

Phonological short-term memory as a predictor for the uptake of collocations

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Abstract

It has been widely attested that L2 learners' acquisition of collocations, a subset of formulaic sequences (FS), shows large individual variation. At the same time, there is a growing consensus among scholars that working memory is a central component of foreign language aptitude that largely determines differences in second language success. Research has demonstrated that especially phonological short-term memory (PSTM) – a component of working memory – plays an important role in foreign language acquisition. The aim of the present study is to investigate if there is a relationship between learners' PSTM and their uptake of collocations in a classroom context. Therefore, the PSTM of 20 Dutch-speaking university students majoring in German was measured by means of a serial nonword recognition task. To measure students' uptake of collocations, a pre-test post-test design was adopted. Between pre-test and post-test, the students took part in incidental as well as intentional learning in a classroom context. To be able to control for vocabulary size in the analysis of the data, two standardized vocabulary size tests were administered: one for receptive and one for productive vocabulary knowledge. Results of the multiple regression analysis show that in this study, PSTM predicts 29,7% of the variance in the uptake of collocations, whereas students' receptive and productive vocabulary size did not predict this uptake.

Keywords: collocations; foreign language acquisition; phonological short-term memory

1. Introduction

In recent years, it has been widely attested that collocations, i.e., frequently recurring two-to-three word syntagmatic units (Henriksen, 2013) are important for learners' foreign language development (e.g., Szudarski & Carter, 2014). During the last decades, the number of studies on formulaic sequences (FS) and collocations has steadily increased, due to their ubiquity in natural language (Erman & Warren, 2000; Meunier, 2012) and their fundamental role in language comprehension and production (e.g., Boers, Eyckmans, Kappel, Stengers, & Demecheleer, 2006; Pawley & Syder, 1983; Wood, 2012). To put it in Ellis' words: "Nativelike competence, fluency, and idiomaticity require an awful lot of figuring out which words go together" (Ellis, 2002, p. 157).

Research also showed that the acquisition of collocations is particularly challenging for most foreign language learners (Laufer & Waldman, 2011; Meunier, 2012; Nesselhauf, 2004; Wood, 2010), especially at the productive level (Peters, 2016). Reasons which have been put forward to explain learners' difficulty in acquiring collocations, especially in a classroom-context, are a lack of rich input or exposure (Durrant & Schmitt, 2010), the influence of the L1 (Nesselhauf, 2003), and the lack of semantic and perceptual salience of many collocations (Boers, Lindstromberg, & Eyckmans, 2014).

Furthermore, there appears to be considerable individual variation between learners in their acquisition of FS (Schmitt, Dörnyei, Adolphs, & Durow, 2004). This individual variation can be explained by differences on a motivational, but also on a cognitive level. Dörnyei, Durow and Zahran (2004) for example found that, in an immersion context, three factors appeared to be related to the successful uptake of formulaic sequences (e.g., collocations): language aptitude, motivation, and sociocultural adaptation. In this paper we are particularly interested in the influence of aptitude, more specifically the phonological component of working memory, on the acquisition of collocations.

Several studies have suggested that working memory is a central component of foreign language aptitude that largely determines differences in second language success (e.g., Biedroń & Szczepaniak, 2012; Dörnyei, 2005; Singleton, 2017; Wen, Biedroń, & Skehan, 2017). Especially phonological short-term memory (PSTM) can be considered as an important component of language aptitude (e.g., Ellis, 1996; Gathercole & Thorn, 1998; Hummel & French, 2016), which explains individual differences in L2 outcomes (Linck, Osthus, Koeth, & Bunting, 2014). PSTM has been shown to be related to the acquisition of L2 vocabulary and grammar (e.g., Martin & Ellis, 2012; Papagno, Valentine, & Baddeley, 1991; Speciale, Ellis, & Bywater, 2004), to oral fluency gains (O'Brien, Segalowitz, Freed, & Collentine, 2007) and to the acquisition of formulaic sequences (Bolibaugh & Foster,

2013; Ellis & Sinclair, 1996; Foster, Bolibaug, & Kotula, 2014; Skrzypek & Singleton, 2013; Wen, 2015). However, most of these studies were carried out in a laboratory setting or in an immersion context. In this study, we will explore whether PSTM is a predictor for the uptake of collocations in a foreign language classroom context. Since the study is set within this context, the learning that takes place can be called intentional in the sense that both the teacher and learners have the intention that information is memorized and retained (Hulstijn, 2003). At the same time, a classroom context also provides opportunities for incidental learning, for example through listening and reading activities (Hulstijn, 2003). In the data that will be presented in this paper regarding the uptake of collocations, we will focus on incidental learning only, which we define as “the picking up of words and structures, simply by engaging in a variety of communicative activities, in particular reading and listening activities, during which the learner’s attention is focused on the meaning rather than on the form of the language” (Hulstijn, 2003, p. 349).

