

Frequency and working memory effects in incidental learning of a complex agreement pattern

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Accepted Version

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Denhovska, N., Serratrice, L. ORCID: <https://orcid.org/0000-0001-5141-6186> and Payne, J. (2018) Frequency and working memory effects in incidental learning of a complex agreement pattern. *Lingua*, 207. pp. 49-70. ISSN 00243841 doi: <https://doi.org/10.1016/j.lingua.2018.02.009> Available at <https://centaur.reading.ac.uk/76938/>

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Published version at: <http://dx.doi.org/10.1016/j.lingua.2018.02.009>

To link to this article DOI: <http://dx.doi.org/10.1016/j.lingua.2018.02.009>

Publisher: Elsevier

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Abstract

Complex grammatical structures have been assumed to be best learned implicitly (Krashen, 1982, 1994; Reber, 1989). However, research to date has failed to support this view, instead finding that explicit training has overarching beneficial effects. The present study attempted to elucidate this issue by examining how type and token frequencies in incidental learning input and individual differences in the learner's working memory (WM) combine to affect the receptive and productive learning of a complex agreement pattern in a novel language. The findings indicated that type frequency significantly enhanced receptive knowledge acquisition even more than explicit instruction. Performance on the productive knowledge retrieval task was poor under all learning conditions but most accurate under the explicit learning condition. WM was not implicated in incidental learning, possibly indicating that all learners experience high cognitive demand imposed by the target structure regardless of variation in WM capacity.

18 *Keywords:* L2 grammar, linguistic complexity, incidental learning, frequency, working
19 memory

20

21 **1. Introduction**

22 A subject of long-standing debate has been whether a complex grammatical
23 pattern can be more successfully learned under implicit (Krashen, 1982, 1994;
24 Reber, 1989) rather than explicit learning conditions (Hulstijn & de Graaff, 1994). To
25 date, extensive second language acquisition (SLA) research has determined that
26 explicit training/classroom instruction is generally more beneficial than implicit training
27 for learning a complex structure in L2 (DeKeyser, 1995; N. Ellis, 1993; Norris & Ortega,
28 2000; Robinson, 1996; Spada & Tomita, 2010). However, it may be that it is the
29 combined effects of multiple factors that trigger successful knowledge acquisition in
30 incidental learning contexts, a facet we currently know little about. Importantly, with
31 regard to considering incidental learning, Hulstijn (2005) highlighted that it is essential to
32 understand the interactions among the following factors rather than studying each factor
33 in isolation: 1) the complexity of the system underlying the data; 2) the frequency with
34 which the linguistic structures are presented to the learners in the input; and 3) learners'

individual differences with respect to knowledge, skills, and information processing (p. 133).

The linguistic complexity of the structure is often associated with cognitive complexity or learning difficulty (DeKeyser, 2005; Housen, 2014; Marsden, Williams, & Liu, 2013), which is affected in turn by individual differences in cognitive abilities, including working memory (WM) capacity variability (Grey, Williams, & Rebuschat, 2015; Juffs & Harrington, 2011; Tagarelli, Ruiz-Hernandez, Vega & Rebuschat, 2016). In addition, it has been posited that the complexity of a linguistic structure interacts with its input-related properties, such as the frequency of the occurrence of the structure in the input, making it more or less accessible for acquisition (Housen & Simoens, 2016). Hence, frequency may mediate adult incidental learning by creating a more or a less effective learning context. For L1 acquisition of complex morphologies, type and token frequencies are known to be vital (Tomasello, 2000, 2008). The present study thus attempts to understand the effects of type and token frequencies on adult acquisition of a complex L2 pattern and the extent to which the manipulation of type and token frequencies in the incidental learning condition impacts the effectiveness of learning such a structure. In particular, this paper focuses on the acquisition of a complex noun-

adjective agreement pattern in a richly inflected language (Russian) by adult novice learners (who are speakers of an L1 with a less rich morphology) in terms of comprehension and production modalities. Further, this paper examines how individual differences in learners' WM mediate this acquisition under different learning conditions.

L2 morphology is known to be one of the major stumbling blocks for the novice adult learner, particularly if the learner's L1 does not share the feature to be acquired in L2 (DeKeyser, 2005; Larsen-Freeman, 2010). Although numerous studies have examined the acquisition of inflectional morphology (Brooks, Kempe & Donachie, 2011; Kempe, Brooks & Kharkhurin, 2010; Kempe & McWhinney, 1998), few have devoted attention to its incidental acquisition (Brooks & Kempe, 2013; Rogers, Revesz, & Rebuschat, 2015), and to our knowledge, no studies have explored the combined effect of frequency and WM during the incidental learning of such complex systems.

2. Background

2.1. Definition of terminology

First, it is important to introduce the applicable terminology. Although the terms incidental learning and implicit learning are used interchangeably in the literature,

implicit learning is typically understood as a process of acquiring a target structure without intention and awareness that results in the accumulation of implicit knowledge (Williams, 2009). By contrast, explicit learning is a process during which the learner is consciously involved in the processing of the stimulus input. The term incidental learning is used to denote the experimental condition in which the learner is directed to the meaning rather than to the grammatical structure of interest and is not informed regarding any testing to follow (Rebuschat & Williams, 2012). Accordingly, learning under such conditions may or may not result in implicit knowledge. The present paper does not address the issue of conscious/unconscious knowledge developed under these conditions. Sometimes, the notion of the “implicit learning condition” is used to refer to a similar experimental paradigm (Morgan-Short et al., 2010, 2012). In the present study, we follow Rebuschat and Williams (2012) and adopt the definition of incidental learning as a training condition. In contrast, we use the term explicit learning condition to refer to a condition where knowledge acquisition is fostered by providing metalinguistic information about the target structure (Spada & Tomita, 2010; Robinson, 1996).

We begin the paper by reviewing the literature on the incidental learning of complex structures, frequency and WM. We then present and discuss our investigation of the incidental learning of a number agreement pattern in a novel natural and fusional language (Russian) that simultaneously marks gender and case.

2.2. Acquisition of complex grammatical patterns under incidental learning conditions

Various studies have employed different understandings of complexity, including pedagogical, linguistic and psycholinguistic complexities (Collins, Trofimovich, White et al., 2009; see Spada & Tomita, 2010 for meta-analysis). Most commonly, however, research has adopted the absolute or the relative approach to defining the complexity of language structure. The present study utilizes the absolute (Dahl, 2004; McWhorter, 2001, 2007) or structural approach (Bulte & Housen, 2012; Miestamo, 2008; Pallotti, 2015), which asserts that the more parts a system has, the more complex it is. Based on this definition, a morphological pattern similar to the subject of the present study, which has inflectional markers signalling agreement based on number, gender and case, would be considered complex as opposed to a morphological pattern that factors

103 in only one of these features. The relative approach (Kusters, 2003), in contrast, defines
104 complexity in terms of processing costs and difficulty for language users, predicting that
105 linguistically complex structures also demand that more cognitive resources be
106 expended by the learner.

107 DeKeyser (2005) further distinguishes formal structural complexity, which
108 emphasizes the complexity of the form, such as the number of forms in a paradigm, and
109 suggests – consistent with the taxonomic model of L2 complexity (Bulte & Housen,
110 2012) – that morphological systems are more complex in richly inflected languages.
111 Consequently, scholars have noted that features in L2 that are different from the
112 learner's L1 are difficult to learn from input either implicitly or explicitly because
113 morphology is a weak cue during the initial stages of language learning.

114 Conversely, Krashen (1982) introduced the distinction between complex
115 structures that are easy to acquire [implicit] but difficult to learn [via explicit instruction]
116 and simple structures that are easy to learn but difficult to acquire, which led to several
117 experimental studies (de Graaff, 1997; DeKeyser, 1995; Robinson, 1996; Tagarelli,
118 Ruiz-Hernandez, Vega & Rebuschat, 2016; Van Daele, 2005). Research that directly
119 compared knowledge attainment of different L2 grammar structures (e.g., word order,

120 plural marking, passives, and gender agreement) generally found similar retention
121 levels under both implicit and explicit conditions (Andringa, De Gloppe, & Hacquebord,
122 2011; de Graaff, 1997; DeKeyser, 1995; Morgan-Short et al., 2010, 2012; Robinson,
123 1996; Williams & Evans, 1998). Similar findings were obtained by research in classroom
124 settings that employed implicit (meaning-focused) and explicit (form-focused) instruction
125 for learning grammar structures in L2 French that were simple (i.e., negation) and
126 complex (i.e., passive constructions) (Van Daele, 2005). This trend was partially
127 confirmed in more recent research by Tagarelli et al. (2016), who used syntactic
128 structures of different complexity modelled on German word order in a semi-artificial
129 language to study how complexity interacts with implicit/explicit learning conditions.
130 Higher learning effects were found for all structures in the explicit learning condition.

131 Nevertheless, previous research has generally overlooked the role of factors
132 such as frequency that may mediate incidental learning, which may explain why such
133 research has failed to find the benefits of incidental learning over explicit training in
134 acquiring complex structures. The subsequent section outlines the importance of the
135 frequency factor in incidental learning and reviews the experimental literature on the
136 role of frequency in grammatical knowledge acquisition.

