experiment described in this Chapter is a second attempt to replicate Passolunghi, Brandimonte and Cornoldi's (1995) findings with three new modifications. First, the design is reduced to two encoding modality conditions, motoric and visual, although the procedures remain relatively loyal to those described in the previous chapter. Second, each participant was presented with one pair of target pictures rather than words. Third, only two age groups are tested: 9- and 11-year-olds.

With these changes in place it was expected that a new set of results would be observed, particularly with respect to the two encoding conditions. Based on the results of Passolunghi *et al* (1995), together with those of Hitch, Woodin and Baker (1989), it was expected that visual encoding would improve the younger children's prospective memory and motoric encoding would enhance older children's performance on the task.

Apart from the modifications mentioned, the overall design is consistent with that described in the previous chapter. Each participant was asked to carry not only the prospective memory task but also the Subject-Performed Task, two measures from the Test of Everyday Attention for Children (TEA-Ch) battery and the British Picture Vocabulary Scale (BPVS). Expectations for these measures were consistent with those stated in the previous chapter due to the fact that the principles behind the prospective memory design remained the same. The reader is reminded that analyses investigating the relationship between measures of executive function and prospective memory are presented in Chapter 6. This allows data from the current and the previous experiments to be amalgamated into a series of related analyses with more experimental power.

5.2 EXPERIMENT 5

5.2.1 Method

5.2.1.1 Participants

For both age groups (8-9- and 10-11-year-olds), thirty participants were recruited from two primary schools (Katesgrove Primary and Loddon Junior) in Reading. The 8-9 year-olds ranged between 8 years 2 months and 9 years 9 months, with a mean age of 8 years 9 months, and fifteen boys and fifteen girls. The 11-year-olds ranged between 10 years and 11 years 1 month, with a mean age of 10 years 6 months, and sixteen boys and fourteen girls. All participants were tested individually and assigned to one of two experimental conditions, *motoric* or *visual* encoding modality.

5.2.1.2 Materials

The materials used in this experiment were identical to those used in Experiment 4 with the exception that line drawings were used rather than words.

All participants were seated in front of the same Toshiba Tecra 8000 laptop computer used in all previous experiments. Similar to Experiment 4, the task involved presenting participants with a set of five stimuli on each of forty trials. Importantly, on this occasion the stimuli were line drawings and not words. For each set, the child was asked to identify the line drawings as quickly and accurately as possible and respond accordingly upon presentation of a target line drawing.

In line with Passolunghi *et al* (1995) the trials consisted of four blocks of ten trials each with a rest between blocks. The line drawing sets were selected from a pool of fifty images and randomly allocated to sets of five (see Appendix 11 for examples). Some of these line drawings were taken from the Snodgrass and Vanderwart (1980) collection and some from an online collection (*The International Picture Naming Project*). The line drawings adhered to the same criteria as those for the words in Experiment 4. The majority of the pictures mapped onto the words used in Experiment 4 although there were some instances where words could not be easily transferred into easily discriminable pictures and other instances where an appropriate line drawing was unavailable. For both encoding modalities, a different instruction script was employed (Appendix 12). For the *Visual* condition printed copies of the paired target line drawings were required to present to the participants.

For the test phase, the experimenter used a score sheet similar to that used in Experiment 4. The experimenter wrote notes and a pseudo-score were written on this to reinforce the picture-naming game concept. A post-test questionnaire, based on that used in Experiment 4, was also included to find out what each participant remembered of the task and, more importantly, whether they remembered the prospective instruction.

TEA-Ch Materials

Two tests were taken from the Test of Everyday Attention for Children (TEA-Ch) (Manly *et al* 2001) - *Sky Search* and *Opposite Worlds*. (See 3.4.2 for further details).

SPT Materials

Details of these materials were as described in section 3.2.1 of Experiment 1.

BPVS Materials

Details of these materials were as described in section 3.3.2 of Experiment 2.

5.2.1.3 Design

All participants undertook all four of the experimental tasks. The tasks were spread out over a single session in the following order: Prospective memory (PM), TEA-Ch, SPT, BPVS. For the PM task, target drawing pair presentation and condition were counterbalanced across participants: in each age group fifteen children were exposed to the motoric condition and fifteen to the visual condition. Within each group of fifteen children, five were presented with the line drawings, “*Boat*” and “*Chair*”, five, “*Bike*” and “*Cup*” and five, “*Bucket*” and “*Tree*”.

Counterbalancing measures for the SPT task employed in previous experiments were also applied here.

5.2.1.4 Procedure

Following parental consent, the children were all seen individually for a single session. Tests were always completed in a fixed order, described above. The total duration of testing was approximately 40 minutes. The testing sessions usually took place in the school library where the conditions were quiet and free from distraction. Auditory materials were presented using a conventional tape player, set to a comfortable volume. Each child was asked for both verbal and written confirmation for participation in the experiment. All of the participants endorsed both forms of consent.

The PM Procedure

All participants were given oral instructions explaining that the PM task was a game to look at picture-naming ability. They were told that they would be presented with a series of pictures, five at a time, on the computer screen and that they should attempt to name these pictures, out loud, as accurately and quickly as possible. This latter point was emphasised as exposure to each trial only lasted for seven seconds[21]. The trials consisted of four blocks of ten trials, where each trial consisted of five line drawings selected from the pool. Within each condition, each of the two target drawings appeared four times each, twice per block, giving eight opportunities in total for a prospective memory response. Participants were not made aware of this information.

The encoding modality for each condition was manipulated as follows: In the *Motoric* condition, the instructions were given in a purely verbal form: Each participant performed the associated actions (e.g., pretending to *paint a boat* and

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[21] In Experiment 4, the presentation time was five seconds for each word set. However, this was deemed too brief for this experiment. In initial pilot tests, even slightly older children experienced some difficulty identifying all of the pictures within five seconds. On the other hand, too much time would give the participants greater opportunity to identify the targets. Seven seconds was therefore used as a compromise.

pick up a chair). Immediately after the participant had performed both actions, the experimenter asked him/her to take part in an articulatory suppression task. This acted as a mini-retention interval and also to prevent subvocal rehearsal of the targets, under the assumption that this age group might tend to try and re-code the motoric instruction into a verbal code (c.f. Hitch, Woodin and Baker 1989). In the articulatory suppression task, introduced as a counting game, the child was asked to count from one to ten continuously until the experimenter asked him/her to stop (after approximately thirty seconds). The experimenter pointed out that the child should try to count roughly two numbers every second and, to help, started off the counting and encouraged the child to continue at that rate. All of the children in the *Motoric* condition took part in this.

Children in the *Visual* condition were shown printed copies of the two target drawings and asked to repeat a description of the associated actions (e.g. "*Push the bike*" and "*Turn over the cup*") if they saw them during the game. Therefore, unlike the corresponding condition from Experiment 4, participants here were asked to verbally describe, rather than perform the associated actions. Immediately after they had done this, the experimenter asked participants to partake in a motor suppression task. This, introduced as an air-drawing game, required the participant to draw an imaginary circle in the air with his/her finger continuously until the experimenter told the participant to stop (also after approximately thirty seconds). This acted as both a retention interval and as a means of preventing motoric rehearsal of the visually presented instructions. All of the children in the Visual condition undertook this task.

After ensuring that the participant fully understood what was required of him or her, the experimenter began a training activity. During this activity, a series of ten trials were presented. It is important to note that the original instructions were not reiterated to the participant: The experimenter simply asked the child to commence the task. Also, as in Experiment 4 and in line with Passolunghi *et al* (1995), no targets appeared during this activity.

After the tenth trial, the sentence, "*End of block press space bar to continue*" was shown indicating to the experimenter that the training activity was over. At this point, the experimenter explained to the participant that the computer needed to do something before the picture-naming game could continue and that whilst waiting, s/he would take part in another game. As in Experiment 4, the *Sky Search* task from the *TEA-Ch* battery (see below) was employed to extend the retention interval within the PM task, designed to induce prospective forgetting (Einstein & McDaniel 1990; McDaniel & Einstein 1993). Before commencing the task, it was emphasised to the participants that they would return to the PM task within a few minutes.

After the *Sky Search* task was completed (about three minutes), the participant's attention was redirected to the picture-naming game. The experimenter checked that the participant was happy to continue and recommenced the PM task.

After the participant had completed all forty trials in the PM task, a message appeared on the screen to acknowledge the end of the game. At this point the experimenter administered the post-task questionnaire and asked the participant a series of questions to ascertain what s/he had remembered from the task. As in Experiment 4, these questions were presented in a hierarchical form, gradually providing more cues about the experimental instructions, specifically the prospective memory task instructions. First, the experimenter simply asked, "*Can you remember what it was that you had to do in this game?*" If the participant correctly recalled the entire procedure including the target drawings and their respective actions/statements, the experimenter noted a maximum score of fourteen. If, however, the participant failed to mention either of the target drawings or their actions, the experimenter then asked, "*Do you remember that there were some pictures that I asked you to look out for?*" Successful recall of both target drawings and their actions/statements at this point resulted in a score of twelve. This continued in subsequent questioning, where more information was betrayed and the overall score reduced. If the child got as far as the final question, the experimenter would explain the whole procedure and ask whether or not s/he had remembered to carry out the prospective task. Thus it was possible for a participant to obtain a score of zero if they failed to recall any details of the PM task procedure. On completion of the questionnaire, the experimenter moved onto presenting the child with the Opposite Worlds component of the *TEA-Ch* battery:

The TEA-Ch Procedure

The procedures for both the first (*Sky Search*) and second (*Opposite Worlds*) TEA-Ch tests were identical to those described in section 3.4.2 of Experiment 3.

The SPT Procedure

Details for this procedure can be found in section 3.2.1 of Experiment 1.

The BPVS Procedure

The procedure for the BPVS task was identical to that described in section 3.3.2 of Experiment 2.

5.2.2 Results

5.2.2.1 Prospective Memory Task

Consistent with Experiment 4, analysis of the data from the post-test questionnaire is provided before the performance data.

For each of the six items in the questionnaire, a score out of 2 was given. Therefore, each individual's score was out of a maximum of 12. These scores were then categorised using a Likert scale similar to that described in Experiment 4, where '**0**' indicated nothing was remembered about the prospective memory task, '**1**' where target pictures were remembered from the instruction but not the actions, '**2**' where actions but not the target pictures were remembered from the instruction and '**3**' where the entire prospective instruction was remembered. 0

provides a summary of each age group post-test memory for the prospective memory task instructions.

: What each age group remembered, based on their questionnaire responses

Age Group	Remembered	N
9-year-olds	*0*	1
	1	3
	2	0
	3	26
11-year-olds	*0*	0
	1	2
	2	2
	3	26

In line with Experiment 4, a 2 x 2 between-subjects ANOVA focused on PM performance data using the post-test questionnaire measure. 0 displays these data.

: Amount of information remembered for

each prospective memory condition and age group.

Age Group	PM Condition	Mean	SD	N	
9-year-olds	*Motoric*	2.80	0.77	15	
	Visual	2.60	0.83	15	
11-year-olds	*Motoric*	2.87	0.35	15	
	Visual	2.73	0.70	15	

However, the analysis failed to reveal any reliable main effects of either age group or encoding condition, nor a reliable interaction (Fs < 1). This is in contrast to the findings from Chapter 4 where a main effect of age was revealed. This will be discussed further at the end of this Chapter.

0 shows prospective memory performance for each age group in each encoding condition, measured by the mean proportion of prospective memory targets that were given a correct response.

: Mean performance (proportional total targets responded to) for each prospective memory condition and age group

Age Group	**PM Condition**	**Mean**	**SD**	**N**	
9-year-olds	*Motoric*	0.775	0.407	15	
	Visual	0.767	0.323	15	
11-year-olds	*Motoric*	0.783	0.349	15	
	Visual	0.617	0.490	15	

A 2 x 2 between-subjects ANOVA was performed on the performance data with encoding condition (motoric vs. visual) and age group (9- and 11-year-olds) as between- subjects factors. This analysis failed to reveal reliable main effects of either age group or encoding condition or the interaction between these variables (all Fs < 1). Nevertheless, there appears to be a trend in the 11-year-old group such that PM performance is better following motoric encoding (M=0.783) than after visual encoding (M=0.617). These data were re-analysed in a third ANOVA, following the removal of those participants who failed to recall the whole prospective phrase (e.g. "*Turn the key*") during the post-test questionnaire. As can be seen from the data in 0, this amendment resulted in one participant being removed. Interestingly, the removal of this participant appears to have impacted on the 9-year-old group data to produce a pattern similar to that of the 11-year-olds. Thus for all participants PM performance appears to be better after motoric than after visual encoding of the PM instruction.

: Mean performance for each prospective memory condition and age group, minus those participants who failed to remember both the words and actions.

Age Group	**PM Condition**	**Mean**	**SD**	**N**	
9-year-olds	*Motoric*	0.830	0.359	14	
	Visual	0.767	0.323	15	
11-year-olds	*Motoric*	0.783	0.349	15	
	Visual	0.617	0.490	15	

A final 2 x 2 between-subjects ANOVA, however, revealed results similar to those reported above: no reliable main effect of age group ($F < 1$) no main effect of encoding condition, $F(1,55)=1.311$, $p=.257$), and no interaction ($F < 1$). These results were similar to those found in Experiment 4, for these age groups, although it should be noted that here the previous, non-significant, difference appears to have been substantially reduced.

5.2.2.2 SPT Results

The trimming technique, described in Experiment 1, was applied here for both age groups. For the 9-year-old group, approximately 10.6% (n=89) of correct responses were removed from all analyses and for the 11-year-old group approximately 6.8% (n=57) of correct responses were removed. No participants were replaced due to high numbers of false positives. For each measure, paired-sample t-tests were used to investigate differences in accordance with all previous experiments.

Recognition latency

All participants from both age groups were included in the recognition latency analyses. The mean number of correct response times for each age group and condition is shown in 0.

: Mean recognition latencies (ms) for each encoding condition and age group

Age Group	**Method of encoding**	**Mean Recognition latency (ms)**
9-year-olds	*Motoric (SPT)*	*1405 (340)*
	Verbal (VT)	*1428 (358)*
11-year-olds	*Motoric (SPT)*	*1088 (178)*
	Verbal (VT)	*1135 (235)*

(Standard deviations in parentheses)

For the 9-year olds, there was no reliable difference between the latencies for the SPT versus VT conditions; t (28) = -0.513, p=0.612. This was the case also for the 11-year olds; t (29) = -1.133, p=0.266. Notwithstanding, it should be noted that the pattern of latencies is similar to that observed in Experiment 4 where latencies are shorter for material acted at encoding than to material that was verbally encoded i.e., in the expected direction.

Recognition accuracy

All participants from both age groups were included in the two recognition accuracy analyses. The mean number of hits (items correctly recognised as old) for each condition and age group is shown in 0.

