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

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.

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

1. Introduction

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

34 individual differences with respect to knowledge, skills, and information processing (p.
35 133).

36 The linguistic complexity of the structure is often associated with cognitive
37 complexity or learning difficulty (DeKeyser, 2005; Housen, 2014; Marsden, Williams, & Liu,
38 2013), which is affected in turn by individual differences in cognitive abilities, including
39 working memory (WM) capacity variability (Grey, Williams, & Rebuschat, 2015; Juffs &
40 Harrington, 2011; Tagarelli, Ruiz-Hernandez, Vega & Rebuschat, 2016). In addition, it has
41 been posited that the complexity of a linguistic structure interacts with its input-related
42 properties, such as the frequency of the occurrence of the structure in the input, making
43 it more or less accessible for acquisition (Housen & Simoens, 2016). Hence, frequency
44 may mediate adult incidental learning by creating a more or a less effective learning
45 context. For L1 acquisition of complex morphologies, type and token frequencies are
46 known to be vital (Tomasello, 2000, 2008). The present study thus attempts to
47 understand the effects of type and token frequencies on adult acquisition of a complex
48 L2 pattern and the extent to which the manipulation of type and token frequencies in the
49 incidental learning condition impacts the effectiveness of learning such a structure. In
50 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 in only one of

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

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

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

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

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

135 *2.3. Frequency and L2 learning*

136

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

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

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

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

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

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

187 authors compared the effectiveness of learning under a condition in which metalinguistic
188 explanations of the rule were provided to another condition where no such information
189 was provided, both conditions being enhanced by token frequency. The authors
190 employed intentional rather than incidental learning conditions triggered by frequency
191 but found that training with the provided metalinguistic information was more beneficial
192 for learning French gender morphology among L1 English speakers. The present study
193 extends a step further, as in the current study we manipulate both type and token
194 frequencies under incidental learning conditions in order to examine their effects on the
195 acquisition of a complex morphological agreement pattern and to compare the learning
196 effect in such conditions to the explicit learning condition.
197
198 *2.4. Working memory*
199
200 The relationship between structure complexity and the training conditions may be
201 mediated by a third factor – the learner's WM capacity. From extensive research, we
202 know that WM – understood as a system of temporary storage and manipulation of
203 information during complex cognitive activities such as language comprehension and
204 learning (Baddeley, 2010) – is a predictor of L2 learning success (Hummel, 2009; Juffs &

205 Harrington, 2011; Linck, Osthus, Koeth, & Bunting, 2014; Mackey, Philp, Egi, Fujii, &
206 Tatsumi, 2002; Martin & N. Ellis, 2012; Williams, 2012; Speciale, Ellis, & Bywater, 2004).
207 However, despite the overarching effect of IDs in cognitive abilities found in L2 morpho-
208 syntactic acquisition (Michael & Gollan, 2005; Miyake & Friedman, 1998; Sagarra, 2007),
209 including grammatical agreement (Keating, 2009; Kempe, Brooks, & Kharkhurin, 2010;
210 Sagarra, 2007; Sagarra & Herschensohn, 2010, 2012), the traditional view holds that WM
211 is not implicated in implicit learning (Conway, Baurnschmidt, Huang, & Pisoni, 2010;
212 Kaufman et al., 2010) or in the incidental acquisition of knowledge (Brooks and Kempe,
213 2013; Grey, Williams, & Rebuschat, 2015; Tagarelli et al., 2011).
214 Accepted in the field, this perspective is nonetheless contradicted by several
215 studies that demonstrate a relationship with WM (Author, XXX; Janacsek & Nemeth, 2013;
216 Bo et al., 2011; Robinson, 2005; Weitz et al., 2011; Williams & Lovatt, 2003). Such mixed
217 findings might be attributed to the interaction between the nature of the target stimulus
218 being acquired and the learning context, different tasks being used for measuring WM
219 and implicit learning, and the L2 learning domain (e.g. comprehension vs. production)
220 being tested.

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

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

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 a structure is particularly important because, for the L2 learner with a relatively poor L1 morphology, acquiring fusional morphological pattern is a challenging task (Kempe and

MacWhinney, 1998; McDonald, 1987) that will potentially draw on available cognitive resources.

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

4. Method

A between-subjects design was employed such that the learners were assigned to one of the incidental learning conditions or the explicit learning condition. In L2 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 with *-ek* in the genitive case plural, such as *babushka* 'grandmother' (pl. *babush**ek***), were excluded.

TABLE 1

The set of training sentences contained noun-adjective agreement phrases in nominative, dative, instrumental, and genitive cases for singular and plural forms of the noun, and each adjective was paired with only one noun to create a novel phrase. The four cases were selected based on how easy it would be to create a short story. Each story depicted feminine or masculine characters and consisted of eight slides presented sequentially, (four that corresponded to the agreement in the singular (nominative, dative, instrumental and genitive) and four that correspond to agreement in the plural (nominative, dative, instrumental and genitive)) presented sequentially. Each slide contained a picture and a Russian sentence, as illustrated in Figure 1 and Table 2. There were 7 novel stories in the high type frequency condition and 3 - in the low type frequency condition. A token represented the repetition of a particular story and therefore of the specific noun-adjective phrase in a certain agreement form (e.g., *mal**omu** karlik**u*** '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 × 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.