137 2.3. Frequency and L2 learning

138

139 Frequency constitutes the nucleus of implicit learning, as implicit learning is
140 understood as a process of tracking the frequencies of the items co-occurring in the
141 input and storing them in memory (Johnstone & Shanks, 2001; Knowlton & Squire,
142 1994; Knowlton, Ramus, & Squire, 1992; Perruchet & Pacteau, 1990). Many theoretical
143 models – such as the usage-based approach to grammar (Bybee, 1998; Goldberg,
144 2006; Langacker, 1987) and connectionist models of language learning and processing
145 (Christiansen & Chater, 1999, Elman, 1991; MacWhinney, 1998) – credit frequency with
146 a fundamental role in learning. While assuming that the acquisition of grammar is a
147 piecemeal accumulation of specific constructions and frequency-based abstractions of
148 regularities within them, the usage-based approach distinguishes the different roles of
149 type and token frequencies (Bybee, 1985, 2010; Ellis, 2002, 2006; Hulstijn, 2005;
150 Tomasello, 2000, 2008). Token frequency is believed to play a significant role in
151 strengthening new representations of specific schemas and is important during the
152 initial stages of learning, whereas type frequency has a privileged role in subsequent
153 knowledge abstraction. Although having been extensively studied from the perspective
154 of L1 acquisition and processing (Abbot-Smith, Lieven, & Tomasello, 2004; Arnon &

155 Snider, 2010; Lieven & Tomasello, 2008; Tomasello, 2003) and greatly emphasized in
156 terms of L2 acquisition (Gass & Mackey, 2002; Ellis, 2002; Ellis & Ferreira-Junior,
157 2009), experimental evidence remains limited at present with regard to the effects of
158 type and token frequencies in adult incidental learning of complex morphology.

159 The theoretical motivation for understanding the roles of type and token
160 frequencies in the incidental learning of L2 complex morphology stems from the debate
161 whether the same or different mechanisms underlie L1/L2 acquisition (Abutalebi &
162 Green, 2008; Perani & Abutalebi, 2005; Ullman, 2004). If the same mechanisms that
163 guide L1 grammatical development are available in adulthood, then the incidental
164 learning of L2 grammar in post-puberty learners should be promoted by type and token
165 frequencies in a similar manner. An alternative theoretical perspective stipulating that L2
166 grammar learning is fundamentally different from L1 (Bley-Vroman, 1989) and largely
167 relies on declarative rather than procedural mechanisms (Ullman, 2004) also relies on
168 the importance of frequency. Pursuant to this approach, frequency may be the trigger
169 that initiates the shift towards the recruitment of procedural mechanisms by providing
170 more experience (practice) with language (Ullman, 2001). With regard to the acquisition
171 of complex L2 structures, some approaches propose developmental timing as a function

172 of the structure complexity, positing that it requires more time to master complex
173 features (Pienemann, 1989; Collins, Trofimovich, White, Cardozo, & Horst, 2009). This
174 view implies that frequency might be one of the tools that bridges the gap between the
175 emergence and mastery of such structures.

176 As noted by Bulte and Housen (2014), complexity is rarely investigated for its
177 own sake but instead with the aim of diagnosing learning success. Therefore, it is
178 important to examine the effects of high/low frequency (both type and token) with the
179 attempt to understand what fosters learning of complex structures under incidental
180 exposure.

181 From previous research, it is known that constructions appearing in the input with
182 high frequency are acquired faster than with low frequency (Bybee, 2006; Ellis, 2001,
183 2009; Ellis & Collins, 2009; Ellis & Ferreira-Junior, 2009). Experimental research on the
184 role of token frequency in the incidental learning of L2 grammar demonstrated that it
185 does promote learning to some extent (Robinson, 1996, 2005). For instance, Robinson
186 (2005) found that although novice learners (L1 Japanese speakers) failed to generalize
187 the newly acquired pattern to novel items, they exhibited memorization-based learning
188 of ergativity marking in a previously unfamiliar L2 (Samoan). The study by Presson,

MacWhinney, and Tokowicz (2014) is directly relevant to the present research. The authors compared the effectiveness of learning under a condition in which metalinguistic explanations of the rule were provided to another condition where no such information was provided, both conditions being enhanced by token frequency. The authors employed intentional rather than incidental learning conditions triggered by frequency but found that training with the provided metalinguistic information was more beneficial for learning French gender morphology among L1 English speakers. The present study extends a step further, as in the current study we manipulate both type and token frequencies under incidental learning conditions in order to examine their effects on the acquisition of a complex morphological agreement pattern and to compare the learning effect in such conditions to the explicit learning condition.

2.4. Working memory

The relationship between structure complexity and the training conditions may be mediated by a third factor – the learner’s WM capacity. From extensive research, we know that WM – understood as a system of temporary storage and manipulation of information during complex cognitive activities such as language comprehension and

207 learning (Baddeley, 2010) – is a predictor of L2 learning success (Hummel, 2009; Juffs
208 & Harrington, 2011; Linck, Osthus, Koeth, & Bunting, 2014; Mackey, Philp, Egi, Fujii, &
209 Tatsumi, 2002; Martin & N. Ellis, 2012; Williams, 2012; Speciale, Ellis, & Bywater,
210 2004). However, despite the overarching effect of IDs in cognitive abilities found in L2
211 morpho-syntactic acquisition (Michael & Gollan, 2005; Miyake & Friedman, 1998;
212 Sagarra, 2007), including grammatical agreement (Keating, 2009; Kempe, Brooks, &
213 Kharkhurin, 2010; Sagarra, 2007; Sagarra & Herschensohn, 2010, 2012), the traditional
214 view holds that WM is not implicated in implicit learning (Conway, Baurnschmidt,
215 Huang, & Pisoni, 2010; Kaufman et al., 2010) or in the incidental acquisition of
216 knowledge (Brooks and Kempe, 2013; Grey, Williams, & Rebuschat, 2015; Tagarelli et
217 al., 2011).

218 Accepted in the field, this perspective is nonetheless contradicted by several
219 studies that demonstrate a relationship with WM (Author, XXX; Janacsek & Nemeth,
220 2013; Bo et al., 2011; Robinson, 2005; Weitz et al., 2011; Williams & Lovatt, 2003).
221 Such mixed findings might be attributed to the interaction between the nature of the
222 target stimulus being acquired and the learning context, different tasks being used for

223 measuring WM and implicit learning, and the L2 learning domain (e.g. comprehension
224 vs. production) being tested.

225 With regard to the nature of the stimulus, we know that complex items are more
226 difficult to process than simple items (Hunter, Ames, & Koopman, 1983), while it is also
227 known that inflectional morphology has repeatedly been found to be difficult for adult L2
228 learners (Jiang, 2004, 2007). While the acquisition of complex structures depends on
229 individual differences in WM, the manner in which such a dependency interacts with
230 other factors in the learning context cannot be ignored. For instance, research suggests
231 that high token frequency mediates the availability of items in memory, leading to less
232 effort for processing (Ellis, 1996, 2001; Just & Carpenter, 1992; Melton, 1963).

233 Understanding how the learner's WM capacity mediates the acquisition of a
234 complex morphological pattern under different incidental learning conditions in which
235 frequency is manipulated would provide insights into whether incidental exposure, at
236 large, leads to a more successful acquisition of complex grammatical structures. The
237 present paper thus aims to further examine the combined effects of WM and frequency
238 on the successful acquisition of a complex pattern under incidental exposure.

239

3. The present study

The present study focuses on the acquisition of a complex noun-adjective agreement pattern in Russian singular and plural noun phrases by novice adult learners under the three incidental learning conditions, where type and token frequencies are manipulated and there is an explicit learning condition. Following Ellis (2011), we adopted the following definitions of type and token frequencies: 1) token frequency refers to how often a particular form with a specific lexical item appears in the input, and 2) type frequency accounts for the number of distinct lexical items that can be substituted in a given construction.

In English, number is the major agreement category and bears an explicit morphological marker -s added to the noun's root (Eberhard, Cutting & Bock, 2005), whereas in more fusional languages, such as Russian, both the adjective and the noun are inflectionally marked not only for number but also for gender and case (Lorimor et al., 2008). This study uses a natural language with a complex morphology as a stimulus input. It also includes measures of both receptive and productive knowledge attainment. Finally, understanding the extent to which WM is engaged in incidental learning of such

257 a structure is particularly important because, for the L2 learner with a relatively poor L1
258 morphology, acquiring fusional morphological pattern is a challenging task (Kempe and
259 MacWhinney, 1998; McDonald, 1987) that will potentially draw on available cognitive
260 resources.

261 We address several research questions. (1) How do type and token frequencies
262 affect the acquisition of receptive and productive knowledge of a complex agreement
263 pattern under incidental learning conditions? (2) Do incidental learning conditions with a
264 manipulated frequency effect lead to more effective acquisition of a complex agreement
265 structure than an explicit learning condition? (3) Is a mediating effect of WM on
266 receptive and productive knowledge acquisition observable under different learning
267 conditions?