: Mean number of hits for each encoding condition and age group

Age Group	Method of encoding	Hits
9-year-olds	*Motoric (SPT)*	*8.60 (2.47)*
	Verbal (VT)	*6.13 (2.69)*
11-year-olds	*Motoric (SPT)*	*9.50 (2.08)*
	Verbal (VT)	*8.13 (2.01)*

(Standard deviations in parentheses)

For the 9-year olds, a highly reliable difference was found where the number of hits for the SPT condition exceeded those for the Verbal VT condition; t (29) = 5.691, $p<0.001$. This difference was evident also for the 11-year old group; t (29) = 2.887, p=0.007.

Free recall

As in previous experiments, all participants were included in the free recall analyses, including those who failed to correctly recall any of the targets. The mean number of items correctly recalled for each condition is shown in 0.

: Mean number of targets recalled for each encoding condition and age group

Age Group	Method of encoding	Targets Recalled
9-year-olds	*Motoric (SPT)*	*7.37 (3.12)*
	Verbal (VT)	*3.03 (2.66)*
11-year-olds	*Motoric (SPT)*	*6.63 (2.77)*
	Verbal (VT)	*4.93 (3.28)*

(Standard deviations in parentheses)

For the 9-year olds, a reliable difference was found such that the number of targets recalled for the SPT condition exceeded those for the VT condition; t (29) = 5.286, $p<0.001$. This pattern was observed also for the 11-year old group, although in this instance the difference was less marked; t (29) = 2.115, p=0.043.

5.2.2.3 Test Battery Results

British Picture Vocabulary Score (BPVS)

For the 9-year old group, the BPVS scores ranged from 59 to 121 with a group mean of 100.43 (SD = 14.23). For the 11-year old group, the scores ranged from 71 to 124 with a group mean of 100.47 (SD = 12.61).

For both age groups, the mean, range and median descriptive statistics for BPVS are shown in 0. As in previous experiments, the median scores were used to analyse whether or not BPVS had any effect on SPT and PM performance. No participants were removed in the 9-year-old group but two were removed in the 11-year-old group due to scores matching the median following a median split on the BPVS data.

: BPVS descriptive data for each age group

	9-year-olds	**11-year-olds**
Mean	100.43 (14.23)	100.47 (12.61)
Range	59 – 121	71-124
Median	102	100

(Standard deviations in parentheses)

0 shows how the median split groups differed with respect to mean BPVS performance.

: Mean BPVS performance for low and high groups.

Age group	**Higher BPVS Score Group**		**Lower BPVS Score Group**	
	Mean	*N*	*Mean*	*N*
9-year-olds	110.8 (6.50)	15	90.7 (12.13)	15
11-year-olds	110.93 (7.14)	14	90.07 (8.33)	14

(Standard deviations in parentheses)

As in previous experiments, two 2 x 2 mixed ANOVAs were conducted for each age group, both using BPVS group and encoding condition as between-subjects factors. Consistent with previous experiments, the first ANOVA used participants' recognition accuracy and the second recall performance as the respective dependent variables.

SPT Data + BPVS

9-year-old age group

: 9-year-old mean SPT recognition accuracy and recall performance for low and high BPVS performance groups

BPVS Performance	**SPT Encoding Condition**			
	Recognition Accuracy		*Recall*	
	SPT	VT	SPT	VT
Low	8.00 (2.45)	4.80 (2.91)	7.60 (3.58)	2.47 (1.64)
High	9.20 (2.43)	7.47 (1.64)	7.13 (2.70)	3.60 (3.36)

(Standard deviations in parentheses)

The accuracy data for the 9-year-olds (0) suggests that the 9-year old children with relatively higher BVPS scores appeared to accurately recognise more material than those with lower BPVS scores. Moreover, there also appears to be a trend for more accurate performance for material enacted at encoding (M=8.60) compared to that verbally encoded (M=6.13). The ANOVA on these data revealed a highly reliable effect of encoding, $F(1,28) = 34.690$, $p<.001$, and BPVS, $F(1,28) = 6.308$, $p=.018$, in the absence of a reliable interaction, $F(1,28) = 3.066$, $p=.091$. Thus in contrast to the same analysis used in Experiment 4, this finding indicates that BPVS has some effect on SPT performance in this group of 9-year-olds such that the children with relatively high verbal comprehension were accurately recognising more targets than those with lower verbal comprehension. Although the interaction is obviously nonsignificant, a closer inspection of the mean data in 0 indicates a trend for a more marked SPT effect in those children with low BPVS compared to those with high BPVS. Overall, these data would appear to be another example where the SPT effect seems to be greater for the lower than for the higher BPVS group (c.f. the 7-year-olds from Experiment 4).

For the recall measure, the data are not so clear-cut. Nevertheless, they are consistent with those found in Experiment 4 where, although a highly reliable SPT effect was revealed, F (1,28) = 27.894, p<.001, this was not affected by BPVS scores (Fs<1 for both the effect of BPVS and the interaction). Therefore, for this group of 9-year-olds, there appears to be very little relationship between recall performance and verbal comprehension.

11-year-old age group

: 11-year-old mean SPT recognition accuracy and recall performance for low and high BPVS performance groups

BPVS Performance	**SPT Performance Measure / Encoding Condition**			
	Recognition Accuracy		*Recall*	
	SPT	VT	SPT	VT
Low	9.29 (2.16)	7.57 (2.14)	6.07 (1.86)	4.43 (3.34)
High	9.71 (1.98)	8.64 (1.95)	7.43 (3.30)	5.00 (2.94)

(Standard deviations in parentheses)

The 11-year-old mean recognition accuracy data suggest trends similar to those found for the 9-year-olds such that higher BPVS scores and motoric encoding appear to result in more accurate recognition. However, the ANOVA conducted on these data revealed only one reliable difference for encoding modality; F (1,26) = 7.685, p=.010. Neither the main effect of BPVS nor the interaction were reliable; F (1,26) = 1.594, p=.218 and F (1,26) = 0.409, p=.528, respectively. This finding is consistent with the results from the same analysis in Experiment 4 suggesting that verbal comprehension has little effect on SPT performance.

Finally, for the recall measure, the data suggests a similar pattern to that described by the accuracy data. The ANOVA on these data revealed a reliable main effect of encoding, F (1,26) = 7.311, p=.012, but no effect of BPVS, F (1,26) = 1.425, p=.243, and no interaction (F < 1). Interestingly, this result is *inconsistent* with that found in the same analysis for the 11-year-old group in Experiment 4 leaving some uncertainly as to the exact effect of verbal comprehension performance on the SPT paradigm, with respect to the free recall measure.

Prospective Memory Data + BPVS

In Experiment 4 a 2 x 2 mixed-design ANOVA using the data from all three age groups in a single analysis, was used to examine the effect of BPVS scores on prospective memory performance.

A summary of the prospective memory data, collapsed across age group, is shown in 0 where performance is the proportional measure displayed in 0.

: Prospective memory performance for low and high BPVS performance groups

BPVS Performance	Prospective memory condition	
	Motoric	*Visual*
Low	0.71 (0.39)	0.51 (0.44)
High	0.91 (0.27)	0.84 (0.33)

(Standard deviations in parentheses)

The data displayed here suggests that those children classed as having lower BPVS performance (M=0.61, SD=0.42) showed poorer performance on the prospective memory task compared to those children classed as having high BPVS performance (M=0.88, SD=0.30). Moreover, if we focus on the two BPVS groups individually, those children in the motoric encoding condition appear to perform better (i.e. correctly responded to more targets) than those children in the visual encoding condition.

The 2 x 2 mixed-design ANOVA revealed a significant effect of BPVS performance (F (1,54) = 7.789, p=.007) but no effect of encoding condition (F (1,54) = 1.960, p=.167) or an interaction (F (1,54) = 0.462, p=.500). Therefore, this suggests that those children who demonstrated low verbal comprehension had more difficulty with the prospective memory task compared to those who demonstrated high verbal comprehension.

TEA-Ch

The mean age-scaled (standardised) scores for each subtest across both age groups are summarised in 0. As noted earlier, these data are not discussed any further but reported later to investigate the effect of executive skill development on prospective memory performance (Chapter 6).

: Mean age-scaled (standardised) scores for each subtest by age group

	Age group	
	9-year olds (n=30)	*11-year olds (n=30)*
Sky Search	*9.20 (1.85)*	*10.17 (1.72)*
Opposite Worlds	*9.80 (2.20)*	*11.30 (1.75)*

(Standard deviations in parentheses)

5.2.3 Discussion

The main purpose of Experiment 5 was to build on and develop the findings from Experiment 4 to explore further the effects of manipulating encoding modality on prospective memory ability in young children. The ongoing task was changed from reading words to naming pictures to allow the inclusion of a visual encoding task that mimicked that used by Passolunghi *et al.*, while maintaining the link between the form in which the target was seen at study and test in this condition, unlike Passolunghi *et al.* Only 9- and 11-year olds participated in this study to study further the nature of the age-related improvement in prospective remembering observed between these groups in Experiment 4. Additional measures of verbal comprehension and executive functioning were included to investigate the degree to which these affect performance on the prospective memory task.

5.2.3.1 Memory for delayed intentions in children

The findings from Experiment 4 revealed that overall there was an improvement in prospective memory performance across the three age groups, particularly between the 7- and 11-year-olds and also the 9- and 11-year-olds. However, this improvement did not relate to encoding of the prospective memory instruction which, in turn, did not appear to highlight any specific benefits to performance in any of the age groups. This pattern was also observed in the present experiment where neither encoding modality seemed to benefit performance on the prospective memory task. Interestingly, the present experiment also failed to uncover any performance differences between the 9- and 11-year-olds. What follows is a discussion of potential reasons why these observations were found.

Looking more closely at the data from this and the previous Experiments, it would appear that there are some striking performance differences. For example, whereas the 9-year-olds in Experiment 4 were remembering 44% and the 11-year-olds were remembering 66% of the items (irrespective of encoding condition), the same groups in Experiment 5 remembered 77% and 70% respectively; a reverse developmental trend, but one where there is tremendous performance improvement in the younger 9-year-olds compared to the older 11-year-olds. One possible reason for such considerable differences in performance could relate to the design of the two Experiments or more specifically the stimuli. Whereas Experiment 4 used verbal stimuli, there was a concern that some of the participants found these difficult to work with. Consequently, the words were replaced with pictures in Experiment 5. But it would appear that these have had the reverse effect with both groups responding to over two thirds of the targets.

An interesting follow up, therefore, could manipulate the test stimuli so as to present one group verbal stimuli and one group slightly more taxing pictorial stimuli and then compare performance directly, but without manipulating the encoding of the prospective instruction. Indeed, as mentioned in the Introduction to this and the previous Chapters, one principle aim of both Experiments was to identify whether the encoding modality in which PM instructions are presented could benefit prospective memory performance in any of the age groups. In Experiment 4, three encoding conditions were used and none appeared to have a reliable advantage over the others for any of the three age groups studied. In this experiment, one of the encoding conditions (verbal encoding) was removed since the data from Experiment 4 appeared to suggest that the most advantageous encoding modalities required presentation or inclusion of a target, either through enactment of the intended action (motoric encoding) or through presentation of a visual representation of the target (visual encoding).

However, in this experiment neither encoding condition was found to benefit prospective memory performance in either age group. Although consistent with the findings from the previous experiment, this finding is contrary to the results of Passolunghi, Brandimonte and Cornoldi (1995) who found a distinct advantage for older participants (10-11 years) who performed the intended activity during study of the prospective instruction.

One possible reason for this set of findings relates to the greater performance level exhibited by the participants in this Experiment compared to those in the previous Experiment. It could be argued that any differences between the encoding conditions could be difficult to detect due to near-ceiling effects. A closer look at the data reveals that 50% of the 9-year-old and 56% of the 11-year-old participants responded to all of the targets. It is perhaps unsurprising, therefore, that there was no reliable difference found between the two groups.

Nevertheless, there was at least one interesting trend relating to the older group: Although not found to be significantly different, the 11-year-olds exposed to the motoric encoding condition were showing better performance compared to their peers in the visual encoding condition. This ties in with Passolunghi *et al* (1995) who found that older participants (aged 10-11 years) also benefited from motoric encoding of the prospective memory condition. These findings are discussed together with those from Experiment 4, in more detail and with reference to further modifications and adaptations in Chapter 7.

5.2.3.2 The effect of enacting material at encoding and of verbal comprehension

The Subject-Performed Task

As in the previous three experiments, the recognition accuracy and recall results were of primary interest (although recognition latency was also measured at test). For both of these measures across both age groups, material enacted at encoding was retained better than material encoded by verbal repetition. The reader might recall that in Experiment 2, the 9-year-olds only showed a marginally reliable SPT effect with respect to recall. One cited reason for this related to insufficient participants. Interestingly, in this experiment although fewer participants were used, a significant SPT effect was observed for both the free recall and the recognition accuracy data (consistent with the findings of Experiment 4). Furthermore, significant SPT effects were also found with these measures for the older 11-year-olds (as expected). Taken together with the findings from Experiment 4, these findings support Cohen and Stewart's (1982) proposal that the SPT effect is automatic in nature. Interestingly, this is in contrast to the failure to observe any reliable ISE in Experiments 1 and 2. Therefore, although similar (motoric) processes may underlie the ISE and SPT effect, as Freeman and Ellis (2003b) have suggested, these findings are consistent with the suggestion that the processes that support the SPT effect require fewer attentional resources. These points are discussed in greater detail in Chapter 7.

The British Picture Vocabulary Scale Measure

The results of the SPT+BPVS analyses from Experiment 4 indicated that essentially, verbal comprehension had very little effect on the SPT paradigm. There was only one instance where BPVS seemed to play some role: A marginal difference was observed in the 11-year-old free recall data where those participants who demonstrated lower BPVS (M=8.76) recalled less items overall than those who demonstrated higher BPVS (M=11.36). Conversely, the same analyses from the present experiment found that BPVS only exhibited a significant difference in the 9-year-old recognition accuracy data where, once again, those with higher verbal comprehension outperformed those with lower verbal comprehension. Therefore, it would appear that in these groups of children verbal comprehension plays a very small role with respect to performance on the subject-performed task.

This is not the case for prospective memory performance, on the other hand. Recall that in Experiment 4, when the data from the three age groups was collapsed into one analysis, a strong effect of verbal comprehension was observed where those children with high BPVS were able to respond to proportionally more targets than those children with low BPVS. A similar analysis with the two age groups in the present experiment found a comparable finding with high verbal comprehension children outperforming children with low verbal comprehension. Although it is difficult to break this down into the respective age groups without further analysis, these findings are nevertheless very interesting in the suggestion that a child's verbal comprehension could potentially dictate their prospective memory performance. Further discussion and possible modifications are discussed in Chapter 7.

CHAPTER 6:

THE INFLUENCE OF EXECUTIVE FUNCTIONING ON MEMORY FOR ACTIONS IN CHILDREN

6.1 INTRODUCTION

The experiments reported in the previous chapters have addressed memory for actions in 7-, 9- and 11-year-old children. Various findings have been highlighted and discussed in detail but the question of whether executive functioning has an influence on memory for actions both retrospectively (the Subject-Performed Task) and prospectively (the Prospective Memory task) has not been addressed. Using data collected during these studies, discussed in the previous chapters, this chapter aims to investigate what, if any, executive skills influence memory for actions in 9- and 11-year-old children[22].