4.4.1. Pretraining

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

4.4.2. Training in incidental learning conditions

Participants in the incidental learning conditions were not informed about the linguistic structure or that there would be a testing phase. These participants were randomly assigned to one of the three incidental learning conditions (low type/high

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

390 from a stereotypical story character or characters of a feminine or a masculine gender
391 (e.g., dwarf). The presentation of each sequence was randomized.
392
393 *4.4.3. Training in the explicit learning condition*
394
395 During training, participants in the explicit learning condition were provided with
396 metalinguistic information about noun-adjective agreement and were informed that they
397 would be tested on their acquisition of this knowledge. Agreement according to number,
398 gender and case was explained using two examples for each agreement rule. Each
399 example was represented by a slide containing a Russian sentence that was transliterated
400 into the Latin alphabet with adjectival and noun endings highlighted in bold, an English
401 translation written underneath the transliteration and a semantically corresponding
402 picture similar to the pictures presented to participants in the incidental learning
403 conditions. After receiving metalinguistic explanations regarding the agreement rules,
404 participants were given 15 minutes to examine the slides again at their own pace and to
405 memorize the morphological pattern.
406

4.4.4. Testing

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

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

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

5. Results

441 The data were analysed using logistic and linear regression models in R, version
442 3.2.3, by applying a Generalized Linear Model (GLM) in the R Commander software
443 package (R Development Core Team, 2015). We checked for normality and homogeneity
444 by visual inspections of the plots of residuals against fitted values. A backwards model
445 selection procedure was employed that began with a full model including all parameters
446 and then excluded the parameters one at a time. An ANOVA function was used to
447 determine whether the parameter significantly improved the model (Baayen, 2008).
448 When fitting the model, all fixed effects of theoretical interest were retained in the
449 models, even if they were non-significant. For a summary of model coefficients, see Table
450 4. Throughout the paper, MCMC-estimated p values that are considered significant at
451 the $\alpha = 0.05$ level are presented.
452
453 *5.1. Explicit vs incidental learning*
454
455 The responses were scored for accuracy. A response was coded as correct if the learner
456 was able to recognize the number agreement or produce the complete appropriate
457 ending for the agreement pattern. Each participant received a maximum of 28 points for

458 correct responses in calculating their accuracy scores (see Table 5 for the overall
459 accuracy and WM scores). Although general performance for comprehension accuracy
460 was above chance (see Figure 2 for mean scores per condition), production levels under
461 all conditions were low (Figure 3).
462
463 FIGURE 2
464 FIGURE 3
465
466 First, a logistic regression with *glmer* model function was run to analyse the
467 accuracy of comprehension of the agreement pattern under both explicit and incidental
468 learning conditions. Condition (explicit learning, high type/low token; low type/high
469 token; low type/low token frequency), block (old items, new items; with old items used as
470 a reference category) and the operation span score were included in the model as fixed
471 effects, and item was entered as a random effect. The data were treatment-coded for
472 learning condition. To compare the effectiveness of the learning condition on knowledge
473 retention, the explicit learning condition was used as the reference category. As
474 presented in Table 7, participants in the high type/low token frequency (incidental

475 learning) condition exhibited higher accuracy for comprehension of the agreement
476 pattern than participants in the explicit learning condition. Individual reaction times (*RT*s)
477 collected during the recognition task exceeding ± 2 *SD* were eliminated. The mean error
478 rate was 0.2%. We then ran a linear regression with *glmer* model function with
479 condition (explicit learning, high type/low token; low type/high token; low type/low token
480 frequency), block (old items, new items) and operation span score as fixed effects and
481 with item as the random effect to investigate the differences in *RT*s. Significantly shorter
482 *RT*s were found for the participants in the low type/low token frequency condition than
483 for those in the explicit learning condition; moreover, participants in the latter group also
484 performed less accurately in agreement comprehension. However, with respect to
485 comprehension accuracy and *RT*s, no difference between old and new items was found,
486 and there was no effect of WM on either comprehension accuracy or *RT*s.
487
488 FIGURE 4
489 TABLE 6
490
491 Participants' responses to the fill-in-the blank task were coded for accuracy such
492 that 1 indicated that the participant produced a complete adjectival ending in a relevant

493 position and 0 indicated that the participant produced either no ending or an inaccurate
494 ending. The same model used in the analysis of comprehension accuracy was run to
495 determine production accuracy. The analysis revealed that participants in the explicit
496 learning condition significantly outperformed participants engaged in all of the incidental
497 learning conditions in the production of complete endings. Moreover, it was determined
498 that participants correctly answered questions regarding old items significantly more
499 than new items. Finally, in contrast to production, there was an effect of WM on
500 productive knowledge retrieval.
501
502 TABLE 7
503
504 *5.2. Frequency and knowledge acquisition under incidental learning conditions*
505
506 To further explore the effect of frequency on incidental learning, we ran the same model
507 but included only the incidental conditions. The model included condition (high type/low
508 token; low type/high token; low type/low token frequency), block (old items, new items;
509 with old items as a reference category) and operation span scores as fixed effects and
510 item as a random effect.