268

269 **4. Method**

270

271 A between-subjects design was employed such that the learners were assigned
272 to one of the incidental learning conditions or the explicit learning condition. In L2
273 research, implicit/incidental learning research training conditions are often manipulated

on a continuum from explicit learning conditions, in which learners are provided with metalinguistic information (e.g., pedagogical rules) (DeKeyser, 1995; Norris & Ortega, 2000; Robinson, 1996), to implicit learning conditions, in which participants are asked to focus on meaning and are not informed about the testing that will follow (Rebuschat & Williams, 2012; Tagarelli et al., 2011). Following the implications of the findings by Presson et al. (2014) and the vision that the rule-search condition allows for a certain degree of implicitness during learning, we employed metalinguistic explanations of the rule as a method of training in the explicit learning condition. The amount of time spent by participants during training in the explicit and the incidental learning conditions was similar. Performance accuracy was measured using both comprehension and production tasks.

4.1. Participants

Eighty adult native speakers of English (age range: 18-45, $M_{age} = 21$) without knowledge or exposure to Russian (or any other Slavic language) were included in the study (males: $n = 21$; females: $n = 59$). Following Leung and Williams (2011), participants with advanced knowledge of a language other than English were excluded

from the study. The participants were students of humanities ($n = 48$), social sciences ($n = 12$), or natural sciences ($n = 15$) or were members of the administrative staff ($n = 5$) at a large university and were randomly allocated to one of the four learning conditions ($n = 20$ per condition). Participants received either course credit or monetary compensation for their participation.

4.2. Materials

The set for vocabulary pre-training included Russian words, specifically, six nouns and four adjectives (see Appendix for the full list of stimuli) three prepositions (*k* 'towards', *ot* 'away from', *s* 'with'), a particle (*eto* 'this'), as well as colour pictures compiled using ClipArt. Only adjectives that could be easily identified in the context of the pictures (e.g., small, white, old) were selected. All nouns were concrete nouns depicting animate stereotypical story characters (e.g., *karlik* or 'dwarf') of either feminine or masculine natural gender. The stimuli were matched based on the number of syllables. Nouns contained two or three syllables, and all adjectives were disyllabic. To maintain a consistent pattern, only nouns and adjectives that belonged to the inflectional paradigm represented in Table 1 were chosen. For instance, feminine nouns that ended

310 with *-ek* in the genitive case plural, such as *babushka* ‘grandmother’ (pl. *babushek*),
311 were excluded.

312

313 TABLE 1

314

315 The set of training sentences contained noun-adjective agreement phrases in
316 nominative, dative, instrumental, and genitive cases for singular and plural forms of the
317 noun, and each adjective was paired with only one noun to create a novel phrase. The
318 four cases were selected based on how easy it would be to create a short story. Each
319 story depicted feminine or masculine characters and consisted of eight slides presented
320 sequentially, (four that corresponded to the agreement in the singular (nominative,
321 dative, instrumental and genitive) and four that correspond to agreement in the plural
322 (nominative, dative, instrumental and genitive)) presented sequentially. Each slide
323 contained a picture and a Russian sentence, as illustrated in Figure 1 and Table 2.
324 There were 7 novel stories in the high type frequency condition and 3 - in the low type
325 frequency condition. A token represented the repetition of a particular story and
326 therefore of the specific noun-adjective phrase in a certain agreement form (e.g.,
327 *malomu karliku* ‘towards the short dwarf; masculine, dative, singular). Thus, there were

7 repetitions of each story in the high token frequency condition and 3 in the low token frequency condition (see Table 3 for the breakdown of trials in each condition).

Therefore, on the basis of this there were the following conditions created and participants were allocated to the following groups: high type/low token frequency, low type/high token frequency and low type/low token frequency.

TABLE 2

FIGURE 1

TABLE 3

4.3. WM testing

An operation span task (Unsworth, Heitz, Schrock, & Engle, 2005) was used to measure WM. This task was obtained from the Attention and WM Lab at Georgia Institute of Technology and has been previously used in several studies (Redick et al., 2012; Turner & Engle, 1989; Unsworth & Engle, 2008). The operation span task (Juffs &

Harrington, 2011) is a complex WM span task that measures both the storage and processing components of WM.

In this task, participants were presented with simple arithmetical operations, such as $(2 \times 1) + 1 = 3$, and were asked to judge their correctness as quickly as possible by mouse-clicking a true or false box on the computer screen. Immediately after each operation was judged, an English letter appeared on the screen, and participants were instructed to memorize the letters in the order in which they were presented. Following Unsworth et al. (2005), the OSpan score was calculated as the sum of all set sizes that were perfectly recalled, considering the order of presentation. The highest possible score was 75.

4.4. Procedure

Participants first completed the WM test, then a pretraining phase, followed by the training and the testing phases. The testing phase consisted of two immediate post-tests that measured receptive and productive knowledge.

361 4.4.1. Pretraining

362 For the vocabulary test, participants were instructed to memorize the six target
363 Russian nouns, four adjectives, three prepositions, and the particle *eto* (see Appendix)
364 while reading through the slides on their computer screens at their own pace. Each slide
365 contained a Russian word (transliterated into the Latin alphabet), its English translation,
366 and a matching picture. The adjectives were presented in the masculine gender,
367 nominative case, and singular form. Following the memorization phase, participants
368 completed the vocabulary test. They saw a picture and a transliterated Russian word
369 presented via E-Prime 2 (Psychology Software Tools, Pittsburgh, PA) and were asked
370 to press 1 (match) or 2 (mismatch) on the keyboard to indicate whether the word
371 matched the picture. After their response, either Correct or Incorrect, together with the
372 overall percentage score, appeared on the computer screen. Participants had to score
373 at least 85% on the vocabulary test to proceed to the training phase.

374

375 4.4.2. Training in incidental learning conditions

376 Participants in the incidental learning conditions were not informed about the
377 linguistic structure or that there would be a testing phase. These participants were

378 randomly assigned to one of the three incidental learning conditions (low type/high
379 token, low type/low token, high type/low token frequency). Depending on the condition,
380 they were presented with varying numbers of types and tokens for the training items
381 (see Table 3). Participants were informed that they were going to view stories about
382 different characters and that their task was to look at the pictures, read the Russian
383 sentences silently and try to understand the meaning. Participants received the
384 following instructions: “Now you will see stories about different characters. Please, look
385 at the picture, read the sentence to yourself and try to understand its meaning”. In each
386 condition, as presented on the computer screen via E-Prime 2 (Psychology Software
387 Tools, Pittsburgh, PA), participants viewed sequences of pictures about stereotypical
388 story characters of masculine and feminine grammatical gender overlapping with their
389 biological gender and written Russian sentences containing the agreement pattern in
390 singular and plural forms. Each sequence contained eight pictures that were presented
391 for 3000 ms each in the following order: nominative (singular, plural); dative (singular,
392 plural); instrumental (singular, plural); and genitive cases (singular, plural) (see Figure
393 1). Each slide contained a Russian sentence with embedded noun-adjective agreement
394 in singular or plural form and a picture representing a boy going towards, with or away

from a stereotypical story character or characters of a feminine or a masculine gender
(e.g., dwarf). The presentation of each sequence was randomized.

4.4.3. Training in the explicit learning condition

During training, participants in the explicit learning condition were provided with metalinguistic information about noun-adjective agreement and were informed that they would be tested on their acquisition of this knowledge. Agreement according to number, gender and case was explained using two examples for each agreement rule. Each example was represented by a slide containing a Russian sentence that was transliterated into the Latin alphabet with adjectival and noun endings highlighted in bold, an English translation written underneath the transliteration and a semantically corresponding picture similar to the pictures presented to participants in the incidental learning conditions. After receiving metalinguistic explanations regarding the agreement rules, participants were given 15 minutes to examine the slides again at their own pace and to memorize the morphological pattern.

412 4.4.4. *Testing*

413 For all the conditions, the participants completed a recognition and a production
414 task immediately after training. The recognition task was a number decision task that
415 tested their receptive knowledge of the agreement pattern in all its possible variations.
416 Such a task draws more upon implicit processing than a grammaticality judgement task
417 (GJT) (Anton-Mendez, 1999). The researchers assessed whether the learner could
418 abstract the notion of plurality/singularity expressed by the complex pattern of
419 inflectional markers different across the masculine and feminine agreement
420 constructions in different cases that were presented during training. Participants were
421 told that they would next see sentences similar to those they had previously seen, and
422 they were asked to press *1* to indicate that the sentence described one character or *2* if
423 the sentence described more than one character. The test consisted of 28 grammatical
424 Russian sentences. There were 14 old items, i.e., sentences presented during training,
425 and 14 new items, i.e., sentences composed of previously unseen nouns and
426 adjectives. If no response was recorded, each stimulus would time out after 3000*ms*.
427 Sentences presented during training and containing familiar adjectival phrases were
428 included to test whether the learning was based on memorization, whereas new items

429 were included to test whether participants could generalize acquired knowledge to new
430 instances. The same factors that were controlled in the training items were controlled in
431 the new items. Accuracy of the participant response and reaction time (*RT*) on each
432 item were collected during the recognition task via E-Prime 2.