The area of focus in this chapter follows on from numerous studies that have highlighted links between executive function and prospective memory. For example, it is now widely accepted that executive processing is a complex, inter-related but most likely fractionated system that is at least partly responsible for goal-directed behaviour (Anderson 2002; Stuss & Alexander 2000; Zelazo, Frye, Reznick, Schuster & Argitis 1995). Anderson (2002) proposed a model of executive function with four principle domains: Cognitive flexibility, goal setting, information processing and attentional control. Citing evidence from various developmental and normative studies, Anderson suggested that the last domain shows dramatic development during early childhood, with maturation pre-teens. The remaining three domains are all thought to be relatively mature by 12 years.

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[22] The 7-year-old data from Experiment 4 was ignored because the age group was not used in Experiment 5.

This is certainly consistent with research outlined earlier (see 2.1.2) by, for example, Welsh (2002).

More recently, Martin, Kliegel and McDaniel (2003) addressed the relationship between frontally mediated executive functions and prospective memory in adults. They reported that although a number of executive functions are involved in prospective memory, exactly which one depends on aspects of (e.g. retention interval and complexity of the task) and the particular stage (e.g., encoding, retrieval) in the task. It also appears to depend on the nature of the retrieval cue (or target) for that task e.g., a time or an event. For example, in a laboratory *time*-based task, the Wisconsin Card Sorting Task (WCST) emerged as the only significant predictor of prospective memory performance. Inhibition, on the other hand, was found to be the only significant predictor for a laboratory *event*-based task. As noted in the previous chapters, the prospective task involved an event-based design. However, due to time constraints inhibition was not measured with the three age groups of children studied in this thesis. Instead, the Test of Everyday Attention for Children (TEA-Ch) was used to administer a range of attentional measures.

Denckla (1994) states that assessment of executive function should include measures that, "*in hierarchically conceived fashion, at one end challenge the subject's 'boredom tolerance' and at the uppermost end challenge the subject's metacognitive, highest order problem-solving skills.*" (p. 123). Moreover, when testing executive functioning in young children, the tasks should be child-friendly / age-appropriate (Archibald & Kerns 1999) and taxing. Levin and colleagues (Levin *et al* 1991) point out that early cognitive tasks used to study frontal lobe functioning in children could be classified as either (a) downward extensions of measures originally used to study adults or (b) tasks with a developmental theory origin. Archibald and Kerns (1999) argue that as executive skills develop, measures that are "*developmentally appropriate*" must be employed.

The original Test of Everyday Attention (TEA), developed by Robertson, Ward, Ridgeway and Nimmo-Smith (1994), was designed for use with adults. The more recent Test of Everyday Attention for Children (TEA-Ch) was developed by Manly *et al* (1999) as an adaptation of the adult version so as to appeal to and be appropriate for children aged 6 to 16 years. To avoid contamination from individual differences in basic, non-executive cognitive processes, Manly *et al* designed the battery to make minimal demands on memory, reasoning, task comprehension, motor speed, verbal ability and perceptual acuity, while still producing tasks that were challenging to each age group. Manly and colleagues (Manly *et al* 2001) also examined the performance of a clinical developmental group (24 boys diagnosed with Attention Deficit Hyperactivity Disorder, ADHD) on six measures from the TEA-Ch battery. Consistent with other cited research, the results showed large deficits in the group on measures of sustained attention (Score!, Score DT, Walk Don't Walk) and attentional control (Opposite Worlds) when compared to age-matched controls. Taken together with another, earlier study (Anderson, Fenwick, Manly & Robertson 1998), the TEA-Ch is widely accepted as a useful battery for measuring children's attention performance both for rehabilitation and assessment purposes.

In this Chapter, three subtests from the TEA-Ch test battery are examined. *Sky Search* is a measure of selective attention or, "*…a capacity to enhance the processing of particular target characteristics regardless of spatial location*." (p.1066 Manly *et al* 2001). Within the prospective memory domain, this function is important to be able to distinguish target from distracter items in order to successfully complete the task. *Sky Search Dual Task* (used exclusively in Experiment 4) is a measure of divided attention where the participant must divide his/her concentration between the two tasks simultaneously. Similarly, in a typical prospective memory task, the participant must attend to the ongoing task but also be primed to respond to the prospective element (i.e. making a response) at the appropriate time. Finally, the *Opposite Worlds Task* is a measure of attentional switching. Similar to the Wisconsin Card Sorting Task (Milner 1963), the task involves children responding to numerical stimuli using two opposing rules over four trials (i.e. each rule is used twice). Therefore, the child must remember and apply each rule appropriately. Although not specific to the prospective memory domain, typical tasks could be argued to require this function when encoding and then applying both the ongoing and the prospective elements of the task. Moreover, during the task the participant must engage fully in the ongoing task but also be prepared to switch to the prospective memory task at the appropriate time.

It is predicted that those children with high performance on each of these skills should also demonstrate good performance at the prospective memory task. Therefore, those children who are able to demonstrate good selective attention (Sky Search Task), divided attention (Sky Search Dual Task) and attentional switching (Opposite Worlds Task) performance should also demonstrate adeptness on the prospective memory task. Conversely, those children with difficulties on some or all of these executive tasks are likely to have problems also with the prospective memory task.

Working memory has also been regarded as an executive functioning component (Lehto 1996). One reason for this is that successful performance on tasks that involve (e.g.) planning and inhibition can depend on the ability to process information in working memory. In research shortly to be published, Gathercole and colleagues (Gathercole, Pickering, Ambridge & Wearing 2004) focused on the development of working memory between 4 and 15 years. Children were presented with a range of tasks designed to test the three principle components of working memory (WM) – the central executive, articulatory loop and the visuo-spatial sketchpad (Baddeley 1986; Baddeley & Hitch 1974). Gathercole *et al* made two key observations. First, although task performance increased at a relatively consistent rate between ages 4 and 14, a levelling off was observed between 14 and 15 years. Second, the three components of WM appeared to present themselves at 6-years-old and continue to develop. In view of these findings, the analyses presented in this chapter also address the influence of retrospective on prospective memory across both age groups, using the verbal data (VT) from the SPT paradigm. Similar to the predictions for the TEA-Ch measures, it was expected that the younger 9-year-olds would show comparatively worse performance than the 11-year-olds thus highlighting a developmental trend.

In summary, this chapter investigates prospective memory performance in two age groups and relates this performance to other executive functioning ability.

6.2 EXECUTIVE PROCESSING AND MEMORY FOR ACTIONS

6.2.1 Additional Analyses

Data from the participants tested in Experiments 4 and 5 were used in the same conditions. It should be pointed out that most of the analyses reported here concentrate on the 9- and 11-year-old age groups as more relevant data was available for these groups[23]. The main area of focus for this chapter is an investigation into the effect of executive functioning on memory for performed (SPT) and to-be-performed actions (PM). 0 below illustrates the wealth of data made available from Experiments 4 and 5 used in this Chapter to address the questions outlined in 6.1.

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[23] The 7-year-old data from Experiment 4 is only addressed when investigating the affect of executive functioning on memory for actions.

: Experiments, age groups and measures tested

Experiment No.	Age Groups Tested (years)	PM Conditions Tested*	TEA-Ch Measures**	Additional Measures
4 (N=135)	7, 9,11	M, Ve, Vi	SS, SSDT, OW	SPT, BPVS
5 (N=60)	9,11	M, Vi	SS, OW	SPT, BPVS

*M=Motoric, Ve=Verbal, Vi=Visual **SS= Sky Search, SSDT = Sky Search Dual Task, OW = Opposite Worlds

As can be seen from 0, there are potentially a number of additional analyses that can be conducted with these data, particularly because the methodology for each test was identical except for the prospective memory tests where although different stimuli and procedures were used, the findings were very similar. The primary concern is to focus on three discussion questions. First, are the SPT data consistent across all three age groups? If so, what happens when the data are analysed regardless of age group? Second, does verbal comprehension effect memory for encoded actions and third, do verbal comprehension and executive functions influence memory for to-be-enacted actions? These are answered in the next section.

6.2.2 Results

6.2.2.1 Consistency of the SPT data

The trimming technique, described in Experiment 1, has already been applied to the data used here so it was not necessary to perform a second procedure. As with previous experiments, paired samples t-tests were performed for three sets of data: recognition latency, recognition accuracy and free recall. For each, three analyses were conducted. First, all the 9-year-old data from Experiments 4 and 5, second all the 11-year-old data from Experiments 4 and 5 and finally all the participant data from Experiments 4 and 5 including the data from the 7-year-old age group. These analyses are described separately.

Recognition latency

For each group analysed, all participants were included in the analyses. The mean number of correct response times for each group and condition is shown in 0.

: SPT task mean recognition latencies (ms)

for each encoding condition and group

Group	Method of encoding	Mean Recognition latency (ms)
9-year-olds (n=74)	*Motoric (SPT)*	1319 (312)
	Verbal (VT)	1342 (360)
11-year-olds (n=75)	*Motoric (SPT)*	1153 (209)
	Verbal (VT)	1180 (253)
All data (n=194)	*Motoric (SPT)*	1259 (279)
	Verbal (VT)	1282 (303)

(Standard deviations in parentheses)

Although the direction was consistent with previous findings (i.e. SPT materials accurately recognised more quickly than VT material), there were no reliable differences within any of the groups (ts < 1).

Recognition accuracy and Free recall

For each group analysed using the accuracy data, all participants were included in the appropriate analysis. The mean number of hits for each group and condition is shown in 0.

: Mean number of hits for each encoding condition and group

Group	Method of encoding	Hits
9-year-olds (n=75)	*Motoric (SPT)*	8.63 (2.34)
	Verbal (VT)	7.07 (2.75)
11-year-olds (n=75)	*Motoric (SPT)*	9.33 (2.00)
	Verbal (VT)	7.95 (2.02)
All data (n=195)	*Motoric (SPT)*	8.78 (2.31)
	Verbal (VT)	7.37 (2.41)

(Standard deviations in parentheses)

For the 9-year-old group, a highly significant difference was found where the number of hits for the SPT condition exceeded those for the VT condition; t (74) = 5.324, p<0.001. This highly significant difference was also present for both the 11-year-old group, t (74) = 4.971, p<0.001, and for the amalgamated group (t (195) = 8.001, p<0.001).

All participants were also included in the appropriate free recall analysis, including those who failed to correctly recall any of the targets. The mean number of items correctly recalled for each condition is shown in 0.

: Mean number of targets recalled for each encoding condition and age group

Age Group	Method of encoding	Targets Recalled
9-year-olds (n=74)	*Motoric (SPT)*	5.96 (3.09)
	Verbal (VT)	3.13 (2.24)
11-year-olds (n=75)	*Motoric (SPT)*	6.27 (2.74)
	Verbal (VT)	4.40 (2.89)
All data (n=194)	*Motoric (SPT)*	5.57 (3.02)
	Verbal (VT)	3.52 (2.50)

(Standard deviations in parentheses)

Highly significant differences were observed for all three groups where the number of SPT targets recalled exceeded those recalled in the VT condition (9-year-old group t (74) = 5.324, p<0.001; 11-year-old group t (74) = 4.971, p<0.001; amalgamated data group t (195) = 7.642, p<0.001).

6.2.2.2 Does BPVS affect memory for encoded actions?

To answer this question, six separate analyses were conducted: two for both of the age groups for the SPT accuracy and recall data and two for the amalgamated data (7-, 9- and 11-year-old data from Experiments 4 and 5) for the SPT accuracy and recall data.

For the 7-year old group, the BPVS scores ranged from 76 to 114 with a group mean of 94.88 (SD = 9.61) and a median of 95. For the 9-year old group, the BPVS scores ranged from 59 to 121 with a group mean of 96.97 (SD = 13.03) and a median of 98. For the 11-year old group, the scores ranged from 60 to 126 with a group mean of 94.52 (SD = 14.60) and a median of 94.

As in previous experiments, median scores were used to analyse whether or not BPVS had any effect on SPT performance. The same trimming technique used in Experiments 4 and 5 was employed here where participants were only removed when BPVS scores matched the group median. These were 3, 2 and 3 for the 7-, 9- and 11-year-old age groups respectively. 0 shows how the groups differed with respect to mean BPVS performance. It should be noted that the data for the 7-year-old group is not reported here as it is identical to that described in Experiment 4 since Experiment 5 did not include a 7-year-old group.

: Mean BPVS performance for low and high groups.

Age group	High BPVS Score Group		Low BPVS Score Group	
	Mean	*N*	*Mean*	*N*
9-year-olds (n=73)	107.36 (7.16)	36	86.49 (8.07)	37
11-year-olds (n=72)	105.92 (8.98)	36	83.17 (9.10)	36
All ages (n=187)	105.87 (7.81)	92	85.44 (8.03)	95

(Standard deviations in parentheses)

Consistent with the previous two experiments (4 and 5), two 2 x 2 mixed-design ANOVA analyses were conducted for each group, both using BPVS performance and encoding modality as the between-subjects factors. The first used recognition accuracy and the second recall performance as the respective dependent variables.

SPT Data + BPVS

9-year-old age group

: 9-year-old mean SPT recognition accuracy and recall performance for low and high BPVS performance groups

BPVS Performance	SPT Performance Measure / Encoding Condition			
	Recognition Accuracy		*Recall*	
	SPT	VT	SPT	VT
Low	8.27 (2.56)	6.57 (2.88)	5.24 (3.15)	2.78 (1.96)
High	8.97 (2.09)	7.55 (2.56)	6.66 (2.90)	3.47 (2.47)

(Standard deviations in parentheses)

The accuracy data for the 9-year-olds, above, indicates that those with high BVPS appeared to accurately recognise more items than those with low BPVS. Moreover, as expected, there also appears to be an SPT effect with more accurate performance for material enacted at encoding (M=8.63) compared to that verbally encoded (M=7.07).

The results of the analysis revealed the predicted highly significant effect of encoding, F (1,73) = 28.113, p<.001, but no effect of BPVS, F (1,73) = 2.782, p=.1, and no interaction; F< 1.

Interestingly, for the recall measure not only was the SPT effect again observed, F (1,73) = 35.183, p<.001, but there was also a significant effect of BPVS, F (1,73) = 7.362, p=.008, although the interaction was not reliable (F < 1). With reference to the data in 0, these indicate that as well as more SPT items being recalled, compared to VT items, there was also a difference between the BPVS performance groups where those with relatively high BPVS scores (M=10.90) recalled more items overall than those with lower BPVS scores (M=8.81).

11-year-old age group

: 11-year-old mean SPT recognition accuracy and recall performance for low and high BPVS performance groups

BPVS Performance	**SPT Performance Measure / Encoding Condition**			
	Recognition Accuracy		*Recall*	
	SPT	VT	SPT	VT
Low	9.11 (2.17)	7.83 (2.21)	5.86 (2.59)	3.75 (2.63)
High	9.54 (1.83)	8.05 (1.85)	6.64 (2.86)	5.00 (3.02)

(Standard deviations in parentheses)

Looking first at the accuracy data in 0, there appeared to be a similar pattern as that for the 9-year-olds with a clear SPT effect and more items recalled overall for higher BPVS scores compared to lower BPVS. The ANOVA revealed a significant effect of encoding modality, F (1,73) = 24.242, p<.001, but no main effect of BPVS or a significant interaction (Fs<1).