511

512 *5.2.1. Frequency and receptive knowledge*

513

514 The analysis using the model with the high type/low token frequency condition as a

515 reference category revealed that participants in the low type/high token condition (*M* =

516 84.50%, *SD* = 11.50%, β = -3.83, *Wald z* = -2.05, *SE* = 1.87, p = .04) and the low type/low

517 token frequency (*M* = 70.50%, *SD* = 27.80%) condition recognized the agreement

518 pattern less accurately than participants in the high type/low token frequency condition

519 (*M* = 89.50%, *SD* = 5.90%; β = -1.17, *Wald z* = -6.74, *SE* = 1.74, p < .001). We then ran the

520 same model using the low type/low token frequency condition as a reference category

521 and found that participants in the low type/high token frequency condition performed

522 significantly better than participants in the low type/low token frequency condition (β =

523 7.88, *Wald z* = 5.21, *SE* = 1.51, p < .001). No significant difference between old vs new

524 items with respect to participant accuracy was found (β = 7.28, *Wald z* = 1.32, *SE* = 5.53,

525 p = .18).

526 To analyse *RT*s, a linear regression model was run with the same variables as

527 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, β = 6.97, *t 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 (β = -132.52, *t 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' *RT*s in the low type/high token frequency condition (β = 139.50, *t value* = 4.12, SE = 33.90, p < .001) were also significantly longer than the *RT*s for participants in the low type/low token frequency condition. No significant difference was found in participants' accuracy between old and new items (β = -49.65, *t value* = - .48, SE = 103.54, p = .63), and no WM effect was found for either comprehension accuracy (β = 8.58, *Wald z* = 1.58, SE = 5.43, p = .11) or *RT*s (β = 1.60, *t value* = 1.49, SE = 1.07, p = .14).

5.2.2. Frequency and productive knowledge

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

6. Discussion

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

Our findings indicate that even during the initial stages of learning under incidental exposure, speakers of an L1 with a relatively poor morphological system were sensitive to morphological cues and could successfully recognize plurality represented by a complex morphological pattern. This confirms previous research on languages with less fusional morphology, such as in L2 Spanish and French (De Garavito & White, 2002; McCarthy, 2008; White et al., 2004), and on languages with a high fusional agreement morphology, such as Russian (Brooks, Kempe, & Sionov, 2006; Kempe et al., 2010), as well as incidental learning studies regarding the acquisition of complex morphological systems (Brooks & Kempe, 2013; Rogers, Revesz, & Rebuschat, 2015). The accessibility of

579 the concept of plurality, based on the dichotomous distinction between one and more
580 than one referent (Dispaldro, Ruggiero, & Scali, 2014) may provide an additional
581 contribution to the learning of such complex morphological patterns. Although
582 grammaticalized in English, number is believed to be prelinguistic in nature and more
583 semantically salient (Dispaldro, Ruggiero, & Scali, 2014; Eberhard, 1999).
584 Moreover, the complexity of the stimulus itself may facilitate its proneness to
585 being better captured by the implicit learning mechanisms. Even within the artificial
586 language learning paradigm, research demonstrates a stronger learning effect when the
587 input was complex and contained multiple levels of regularities as opposed to when it
588 was simplified (Saffran & Wilson, 2003; Thiessen & Saffran, 2009). Since natural
589 languages are believed to be inherently richer in cues and complexity than artificial
590 language systems (Erickson & Thiessen, 2015), when employing a natural language as a
591 stimulus in research, more pronounced incidental learning effect may be found.
592 In addition, despite the assumption that utilizing artificial language systems in
593 incidental learning experiments, generally provides insight into the natural language
594 learning (Ettlinger et al., 2016; Robinson, 2010), scholars, nevertheless, underscore the
595 importance of employing more natural language stimuli in current incidental learning

596 research (Erickson & Thiessen, 2015). To date, only a few studies used natural languages
597 as a material (Brooks & Kempe, 2013; Godfroid, 2016). The present study, therefore, adds
598 to this trend and extends the existing artificial language learning research by utilizing a
599 natural language within the incidental learning paradigm.
600 Some incidental learning conditions in the present study appeared to be more
601 effective at promoting learning at the level of recognition of a complex linguistic pattern
602 than the explicit learning condition where knowledge acquisition was fostered by
603 metalinguistic information. This finding is consistent with the theoretic stipulation that
604 incidental exposure bestows a greater advantage on learning a complex grammatical
605 structure (Krashen, 1982, 1994; Reber, 1989), and it also confirms the existent research
606 that provides evidence of higher knowledge attainment under incidental learning
607 conditions as opposed to intentional learning conditions (DeKeyser, 1995; Robinson,
608 1996) in adult L2 learners. It is widely acknowledged in the literature that L2 inflectional
609 morphology represents the greatest challenge for learners compared to other areas of
610 morpho-syntax (DeKeyser, 2005; Larsen-Freeman, 2010). This premise is confirmed by
611 research that compares different types of grammatical knowledge and finds fewer errors
612 in word order acquisition compared to morphology (Grey et al., 2014). Moreover, during