433 After completing the recognition task, participants were asked to complete a fill-
434 in-the-blank production task that consisted of 28 slides containing pictures and
435 grammatical Russian sentences (14 old and 14 new). In each block, half of the stimuli
436 consisted of agreement in the singular and half consisted of agreement in the plural.
437 Across the blocks, there were seven items with agreement in the feminine singular,
438 seven in the feminine plural, seven in the masculine singular, and seven in the
439 masculine plural. Participants had to fill in a blank for the adjectival ending (e.g., *Idu k*
440 *mal___ karliku* 'I am going towards the small dwarf'); accuracy for each item were
441 recorded. Production and recognition tasks were counterbalanced across the
442 participants, with half of the participants completing a recognition task first, and half – a
443 production task first. All tasks were completed in one session, which lasted between 60
444 and 90 minutes.

445

5. Results

The data were analysed using logistic and linear regression models in R, version 3.2.3, by applying a Generalized Linear Model (GLM) in the R Commander software package (R Development Core Team, 2015). We checked for normality and homogeneity by visual inspections of the plots of residuals against fitted values. A backwards model selection procedure was employed that began with a full model including all parameters and then excluded the parameters one at a time. An ANOVA function was used to determine whether the parameter significantly improved the model (Baayen, 2008). When fitting the model, all fixed effects of theoretical interest were retained in the models, even if they were non-significant. For a summary of model coefficients, see Table 4. Throughout the paper, MCMC-estimated p values that are considered significant at the $\alpha = 0.05$ level are presented.

5.1. Explicit vs incidental learning

The responses were scored for accuracy. A response was coded as correct if the learner was able to recognize the number agreement or produce the complete

appropriate ending for the agreement pattern. Each participant received a maximum of 28 points for correct responses in calculating their accuracy scores (see Table 5 for the overall accuracy and WM scores). Although general performance for comprehension accuracy was above chance (see Figure 2 for mean scores per condition), production levels under all conditions were low (Figure 3).

FIGURE 2

FIGURE 3

First, a logistic regression with *glmer* model function was run to analyse the accuracy of comprehension of the agreement pattern under both explicit and incidental learning conditions. Condition (explicit learning, high type/low token; low type/high token; low type/low token frequency), block (old items, new items; with old items used as a reference category) and the operation span score were included in the model as fixed effects, and item was entered as a random effect. The data were treatment-coded for learning condition. To compare the effectiveness of the learning condition on knowledge retention, the explicit learning condition was used as the reference category.

As presented in Table 7, participants in the high type/low token frequency (incidental learning) condition exhibited higher accuracy for comprehension of the agreement pattern than participants in the explicit learning condition. Individual reaction times (*RTs*) collected during the recognition task exceeding ± 2 *SD* were eliminated. The mean error rate was 0.2%. We then ran a linear regression with *glmer* model function with condition (explicit learning, high type/low token; low type/high token; low type/low token frequency), block (old items, new items) and operation span score as fixed effects and with item as the random effect to investigate the differences in *RTs*. Significantly shorter *RTs* were found for the participants in the low type/low token frequency condition than for those in the explicit learning condition; moreover, participants in the latter group also performed less accurately in agreement comprehension. However, with respect to comprehension accuracy and *RTs*, no difference between old and new items was found, and there was no effect of WM on either comprehension accuracy or *RTs*.

FIGURE 4

TABLE 6

Participants' responses to the fill-in-the blank task were coded for accuracy such that 1 indicated that the participant produced a complete adjectival ending in a relevant position and 0 indicated that the participant produced either no ending or an inaccurate ending. The same model used in the analysis of comprehension accuracy was run to determine production accuracy. The analysis revealed that participants in the explicit learning condition significantly outperformed participants engaged in all of the incidental learning conditions in the production of complete endings. Moreover, it was determined that participants correctly answered questions regarding old items significantly more than new items. Finally, in contrast to production, there was an effect of WM on productive knowledge retrieval.

TABLE 7

5.2. Frequency and knowledge acquisition under incidental learning conditions

To further explore the effect of frequency on incidental learning, we ran the same model but included only the incidental conditions. The model included condition (high type/low token; low type/high token; low type/low token frequency), block (old items, new items;

with old items as a reference category) and operation span scores as fixed effects and item as a random effect.

5.2.1. Frequency and receptive knowledge

The analysis using the model with the high type/low token frequency condition as a reference category revealed that participants in the low type/high token condition ($M = 84.50\%$, $SD = 11.50\%$, $\beta = -3.83$, $Wald\ z = -2.05$, $SE = 1.87$, $p = .04$) and the low type/low token frequency ($M = 70.50\%$, $SD = 27.80\%$) condition recognized the agreement pattern less accurately than participants in the high type/low token frequency condition ($M = 89.50\%$, $SD = 5.90\%$; $\beta = -1.17$, $Wald\ z = -6.74$, $SE = 1.74$, $p < .001$).

We then ran the same model using the low type/low token frequency condition as a reference category and found that participants in the low type/high token frequency condition performed significantly better than participants in the low type/low token frequency condition ($\beta = 7.88$, $Wald\ z = 5.21$, $SE = 1.51$, $p < .001$). No significant difference between old vs new items with respect to participant accuracy was found ($\beta = 7.28$, $Wald\ z = 1.32$, $SE = 5.53$, $p = .18$).

To analyse *RTs*, a linear regression model was run with the same variables as those used for the analysis of comprehension accuracy. There was no significant difference between participants' response times for those in the high type/low token condition ($M = 1014.58$, $SD = 20.76$) and those in the low type/high token frequency condition ($M = 1034.64$, $SD = 23.20$, $\beta = 6.97$, $t \text{ value} = .20$, $SE = 37.02$, $p = .84$). However, the response times for those in the low type/low token frequency condition were significantly shorter than the response times for those in the high type/low token condition ($\beta = -132.52$, $t \text{ value} = -3.76$, $SE = 35.26$, $p < .001$). When running the model for the low type/low token frequency condition ($M = 896.50$, $SD = 27.50$) as the reference category, it was found that participants' *RTs* in the low type/high token frequency condition ($\beta = 139.50$, $t \text{ value} = 4.12$, $SE = 33.90$, $p < .001$) were also significantly longer than the *RTs* for participants in the low type/low token frequency condition. No significant difference was found in participants' accuracy between old and new items ($\beta = -49.65$, $t \text{ value} = -.48$, $SE = 103.54$, $p = .63$), and no WM effect was found for either comprehension accuracy ($\beta = 8.58$, $Wald z = 1.58$, $SE = 5.43$, $p = .11$) or *RTs* ($\beta = 1.60$, $t \text{ value} = 1.49$, $SE = 1.07$, $p = .14$).

5.2.2. Frequency and productive knowledge

550

551 The same logistic regression model used for the analysis of comprehension
552 accuracy was employed for investigating production accuracy. First, the model was run
553 with high type/low token frequency as a reference level and determined that participants
554 in the low type/high token frequency condition were more likely to recall the correct
555 adjectival ending ($M = 13.90\%$, $SD = 14.9\%$) than participants in the high type/low token
556 frequency condition ($M = 8.60\%$, $SD = 9.90\%$, $\beta = 5.46$, $Wald\ z = 2.62$, $SE = 2.08$, $p =$
557 $.009$). Production accuracy performance did not differ between participants in the low
558 type/low token frequency condition ($M = 9.80\%$, $SD = 10.50\%$) and the high type/low
559 token frequency condition ($\beta = 1.14$, $Wald\ z = .52$, $SE = 2.22$, $p = .61$). The analysis of
560 the low type/low token frequency condition as a reference category indicated that
561 participants in the low type/high token frequency condition recalled endings more
562 accurately than those in the low type/low token frequency condition ($\beta = 4.39$, $Wald\ z =$
563 2.25 , $SE = 1.95$, $p = .02$). Participants also recalled significantly more correct endings
564 for old items than for new items ($\beta = 1.95$, $Wald\ z = 2.94$, $SE = 6.63$, $p = .03$). Finally,
565 with respect to comprehension, the analysis revealed that WM had no significant effect
566 on production ($\beta = 7.85$, $Wald\ z = 1.20$, $SE = 6.57$, $p = .23$).

567

568 6. Discussion

569

570 This study aimed to investigate the roles of type and token frequencies in the
571 incidental acquisition of a complex noun-adjective agreement pattern and the mediating
572 effect of individual differences in learners' WM. We were interested in examining the
573 extent to which the combined effects of frequency in the incidental input and the
574 learner's WM might help to override the lack of explicit instruction when acquiring a
575 complex structure.