Interestingly, when focusing on the recall measure, the ANOVA confirmed significant main effects of both encoding modality, F (1,73) = 19.823, p<.001, and also BPVS performance, F (1,73) = 4.340, p=.041. The interaction, however, was not reliable (F<1).

All age groups

: All age groups: mean SPT recognition accuracy and recall performance for low and high BPVS performance groups

BPVS Performance	**SPT Performance Measure / Encoding Condition**			
	Recognition Accuracy		*Recall*	
	SPT	VT	SPT	VT
Low	8.55 (2.35)	7.07 (2.51)	5.15 (2.87)	3.07 (2.28)
High	9.04 (2.22)	7.71 (2.31)	5.96 (3.11)	4.01 (2.66)

(Standard deviations in parentheses)

Looking at the data displayed in 0, across both measures there appears to be a replication of the patterns described earlier for both the 9- and the 11-year-old data whereby a strong SPT effect is apparent together with a performance difference between the two BPVS groups.

For the accuracy analysis first, a highly significant encoding modality effect on recognition accuracy such that more SPT material was recognised compared to VT, F (1,185) = 62.082, p<0.001. Although the interaction was not reliable (F<1), the effect of BPVS performance was marginally significant, F (1,185) = 3.681, p=.057: marginally more items were recalled for those scoring higher on BPVS (M=16.75) compared to those scoring lower (M=15.62).

For the recall analysis, the SPT effect was again observed and found to be highly significant, F (1,185) = 53.250, p<.001, together with an effect of BPVS such that participants with low BPVS (M=8.22) recalled significantly less items than those with high BPVS (M=9.97); F (1,185) = 71.268, p=.003. Consistent with previous analyses, the interaction was again nonsignificant (F (1,185) = 0.054, p=.816).

6.2.2.3 Do verbal comprehension and executive functions affect memory for to-be-enacted actions?

For this question, two sets of analyses were conducted: one set for the verbal comprehension component of the question and one set to address the executive function component. The verbal comprehension analyses are described first.

For the verbal comprehension component, three analyses were conducted; one for both age groups and one for the amalgamated data (7-, 9- and 11-year-old data from Experiments 4 and 5). Each analysis used the proportional prospective memory performance measure as the dependent variable.

Median scores (see 6.2.2.2) were used to investigate whether or not BPVS had any effect on prospective memory performance. Each analysis used all participants except those removed due to their BPVS scores matching the group median (see 6.2.2.2).

Independent t-tests were used for each analysis. This was for two reasons. First, there were three PM encoding conditions in Experiment 4 and only 2 in Experiment 5. Therefore, if this factor had been used, it would have removed some of the participants in each age group. Second, no reliable effect of PM encoding condition had been observed in either experiment. Therefore t-tests were chosen as a suitable compromise.

PM Data + BPVS

9-year-old age group

This analysis revealed a significant difference between the two BPVS performance groups such that those with lower verbal comprehension ($M=0.45$, $SD=0.45$) performed worse on the prospective memory task compared to those with higher verbal comprehension scores ($M=0.69$, $SD=0.39$); $t(73) = -2.464$, p=.016. Therefore, it would appear that for the 9-year-old participants, verbal comprehension had some effect on overall prospective memory performance.

11-year-old age group

The analysis for the 11-year-old group, on the other hand, revealed no significant difference between the two BPVS groups; t(73) = -0.577, p=.565. Children with lower verbal comprehension (M=0.65, SD=0.42) performed as well on the prospective memory task as those with higher verbal comprehension (M=0.71, SD=0.41) t(73) = -0.577, p=.565.

All age groups

Finally, when the data was amalgamated, the analysis revealed a highly significant difference between those participants with higher versus those with lower BPVS scores; t(185) = -3.149, p=.002). Participants with higher verbal comprehension (M=0.66, SD=0.40) were responding to more PM targets than participants with low verbal comprehension (M=0.41, SD=0.45).

PM Data + Executive Functions

The mean age-scaled (standardised) scores for each measure across age groups are summarised in 0. This table illustrates Sky Search (a measure of selective attention), Opposite Worlds (a measure of attentional switching) and VT recall (a measure of short term memory) performance. This last measure has been borrowed from the SPT paradigm and acts here as a good indicator of each group's overall working memory ability. Each set of data displayed in 0 indicates a gradual improvement with age. 0 displays the data for each measure split by prospective memory encoding condition. It should be noted that only the data for the motoric and visual encoding conditions are displayed. This is because the verbal encoding condition was not used in Experiment 5.

: Mean performance scores for each measure by age group

	Age group		
	7-year-olds (n=45)	*9-year-olds (n=75)*	*11-year-olds (n= 75)*
Sky Search*	8.12 (3.18)	9.07 (2.13)	9.53 (2.32)
Opposite Worlds*	0.64 (2.76)	0.17 (2.61)	-0.49 (2.20)
VT Recall	2.69 (1.68)	3.13 (2.24)	4.40 (2.89)

*Indicates age-scaled (standardised) scores (Standard deviations in parentheses)

: Mean performance scores for each measure by

prospective memory encoding condition

	PM Encoding Condition	
	Motoric (n=75)	*Visual (n=74)*
Sky Search*	8.81 (2.59)	9.18 (2.41)
Opposite Worlds*	0.16 (2.63)	-0.28 (2.42)
VT Recall	3.33 (2.51)	3.78 (2.74)

*Indicates age-scaled (standardised) scores (Standard deviations in parentheses)

Multiple regression analyses were carried out in order to examine the role of the TEA-Ch and WM measures as predictors of prospective memory performance, under the two encoding conditions. For each regression, prospective memory performance was measured using the proportional total number of correct responses made by each participant. An initial series of analyses loaded age followed by Sky Search and VT Recall onto two regressions; one for each encoding condition. For the *motoric* encoding condition (R^2 = 0.151, Adjusted = 0.115, Beta=0.077), neither age, F(1,71)=2.356, p=.129, or VT Recall, F(1,71)=0.930, p=.338, had a reliable effect, but Sky Search was a significant predictor even when age and VT Recall had been taken into account; F(1,71)=9.344, p=.003. For the *visual* encoding condition age was a significant predictor, F(1,71)=5.452, p=.022, but Sky Search and VT Recall were found to have no effect once age had been taken into account (both Fs < 1) (R^2 = 0.082, Adjusted = 0.43, Beta=-0.360).

A second series of analyses loaded VT Recall followed by Sky Search and Age onto two regressions. For the *motoric* encoding condition (R^2 = 0.151, Adjusted = 0.115, Beta=0.077), VT Recall was found to be a marginally significant predictor on prospective memory performance; F(1,71)=3.563, p=.063. Sky Search was again found to make a significant contribution, F(1,71)=8.622, p=.004, but age again failed to be a significant predictor, F(1,71)=0.444, p=.507, when VT recall had been taken into account. For the *visual* encoding condition (R^2 = 0.082, Adjusted = 0.043, Beta=-0.360) VT Recall was not a significant predictor; F(1,71)=1.084, p=.301. Similarly, Sky Search was not a significant predictor after VT Recall had been taken into account; F(1,71)=0.974, p=.327. However age was a significant predictor even after when VT recall and Sky Search had been taken into account; F(1,71)=4.207, p=.044.

A third series of analyses loaded Opposite Worlds followed by VT Recall, Sky Search and Age onto two regressions. For the *motoric* encoding condition (R^2 = 0.194, Adjusted = 0.148, Beta=0.011), Opposite Worlds was found to be a significant predictor; F(1,70)=5.203, p=.026. VT Recall was not found to be a significant predictor, after Opposite Worlds had been accounted for; F(1,70)=2.640, p=.109. Sky Search once again made a significant contribution; F(1,70)=8.832, p=.004. Lastly, age was not a significant predictor after the three other measures had been taken into account; F(1,70)=0.153, p=.697. For the *visual* encoding condition (R^2 = 0.083, Adjusted = 0.043, Beta=-0.392) age was the only significant predictor, F(1,69)=4.525, p=.037, even after Opposite Worlds, F(1,69)=0.080, p=.778, VT Recall, F(1,69)=1.147, p=.288, and Sky Search, F(1,69)=0.930, p=.338, had been accounted for.

6.2.3 Discussion

The main aim of this chapter was to investigate the relationship between executive functioning and memory for actions in the 9- and 11-year-old age groups from the previous two Chapters. As mentioned in 6.2.1, there were three main areas of interest. What follows is a discussion of the findings from these areas.

Is the SPT data consistent across the Experiments?

In line with previous analyses, the SPT data was analysed using recognition latency, recognition accuracy and free recall measures. For the latency data, there were no reliable differences within either of the groups, consistent with previously reported analyses. Nevertheless, with such a large sample size, this is a little surprising, particularly with reference to some previous research that has found a significant SPT effect using this measure (e.g. Freeman & Ellis 2003c; Zimmer 1984 cited in Zimmer 1986). It could be argued, therefore, that the replicability of the SPT effect on recognition latency remains to be established.

For recognition accuracy and free recall, the results were consistent to those observed in Experiments 1 and 3-5 where SPT items are retained better than VT items. Thus, the presence of a reliable SPT effect in 9- and 11-year-olds is confirmed, lending support to the assertion that this effect is largely supported by automatic processes (Cohen and Stewart 1982). Not only has the SPT effect been observed consistently across a number of experiments and across three age groups, but it has also been found with both recognition accuracy and free recall measures. At this point, however, it remains unclear as to whether or not verbal comprehension, measured by the British Picture Vocabulary Scale, plays a role in this effect. This is now addressed.

Does BPVS affect memory for encoded actions?

In order to investigate the relationship between BPVS and SPT, the analyses focused on recognition accuracy and free recall measures for the two age groups. When analysing the 9- and 11-year-old groups separately, although there was no evidence of a direct relationship between BPVS and the SPT effect, there was a relationship between BPVS and free recall of overall encoded material. Moreover, those participants who scored high verbal comprehension recalled more items than those who scored low verbal comprehension. This was also found when data from the 7-, 9- and 11-year-olds was amalgamated. Therefore, it would seem that for these participants, verbal comprehension skills can aid free recall of overall task phrase material. However, it is important to note that BPVS performance does not appear to have any bearing on the relative size or presence of the SPT effect.

Do verbal comprehension and executive functions affect memory for to-be-enacted actions?

When comparing BPVS and prospective memory performance for the 9- and 11-year-old groups separately, there was a suggestion of a developmental effect: Whereas verbal comprehension was found to have a significant effect for the younger group, this was not the case for the older participants. Interestingly, when the data from the 7-year-old group in Experiment 4 was added to all the 9- and 11-year-old data, the effect of BPVS was again observed. A possible reason for this could relate to the inclusion of the 7-year-old data. By returning to look at the analysis for these participants in Experiment 4 (see 4.2.2.3), we find a significant effect of BPVS. Therefore, it could be argued that those participants – particularly the younger ones – who exhibit high verbal comprehension, perform better on the prospective memory task than those who show low verbal comprehension.

The final set of analyses investigated the relationship between different measures of executive functioning and prospective memory performance, under the visual and motoric encoding conditions. For those participants assigned to the visual encoding condition, the analyses revealed only one predictor for prospective memory performance: Age. Therefore, it would appear that the executive function measures employed here did not have any direct relationship to prospective memory performance. Moreover, only a participant's age could predict their performance on the task. Nevertheless, there is scope for future research to include other measures of executive functioning to identify potential predictors.

Interestingly, when focusing on those participants assigned to the motoric encoding condition, the analyses revealed selective attention and attentional switching as strong predictors of performance. Therefore, under this encoding condition performance was enhanced particularly for those participants who could selectively attend to a stimulus and/or switch between two attentional streams. Selective attention is arguably important in prospective memory performance because participants must attend to both the ongoing task and allocate resources to the prospective task. Similarly, attentional switching is important because the participants must be able to direct attention to the prospective task during the performance interval. But why are these two measures of executive functioning particularly important following motoric encoding of the prospective memory instruction? Perhaps it could relate to the encoding providing a more salient cue than the other forms of instruction encoding. Or perhaps it could link in with the work of Schaefer, Kozak and Sagness (1998; see also 4.1) who found that adult participants who enacted prospective tasks at study were *less* likely to perform them at test compared to participants presented with EPTs or VTs at study. Using their "*metacognitive-expectation hypothesis*", they suggested that participants who performed the tasks at study may be more likely to over-estimate the likelihood of subsequent recollection. Because of this, they therefore allocate fewer resources to prospective remembering.

Thus referring back to the regression results, it could be that the motoric encoding group are more confident following performance and devote fewer on-line resources to the PM task. To compensate, selective attention and task-switching skills become more highly activated.

The results from these analyses suggest that executive function has some relationship with prospective memory performance, although only following motoric encoding of the instruction. There is certainly some agreement that executive processes make some contribution towards goal-directed behaviour (Anderson 2002; Stuss & Alexander 2000; Zelazo, Frye, Reznick, Schuster & Argitis 1995; see also Ratner & Foley's Activity Memory Framework, 1994). As mentioned in the Introduction of this Chapter, Martin, Kliegel and McDaniel (2003) suggested that identifying the involvement of specific executive functions is dependent on the design of the task. For example, they suggested that inhibition was only a significant predictor for an event-based task. Interestingly this is the design employed here and although inhibition was not measured, other measures of executive function were employed and at least two of these were found to predict prospective memory performance but following motoric encoding only. Therefore, there is some consistent evidence that executive functioning has a contributory relationship with prospective memory performance and that the specific executive skills required to complete a PM task depend on the characteristics of that task. It is therefore important to measure not only a range of executive skills but also take account of the nature of a PM task in studies of the development of prospective memory.

CHAPTER 7:

FINAL DISCUSSION

7.1 RESEARCH QUESTIONS REVISITED / THEORETICAL IMPLICATIONS

The central purpose of this thesis was to examine the development of memory for action-related information, enacted and to-be-enacted, in children aged from 7 to 11 years. This chapter will evaluate the contribution made by each of the various paradigms used in this undertaking. The pattern of results found in the youngest, 7-year-old participants will be compared with that of the older 9- and 11-year-old participants in order to develop an integrated view that incorporates the results across the four experimental chapters included here. The discussion will focus separately on three central research questions, before drawing together the main points.

7.1.1 Is there a link between the development of the Subject-Performed Task and Intention Superiority Effects in nine- and eleven-year-old children?

Research on the subject-performed task (SPT), or enactment effect, commenced over twenty years ago in two separate laboratories. Both research groups found that recall performance was enhanced following enactment of task phrases at encoding compared to verbal repetition. To date, the explanation for this benefit for enactment remains a matter of debate between four dominant propositions put forward by Cohen (1981, 1983, 1985), Bäckman and Nilsson (1984, 1985; Bäckman, Nilsson & Chalom 1986), Engelkamp and Zimmer (1985) and Ratner and Foley (1994). Although there is some disagreement concerning the exact reasoning behind the SPT effect, all the theorists acknowledge that encoding an action through enactment has tremendous benefits for memory.