613 the post-critical period age, such knowledge must be acquired explicitly and be triggered
614 by declarative mechanisms, as some theories suggest (Ullman, 2004). Therefore, the high
615 learning effect obtained in the present study under the incidental learning condition and
616 enhanced by type frequency supports both the assumption that incidental exposure can
617 help adults to override maturational constraints on learning and Krashen's claim
618 (Krashen, 1982, 1994), with the correction, however, that an incidental learning mode
619 requires additional triggers. The role of frequency, as one such trigger, is generally
620 consistent with the cognitive-associative view of L2 acquisition (N. Ellis, 2002; 2012) and
621 the research that demonstrates the positive frequency impact on L2 morphology
622 learning (Bowden, Gelfand, Sanz, & Ullman, 2010).
623 Overall, as our findings suggest, although the participants in the explicit learning
624 conditions exhibited higher production accuracy than those in the incidental learning
625 conditions, the explicit learning mode was not effective for acquiring a complex pattern.
626 In the present study, performance, even in production domain, that is dependent on
627 higher order processes (Keenen & MacWhinney, 1987) and conscious knowledge
628 remained below chance in all learning conditions, including the explicit learning
629 condition. Future research may consider ways to improve such performance in a

longitudinal study. Perhaps adopting a paradigm in which training is conducted over multiple sessions would help to identify those factors involved in successful productive knowledge acquisition and the exposure mode that is most beneficial.

6.1. Frequency and incidental learning

As demonstrated by the results of the present study, frequency interacts with the learning condition and provides interesting and differential effects for the productive and receptive acquisition of a complex pattern under incidental exposure. Receptive knowledge acquisition is affected by type frequency, whereas productive knowledge acquisition is affected by token frequency. According to Bybee (1985), type frequency promotes the generalization of grammatical structures. Thus, for successful recognition, the learner must develop an abstract schema by collecting a sizeable number of types of a given construction (Bybee & Thompson, 2000; N. Ellis, 2002; Plunkett & Marchman, 1991). Our findings indicate that the larger the number of different lexical items appearing within a complex stimulus pattern during training, the more accurate the identification and generalization of the agreement structure.

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

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

To better understand how frequency impacts the acquisition of a complex structure under incidental exposure in different modalities and the extent to which we

664 can examine effective learning in the production domain, a more extended study may be
665 insightful. For instance, providing enhanced training over several sessions or
666 manipulating different degrees of frequency in the input would yield a more
667 comprehensive picture.
668
669 *6.2. Working Memory*
670 Finally, we also aimed to explore the mediating effect of WM on the acquisition of
671 a complex structure under different incidental learning conditions enhanced by type and
672 token frequencies. The null WM effect indicates that it is the frequency alone that shapes
673 the learning of a linguistically complex structure. One possible explanation, which is also
674 consistent with the assumption of automaticity and the effortless nature of the implicit
675 learning process (Shiffrin and Schneider, 1977), is that when the stimulus is sufficiently
676 complex, implicit learning mechanisms underpin such learning without relying on
677 cognitive resources.
678 To support this assumption, previous research on adult implicit learning provides
679 ample evidence suggesting that WM is not implicated. This applies to those studies
680 focusing on the relationship between WM and grammatical knowledge acquisition under

681 incidental learning conditions (Tagarelli et al., 2011, 2016; Yang & Li, 2012), to studies
682 employing sequence learning (Conway et al., 2011; Kaufman et al., 2010), and to research
683 focusing on the productive acquisition of a Russian case-marking system (Brooks and
684 Kempe, 2013).

685 An alternative interpretation of the null WM effect could relate to the nature of
686 the agreement structure used in the present study. It might be the case that plurality
687 itself may induce a processing cost (Tanner et al., 2014) or that the linguistic complexity
688 of the morphological system, which factors in several agreement variables, places a high
689 cognitive demand on knowledge retrieval, thus hindering access to WM (Caplan and
690 Waters, 1999; Hopp, 2006, 2010; McDonald, 2006). This line of thinking may suggest that
691 the structure employed in the current study was, in principle, too complex to be
692 acquired, regardless of individual variations among learners with respect to their WM
693 capacity. For instance, Sagarra (2007), who investigated agreement processing in L2,
694 found that WM was engaged when the complexity of the target structure was low but
695 that WM was not involved in the processing of more complex structures. WM was found
696 to be a predictor for understanding sentences with within-phrase gender agreement
697 violations (e.g., La mujer lava la blusa *blanco en la cocina 'The woman washes the

*white (masc) blouse (fem) in the kitchen') by English L2 learners of Spanish but was not a predictor for sentences that contained gender agreement violations across clauses, which represents a more challenging task for the learner. In this sense, the linguistic complexity of the structure under investigation taps into cognitive complexity. The null correlation with WM may indicate that the present pattern is more cognitively demanding for all language learners (Housen & Simoens, 2016) when it is to be acquired without intention and awareness.

