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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: 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.

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'

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

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.

2.3. Frequency and L2 learning

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

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

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

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

292 from the study. The participants were students of humanities (*n* = 48), social sciences (*n*
293 = 12), or natural sciences (*n* = 15) or were members of the administrative staff (*n* = 5) at
294 a large university and were randomly allocated to one of the four learning conditions (*n*
295 = 20 per condition). Participants received either course credit or monetary
296 compensation for their participation.
297
298 *4.2. Materials*
299
300 The set for vocabulary pre-training included Russian words, specifically, six
301 nouns and four adjectives (see Appendix for the full list of stimuli) three prepositions (*k*
302 'towards', *ot* 'away from', *s* 'with'), a particle (*eto* 'this'), as well as colour pictures
303 compiled using ClipArt. Only adjectives that could be easily identified in the context of
304 the pictures (e.g., small, white, old) were selected. All nouns were concrete nouns
305 depicting animate stereotypical story characters (e.g., *karlik* or 'dwarf') of either feminine
306 or masculine natural gender. The stimuli were matched based on the number of
307 syllables. Nouns contained two or three syllables, and all adjectives were disyllabic. To
308 maintain a consistent pattern, only nouns and adjectives that belonged to the inflectional
309 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.

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

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

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

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 (*RT*s) 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 *RT*s. Significantly shorter *RT*s 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 *RT*s, no difference between old and new items was found, and there was no effect of WM on either comprehension accuracy or *RT*s.

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;

515 with old items as a reference category) and operation span scores as fixed effects and
516 item as a random effect.
517
518 *5.2.1. Frequency and receptive knowledge*
519
520 The analysis using the model with the high type/low token frequency condition as a
521 reference category revealed that participants in the low type/high token condition (M =
522 84.50%, SD = 11.50%, β = -3.83, *Wald* z = -2.05, SE = 1.87, p = .04) and the low
523 type/low token frequency (M = 70.50%, SD = 27.80%) condition recognized the
524 agreement pattern less accurately than participants in the high type/low token frequency
525 condition (M = 89.50%, SD = 5.90%; β = -1.17, *Wald* z = -6.74, SE = 1.74, p < .001).
526 We then ran the same model using the low type/low token frequency condition as a
527 reference category and found that participants in the low type/high token frequency
528 condition performed significantly better than participants in the low type/low token
529 frequency condition (β = 7.88, *Wald* z = 5.21, SE = 1.51, p < .001). No significant
530 difference between old vs new items with respect to participant accuracy was found (β =
531 7.28, *Wald* z = 1.32, SE = 5.53, p = .18).

To analyse *RT*s, 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, 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 the concept of plurality, based on the dichotomous distinction between one and more than one referent (Dispaldro, Ruggiero, & Scali, 2014) may provide an additional contribution to the learning of such complex morphological patterns. Although grammaticalized in English, number is believed to be prelinguistic in nature and more semantically salient (Dispaldro, Ruggiero, & Scali, 2014; Eberhard, 1999).

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

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

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

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

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

Overall, as our findings suggest, although the participants in the explicit learning conditions exhibited higher production accuracy than those in the incidental learning conditions, the explicit learning mode was not effective for acquiring a complex pattern. In the present study, performance, even in production domain, that is dependent on 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

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 can examine effective learning in the production domain, a more extended study may be insightful. For instance, providing enhanced training over several sessions or manipulating different degrees of frequency in the input would yield a more comprehensive picture.

6.2. Working Memory

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

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

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

that WM was not involved in the processing of more complex structures. WM was found to be a predictor for understanding sentences with within-phrase gender agreement 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

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).