In prospective memory, on the other hand, the action cannot be carried out immediately but – at encoding – is intended for *future* performance. The status of this future intention was addressed in research initiated by Goschke and Kuhl (1993) who suggested that intentions are represented in declarative memory with a heightened state of activation. They predicted that this heightened activation should be observed in faster recognition responses for words from an execution (to-be-performed) script than to those words from a neutral (to-be-remembered) script. In four separate experiments, they found this to be the case and described this as an *Intention Superiority Effect* (the ISE). This work has since been replicated and extended, using the lexical decision task (LDT) paradigm, by Marsh, Hicks and colleagues (Marsh, Hicks & Bink 1998; Marsh, Hicks & Bryan 1999). Arguing that the LDT was a purer measure of activation, they not only observed an ISE but also inhibitory effects (i.e. slower lexical judgements) for cancelled and completed intentions.

Although there has been huge interest surrounding both of these effects, to date the vast majority of the research has focused only on adult participants. Experiments 1-2 were designed to address this by studying both effects in children aged 9- and 11-years. Subsequent experiments (Chapters 4-5) attempted to build on this work by studying the SPT paradigm with larger sample sizes and also with a younger group of 7-year-old participants. What follows is a brief introduction to each experiment followed by discussions of the principle experimental findings.

Experiment 1. This experiment was an investigation into the effects of encoding actions (SPT) and intended actions (ISE) on memory performance measures in a sample of adult participants. Additional measures were also included to test for participants' verbal intelligence (the National Adult Reading Test, NART) and their ability to inhibit prepotent responses (the Hayling sentence completion task) and to examine whether these had any influence on the central tasks.

Experiments 2-3. These experiments built on the findings from Experiment 1 by using the same materials and procedure from the SPT and ISE paradigms in Experiment 1 and employing them with a group of 9- (Experiment 2) and 11-year-old (Experiment 3) children. To obtain age-scaled measures of verbal comprehension and inhibitory performance, the British Picture Vocabulary Scale (BPVS) and a modified Stroop task were employed.

Experiments 4-5. Although the primary focus of these experiments was to look at PM performance (see 7.1.2), both experiments included an SPT paradigm identical to that used in Experiments 1-3. Moreover, in Experiment 4 this task was presented to large groups of 7-, 9- and 11-year-old children. Similarly, in Experiment 5 the task was presented to two new groups of 9- and 11-year-olds. All participants were also asked to complete the BPVS to obtain an additional comparison measure.

Summary of Experimental Findings

For all the experiments in this thesis that used either / both the SPT and the ISE tasks, retention of encoded material was measured using recognition accuracy, recognition latency and free recall. In line with previous research the recognition accuracy and recall measures were of primary interest for the SPT task. Similarly, the recognition latency measure was of primary interest for the ISE task.

Experiment 1 was designed to provisionally test the materials and experimental instructions with a group of adults to ensure the effects were relatively robust. For the SPT task and as predicted, adults showed better retention (with respect to recognition accuracy and free recall performance) for items encoded motorically than for items encoded through verbal repetition. This is consistent with previous adult research on the SPT paradigm (c.f. Engelkamp 1998) highlighting the benefit of encoding task phrase material using enactment versus verbal repetition. More importantly, this result confirmed that the materials and instructions were able to illicit the desired effect.

For the ISE task, the adults showed faster responses to material intended for enactment compared with material intended for verbal report. Although the difference was marginal, the pattern is consistent with that found by Goschke and Kuhl (1993), despite employing a different methodology. Whereas Goschke and Kuhl presented scripts (e.g. "*setting the table*") of related activities (e.g. "*spread the table cloth*") for participants to learn, the paradigm employed here used lists of unrelated action phrases (e.g. "*knock on the door*"; "*lift a fork*"). Nevertheless, the results hint at sustained activation for the intention representation of items from the to-be-performed material, compared to those items intended for verbal recall. Notwithstanding this, because of the marginal result, it is difficult to predict that a similar effect would be observed with younger participants in subsequent experiments.

The SPT / ISE tasks in Experiments 2-3, together with the SPT task included in Experiments 4-5, employed the methodology from Experiment 1 and applied this to groups of 7- (Experiment 4), 9- (Experiments 2, 4 and 5) and 11-year-old (Experiments 3, 4 and 5) children. Interestingly, an inconsistency was uncovered for the 9-year-olds. In Experiment 2 these children failed to show a significant SPT effect in either of the crucial measures (accuracy and recall). However, the 9-year-olds in Experiments 4 and 5 revealed very robust SPT effects for both measures, despite identical materials and instructions being used in all three experiments. Performance on the task by the 11-year-old groups, on the other hand, was consistent across Experiments 3-5 where a strong SPT effect was observed with both accuracy and recall data. This was also true of the 7-year-old group in Experiment 4.

Taken together, these findings reveal the benefits of enactment at encoding for 7-, 9- and 11-year-old children that is consistent with a range of adult research that has observed strong SPT effects on recognition accuracy and recall performance (c.f. Engelkamp 1998). Importantly these findings are also in line with Cohen and colleagues' suggestion that the SPT effect results from a nonstrategic form of encoding (Cohen 1981; 1983; Cohen & Bean 1983; Cohen & Stewart 1982), which exhibits characteristics unlike those that typically denote the use of effortful encoding strategies in verbal learning.

With respect to the second paradigm, the Intention Superiority Effect, the reader is reminded that this task was only presented to the 9- and 11-year-old participants in Experiments 2 and 3. Indeed, following on from the concern outlined earlier relating to the marginal ISE observed with the adult sample, it was perhaps unsurprising that in neither Experiment 2 nor Experiment 3 was a reliable effect revealed where material intended for performance were retained better than material intended for verbal report. Nevertheless, there are some points that should be considered regarding this effect.

First, as mentioned in Chapter 1 (see 1.4) Foley and Ratner (2001) suggest that planning is not crucial to the SPT effect. Arguably however, successful planning is crucial to the ISE paradigm used in Experiments 1-3 where material is presented for recollection in the future, either motorically or verbally. McDaniel and Einstein (2000) have reported that in a prospective memory task, planning processes can be disrupted by dividing attention and argued that planning therefore requires attentional resources, particularly for successful prospective memory performance (see 2.3.1.1). Relating this to the results revealed in Experiments 1-3, it could be that the SPT task does not require planning but the ISE task does. Moreover, the observed performance differences could result from poor planning abilities amongst the developmental samples. Interestingly, McDaniel and Einstein (2000) also found that the disruption of planning impacted quite significantly on prospective memory performance. Therefore, another reason for the lack of a significant ISE in the 9- and 11-year old children from Experiments 2-3 could relate to the development of executive processes, particularly the ability to manage dual task situations. In her chapter on developmental variations in executive functions, Welsh (2002) cites the findings from a number of studies that suggest that the ability to engage in complex planning is one executive function that tends to mature quite late. In one such study, complex planning was seen not to reach adult level until age twelve (Welsh, Pennington & Grossier 1991). Therefore, it is the suggestion here that the children in Experiments 2-3 had simply not developed the executive skills necessary to cope with the task. One could speculate that if future studies were to use older children of 12 years or above, there could be some observable differences where material intended for performance is retained better than material intended for verbal report.

When the test battery measures were included in additional analyses, the results were somewhat inconsistent. First, verbal comprehension was found to have some effect on the retention of both SPT and ISE task material: Participants with high BPVS tended to demonstrate better retention of the material compared to those with low BPVS although there was never an instance where the BPVS directly affected the size of the ISE or SPT effect. Arguably, therefore, those participants with better verbal comprehension were able to demonstrate the employment of beneficial encoding strategies to aid their retention of the material. It is important, however to point out that if this is the case, these strategies did not favour one type of task material over another.

Interestingly, inclusion of the inhibition measure (the modified Stroop task) in the analyses was found to have no significant effect on performance of either of the two tasks. Looking more closely at the collective Stroop data from Experiments 2 (9-year-olds) and 3 (11-year-olds), the range of Stroop scores stretches from 0.25 to 0.97. However, nearly sixty percent of the scores fall *below* the group mean of 0.48. This might indicate poor or slow development of inhibition in these participants[24]. If this is the case then arguably it is necessary to include other measures of executive processing as the Stroop only one, putative measure of executive processing, commonly regarded as a measure of inhibitory processing. This is particularly important when considering the suggestion by Welsh and Pennington (1988) that adult performance on measures of executive functioning is typically achieved by age twelve. Other measures, such as those in the Test of Everyday Attention in Children (TEA-Ch) battery, could also be key to identifying developmental factors that relate to the ISE. Indeed, because the TEA-Ch battery is designed for use with children, it was hoped that the findings would be more revealing. Interestingly, it would appear that factors measured by the TEA-Ch do not play a significant role in determining response times in the ISE task of the size of the ISE, but only in the 11-year-old group where these measures were employed. This is consistent with the Stroop results from both Experiment 2 and 3. It would be of interest to repeat these tests with a larger group of participants but also a group of older, 12-year-old participants to see whether differences – if present – could be teased apart.

Therefore, it would seem from these results that despite consistent task performance across the three age groups, notwithstanding the surprising results from Experiment 2, the additional measures employed in each experiment were unable to reveal significant insight into individual differences and the effect these have on motoric encoding (SPT) and intended performance (ISE). Moreover, returning to the question that introduces this section, it appears that the three age groups in this study were able to demonstrate significant SPT effects. Following such prominent effects, we should perhaps question whether the processing that underlies SPT encoding is automatic or controlled.

Section 1.2.1 outlines Cohen's theory into the enactment effect with an introduction into the research on the retention properties of verbal (VT) versus

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[24] This was not the case for the adult participants where the split for the Hayling score was 50:50 either side of the group mean.

motoric (SPT) material under different conditions. Zimmer and Cohen (2001), for example, observed that, depending on the number of list items, positional cues in serial recall paradigms were not enhanced by motoric encoding. Interestingly, however, the recency effect has been seen to be enhanced following enactment compared to verbal encoding (Bäckman & Nilsson 1984, 1985; Cohen 1981; Helstrup 1986; Olofsson 1996; Zimmer, Helstrup & Engelkamp 1993 cited in Zimmer & Cohen 2001). Other studies that have focused on the effects of depth of processing (c.f. Craik & Lockhart 1972) suggest little impact following SPT versus VT encoding (Cohen 1981; Helstrup 1987; Nilsson & Craik 1990; Zimmer 1984 cited in Engelkamp 1998; Zimmer & Engelkamp 1999). Collectively, this research suggested that recall of material encoded via enactment does not exhibit characteristics common to verbal learning; characteristics thought to require the use of effortful encoding strategies and develop with age.

Building on these findings, Cohen (1981, 1983) suggested that the processes that underlie SPT encoding are non-strategic because they do not utilise strategies thought to require attentional resources. Indeed subsequent research supported this theory when manipulations involving self-generation and study time (both thought to require attentional resources) were found to have a benefit for VT material but not for SPT material (e.g. Cohen 1985; Kausler, Lichty & Davis 1985; Kausler, Lichty & Freund 1985; Kausler, Lichty, Hakami & Freund 1986; Zimmer & Engelkamp 1999).

However, one must question how Cohen's research relates to the results observed in this thesis. To answer this we return to the work of Hasher and Zacks (1979) who point out that memory skills that place more demands on capacity (e.g. rehearsal) would appear to show most significant changes during childhood. On the other hand, Hasher and Zacks identify a second group of skills described as "*basic*" (e.g. Flavell 1977; Flavell 1985) or non-strategic (e.g. Brown 1975) that show few developmental trends. Thus relating this to the lack of developmental trends uncovered here with respect to the SPT effect, it could be that motoric encoding is non-strategic (automatic) in nature as Cohen (1981; Cohen & Bean 1983; Cohen & Stewart 1982) originally suggested. The same cannot be said for the intention superiority effect, however.

In the experiments where the ISE paradigm was addressed, only the adult sample (Experiment 1) came close to demonstrating the intention superiority effect. Thus, it could be argued that based on this result, the processing that underlies the ISE and SPT effects is unrelated, in contrast to the proposals put forward by Freeman and Ellis (2003b). Note, however, that Freeman and Ellis focused on the degree of similarity between the ISE and the SPT effect, based on the use of motoric processes. Although the current research does not specifically address this question, the findings indicate that the ISE requires the use of more strategic resources than does the SPT effect. However, this proposal is tentative, following the earlier observation where the younger participants were found to have low Stroop scores indicating poor or slow development of inhibitory functioning. Nevertheless, the data from these experiments collectively reveals that the benefit of motoric encoding on memory retention seems to occur at an early age. What follows is a question of whether motoric encoding can also benefit prospective memory and at what age.

7.1.2 How does encoding modality influence prospective memory performance in 7-, 9- and 11-year-olds?

As mentioned in Chapter 2, the representation and accessibility of to-be-enacted actions is of particular interest to researchers in prospective memory (PM), particularly when identifying the processes that underlie the realisation of intended actions. The area of PM has covered a range of themes, particularly in the last ten years. Yet to date, only a handful of studies have focused specifically on PM in children. One central study is that by Passolunghi, Brandimonte and Cornoldi (1995) who investigated the impact of manipulating the encoding modality of the prospective instruction on PM performance. Moreover, in groups of younger (7-8-year-olds) and older (10-11-year-olds) children, they compared different ways of encoding the PM instruction to identify the effect on PM performance. Over three experiments, they found that performance in the younger group seemed to improve when the PM instruction was encoded visually whilst the older group benefited more when the instruction was encoded through performance.

A principle aim of Experiments 4-5 was to replicate and extend this work by looking at the effect of manipulating the encoding modality of the prospective instruction on PM performance across three age groups. 7-, 9- and 11-year-old children were used in Experiment 4 and groups of 9- and 11-year-olds in Experiment 5. In each experiment encoding modality of the instruction was manipulated between subjects where some participants were exposed to verbal encoding (Experiment 4 only), some to visual encoding (both experiments) and some to motoric encoding (both experiments). Other measures were also integrated including verbal comprehension (BPVS) and executive functioning (TEA-Ch subtests).

Experiment 4. The main results from Experiment 4 revealed that although there was a clear developmental improvement in PM performance, encoding modality of the prospective instruction did not play a significant role. Nevertheless, there are some interesting points worth mentioning about non-significant trends within each age group separately.

Data from the 7-year-old group seemed to indicate that motoric and visual encoding of the PM instruction were of most benefit to performance. Although at first this might hint at a consistency with the findings of Passolunghi, Brandimonte and Cornoldi (1995), who found visual encoding to benefit performance in the younger (7-8 years) group, it should be noted that the visual condition in Experiment 4 closely resembles Passolunghi *et al*'s <u>verbal</u> condition.

Therefore, it would seem that for this age group, performance on the delayed intention task benefited most when the cue is presented as a visual cue rather than as verbal instructions.

Interestingly, the data from the 9-year-old group – where motoric encoding of the instruction seemed to tentatively be of most benefit to PM performance – can be likened to the older (10-11 years) group in the Passolunghi *et al* study where motoric encoding was also of most benefit. It would be interesting to see how a 9-year-old group might perform in an exact replication of Passolunghi *et al's* study.