In spite of the positive results reported herein, one possible limitation of the present study involves the comparability between explicit and incidental learning conditions. The rationale behind choosing the metalinguistic explanation training rather than employing a rule-search condition involves the robust learning effect typically reported in the literature in the explicit learning conditions where metalinguistic information about the target structure was provided to the learner. Another potential limitation of the study was the difficulty in teasing apart the categories of gender, case and number when testing the acquisition of a complex agreement pattern. A similar challenge was recorded by Brooks, Kempe and Sionov (2006) and attributed to the inflectional syncretism of the Russian language. However, obtaining information about

how well each of the grammatical category was learned by future research might provide a better understanding about acquisition of complex systems. Finally, exploring how other factors, such as stereotypical gender (Molinaro, Su & Carreiras, 2016; Siyanova-Chanturia, Pesciarelli & Cacciari, 2012) of the stimuli used in the present study, may foster learning of a morphological pattern could be another potential trend of research. Despite its limitations, nevertheless, the advantage of the current research is its contribution to the growing understanding of L2 grammatical acquisition and its use of a natural language system. Studies of the incidental learning of natural language grammars are limited because research traditionally used artificial languages. Despite providing control over confounding factors, artificial languages present a much-simplified version of natural language (Hulstijn et al., 2014).

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).

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Appendix

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		

Training Sentences

Masculine singular

Eto seriy pojarnik/ This is a grey firefighter

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

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

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

Eto maliy karlik/ This is a small dwarf

1056 Idu k malomu karliku/ I am going towards the small dwarf

1057 Idu s malim karlikom/ I am going with the small dwarf

1058 Idu ot malogo karlika / I am going away from the small dwarf

1059

1060 Eto jeltiy begun/ This is a yellow runner

1061 Idu k jeltomu begun/ I am going towards the yellow runner

1062 Idu s jeltim begunom/ I am going with the yellow runner

1063 Idu ot jeltogo beguna/ I am going away from the yellow runner

1064

1065 Eto yuniy shkolnik/ This is a young schoolboy

1066 Idu k yunomu shkolniku/ I am going towards the young schoolboy

1067 Idu s yunim shkolnikom/ I am going with the young schoolboy

1068 Idu ot yunogo shkolnika/ I am going away from the young schoolboy

1069

1070 Eto lisiy letchik/ This is a bald pilot

1071 Idu k lisomu letchiku/ I am going towards the bald pilot

1072 Idu s lisim letchikom/ I am going with the bald pilot

Idu ot lisogo letchika/ I am going away from the bald pilot

Eto temniy fokusnik/ This is a brunette conjurer

Idu k temnomu fokusniku/ I am going towards the brunette conjurer

Idu s temnim fokusnikom/ I am going with the brunette conjurer

Idu ot temnogo fokusnika/ I am going away from the brunette conjurer

Eto krupniy ohotnik/ This is a big hunter

Idu k krupnomu ohotniku/ I am going towards the big hunter

Idu s krupnim ohotnikom/ I am going with the big hunter

Idu ot krupnogo ohotnika/ I am going away from the big hunter

Masculine plural

Eto serie pojarniki/ These are grey firefighters

Idu k serim pojarnikam/ I am going towards the grey firefighters

Idu s serimi pojarnikami/ I am going with the grey firefighters

Idu ot serih pojarnikov/ I am going away from the grey firefighters

Eto malie karliki/ These are small dwarves

Idu k malim karlikam/ I am going towards the small dwarves

Idu s malimi karlikami/ I am going with the small dwarves

Idu ot malih karlikov/ I am going away from the small dwarves

Eto jeltie beguni/ These are yellow runners

Idu k jeltim begunam/ I am going towards the yellow runners

Idu s jeltimi begnami/ I am going with the yellow runners

Idu ot jeltih begunov/ I am going away from the yellow runners

Eto yunie shkolniki/ These are young schoolboys

Idu k yunim shkolnikam/ I am going towards the young schoolboys

Idu s yunimi shkolnikami/ I am going with the young schoolboys

Idu ot yunih shkolnikov/ I am going away from the young schoolboys

Eto lisie letchiki/ These are a bald pilots

Idu k lisim letchikam/ I am going towards the bald pilots

Idu s lisimi letchikami/ I am going with the bald pilots

Idu ot lisih letchikov/ I am going away from the bald pilots

Eto temnie fokusniki/ These are brunette conjurers

Idu k temnim fokusnikam/ I am going towards the brunette conjurers

Idu s temnimi fokusnikami/ I am going with the brunette conjurers

Idu ot temnih fokusnikov/ I am going away from the brunette conjurers