576 Our findings indicate that even during the initial stages of learning under
577 incidental exposure, **speakers of an L1** with a relatively poor morphological system were
578 sensitive to morphological cues and could successfully recognize plurality represented
579 by a complex morphological pattern. This confirms previous research on languages with
580 less fusional morphology, such as in L2 Spanish and French (De Garavito & White,
581 2002; McCarthy, 2008; White et al., 2004), and on languages with a high fusional
582 agreement morphology, such as Russian (Brooks, Kempe, & Sionov, 2006; Kempe et
583 al., 2010), as well as incidental learning studies regarding the acquisition of complex

584 morphological systems (Brooks & Kempe, 2013; Rogers, Revesz, & Rebuschat, 2015).
585 The accessibility of the concept of plurality, based on the dichotomous distinction
586 between one and more than one referent (Dispaldro, Ruggiero, & Scali, 2014) may
587 provide an additional contribution to the learning of such complex morphological
588 patterns. Although grammaticalized in English, number is believed to be prelinguistic in
589 nature and more semantically salient (Dispaldro, Ruggiero, & Scali, 2014; Eberhard,
590 1999).

591 Moreover, the complexity of the stimulus itself may facilitate its proneness to
592 being better captured by the implicit learning mechanisms. Even within the artificial
593 language learning paradigm, research demonstrates a stronger learning effect when the
594 input was complex and contained multiple levels of regularities as opposed to when it
595 was simplified (Saffran & Wilson, 2003; Thiessen & Saffran, 2009). Since natural
596 languages are believed to be inherently richer in cues and complexity than artificial
597 language systems (Erickson & Thiessen, 2015), when employing a natural language as
598 a stimulus in research, more pronounced incidental learning effect may be found.

599 In addition, despite the assumption that utilizing artificial language systems in
600 incidental learning experiments, generally provides insight into the natural language

601 learning (Ettlinger et al., 2016; Robinson, 2010), scholars, nevertheless, underscore the
602 importance of employing more natural language stimuli in current incidental learning
603 research (Erickson & Thiessen, 2015). To date, only a few studies used natural
604 languages as a material (Brooks & Kempe, 2013; Godfroid, 2016). The present study,
605 therefore, adds to this trend and extends the existing artificial language learning
606 research by utilizing a natural language within the incidental learning paradigm.

607 Some incidental learning conditions in the present study appeared to be more
608 effective at promoting learning at the level of recognition of a complex linguistic pattern
609 than the explicit learning condition where knowledge acquisition was fostered by
610 metalinguistic information. This finding is consistent with the theoretic stipulation that
611 incidental exposure bestows a greater advantage on learning a complex grammatical
612 structure (Krashen, 1982, 1994; Reber, 1989), and it also confirms the existent research
613 that provides evidence of higher knowledge attainment under incidental learning
614 conditions as opposed to intentional learning conditions (DeKeyser, 1995; Robinson,
615 1996) in adult L2 learners. It is widely acknowledged in the literature that L2 inflectional
616 morphology represents the greatest challenge for learners compared to other areas of
617 morpho-syntax (DeKeyser, 2005; Larsen-Freeman, 2010). This premise is confirmed by

618 research that compares different types of grammatical knowledge and finds fewer errors
619 in word order acquisition compared to morphology (Grey et al., 2014). Moreover, during
620 the post-critical period age, such knowledge must be acquired explicitly and be
621 triggered by declarative mechanisms, as some theories suggest (Ullman, 2004).
622 Therefore, the high learning effect obtained in the present study under the incidental
623 learning condition and enhanced by type frequency supports both the assumption that
624 incidental exposure can help adults to override maturational constraints on learning and
625 Krashen's claim (Krashen, 1982, 1994), with the correction, however, that an incidental
626 learning mode requires additional triggers. The role of frequency, as one such trigger, is
627 generally consistent with the cognitive-associative view of L2 acquisition (N. Ellis, 2002;
628 2012) and the research that demonstrates the positive frequency impact on L2
629 morphology learning (Bowden, Gelfand, Sanz, & Ullman, 2010).

630 Overall, as our findings suggest, although the participants in the explicit learning
631 conditions exhibited higher production accuracy than those in the incidental learning
632 conditions, the explicit learning mode was not effective for acquiring a complex pattern.
633 In the present study, performance, even in production domain, that is dependent on
634 higher order processes (Keenen & MacWhinney, 1987) and conscious knowledge

635 remained below chance in all learning conditions, including the explicit learning
636 condition. Future research may consider ways to improve such performance in a
637 longitudinal study. Perhaps adopting a paradigm in which training is conducted over
638 multiple sessions would help to identify those factors involved in successful productive
639 knowledge acquisition and the exposure mode that is most beneficial.

640

641 *6.1. Frequency and incidental learning*

642

643 As demonstrated by the results of the present study, frequency interacts with the
644 learning condition and provides interesting and differential effects for the productive and
645 receptive acquisition of a complex pattern under incidental exposure. Receptive
646 knowledge acquisition is affected by type frequency, whereas productive knowledge
647 acquisition is affected by token frequency. According to Bybee (1985), type frequency
648 promotes the generalization of grammatical structures. Thus, for successful recognition,
649 the learner must develop an abstract schema by collecting a sizeable number of types
650 of a given construction (Bybee & Thompson, 2000; N. Ellis, 2002; Plunkett &
651 Marchman, 1991). Our findings indicate that the larger the number of different lexical

652 items appearing within a complex stimulus pattern during training, the more accurate
653 the identification and generalization of the agreement structure.

654 For productive knowledge acquisition, frequency interacts differently with the
655 incidental learning condition and the complex stimulus input, providing a higher learning
656 effect under the condition with high token frequency. This indicates that the item-based
657 learning trend is similar to L1 acquisition, where a learner begins with memorizing the
658 pattern based on specific construction examples (Braine and Brooks, 1995; Brooks,
659 Tomasello, Dodson and Lewis, 1999; Tomasello, 2000, 2008). The item-based learning
660 effect is also supported by the finding that participants performed better on old items
661 than on new items with respect to production but not with respect to comprehension.

662 Such a discrepancy in frequency effects for learning incidentally between
663 production and comprehension reinforces the general assumption that comprehension
664 precedes production in language acquisition (e.g., learning of morphology in children)
665 (Clark & Hecht, 1982); the acquisition of singular-plural constructions (Fraser, Bellugi, &
666 Brown, 1963), and the L2 adult learning of inflectional morphology (Fenson, Dale,
667 Reznick, Bates, et al., 1994). It also reflects the differences in the sub-processes
668 involved in production and comprehension (Tanner, Nicol & Brehm, 2014).

669 To better understand how frequency impacts the acquisition of a complex
670 structure under incidental exposure in different modalities and the extent to which we
671 can examine effective learning in the production domain, a more extended study may
672 be insightful. For instance, providing enhanced training over several sessions or
673 manipulating different degrees of frequency in the input would yield a more
674 comprehensive picture.

675

676 *6.2. Working Memory*

677 Finally, we also aimed to explore the mediating effect of WM on the acquisition of
678 a complex structure under different incidental learning conditions enhanced by type and
679 token frequencies. The null WM effect indicates that it is the frequency alone that
680 shapes the learning of a linguistically complex structure. One possible explanation,
681 which is also consistent with the assumption of automaticity and the effortless nature of
682 the implicit learning process (Shiffrin and Schneider, 1977), is that when the stimulus is
683 sufficiently complex, implicit learning mechanisms underpin such learning without
684 relying on cognitive resources.

685 To support this assumption, previous research on adult implicit learning provides
686 ample evidence suggesting that WM is not implicated. This applies to those studies
687 focusing on the relationship between WM and grammatical knowledge acquisition under
688 incidental learning conditions (Tagarelli et al., 2011, 2016; Yang & Li, 2012), to studies
689 employing sequence learning (Conway et al., 2011; Kaufman et al., 2010), and to
690 research focusing on the productive acquisition of a Russian case-marking system
691 (Brooks and Kempe, 2013).

692 An alternative interpretation of the null WM effect could relate to the nature of the
693 agreement structure used in the present study. It might be the case that plurality itself
694 may induce a processing cost (Tanner et al., 2014) or that the linguistic complexity of
695 the morphological system, which factors in several agreement variables, places a high
696 cognitive demand on knowledge retrieval, thus hindering access to WM (Caplan and
697 Waters, 1999; Hopp, 2006, 2010; McDonald, 2006). This line of thinking may suggest
698 that the structure employed in the current study was, in principle, too complex to be
699 acquired, regardless of individual variations among learners with respect to their WM
700 capacity. For instance, Sagarra (2007), who investigated agreement processing in L2,
701 found that WM was engaged when the complexity of the target structure was low but

702 that WM was not involved in the processing of more complex structures. WM was found
703 to be a predictor for understanding sentences with within-phrase gender agreement
704 violations (e.g., La mujer lava la blusa *blanco en la cocina 'The woman washes the
705 *white (masc) blouse (fem) in the kitchen') by English L2 learners of Spanish but was
706 not a predictor for sentences that contained gender agreement violations across
707 clauses, which represents a more challenging task for the learner. In this sense, the
708 linguistic complexity of the structure under investigation taps into cognitive complexity.
709 The null correlation with WM may indicate that the present pattern is more cognitively
710 demanding for all language learners (Housen & Simoens, 2016) when it is to be
711 acquired without intention and awareness.