Finally, the 11-year-old mean data suggests that visual encoding (or Passolunghi *et al*'s verbal encoding condition) was of most benefit to PM performance. Thus, on the one hand although this group has some inconsistency with the finding of Passolunghi *et al*, there is a hint of correspondence with the findings from a study by Hitch, Woodin and Baker (1989) who found that older children's retrospective memory (RM) benefits most from verbal encoding. Similarly, a closer examination of mean performance of the different age groups within the different modalities suggests that motoric encoding is most beneficial for the 9- and 11-year-old groups (consistent with Passolunghi *et al*) and the visual / verbal encoding conditions are more beneficial for the 11-year-old group than for the 7- and 9-year-old groups (consistent with Hitch *et al*). However, notwithstanding the fact that Hitch *et al* looked at RM rather than PM, it is also important to note that they did not include motoric encoding as a manipulation. Therefore it is difficult to forge a robust link between the findings here and those of Hitch *et al*.

Although some might argue that there was not enough power (i.e. insufficient participants) in this experiment to tease out a significant difference between the three encoding conditions, it should be pointed out that where Passolunghi *et al* (1995) had ten participants for each encoding condition, this study had fifteen. Another discrepancy between the studies concerns the associative link between the target and the intended action. In the Passolunghi *et al* study, the link between the target (i.e. the word "*barca*") and the intended action (pressing a response key on the keyboard) was appropriate only to the experiment. Conversely, the link in Experiment 4 was more closely associated whereby the target and the intended action were already linked (e.g. where the target was *tree*, the intended action was to pretend to *plant a tree*). It is possible that this associative target-action link made the bond that worked so well in Passolunghi *et al*'s experiment redundant. Therefore, perhaps PM performance benefits more from the associative link itself, regardless of whether the link is created directly through verbal instructions or indirectly through enactment.

To end the discussion of this Experiment, the effect of verbal comprehension is considered. When BPVS was incorporated into additional analyses, it was not found to have any significant effect within any of the age groups. Interestingly, when the data was collapsed across the age groups, an effect was uncovered where those participants with high verbal comprehension performed better on the PM task than those with low verbal comprehension. This suggests that performance on a similar PM task could be influenced by a participant's verbal comprehension. Although it is difficult to discuss this further with respect to prospective memory per se (due to a lack of related research), this finding could relate to the retrospective memory element of the task, discussed below. As mentioned in section 2.3.1.1, prospective memory process can be broken down into five principle phases. **Phase A** relates to the formation and encoding of the intention but more importantly this phase identifies the intended action (i.e. what the intention is). For a participant to successfully carry out the delayed intention, they must remember what it is that they are expected to do. Therefore, they rely heavily on their retrospective memory. Perhaps then, the reason for participants having good verbal comprehension could relate to their more developed retrospective memory ability. Consequently, they are more likely to remember the intended action. It would be interesting to investigate this further by comparing verbal comprehension with measures of both prospective and retrospective memory.

Experiment 5. Although this experiment shared the same basic design to that of Experiment 4, there were some fundamental changes. For example, whereas Experiment 4 looked at three age groups (7-, 9- and 11-years), Experiment 5 concentrated on just the two older groups. Furthermore, the stimuli used for the ongoing / prospective tasks were pictorial rather than lexical. These changes propagated some interesting results.

Both age groups were found to perform remarkably well on the PM task (nearly 80% success for those participants exposed to the motoric encoding condition). However, this near-ceiling performance made it difficult to tease out a significant difference between the two groups. Therefore, it was not possible to identify either a beneficial encoding strategy or which age group was showing the most pronounced performance on the task. This first point is particularly apparent in the 9-year-old group where performance on both encoding conditions was extremely similar (M = 77-78% success). Taking this observation with the results from Experiment 4, it could be suggested that there is a developmental transition between the younger 7-year-olds and the older 11-year-olds in terms of utilising a beneficial encoding strategy for successful PM performance. In support of this notion; closer examination of the 11-year-old data (in Experiment 5) reveals a nonsignificant trend between the two encoding conditions where those children who enacted the instruction seem to show better performance than those who were presented with a visual cue. This is consistent with a similar observation made above for the 11-year-old data in Experiment 4, although it is partially inconsistent with Hitch, Woodin and Baker (1989), who would argue that visual encoding should provide most benefit for this age group.

Nevertheless, these suggestions are only tentative particularly when considering an earlier observation that, relative to Experiment 4, performance was much higher in Experiment 5. It is likely, therefore, that any disparities that result from differences in how the PM instruction is encoded are likely to be difficult to detect. Perhaps the ongoing task was simply too easy for these participants – naming pictures rather than reading words (Experiment 4).

As with Experiment 4, a measure of verbal comprehension (BPVS) was analysed to see whether or not it played a part in determining PM performance. When BPVS was incorporated into an additional analysis with PM performance (collapsed by age group), a comparable effect to that found for similar data in Experiment 4 was uncovered: Participants with high verbal comprehension performed better on the PM task than those with low verbal comprehension. However, as with the finding in Experiment 4, this effect could not be assigned to a specific encoding condition: The effect only applied to PM performance overall. This suggests, once again, that successful performance on a delayed intention task could be affected by a participant's verbal comprehension. However, it is difficult to discuss this further due to a lack of other studies that have addressed this variable with respect to prospective memory.

Interestingly, across both studies there is no evidence that enactment of the PM instruction at encoding has a deleterious effect on PM performance as Schaefer, Kozak and Sagness (1998) found with adults. However such effects could arguably have been eliminated due to the simplicity of the PM task, particularly in Experiment 5. Regarding this issue, it is worth noting that the Schaefer *et al* study involved several PM elements making the overall PM task more difficult.

Overall, however, it would appear from these two experiments that the way that a prospective instruction is encoded does not seem to play as significant a role on prospective memory performance in children as Passolunghi, Brandimonte and Cornoldi (1995) first suggested in their study. Nevertheless, the findings from the experiments here do seem to suggest that there is a developmental improvement in PM performance, particularly between 7- and 11-years.

Section 2.4 outlines research into age effects on prospective memory performance. Interestingly, the adult research consists of mixed findings. Some studies have revealed improvements in performance with age (e.g. Maylor 1996, 1998; Park, Hertzog, Kidder, Morrell & Mayhorn 1997; Reese and Cherry 2002) while other research (see Maylor 1998) has indicated consistent performance across different age groups. Interestingly, research from Einstein, McDaniel *et al* (1995) has suggested that typically, time-based tasks tend to produce age differences (see also Maylor 1990) while these differences are absent in event-based task designs. However, this research does not correspond to the design employed in the present studies: Event-based tasks where young participants were asked to respond to two specific cues (e.g. the presentation of "*key*" or "*chair*" as either a word or line drawing). Because an age effect was observed, particularly between 7 and 11 years, the findings from these and indeed other studies – including Passolunghi, Brandimonte & Cornoldi (1995) – would appear to contract with the research from Einstein, McDaniel *et al* (1995). It could be that this pattern is exclusive to developmental populations although since there is such an assortment of diverse findings in the adult literature, it is important to consider other developmental PM studies as well.

Putting together the current experiments with existing research into the development of prospective memory, a range of methodologies have been employed across different age ranges. For example, the findings from Experiment 4 and those from Passolunghi, Brandimonte and Cornoldi (1995) revealed that, depending on the design employed, older 10-11-year-old children performed better than the younger 7-8-year-olds on event-based tasks. Similarly, Guajardo and Best (2000) used computer-based and naturalistic, event-based tasks and also found age effects, but between younger 3-5-year-olds. Kvavilashvili *et al* (2001) also used an event-based task but with 4-, 5- and 7-year-old children and also found age effects. Kerns (2000), on the other hand, used a computerised time-based task and found age effects between 6- and 12-

year-old children. In an earlier study, Ceci and Bronfenbrenner (1985) used time-based tasks with participants aged 10-14 years. However, Ceci and Bronfenbrenner focused on the employment of strategies (i.e. clock-watching) rather than improved performance across the age range. They found that the older children spent less time “clock-watching” than the younger children, particularly in a laboratory setting. Nevertheless, Ceci and Bronfenbrenner pointed out that the 10-year-olds were able to employ reasonably sophisticated cognitive strategies to enhance their prospective memory performance.

Overall, therefore, it would appear that prospective memory seems to improve with age; at least from age 3 upwards. It would be of interest to ascertain if there is a greater advance during a particular age. For example, whether there is a more marked improvement between 4- and 7-years versus 7- and 11-years. It would also be of interest to investigate whether this improvement (if any), is dependent on the task design, similar to the distinction found in the adult literature. Furthermore, it would appear that, in contrast to the findings of Passolunghi, Brandimonte and Cornoldi (1995), encoding processes might not play a significant role is prospective remembering. What follows is a discussion of the analyses relating to executive functioning and links with PM performance across the three age groups.

7.1.3 To what extent do attentional measures subserve prospective memory performance in seven-, nine- and eleven-year-olds?

Chapter 6 introduced research that establishes links between executive function and prospective memory (PM). Anderson (2002), for example, proposed a model of executive function where he identified four inter-related domains of executive function. He suggested that one of these, *goal setting*, does not develop until around age twelve where it is relatively mature (although it would arguably continue to develop beyond age twelve). This would suggest a certain amount of cognitive change occurring before this age. Furthermore, because other researchers (e.g. Stuss & Alexander 2000; Zelazo, Muller, Frye & Marcovitch 2003) have suggested that executive function is at least partly responsible for goal-directed behaviour, it seemed logical to investigate the effect of executive functioning, using measures from the TEA-Ch battery, on PM performance in the age groups examined in Experiments 4 and 5. Thus Chapter 6 assembled the PM data from Experiments 4-5, together with measures of executive functioning in an attempt to investigate contributory factors on PM performance.

Chapter 6 revealed some interesting findings across the motoric and visual encoding conditions, relating to three executive function measures. Looking firstly at the motoric encoding condition, Sky Search (selective attention), VT Recall (working memory) and Opposite Worlds (attentional-switching) were all found to be significant predictors of PM performance. Conversely, for the visual encoding condition, age was found to be the only significant predictor of PM performance.

Therefore, it would seem that for those participants in the motoric encoding condition, successful PM performance was determined by three factors: 1) their ability to selectively attend to stimuli, 2) their working or short-term memory ability and 3) their ability to switch attention between two sources of information. Age was not a significant predictor. The opposite was true for those participants in the visual condition, which introduces two discussion questions. First, why is age more influential following visual rather than motoric encoding, particularly when looking back at the results from Passolunghi, Brandimonte and Cornoldi (1995) who suggested the opposite: Visual encoding of a target stimulus appeared to *eliminate* age-related effects. The second question asks why the development of working memory and some attentional measures should underlie age effects after motoric but not visual encoding. One possible reason could relate to the research of Beal (1988) who suggested that children often fail to remember delayed intentions because of a lack of strategic knowledge about how to remind themselves. As other research has indicated (e.g. Ceci & Bronfenbrenner 1985;

Flavell 1985), children are able to learn and develop cognitive strategies although as Beal points out with reference to prospective memory strategies, children may "*…not recognise the need for a specialised association between the reminder and the target*" (p. 368). Therefore, it could be that older children in the visual encoding condition are able to more readily deploy useful strategies that relate to the visual cue and thus construct a more meaningful cue-action association. Children in the other encoding conditions, on the other hand, are more able to identify cue-action associations.

Overall, it would seem that there are a number of determining factors associated with the motoric encoding condition and, notwithstanding the possibility that the ongoing task was too easy, there is the potential for further research in this area.

7.2 PRACTICAL IMPLICATIONS AND FURTHER WORK

The research outlined here has revealed a number of interesting findings relating to the subject-performed task, intention-superiority effect and prospective memory paradigms. But there is still significant scope for further investigation with each. In some earlier work related to the SPT effect, Freeman (1999) stated that, "*Enactment at encoding may be especially beneficial for verbs because it involves the activation of motor information.*" (p.70). Moreover, it could be of interest to focus specifically on verbs rather than whole phrases where the noun can play a key role in recall performance. Anecdotal evidence from data collection for this thesis is perhaps a good example: When attempting to remember the phrases learnt during encoding, one child employed an interesting strategy where he attempted to first remember the object component of each phrase before matching the noun with the relevant verb. Therefore, he might remember "book" and then simultaneously recall that "read" was the associated verb. Consequently, a future manipulation could be to present children with lists of verbs (and activities) rather than whole phrases. However, in so doing researchers should be aware that there are a finite number of lexical stimuli that children can understand. Nevertheless, this manipulation could be used for both the SPT and the ISE paradigms.

In their study on the ISE, Marsh, Hicks and Bink (1998; see also Dockree & Ellis 2001) compared retention for intended versus cancelled scripts where two scripts were introduced as to-be-performed materials. However, before performance was required one script was cancelled. Marsh *et al* then compared lexical decision task latencies for material from both and found that latencies were quicker for intended versus cancelled script material. A similar procedure could also be employed with a developmental sample to investigate the ISE. This would likely have the benefit of being less difficult to comprehend than the task used in Experiments 1-3.

A typical prospective memory task can usually be described as either time- or event-based, depending on the design (Einstein & McDaniel 1990; Einstein, McDaniel, Richardson, Guynn & Cunfer 1995). The task employed in this thesis was the latter where the intended activity is related to the occurrence of a specific event (in this case, the presentation of a target word or picture). However, much research has also been conducted with time-based tasks. Kerns' (2000) CyberCruiser study, for example, presented children with a computer-based driving game where participants had to remember to fill up with petrol before a time limit was exceeded. As well as finding a significant developmental trend (where 12-year-olds had fewer PM failures than 7-year-olds), Kerns also found that PM performance was significantly correlated with inhibition (measured using the Stroop task). Therefore future research could compare performance on both a time- and an event-based design and also look to see whether inhibition has a role on event- as well as time-based PM tasks (Martin, Kliegel & McDaniel 2003).

7.3 CONCLUSIONS

The findings from this thesis have aimed to address and extend current research relating to children's memory for actions. Moreover, the experiments presented have focused on memory for both enacted and to-be-enacted actions in children aged 7-, 9- and 11-years-old. The experiments have provided a number of interesting findings. First, it would seem that children as young as 7-years-old are able to demonstrate a benefit for encoding verb-noun phrases using a motoric encoding strategy, when compared against a verbal encoding strategy. Second, the absence of the ISE in each of the developmental groups provides some support for the proposal that the effect is dependent on strategic rather than automatic processes. Third, results from two event-based prospective memory studies indicate that performance improves with age, irrespective of encoding modality manipulations. Related to this, although there were no explicit conclusions with respect to motoric encoding as a strategy for prospective memory performance, potential reasons are outlined. Finally, a range of executive function measures have been cited as predictors of prospective memory performance in the motoric encoding condition, suggesting that PM performance is inter-related with the development of executive functions.