Eto krupnie ohotniki/ These are big hunters

Idu k krpnim ohotnikam/ I am going towards the big hunters

Idu s krpnimi ohotnikami/ I am going with the big hunters

Idu ot krpnih ohotnikov/ I am going away from the big hunters

Feminine singular

Eto grustnaya vdova/ This is a sad widow

Idu k grustnoy vdove/ I am going towards the sad widow

Idu s grustnoy vdovoy/ I am going with the sad widow

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

Eto belaya nevesta/ This is an white bride

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

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

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

Eto hudaya stryapuha/ This is a thin cook

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

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

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

Eto svetlaya podruga/ This is a blonde friend

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

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

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

Eto tolstaya tkachiha/ This is a fat weaver

Idu k tolstoy tkachihe/ I am going towards the fat weaver

Idu s tolstoy tkachihoy/ I am going with the fat weaver

Idu ot tolstoy tkachihi/ I am going away from the fat weaver

Eto staraya portniha/ This is an old dressmaker

Idu k staroy portnihe/ I am going towards the old dressmaker

Idu s staroy portnihoy/ I am going with the old dressmaker

Idu ot staroy portnihi/ I am going away from the old dressmaker

Eto chernaya plovchiha/ This is a black swimmer

Idu k chernoy plovchihe/ I am going towards the black swimmer

Idu s chernoy plovchihoy/ I am going with the black swimmer

Idu ot chernoy plovchihe/ I am going away from the black swimmer

Feminine plural

Eto grustnie vdovi/ These are sad widows

Idu k grustnim vdovam/ I am going towards the sad widows

Idu s grustnimi vdovami/ I am going with the sad widows

Idu ot grustnih vdov/ I am going away from the sad widows

Eto belieie nevesti/ These are white brides

Idu k beieim nevestam/ I am going towards the white brides

Idu s belimii nevestami/ I am going with the white brides

Iduu ot belih nevest/ I am going away from the white brides

Eto hudie stryapuhi/ These are thin cooks

Idu k hudim stryapuham/ I am going towards the thin cooks

Idu s hudimi stryapuhami/ I am going with the thin cooks

Idu ot hudih stryapuh/ I am going away from the thin cooks

Eto svetlie podrugi/ These are blonde friends

Idu k svetlim podrugam/ I am going towards the blonde friends

Idu s svetlimi podrugami/ I am going with the blonde friends

Iduu ot svetlih podrug/ I am going away from the blonde friends

Eto tolstie tkachihi/ These are fat weavers

Idu k tolstim tkachiham/ I am going towards the fat weavers

Idu s tolstimi tkachihami/ I am going with the fat weavers

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

Eto starie portnihi/ These are old dressmakers

Idu k starim portniham/ I am going towards the old dressmakers

Idu s starimi portnihami/ I am going with the old dressmakers

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

Eto chernie plovchihi/ These are black swimmers

Idu k chernim plovchiham/ I am going towards the black swimmers

Idu s cherntimi plovchihami/ I am going with the black swimmers

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

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

Table 2

Examples of Training Sentences Presented to Participants

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

Note: Stereotypical story characters rather than stereotypical gender characters were included as stimuli

Table 3

Distribution of Types and Tokens during Training

Incidenal 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

Table 4

Model Selection

Predictor	AIC	BIC	Pr (>Chisq)
Condition	1536.88	1553.16	$p < .001$
Operation Span	1536.37	1558.07	.113
Block (old vs. new)	1537.30	1564.43	.548
Number	1539.30	1571.86	.759
Gender	1542.87	1586.28	.810
Case	1538.57	1598.26	.133
Condition x block	1536.52	1607.07	.062
Condition x number	1540.01	1621.41	.724
Number x gender	1543.82	1636.07	.903
Block x number	1544.61	1642.29	.272

Full model: Condition, Operation Span, Block, Number, Gender, Case.
Condition X Block, Condition X Number, Number X Gender, Block X Number

Table 5

Descriptive Statistics for Participants' Accuracy and WM Scores

Condition	WM		Comprehension		Production	
	M	*SD*	*M*	*SD*	*M*	*SD*
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

Table 6

Explicit Learning Condition vs. *Incidental Learning Conditions for Comprehension*

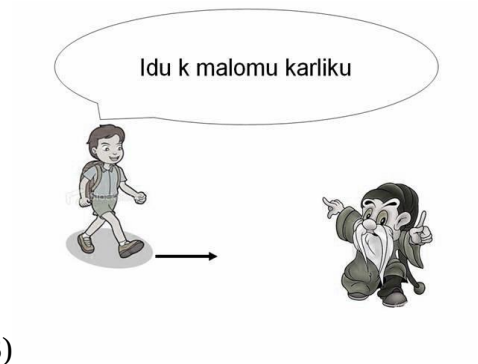
	Comprehension accuracy			Comprehension *RT*s		
Condition	Std. Error	Wald z	*p* value	Std. Error	t value	*p* value
High type/low token frequency	1.76	3.30	< .001***	33.25	0.67	0.51
Low type/high token frequency	1.60	0.74	0.46	33.26	0.94	0.34
Low type/low token frequency	1.45	-4.64	< .001***	33.35	-3.24	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

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*

1) 2)



3) 4)

5) 6)

7) 8)