712 In spite of the positive results reported herein, one possible limitation of the
713 present study involves the comparability between explicit and incidental learning
714 conditions. The rationale behind choosing the metalinguistic explanation training rather
715 than employing a rule-search condition involves the robust learning effect typically
716 reported in the literature in the explicit learning conditions where metalinguistic
717 information about the target structure was provided to the learner. Another potential
718 limitation of the study was the difficulty in teasing apart the categories of gender, case

719 and number when testing the acquisition of a complex agreement pattern. A similar
720 challenge was recorded by Brooks, Kempe and Sionov (2006) and attributed to the
721 inflectional syncretism of the Russian language. However, obtaining information about
722 how well each of the grammatical category was learned by future research might
723 provide a better understanding about acquisition of complex systems. Finally, exploring
724 how other factors, such as stereotypical gender (Molinaro, Su & Carreiras, 2016;
725 Siyanova-Chanturia, Pesciarelli & Cacciari, 2012) of the stimuli used in the present
726 study, may foster learning of a morphological pattern could be another potential trend of
727 research. Despite its limitations, nevertheless, the advantage of the current research is
728 its contribution to the growing understanding of L2 grammatical acquisition and its use
729 of a natural language system. Studies of the incidental learning of natural language
730 grammars are limited because research traditionally used artificial languages. Despite
731 providing control over confounding factors, artificial languages present a much-
732 simplified version of natural language (Hulstijn et al., 2014).

733

734 7. Conclusion

Overall, the present findings confirm that learning effects emerge from the complex synergies of the complexity of the target structure being acquired and the learning context with available facilitating factors. This study offers evidence that the incidental learning condition can be more beneficial for receptive acquisition of a complex structure if fostered by type frequency. It shows that within the receptive domain a complex grammatical structure can be acquired incidentally more effectively, even when compared to the explicit learning mode. This evidence is in line with the theoretical claim that a complex grammatical structure is best to be learned incidentally/implicitly (Krashen, 1982, 1994; Reber, 1989). Moreover, our study also provide empirical evidence for the suggestion that in order to better understand the acquisition of complex structures incidentally it is necessary to study the interaction between the learning condition and the role of other facilitating factors – such as frequency – in the input (Hulstijn, 2005). However, further research is needed to illuminate productive acquisition. Generally, our findings add to the existing incidental learning research and to the usage-based approach to second language acquisition (N. Ellis, 2002, 2012).

752

753

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Appendix1069 *Vocabulary Training and Test*

Noun	Adjective	Preposition
vedma – witch	krasniy – red	Idu k... – I am going towards
karlik – dwarf	jeltiy – yellow	Idu s... – I am going with
nevesta – bride	lisiy – bald	Idu ot... – I am going from
vdova – widow	maliy – small	
pojarnik – firefighter		
begun – runner		

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1072 *Training Sentences*1073 Masculine singular

1074 Eto seriy pojarnik/ This is a grey firefighter

1075 Idu k seromu pojarniku/ I am going towards the grey firefighter

1076 Idu s serim pojarnikom/ I am going with the grey firefighter

1077 Idu ot serogo pojarnika/ I am going away from the grey firefighter

1078

1079 Eto maliy karlik/ This is a small dwarf

- 1080 Idu k malomu karliku/ I am going towards the small dwarf
- 1081 Idu s malim karlikom/ I am going with the small dwarf
- 1082 Idu ot malogo karlika / I am going away from the small dwarf
- 1083
- 1084 Eto jeltiy begun/ This is a yellow runner
- 1085 Idu k jeltomu begun/ I am going towards the yellow runner
- 1086 Idu s jeltim begunom/ I am going with the yellow runner
- 1087 Idu ot jeltogo beguna/ I am going away from the yellow runner
- 1088
- 1089 Eto yuniy shkolnik/ This is a young schoolboy
- 1090 Idu k yunomu shkolniku/ I am going towards the young schoolboy
- 1091 Idu s yunim shkolnikom/ I am going with the young schoolboy
- 1092 Idu ot yunogo shkolnika/ I am going away from the young schoolboy
- 1093
- 1094 Eto lisiy letchik/ This is a bald pilot
- 1095 Idu k lisomu letchiku/ I am going towards the bald pilot
- 1096 Idu s lisim letchikom/ I am going with the bald pilot

- 1097 Idu ot lisogo letchika/ I am going away from the bald pilot
- 1098
- 1099 Eto temniy fokusnik/ This is a brunette conjurer
- 1100 Idu k temnomu fokusniku/ I am going towards the brunette conjurer
- 1101 Idu s temnim fokusnikom/ I am going with the brunette conjurer
- 1102 Idu ot temnogo fokusnika/ I am going away from the brunette conjurer
- 1103
- 1104 Eto krupniy ohotnik/ This is a big hunter
- 1105 Idu k krupnomu ohotniku/ I am going towards the big hunter
- 1106 Idu s krupnim ohotnikom/ I am going with the big hunter
- 1107 Idu ot krupnogo ohotnika/ I am going away from the big hunter
- 1108
- 1109 Masculine plural
- 1110 Eto serie pojarniki/ These are grey firefighters
- 1111 Idu k serim pojarNIKAM/ I am going towards the grey firefighters
- 1112 Idu s serimi pojarNIKAMI/ I am going with the grey firefighters
- 1113 Idu ot serih pojarnikov/ I am going away from the grey firefighters
- 1114

- 1115 Eto malie karliki/ These are small dwarves
- 1116 Idu k malim karlikam/ I am going towards the small dwarves
- 1117 Idu s malimi karlikami/ I am going with the small dwarves
- 1118 Idu ot malih karlikov/ I am going away from the small dwarves
- 1119
- 1120 Eto jeltie beguni/ These are yellow runners
- 1121 Idu k jeltim begunam/ I am going towards the yellow runners
- 1122 Idu s jeltimi begnami/ I am going with the yellow runners
- 1123 Idu ot jeltih begunov/ I am going away from the yellow runners
- 1124
- 1125
- 1126 Eto yunie shkolniki/ These are young schoolboys
- 1127 Idu k yunim shkolnikam/ I am going towards the young schoolboys
- 1128 Idu s yunimi shkolnikami/ I am going with the young schoolboys
- 1129 Idu ot yunih shkolnikov/ I am going away from the young schoolboys
- 1130
- 1131 Eto lisie letchiki/ These are a bald pilots
- 1132 Idu k lisim letchikam/ I am going towards the bald pilots

- 1133 Idu s lisimi letchikami/ I am going with the bald pilots
- 1134 Idu ot lisih letchikov/ I am going away from the bald pilots
- 1135
- 1136 Eto temnie fokusniki/ These are brunette conjurers
- 1137 Idu k temnim fokusnikam/ I am going towards the brunette conjurers
- 1138 Idu s temnimi fokusnikami/ I am going with the brunette conjurers
- 1139 Idu ot temnih fokusnikov/ I am going away from the brunette conjurers
- 1140
- 1141 Eto krupnie ohotniki/ These are big hunters
- 1142 Idu k krpnim ohotnikam/ I am going towards the big hunters
- 1143 Idu s krpnimi ohotnikami/ I am going with the big hunters
- 1144 Idu ot krpnih ohotnikov/ I am going away from the big hunters
- 1145
- 1146 Feminine singular
- 1147 Eto grustnaya vdova/ This is a sad widow
- 1148 Idu k grustnoy vdove/ I am going towards the sad widow
- 1149 Idu s grustnoy vdovoy/ I am going with the sad widow

1150 Idu ot grustnoy vdovi/ I am going away from the sad widow

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1152 Eto belaya nevesta/ This is an white bride

1153 Idu k beloy neveste/ I am going towards the white bride

1154 Idu s beloy nevestoy/ I am going with the white bride

1155 Idu ot beloy nevesti/ I am going away from the white bride

1156

1157 Eto hudaya stryapuha/ This is a thin cook

1158 Idu k hudoy stryapuhe/ I am going towards the thin cook

1159 Idu s hudoy stryapuhoy/ I am going with the thin cook

1160 Idu ot hudoy stryapuhi/ I am going away from the thin cook

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1162 Eto svetlaya podrugа/ This is a blonde friend

1163 Idu k svetloy podruge/ I am going towards the blonde friend

1164 Idu s svetloy podrugoy/ I am going with the blonde friend

1165 Idu ot svetloy podrugі/ I am going away from the blonde friend

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- 1167 Eto tolstaya tkachiha/ This is a fat weaver
- 1168 Idu k tolstoy tkachihe/ I am going towards the fat weaver
- 1169 Idu s tolstoy tkachihoy/ I am going with the fat weaver
- 1170 Idu ot tolstoy tkachihi/ I am going away from the fat weaver
- 1171
- 1172 Eto staraya portniha/ This is an old dressmaker
- 1173 Idu k staroy portnihe/ I am going towards the old dressmaker
- 1174 Idu s staroy portnihoy/ I am going with the old dressmaker
- 1175 Idu ot staroy portnihi/ I am going away from the old dressmaker
- 1176
- 1177 Eto chernaya plovchiha/ This is a black swimmer
- 1178 Idu k chernoy plovchihe/ I am going towards the black swimmer
- 1179 Idu s chernoy plovchihoy/ I am going with the black swimmer
- 1180 Idu ot chernoy plovchihe/ I am going away from the black swimmer
- 1181
- 1182 Feminine plural
- 1183 Eto grustnie vdovi/ These are sad widows