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APPENDICES

Appendix 1: *Practice phrases used in SPT and ISE experiments*

SPT Paradigm:

Practice Phase#1:

Judge
Balloon
Growl
Drum
Beard
Cheese
Triangle
Crown
Horse
Flash
Boom
Mushroom
Feather
Shout
Guitar
Acorn
Ticket
Volcano
Bridge
Dragon

***Bold = seen**; Regular = unseen

Practice Phase#2:

To Enact:
Bend a ruler
Spray a plant
Stir some soup
Dig for treasure

To Verbalise:
Click a switch
Row a boat
Turn a wheel
Wrap a present

ISE Paradigm:

Practice Phase#1*:

Dipsy
Jake
Betty
Willow
Scooby
Bart
Chucky
Max
Barney
Pikachu
Brains
Marge
Spike
Sabrina
Fizz
Pingu
Wilma
Angelina
Homer
Bella

***Bold = seen**; Regular = unseen

Practice Phase#2:

To Enact:
Bite some chocolate
Drill a hole
Paint a wall
Dig for treasure

To Verbalise:
Tie a knot
Row a boat
Plant a tree
Wrap a present

Appendix 2: *Experimental phrases used in SPT and ISE experiments*

1	2	3	4
Knock on the door	Eat an apple	Close a bag	Shake a pillow
Lift a fork	Break a pencil	Fold a dress	Rip some paper
Clean a window	Pull a plug	Stroke a mouse	Peel a potato
Hit a nail	Pour a kettle	Move a lamp	Throw a hammer
Empty a vase	Wipe a peach	Roll a marble	Chop an onion
Play a piano	Write a letter	Wave a flag	Lick a bowl
Squeeze an orange	Scratch your nose	Cut a cake	Read a book

5	6	7	8
Squirt a lemon	Flick a yoyo	Fill a basket	Crush an acorn
Thread a needle	Mash a banana	Spin a bottle	Burst a balloon
Tidy a desk	Play a guitar	Blow a trumpet	Pack a suitcase
Wobble a jelly	Press a button	Push a pram	Wring a towel
Bounce a ball	Polish a shoe	Bend a spoon	Drive a car
Grate a carrot	Answer a telephone	Twirl an umbrella	Fly a kite
Open a box	Slice some bread	Adjust a clock	Bang a drum

Appendix 3: *SPT and ISE participant instructions*

SPT Instructions:

Practice Phase #1:
"*I am now going to read out ten words. I would like you to say each word back to me and try to remember them all. Do you understand this?*"

(PRESENT TEN WORDS FROM PRACTICE PHASE #1)

"*Now we are going to play a counting game. I would like you count backwards from (**RANDOM 3-DIGIT NUMBER**) in 2's. Do you understand this?*"

(FILLER TASK FOR 30 SECONDS)

"*Now let us see if you can remember the ten words I gave you earlier. I am going to give you a little test where I would like you to see whether you remember the words on the screen from the list I gave you at the beginning by pressing a button: If you see the word* **FROG** *and you remember it from the list, then you press the* **YES** *button. If you do not remember seeing* **FROG***, then you press the* **NO** *button.* Make a decision as fast as possible *to each word because the response is timed.*"

Practice Phase #2:
"*Now we are going to play a new game where I am going to say two lists of task phrases, things you must do. The first list I would like you to act out and the second list, repeat what I say, just like before. Do you understand this?*"

(PRESENT TWO LISTS OF PHRASES FROM PRACTICE PHASE #2)

Test Phase:
"*We are now going to play another memory game. Again you will hear two lists of task phrases that describe things you must do. One list I will ask you to act out all of the phrases and for the other list I will ask you to repeat all the phrases. After you have heard both lists, you will do another little counting game. Finally, you will do the memory test using the computer. Do you understand this?*"

(PRESENT LISTS ACCORDING TO THE PRESENTATION SHEET)

"*Now we are going to play another counting game. This time I would like you count backwards from (**RANDOM 3-DIGIT NUMBER**) in 2's. Do you understand this?*"

(FILLER TASK FOR 30 SECONDS)

"*I am now going to give you the final test where I would like you to see whether you remember the words from the two cassettes you heard just now by pressing the relevant button. Please* *press the button as fast as possible* *to each word because the response is timed.*"

Recall Phase:

"Now, how many of the phrases can you remember from the lists that you heard on the cassette tapes?"

ISE Instructions:

Practice Phase #1:
"*I am now going to read out ten names. I would like you to say each name back to me and try to remember them all. Do you understand this?*"

(PRESENT TEN NAMES FROM PRACTICE PHASE #1)

"*Now we are going to play a counting game. I would like you count backwards from (**RANDOM 3-DIGIT NUMBER**) in 2's. Do you understand this?*"

(FILLER TASK FOR 30 SECONDS)

"*Now let us see if you can remember the ten names I gave you earlier. I am going to give you a little test where I would like you to see whether you remember the names on the screen from the list I gave you at the beginning by pressing a button: If you see the name* **FRED** *and you remember it from the list, then you press the* **YES** *button. If you do not remember seeing* **FRED***, then you press the* **NO** *button.* Make a decision as fast as possible *to each word because the response is timed.*"

Practice Phase #2:
"*Now we are going to play a new game. In this game I want you to repeat two lists of task phrases, which are things you must do. I would like you to repeat both lists, like before. But this time after you have said the phrases, I want you to* ***pretend to do*** *the* ***first list*** *and* ***tell me*** *the phrases from the* ***second list****. Do you understand this?*"

(PRESENT TWO LISTS OF PHRASES FROM PRACTICE PHASE #2)

Test Phase: Overview

"We are now going to play another game which also uses task phrases, like those you read out and acted earlier. I am going to play you two lists from this cassette player. I would like you to repeat both lists and try to remember them all. Later, I'm going to ask you to pretend to do the phrases from one of the lists and tell me what the phrases are from the other list. Do you understand this?"

Test Phase: Encoding

"Okay, now I am going to play you both lists. In a few minutes, I would like you to pretend to do the phrases from list ____. Okay? Also in a few minutes I would like you to tell me the phrases from list ____. Okay, now can you remember what you have to do in a few minutes?"

(IF CHILD CANNOT RECITE INSTRUCTIONS CORRECTLY, HELP GIVEN)
(BOTH LISTS ARE THEN PLAYED AND INSTRUCTIONS REITERATED)

Test Phase: Filler Task

"*Now we are going to play another counting game. This time I would like you count backwards from (**RANDOM 3-DIGIT NUMBER**) in 2's. Do you understand this?*"

(FILLER TASK FOR 30 SECONDS)

Test Phase: Recognition Test

"I'm now going to give you another little test. This time I'd like to see whether you can recognise the words that come up on the screen from the two lists I gave you at the beginning by pressing one of the buttons, just like before. Do you understand? Again, please press the buttons as fast as you can because the responses are again timed."

Test Phase: Performance / Recall Test

"Finally, I'd like you to act out all the phrases from the list I asked you to remember to act out and say as many of the words as you can remember from the other list in any order. While you are acting the phrases out, I'd like you to say the phrase. Do you understand this?"

Test Phase: End Of Testing: Questioning / Debriefing

"Thank you for all your help. Could I just ask you a few things, please?

1. *Do you remember what I asked you to do in the last phase?*
2. *Which list did I ask you to act out? (1 or 2)*
3. *Which list did I ask you to tell me the phrases? (1 or 2)*
4. *Can you remember if you did these correctly?*
5. *Have you got any questions?"*

Appendix 4: *Hayling sentence completion score sheet and instructions*

Section 1: *Sensible Completion*

In a moment I am going to read you a list of sentences. Each sentence has the last word missing from it. I want you to listen carefully to each sentence, and when I have finished each one, I want you to give me a word that completes the sentence. Do you understand?

Practice

Before we start, I'll give you a couple of practice sentences to make sure that you understand. Are you ready?

		Response	**Time**
P1	The rich child attended a private		
P2	The crime rate has gone up this		

Test

Okay, that's the end of the practice sentences. The next few sentences are not any more difficult than the two you have just done. The important thing is to give me your answer as quickly as you can – the faster the better. Do you understand that?

		Response	**Time**
1	He posted a letter without a		
2	In the first space, enter your		
3	The old house will be torn		
4	It's hard to admit when one is		
5	The job was easy most of the		
6	When you go to bed turn off the		
7	The game was stopped when it started to		
8	He scraped the cold food from his		
9	The dispute was settled by a third		
10	Three people were killed in a major motorway		
11	The baby cried and upset her		
12	Roger could not believe that his son had stolen a		
13	He crept into the room without a		
14	Billy hit his sister on the		
15	Too many men are out of		
	Total time (**Raw Score**)		
	Scaled Score (Box **A**)		

Section 2: *Unconnected Completion*

Now we are going to move on to the second section of the test. In this section I will read you a set of sentences with the last word missing just like before. BUT this time I want you to give me a word that does not fit at the end of the sentence. I want the word that you give me to be completely unconnected to the sentence. Do you understand?

Practice

Before we start, I'll give you a couple of practice sentences to make sure that you understand. Are you ready?

		Response	Time
P1	London is a very busy (E.g.: BANANA)		
P2	Her new shoes were the wrong		

(For extra help with unforeseen problems, refer to the manual, p8)

Test

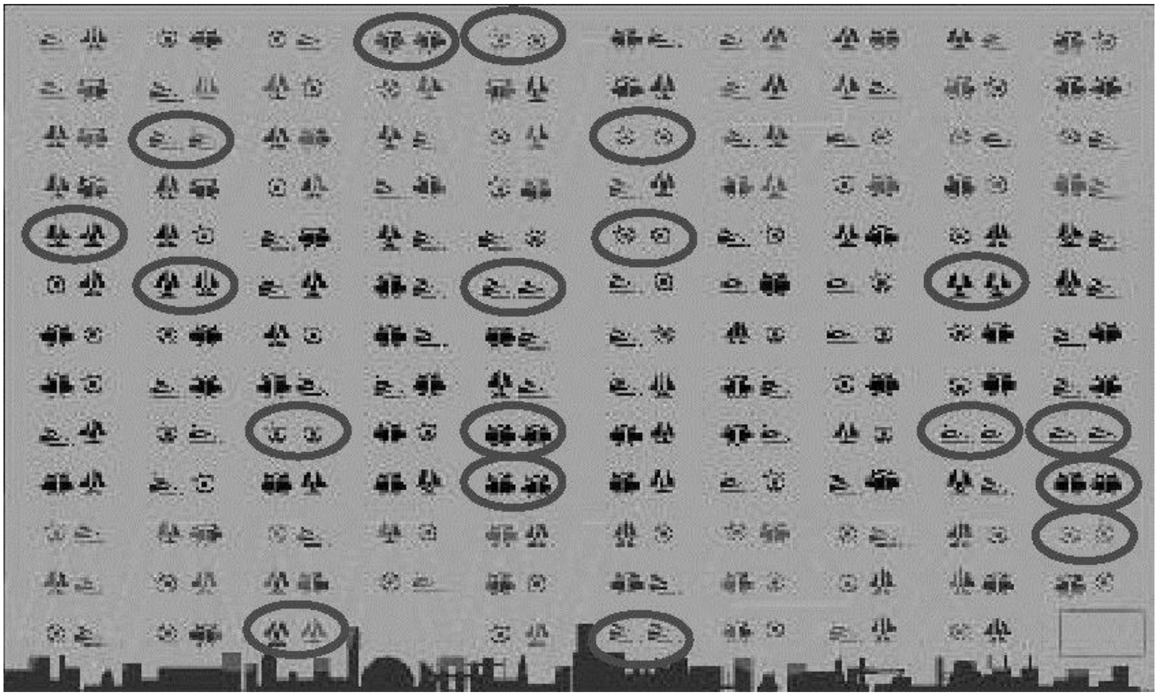
Okay, that's the end of the practice sentences. Remember that the words you give me must be unconnected to the sentence. Please try not to repeat yourself and just like before, please give me your answer as quickly as you can – the quicker the better. Are you ready?

		Response	Time
1	The captain wanted to stay with the sinking		
2	They went as far as they		
3	Most cats see very well at		
4	Jean was glad that the affair was		
5	The whole town came to hear the mayor		
6	Most sharks attack very close to		
7	None of the books made any		
8	The dough was put in the hot		
9	She called the husband at his		
10	All the guests had a very good		
11	He bought them in the sweet		
12	His leaving home amazed all his		
13	At last, the time for action had		
14	The dog chased our cat up the		
15	At night they often took a short		
	Total time (**Raw Score**)		
	Scaled Score (Box **B**)		

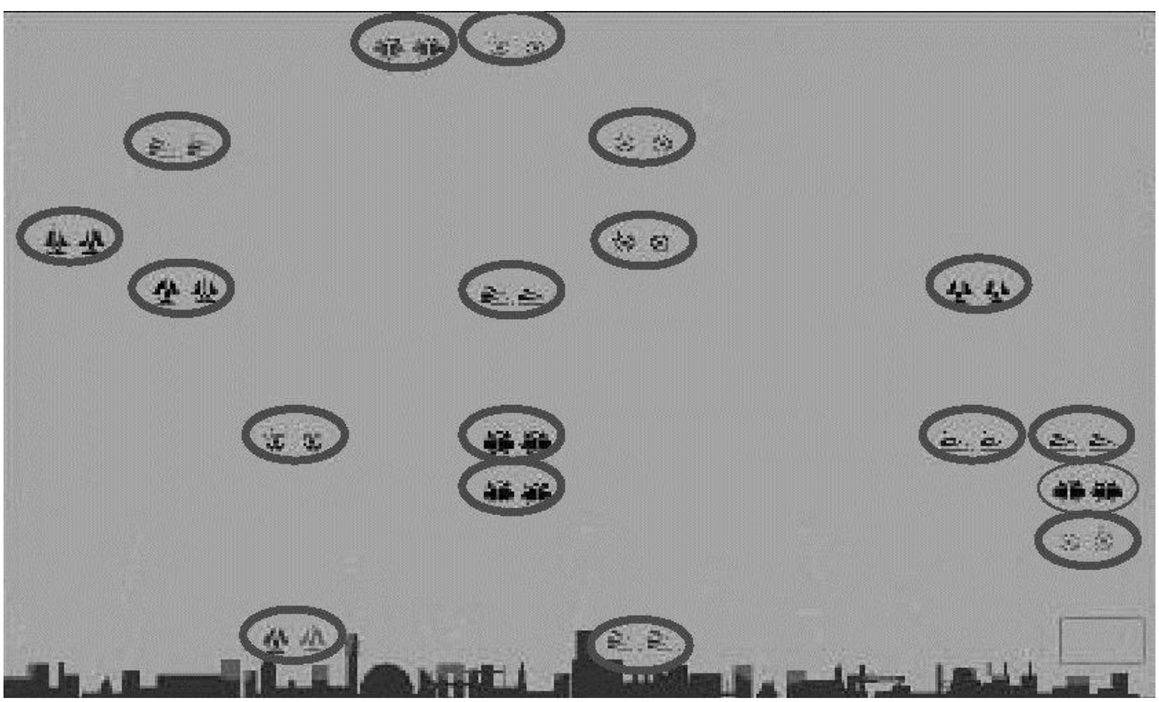
Appendix 5: *National Adult Reading Test Items*

CHORD
ACHE
DEPOT
AISLE
BOUQUET
PSALM
CAPON
DENY
NAUSEA
DEBT
COURTEOUS
RAREFY
EQUIVOCAL
NAÏVE
CATACOMB
GAOLED
THYME
HEIR
RADIX
ASSIGNATE
HIATUS
SUBTLE
PROCREATE
GIST
GOUGE
SUPERFLUOUS
SIMILE
BANAL
QUADRUPED
CELLIST
FAÇADE
ZEALOT
DRACHM
AEON
PLACEBO
ABSTEMIOUS
DÉTENTE
IDYLL
PUERPERAL
AVER
GAUCHE
TOPIARY
LEVIATHAN
BEATIFY
PRELATE
SIDEREAL
DEMESNE
SYNCOPE
LABILE
CAMPANILE

Appendix 6: *TEA-Ch Materials*



Sky Search / DT Work Sheet



Sky Search Motor Control Work Sheet

Appendix 7: *TEA-Ch Instructions*

Sky Search:

Administration of Practice:
"As you can see, these space ships always travel around in pairs. Your job is to find all the pairs where both ships are the same, like these:"

(DEMONSTRATE FIRST EXAMPLE ON PRACTICE SHEET)

"You need to do it as quickly as you can while trying not to miss any – so you don't need to be too neat. When you think that you have finished, put a tick in the box at the bottom here (SHOW THE BOX) *as quickly as you can so that I know how long it took you. Do you understand what I have said?"*

Administration of Sky Search:
"Now, let's see how well you can do exactly the same thing on this big sheet."