2. Literature review

2.1. Collocations

2.1.1. Identifying collocations

Many terms are used to refer to the concept of co-occurring lexical items: collocations, lexical phrases, formulaic sequences, chunks, multiword units, to name but a few. In the literature on corpus linguistics, the term collocation refers to word combinations that occur more frequently than expected by chance (Gries, 2013). They are often categorized as a subset of formulaic sequences (FS) and are placed on a continuum as an intermediate category between free combinations and idioms on the basis of their restricted co-occurrence and semantic transparency (Laufer & Waldman, 2011). Some examples are *fall in love*, *catch a cold*, *hard job*, *rainy day*, *key role*, *safe and sound*, *widely used*, *on purpose*.

When it comes to identifying collocations, two main traditions can be distinguished (Barfield & Gyllstad, 2009; Granger & Pacquot, 2008). The frequency-based tradition identifies collocations on the basis of the frequency of co-occurrence of their constituent words, often as a result of corpus-based analyses (Sinclair, 1995). The phraseological tradition, that is the result of the work of, for example, Cowie (1992), Howarth (1998) and Nesselhauf (2003), treats collocations as word combinations that are “characterized by restricted co-occurrence of elements and relative transparency of meaning” (Laufer & Waldman, 2011, p. 648). Within this tradition, the collocational unit is analyzed syntactically and semantically with the focus on developing a typology, for example between

lexical and grammatical collocations (Benson, Benson, & Ilson, 2010). In recent years, a combination of both approaches has been adopted, in which researchers initially identify frequent co-occurring word combinations through corpus analysis, and then include or exclude specific combinations after manually checking the selected collocations and opposing them to free combinations and idioms (Henriksen, 2013; Moreno Jaén, 2007).

2.1.2. Importance of collocations and difficulties in foreign language acquisition

Since collocations are inherent to formulaic language, they play an important role in foreign language acquisition. Firstly, research in corpus linguistics has demonstrated that these word combinations are widespread in spoken and written native discourse (Erman & Warren, 2000; Meunier, 2012; Sinclair, 1995; Wray, 2002), which means that they are indispensable to reach a native-like level of proficiency (Pawley & Syder, 1983). Secondly, mastery of collocations is needed for adult language learners to process and use language fluently and idiomatically (e.g., Boers et al., 2006; Cowie, 1992; Ellis, 2002; Wood, 2012). There is considerable evidence that L2 learners' language production is considered more proficient when collocations are used in both L2 speaking and writing (Boers et al., 2006; Nesselhauf, 2003). However, there is a general consensus that the acquisition of collocations is slow (Boers et al., 2014) and that even advanced learners have significant difficulties in producing correct collocations (Nesselhauf, 2003). Explanations that have been put forward are a lack of exposure, especially in a classroom context (Durrant & Schmitt, 2010; Wray, 2000; Yamashita & Jiang, 2010); the focus of learners on individual words and not on word sequences (Barfield & Gyllstad, 2009); and language learners' assumption that they can easily be transferred from one language to another, resulting in erroneous collocations in the target language (Biskup, 1992; Nesselhauf, 2003; Paquot & Granger, 2012).

2.2. Phonological short-term memory

Phonological short-term memory, or PSTM, is a cognitive variable that has been investigated extensively in first and second language acquisition. It is an important feature of Baddeley and Hitch's (1974) proposed multi-component working memory model. In this model, PSTM (also called the phonological loop and verbal STM) is viewed as an independent subsystem (along with two other subsystems, namely the visuospatial sketchpad and the episodic buffer) of the central executive. It is responsible for the temporary maintenance of acoustic or speech-based material, and is defined as the ability of individuals to remember small amounts of auditory information over short periods of time (Baddeley, 2000).

PSTM capacity differs among individuals (Gathercole, Pickering, Hall, & Peaker, 2001) and has been linked to vocabulary acquisition in L1 as well as in L2 acquisition in both children and adults (e.g., Baddeley, Gathercole, & Papagno, 1998; Ellis, 2012; Vulchanova, Foyen, Nilsen, & Sigmundsson, 2014). According to Ellis, “much of language acquisition is in fact sequence learning” and “a wide range of language learning abilities are determined by learners’ short-term memory” (Ellis, 1996, p. 91-92). He stated that individual differences in PSTM determine learners’ ability to acquire vocabulary and grammar (Ellis, 1996). However, PSTM does not only seem to have an influence on the acquisition of single words or grammar. Several studies examining the relationship between PSTM and L2 acquisition have found relationships, for example, between PSTM, narrative development and grammatical competence in adult learners (O’Brien, Segalowitz, Collentine, & Freed, 2006), oral fluency gains in adults (O’Brien et al., 2007), students’ performance in writing, use of English and oral fluency and vocabulary (Kormos & Sáfár, 2008) and L2 proficiency (Hummel & French, 2016).