- 1184 Idu k grustnim vdovam/ I am going towards the sad widows
- 1185 Idu s grustnimi vdovami/ I am going with the sad widows
- 1186 Idu ot grustnih vdov/ I am going away from the sad widows
- 1187
- 1188
- 1189 Eto belieie nevesti/ These are white brides
- 1190 Idu k beieim nevestam/ I am going towards the white brides
- 1191 Idu s belimii nevestami/ I am going with the white brides
- 1192 Iduu ot belih nevest/ I am going away from the white brides
- 1193
- 1194 Eto hudie stryapuhi/ These are thin cooks
- 1195 Idu k hudim stryapuham/ I am going towards the thin cooks
- 1196 Idu s hudimi stryapuhami/ I am going with the thin cooks
- 1197 Idu ot hudih stryapuh/ I am going away from the thin cooks
- 1198
- 1199 Eto svetlie podrugi/ These are blonde friends
- 1200 Idu k svetlim podrugam/ I am going towards the blonde friends
- 1201 Idu s svetlimi podrugami/ I am going with the blonde friends
- 1202 Iduu ot svetlih podrug/ I am going away from the blonde friends

1203

1204 Eto tolstie tkachihi/ These are fat weavers

1205 Idu k tolstim tkachiam/ I am going towards the fat weavers

1206 Idu s tolstim tkachiami/ I am going with the fat weavers

1207 Idu ot tolstih tkachih/ I am going away from the fat weavers

1208

1209 Eto starie portnihi/ These are old dressmakers

1210 Idu k starim portniam/ I am going towards the old dressmakers

1211 Idu s starimi portniami/ I am going with the old dressmakers

1212 Idu ot starih portnih/ I am going away from the old dressmakers

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1215 Eto chernie plovchihi/ These are black swimmers

1216 Idu k chernim plovchiam/ I am going towards the black swimmers

1217 Idu s chernimi plovchiami/ I am going with the black swimmers

1218 Idu ot chernih plovchih/ I am going away from the black swimmers

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Table 1

Inflectional Paradigm in Russian for the Adjective and the Noun According to Number, Gender and Case

Case	Masculine				Feminine			
	Singular		Plural		Singular		Plural	
	Adj.	N	Adj.	N	Adj.	N	Adj.	N
Nominative	-iy	Ø	-ie	-i	-aya	-a	-ie	-i
Dative	-omu	-u	-im	-am	-oy	-e	-im	-am
Instrumental	-im	-om	-imi	-ami	-oy	-oy	-imi	-ami
Genitive	-ogo	-a	-ih	-ov	-oy	-i	-ih	Ø

1246 Table 2

1247 *Examples of Training Sentences Presented to Participants*

Case	Masculine singular	Masculine plural
Nominative	Eto maliy karlik- This is a small dwarf <i>Eto mal-iy karlik-Ø</i> This Ø-cop small-M.NOM.SG dwarf-M.NOM.SG	Eto malie karliki- These are small dwarves <i>Eto mal-ie karlik-i</i> These Ø-cop small-M.NOM.PL dwarf-M.NOM.PL
Dative	Idu k malomu karliku- I am going towards the small dwarf <i>Idu k mal-omu karlik--u</i> I am going towards small-M.DAT.SG dwarf- M.DAT.SG	Idu k malim karlikam- I am going towards the small dwarves <i>Idu k mal-im karlik-am</i> I am going towards small-M.DAT.PL dwarf- M.DAT.PL
Instrumental	Idu s malim karlikom- I am going with the small dwarf <i>Idu s mal-im karlik-om</i> I am going with small-M.INST.SG dwarf- M.INST.SG	Idu s malimi karlikami- I am going with the small dwarves <i>Idu s mal-imi karlik--ami</i> I am going with small-M.INST.PL dwarf- M.INST.PL
Genitive	Idu ot malogo karlika- I am going away from the small dwarf <i>Idu ot mal-ogo karlik-a</i> I am going away from small-M.GEN.SG dwarf- M.GEN.SG	Idu ot malih karlikov- I am going away from the small dwarves <i>Idu ot mal-ih karlik-ov</i> I am going away from small-M.GEN.PL dwarf- M.GEN.PL

1248 *Note:* Stereotypical story characters rather than stereotypical gender characters were included as
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Table 3

Distribution of Types and Tokens during Training

Incidental learning condition	Feminine gender	Masculine gender	Case	Number	Repeated	N of trials
high type/low token frequency	7 stories	7 stories	4 cases	2 (singular, plural)	3 times.	336
low type/high token frequency	3 stories	3 stories	4 cases	2 (singular, plural)	7 times	336
low type/low token frequency	3 stories	3 stories	4 cases	2 (singular, plural)	3 times	144

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Table 5
Descriptive Statistics for Participants' Accuracy and WM Scores

Condition	WM		Comprehension		Production	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
High type/low token	51.70	14.22	25.05	1.64	2.40	2.78
Low type/high token	59.90	13.67	23.65	3.23	3.90	4.17
Low type/low token	60.75	10.52	19.75	7.77	2.75	2.95

Note: *M* and *SD* represent raw scores

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Table 6
Explicit Learning Condition vs. Incidental Learning Conditions for Comprehension

Comprehension accuracy				Comprehension RTs		
Condition	Std. Error	Wald z	p value	Std. Error	t value	p value
High type/low token frequency	1.76	3.30	< .001***	33.25	0.67	0.51
Low type/high token frequency	1.60	0.74	0.46	33.26	0.94	0.34
Low type/low token frequency	1.45	-4.64	< .001***	33.35	-3.24	0.001**
Block (old vs. new)	4.35	0.34	0.66	88.43	0.25	0.80
Operation span	4.14	0.29	0.77	0.86	1.56	0.12

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Table 7
Explicit vs. Incidental Learning for Production

Production accuracy			
Condition	Std. Error	Wald z	p value
High type/low token frequency	0.19	-5.53	< .001***
Low type/high token frequency	0.16	-3.50	< .001***
Low type/low token frequency	0.17	-5.43	< .001***
Block (old vs. new)	0.40	-1.94	0.05*
Operation span	0.00	2.16	0.03*

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1)



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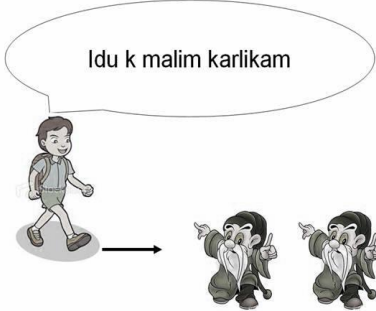
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Figure 1. Example of the set of trials presented to the participants during training