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753 **References**

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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

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

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

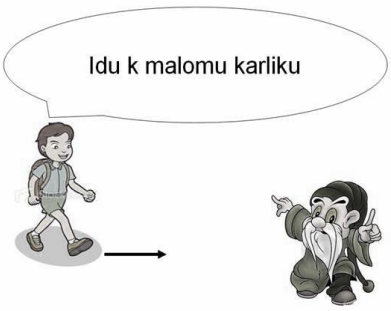
Explicit vs. *Incidental Learning for Production*

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*

Eto maliy karlik

1) 2)

Eto malie karliki



3) 4)

5) 6)

7) 8)

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

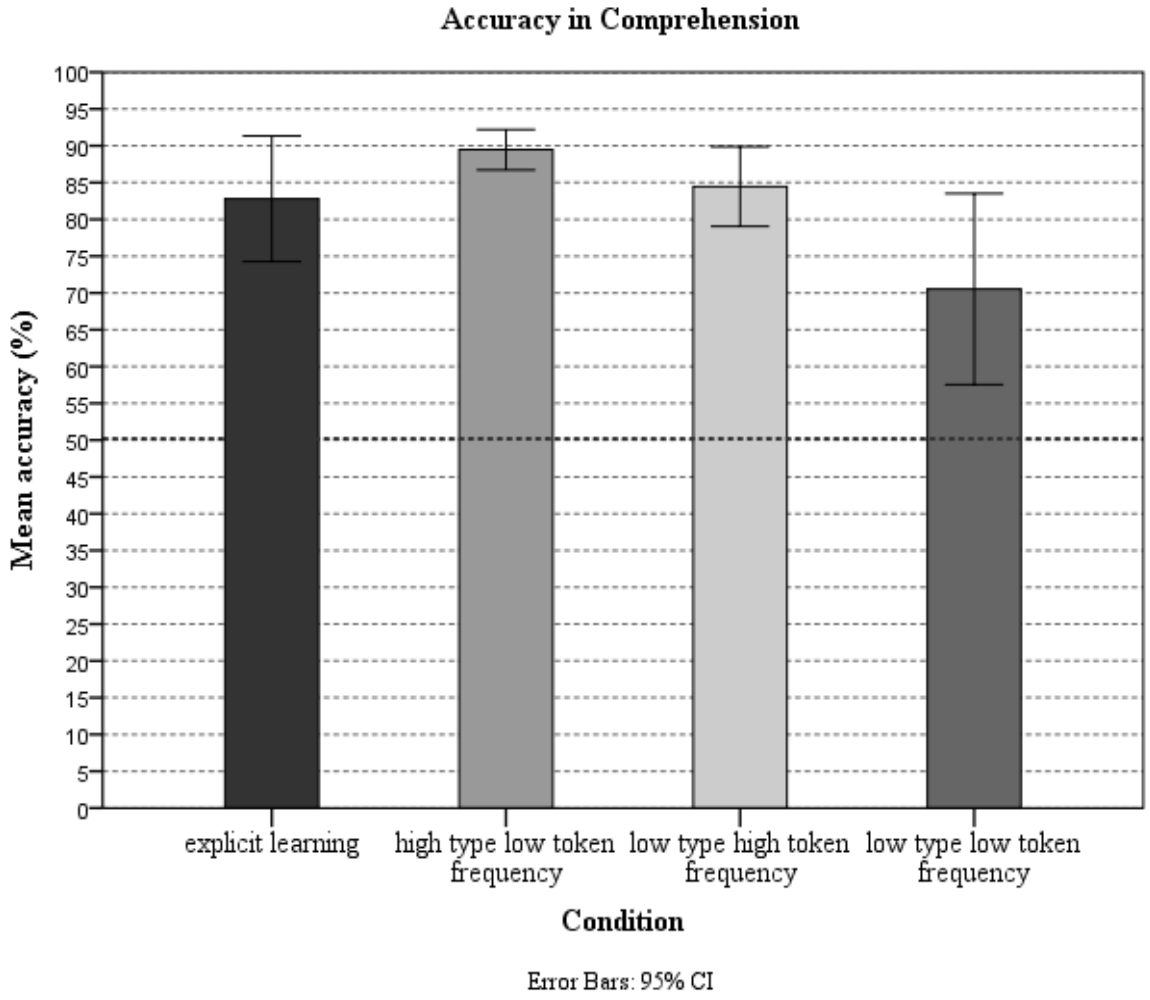


Figure 2. Accuracy performance by percentages of participants in the explicit learning and incidental learning conditions on the recognition task