(PRESENT A3 TEST SHEET)

Timing:
TIMING BEGINS ON "START" AND IS FINISHED WHEN THE BOX IS TICKED. IF IT APPEARS THAT THE CHILD HAS FINISHED BUT FORGOTTEN TO MARK THE BOX, ASK "FINISHED?" AND ONLY ON AGREEMENT, STOP TIMING.

Scoring:
RECORD THE TIME AND COUNT THE NUMBER OF TARGETS CORRECTLY CIRCLED.

Administration of Sky Search (Motor Control):
"It's even easier now because we only have the real ships. When I say, "Start", I want you to put a ring around all the pairs of ships that you can see as quickly as you can while trying not to miss any. Make sure you tick the box at the end when you have finished. Ok… Start."

Timing:
Begin timing on "Start" and stop when the box is marked / child agrees that the task is finished.

Score!

<u>Administration of Practice:</u>
"This game is all about counting. I am going to play you this tape and you have to count how many special sounds you hear – just like you were keeping score by counting the number of scoring sounds in a computer game.

"The first sound you will hear is a whirring sound to tell us when each game begins and ends. After that sound, I want you to start counting each sound and tell me how many at the end.

"Listen to this first example and count along with me."

<u>Administration of Score! test:</u>
"Okay? Now let's begin the real games."

<u>Scoring:</u>
Score 1 for each correctly counted string.

Sky Search DT:

<u>Administration:</u>
"You remember that the ships we needed to find were the ones where both ships in the pair were exactly the same. You need to do that again for this game. BUT this time, at the same time as finding the ships, you will have to do a second and equally important thing – to count the number of scoring sounds on the tape – just like you did before.

"Remember that you have to count how many scoring sounds there are in each game and to tell me how many when you hear the whirring sound. Does that make sense?

"Just to make sure, let's do a practice. In a moment a voice on the tape will say, "Five… four… three… two… one… start". You should then start to circle all of the pairs of ships where there are two of the same. At the same time, when you hear the whirring sound at the end of each game, tell me how many scoring sounds there were. As soon as you have circled all of the paired ships you can see, put a mark in this box: You don't need to wait for the tape to finish."

<u>Timing:</u>
Begin timing on "Start". Stop when the box is marked / child agrees that the task is finished.

<u>Scoring:</u>

Record time and accuracy of count games and visual search on the TEA-Ch score sheet.

Opposite Worlds:

Administration:
"In this game, there are two sorts of world that we are going to visit. There is the Same World where everything is as you would say it here and the Opposite World, where you have to say the opposite of what you would say here. For example:"

(SAME WORLD EXAMPLE)

Here I would say, *"Start…one…one…two…two…one…Stop. Now you try this one."*

(Make sure the you point to every square including Start and Stop, in turn, and only move on if response is correct)

"Okay, we're now going to the Opposite World where we have to say the opposite. Here, when we see a one, we have to say "two" and when we see a two we have to say "one". For example:"
(Opposite World Example)

"Start…one…one…two…one…two…Stop"

(Present in order in the Flip Book)

Timing:
Begin timing on when the child SAYS, "Start". Finish when the child says "Stop".

Scoring:
RECORD THE TIME TAKEN.

Appendix 8: Prospective Memory Task (*Experiment 4*): Stimuli

1	Ant	**26**	Grapes
2	Arm	**27**	Hand
3	Bath	**28**	**Hat (target 2a)**
4	Bed	**29**	Hen
5	Bell	**30**	Horse
6	Bike	**31**	**Key (target 1b)**
7	Boat	**32**	King
8	Bus	**33**	Ladder
9	Camera	**34**	Leaf
10	Castle	**35**	Lion
11	**Chair (target 1a)**	**36**	Moon
12	Cheese	**37**	Owl
13	Cloud	**38**	Pear
14	Clown	**39**	Rabbit
15	Cow	**40**	Rocket
16	Cowboy	**41**	Sheep
17	Cup	**42**	**Ship (target 3a)**
18	Doctor	**43**	Snail
19	Dog	**44**	Star
20	Duck	**45**	Sun
21	Ear	**46**	**Tie (target 3b)**
22	Finger	**47**	Tiger
23	Fish	**48**	Train
24	Flower	**49**	**Tree (target 2b)**
25	Frog	**50**	Wheel

Word	**Associated Action**
Words one and two	
Chair	*Move the chair*
Key	*Turn the key*
Words three and four	
Hat	*Squash the hat*
Tree	*Plant the tree*
Words five and six	
Ship	*Paint the ship*
Tie	*Roll the tie*

Appendix 9: Prospective Memory Task (*Experiment 4*): Instructions

<u>Motor Condition:</u>

"This is a series of games to see how good your reading is. On the screen, you are going to see some words, five at a time. I would like you to read out these words as quickly and correctly as possible.

"Within this game there are a couple of words that I would like you to look out for. These are _______ and _______. If you see these words, I would like you to do a little action for me: If you see the word _______, then I would like you to _____________. (CHILD ACTS OUT THE APPROPRIATE ACTION). *If you see the word _______, then I would like you to _____________.* (CHILD ACTS OUT THE APPROPRIATE ACTION)*.*

"Okay, does that make sense? (IF NOT, REPEAT INSTRUCTIONS). Right before we start the proper games, let's do a few practice games."

(DO PRACTICE GAME)

(FILLER TASK EXPLANATION!)
"Now the computer needs to do a few things before it's ready for us to do the proper game. While we are waiting, would you like to play a different game?"

(FILLER TASK HERE FOLLOWED BY PM TEST)

"Okay, I think that the computer is ready now. Are you ready for the reading game? Then let's begin."

<u>Verbal Condition:</u>

"This is a series of games to see how good your reading is. On the screen, you are going to see some words, five at a time. I would like you to read out these words as quickly and correctly as possible.

"Within this game there are a couple of words that I would like you to look out for. These are _______ and _______. If you see these words, I would like you to do a little action for me: If you see the word _______, then I would like you to _____________. If you see the word _______, then I would like you to _____________.

"Okay, does that make sense? (IF NOT, REPEAT INSTRUCTIONS)*. Right before we start the proper games, let's do a few practice games."*

(DO PRACTICE GAME)

(FILLER TASK EXPLANATION!)
"Now the computer needs to do a few things before it's ready for us to do the proper game. While we are waiting, would you like to play a different game?"

(FILLER TASK HERE FOLLOWED BY PM TEST)

"Okay, I think that the computer is ready now. Are you ready for the reading game? Then let's begin."

Visual Condition

"This is a series of games to see how good your reading is. On the screen, you are going to see some words, five at a time. I would like you to read out these words as quickly and correctly as possible.

"Within this game there are a couple of words that I would like you to look out for. These are _______ and _______. If you see these words, I would like you to do a little action for me: If you see the word _______, (SHOW APPROPRIATE WORD TO CHILD) *then I would like you to ______________. If you see the word _______,* (SHOW APPROPRIATE WORD TO CHILD) *then I would like you to ______________.*

"Okay, does that make sense? (IF NOT, REPEAT INSTRUCTIONS). Right before we start the proper games, let's do a few practice games."

(DO PRACTICE GAME)

(FILLER TASK EXPLANATION!)
"Now the computer needs to do a few things before it's ready for us to do the proper game. While we are waiting, would you like to play a different game?"

(FILLER TASK HERE FOLLOWED BY PM TEST)

"Okay, I think that the computer is ready now. Are you ready for the reading game? Then let's begin."

Appendix 10: PM Task (*Experiment 4*): Scoresheet / Questionnaire

Trial No.	No. Correct	Target Word / Acted?
Practice Game		
1		N/a
…		N/a
10		N/a
Block #1		
1		/
…		(e.g. Chair) / (e.g. ✗)
10		/
Block #2		
11		/
…		/
20		/
Block #3		
21		/
…		/
30		/
Block #4		
31		/
…		/
40		/

(1) Can you remember what it was that you had to do in this game?

	2=Full description of task, words and actions 1=Partial description but fails to mention words/actions 0=Little or no description

(2) Do you remember that there were some special words that I asked you to look out for?

	2=Both words recalled 1=One word recalled 0=No words recalled

(3) Can you remember what the words were?

	2=Both words recalled 1=One word recalled 0=No words recalled

(4) Did you have to do anything when you saw those words?

	2=Accurate and complete description 1=Partial description 0=No description

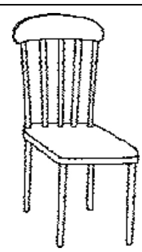
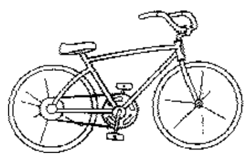
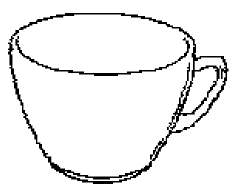
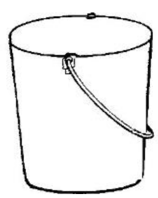
(5) Can you remember what it was that you had to do?

	2=Accurate and complete description 1=Partial description 0=No description

(6) Did you do the actions when you saw the appropriate words?

	2=Correct recollection & performance 1=Partial recollection / performance 0=Incorrect recollection / performance

Appendix 11: PM Task (*Experiment 5*): Target Stimuli

Picture	(Word)	Associated Phrase
	**Boat**	*"Paint the boat"*
	**Chair**	*"Pick up the chair"*
	**Bike**	*"Push the Bike"*
	***Cup***	*"Turn over the cup"*
	***Bucket***	*"Swing the bucket"*
	***Tree***	*"Hug the tree"*

Appendix 12: Prospective Memory Task (*Experiment 5*): Instructions

<u>Motor (Verbal) Condition:</u>

“This is a series of games to look at your picture naming skills. On the computer screen, you are going to see some pictures, five at a time. I would like you to tell me what each picture is as quickly and correctly as possible.

“Within this game there are a couple of pictures that I would like you to look out for. These are _______ and _______. If you see these pictures, I would like you to do a little action for me: If you see the picture _______, then I would like you to ______________. (CHILD ACTS OUT THE APPROPRIATE ACTION). *If you see the picture _______, then I would like you to ______________.* (CHILD ACTS OUT THE APPROPRIATE ACTION).

“Okay, does that make sense? (IF NOT, REPEAT INSTRUCTIONS).

“Right okay, now in a minute we are going to do some practice games. But first of all, we’re going to play a counting game. What I’d like you to do is count from 1 to 10 again and again for one minute. You should try and count two numbers every second: I’ll start and I want you to join in and keep going:

(EXPERIMENTER BEGINS: 1, 2, 3, 4… AND CHILD SHOULD CONTINUE FOR 30 SECONDS)

“Okay, now you’re going to do some practice picture-naming games. Are you ready?”

(DO PRACTICE GAMES)

“Now the computer needs to do a few things before it’s ready for us to continue. While we are waiting, would you like to play a different game?”

(FILLER TASK HERE FOLLOWED BY PM TEST)

“Okay, I think that the computer is ready now. Are you ready to continue the picture-naming game? Then let’s begin.”

<u>Visual (Motor) Condition:</u>

“This is a series of games to look at your picture naming skills. On the computer screen, you are going to see some pictures, five at a time. I would like you to tell me what each picture is as quickly and correctly as possible.

"Within this game there are a couple of pictures that I would like you to look out for. These are _______ and _______. If you see these pictures, I would like you to describe an action: So, if you see the picture _______, then I would like you to say ______________. (CHILD REPEATS THE PHRASE). *If you see the picture _______, then I would like you to say ______________.* (CHILD REPEATS THE PHRASE).

"Okay, does that make sense? (IF NOT, REPEAT INSTRUCTIONS).

"Right okay, now in a minute we are going to do some practice games. But first of all, we are going to play an air-drawing game. What I'd like you to do is pretend to draw a circle in the air with your finger and keep doing it until I say "stop". For example:

(EXPERIMENTER PERFORMS EXAMPLE AND GETS CHILD TO COPY)

"Okay, now keep going" (CHILD CONTINUES TO AIR-DRAW FOR 30 SECONDS)

"Okay, now you're going to do some practice picture-naming games. Are you ready?"

(DO PRACTICE GAMES)

"Now the computer needs to do a few things before it's ready for us to continue. While we are waiting, would you like to play a different game?"

(FILLER TASK HERE FOLLOWED BY PM TEST)

"Okay, I think that the computer is ready now. Are you ready to continue the picture-naming game? Then let's begin."

Appendix 13: PM Task (*Experiment 5*): Scoresheet / Questionnaire

Trial No.	**No. Correct**	**Target / Response**
Practice Game		
1		N/a
…		N/a
10		N/a
Block #1		
1		/
…		(e.g. Chair) / (e.g. ×)
10		/
Block #2		
11		/
…		/
20		/
Block #3		
21		/
…		/
30		/
Block #4		
31		/
…		/
40		/

(1) Can you remember what it was that you had to do in this game?

	3=All remembered; 2=Pictures and actions; 1=Pictures or Actions only; 0=Little or no description

(2) Do you remember that there were some pictures that I asked you to look out for?

	3=All remembered; 2=Both pictures recalled; 1=One picture recalled; 0=No pictures recalled

(3) Can you remember what the pictures were?

	2=Both pictures recalled; 1=One pictures recalled; 0=No pictures recalled

(4) Did you have to do anything when you saw those pictures?

	2=Accurate and complete description; 1=Partial description; 0=No description

(5) Can you remember what it was that you had to do?

	2=Accurate and complete description; 1=Partial description; 0=No description

(6) Did you do what I asked you to do when you saw the pictures?

	2=Correct recollection & performance; 1=Partial recollection / performance; 0=Incorrect recollection / performance