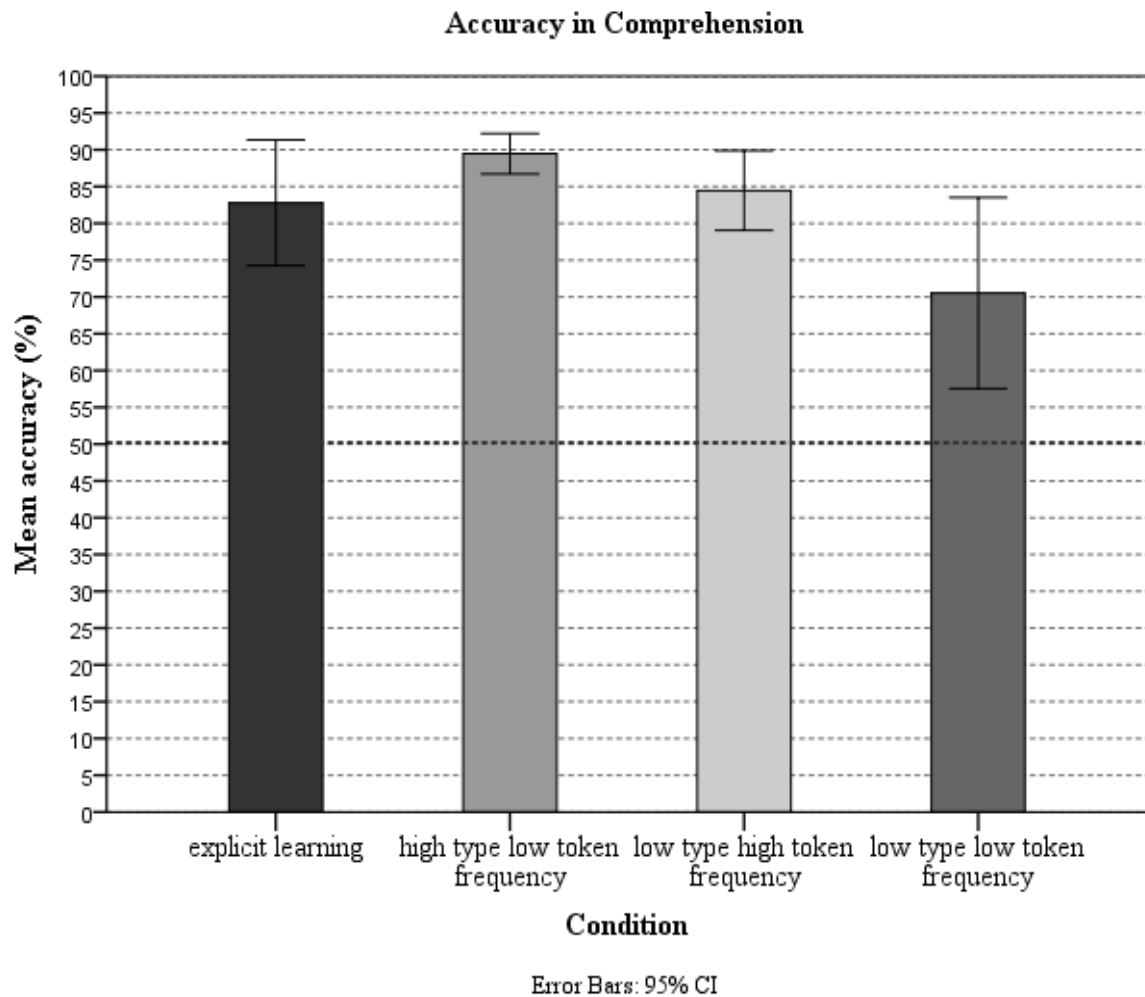
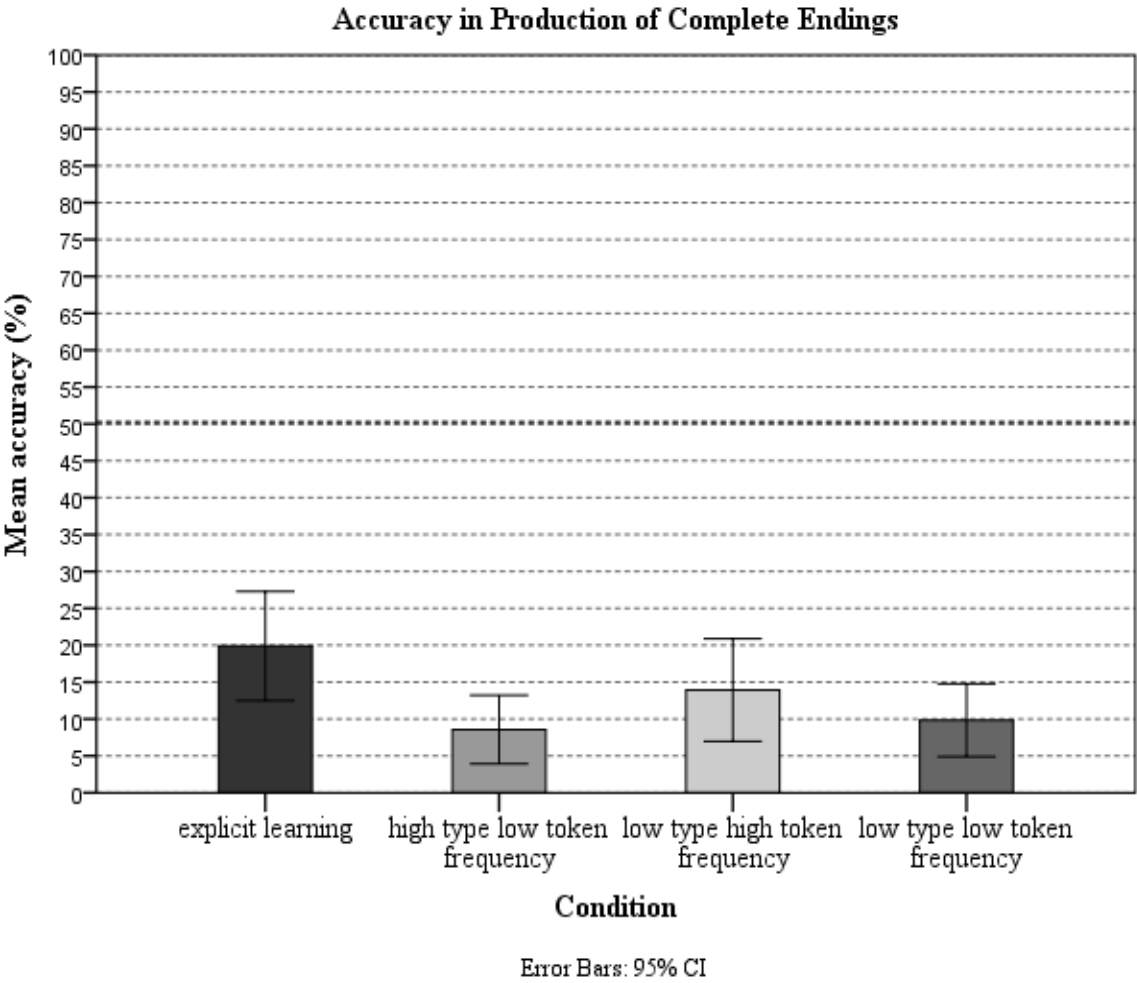


Figure 2. Accuracy performance by percentages of participants in the explicit learning and incidental learning conditions on the recognition task

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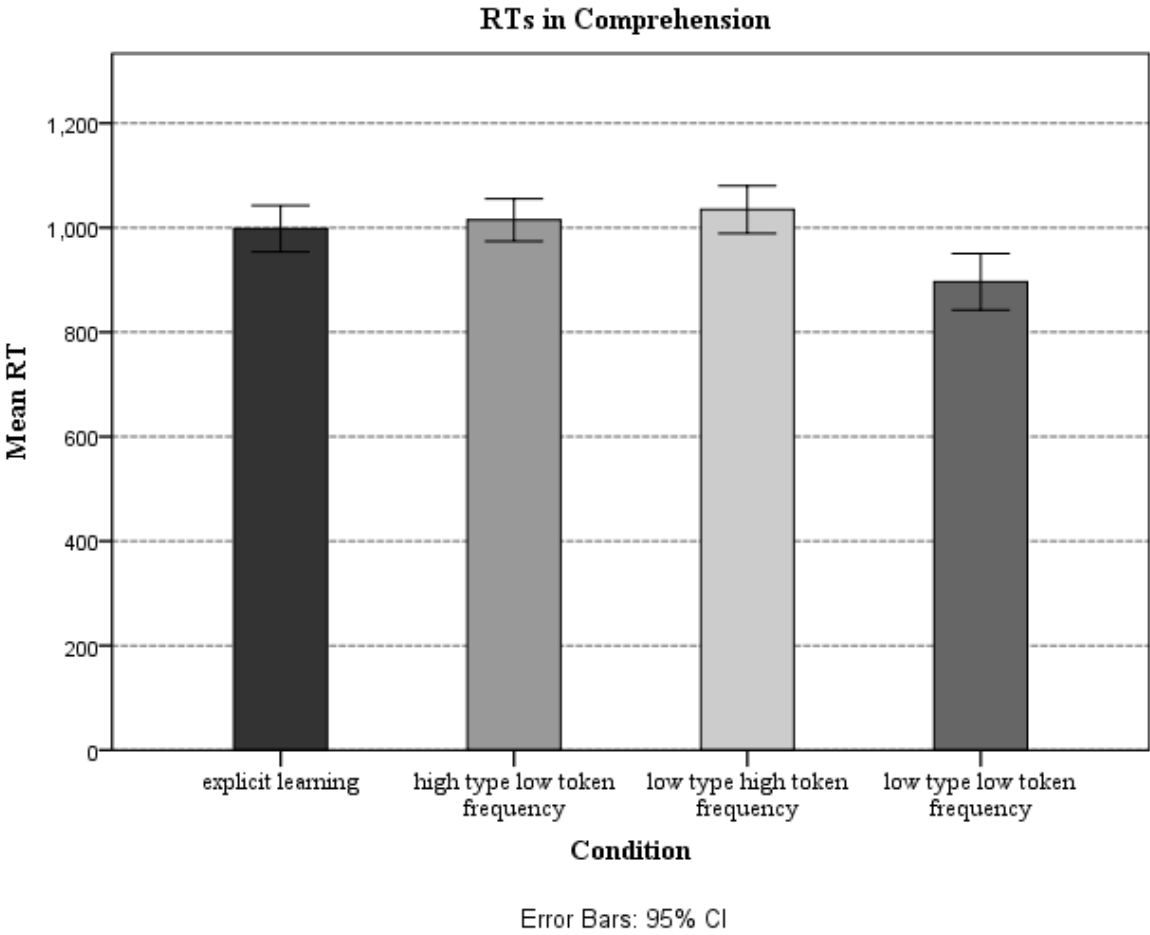


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1391 *Figure 3. Accuracy in production of endings (%) by participants in the explicit learning and*
1392 *incidental learning conditions on the fill-in-the-blank task*

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1405 *Figure 4. Mean RTs of participants in the explicit learning and incidental learning conditions on*
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