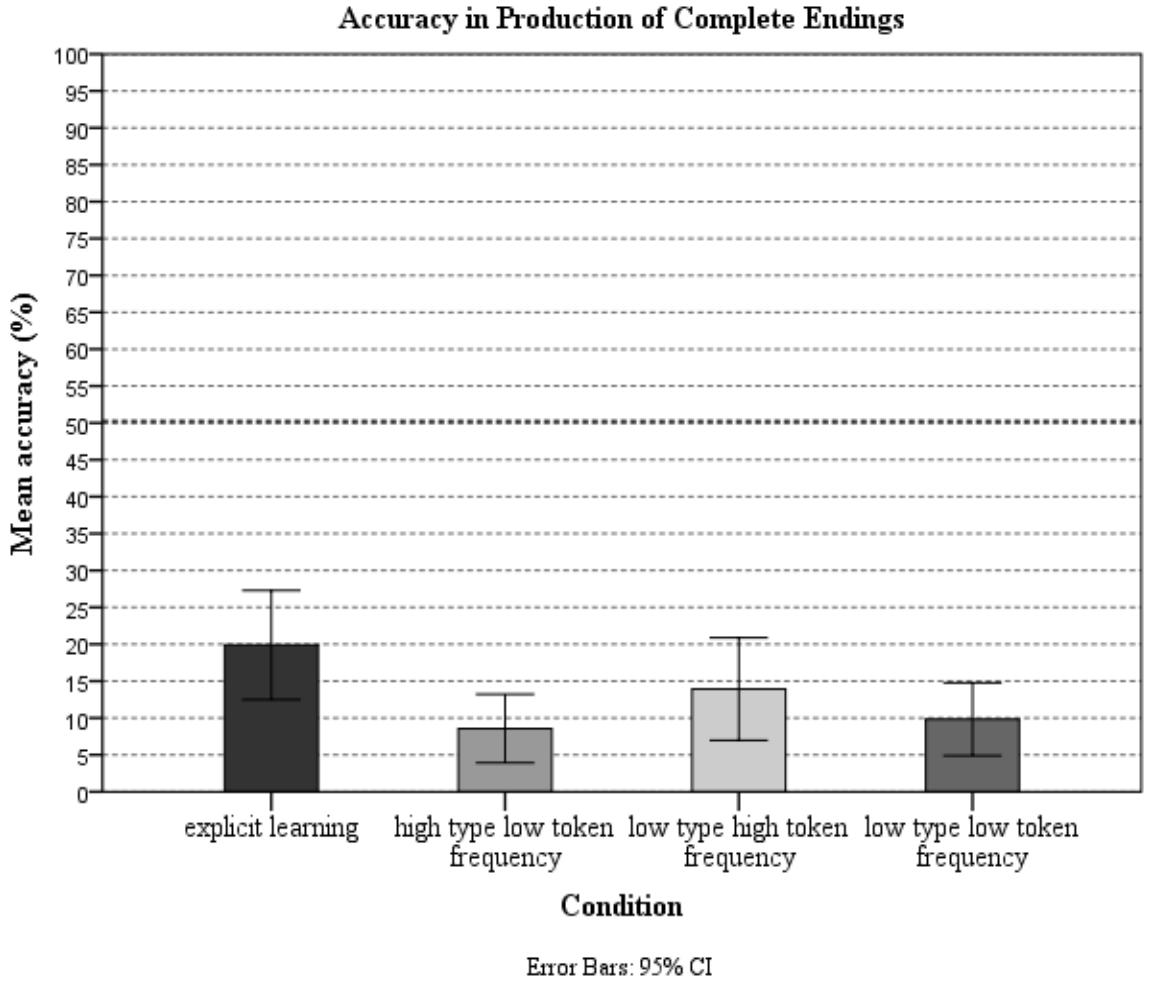


Figure 3. Accuracy in production of endings (%) by participants in the explicit learning and incidental learning conditions on the fill-in-the-blank task