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

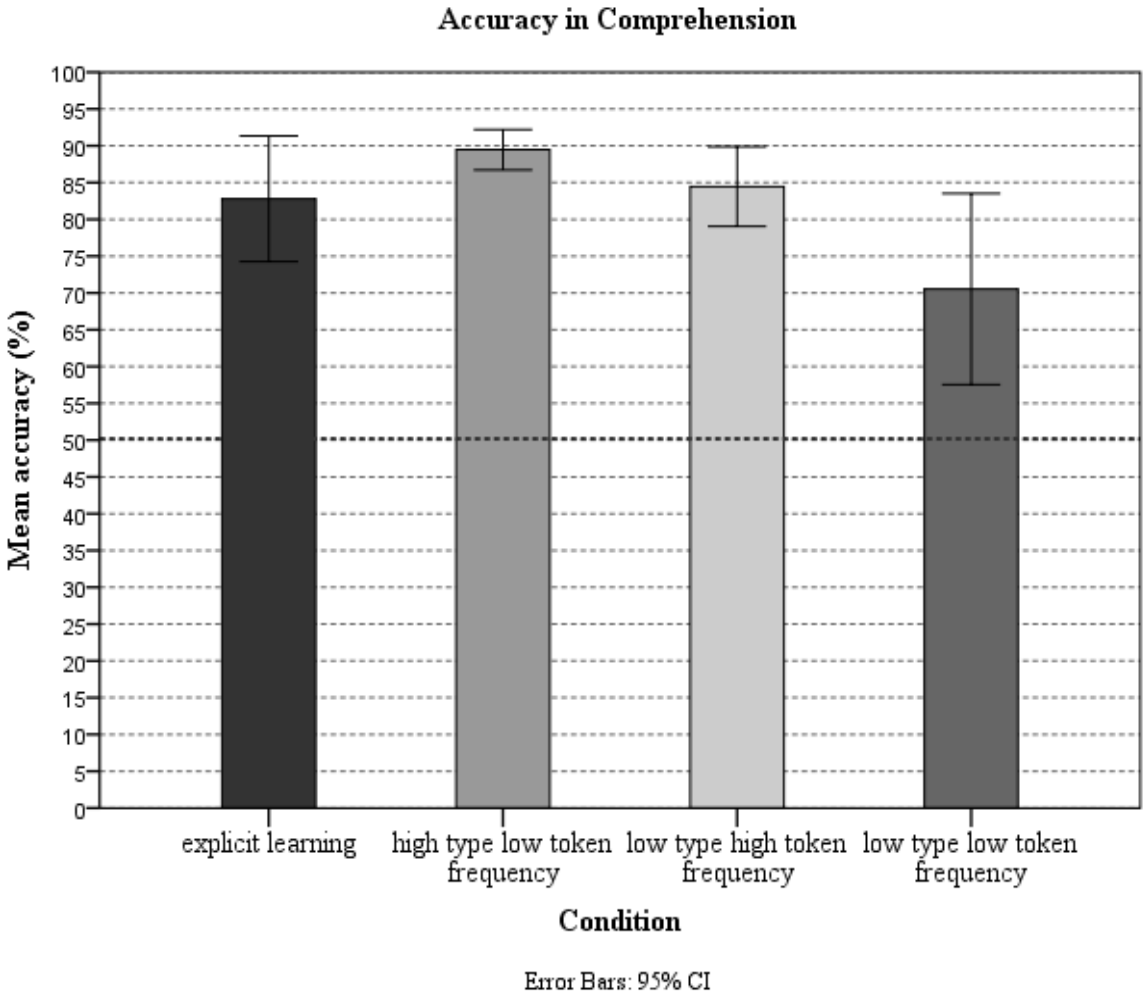


Figure 2. Accuracy performance by percentages of participants in the explicit learning and incidental learning conditions on the recognition task