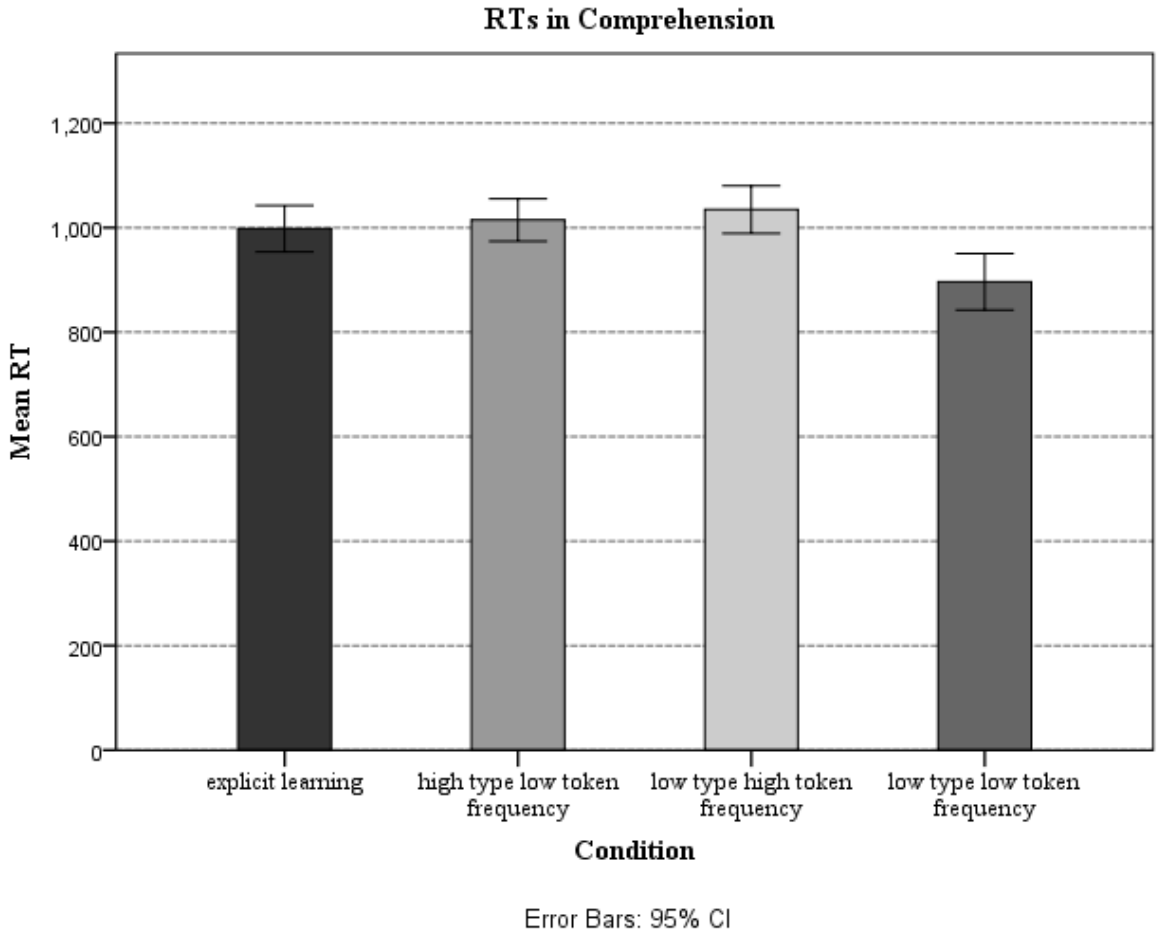


Figure 4. Mean *RT*s of participants in the explicit learning and incidental learning conditions on the recognition task