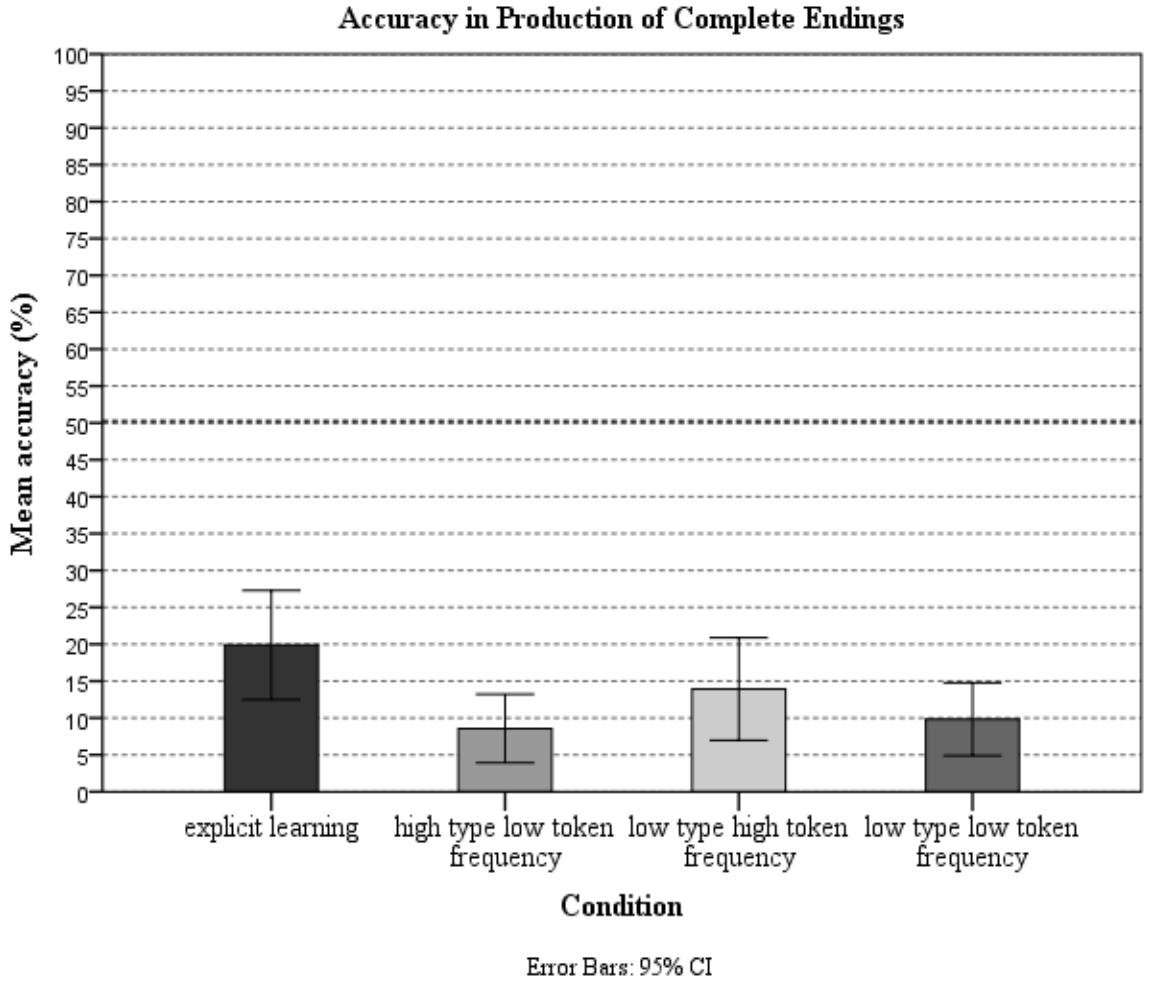


Figure 3. Accuracy in production of endings (%) by participants in the explicit learning and incidental learning conditions on the fill-in-the-blank task

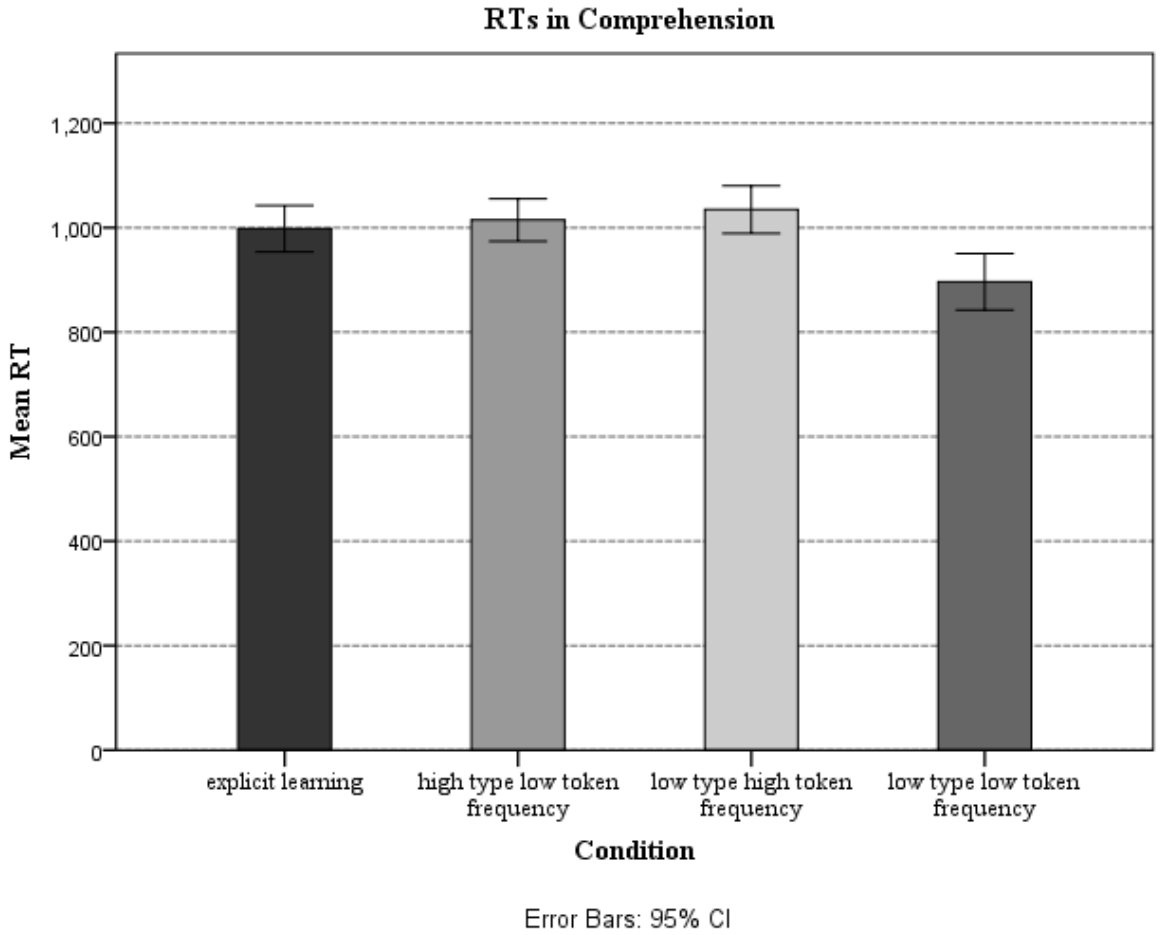


Figure 4. Mean *RT*s of participants in the explicit learning and incidental learning conditions on the recognition task