2.3. Phonological short-term memory in the acquisition of L2 phrases

Despite the amount of studies that have shown a significant relationship between PSTM and L1 and L2 acquisition, there are only a few studies that investigate the influence of PSTM on the acquisition of foreign language collocations. These studies were mostly carried out outside the classroom, in a laboratory setting (Ellis & Sinclair, 1996) or in an immersion setting (Bolibaugh & Foster, 2013; Foster et al., 2014; Skrzypek & Singleton, 2013). Furthermore, PSTM was operationalized in different ways in different studies: by means of articulatory suppression and rehearsal (Ellis & Sinclair, 1996), a serial recall task (Foster et al., 2014), an unknown L3 repetition task (Bolibaugh & Foster, 2013) and serial nonword recall and recognition (Skrzypek & Singleton, 2013).

With reference to our own investigation into the relationship between PSTM and the acquisition of L2 collocations, we will address three studies in more detail. Ellis and Sinclair (1996) report on an experiment where participants were required to learn language utterances in Welsh, a language they were not familiar with. The study compared three groups: a group where participants were encouraged to repeat the phrases, a group where they were prevented from repeating the phrases through articulatory suppression, and a control group with no instruction. The experiment showed that the phonological rehearsal of phrases led to the best performance. Ellis and Sinclair (1996) conclude that PSTM is involved in the learning of phrases and state that “the role of working memory in learning such structures is the same as that for words” (Ellis & Sinclair, 1996, p. 245). More recently, Skrzypek and Singleton (2013) report a study on the relation

between PSTM and the productive knowledge of English collocations. Participants in the study were adult Polish learners, on both A2 and B1 level, and their PSTM was measured on two occasions, by means of a serial nonword recall and a serial nonword recognition task. Participants' productive collocational knowledge was tested by a fill-in-the-blanks collocation test, developed by Gitsaki (1999). A significant relationship was found between PSTM and collocational knowledge at both proficiency levels. In the study of Foster et al. (2014), receptive knowledge of nativelike selections of L2 users of English in both the UK and Poland was investigated and linked to different independent variables, such as PSTM (measured by means of a serial recall task), age of onset and length of exposure. The results showed that for late starters within the target language community, PSTM is the only significant predictor for the ability to recognize nativelike selections. Outside the target community, no influence of PSTM was found. The authors suggest that "for late starters, a good PSTM and L2 immersion are necessary for the acquisition of this dimension of L2 knowledge" (Foster et al., 2014, p. 101).

3. The study

3.1. Research aims

Since PSTM has been shown to be one of the factors to mediate individual differences in various aspects of L2 acquisition, we decided to investigate its influence on the acquisition of collocations. More specifically, our study focuses on the relationship between PSTM and the uptake of German collocations during incidental learning in a classroom-based context. With "incidental" learning we refer to the phenomenon of "picking up" collocations while students engage in different meaning-focused tasks (Hulstijn, 2003). Phonological short-term memory is defined in this study as follows: the ability to retain the serial order of phonological elements (lists of nonwords) in short-term memory. It was measured by means of a serial nonword recognition task, based on Gathercole et al. (2001). The research questions are the following:

1. What is the relationship between students' PSTM and their uptake of German collocations?
2. Is this relationship affected by students' German productive or receptive vocabulary size?

It was hypothesized that there would be a positive relationship between students' phonological memory skills and their uptake of collocations. Additionally, an influence of students' productive and receptive vocabulary size was expected, due to the fact that vocabulary size has been shown to be an important

predictor of L2 proficiency development (Stæhr, 2008), which also includes the acquisition of collocations.

3.2. Participants

Participants in this study were 20 Dutch-speaking university students in their second undergraduate year of an Applied Linguistics program, majoring in German and an additional foreign language at a Belgian university. They all received 190 contact hours of formal instruction in German before the start of the study and their proficiency level for German was at the B1 level of the Common European Framework of Languages (Council of Europe, 2001) for production and at the B2 level for comprehension. Their ages ranged between 19 and 22. With only four male students in the cohort, the majority of the participants in this study ($n = 16$) were female. All participants signed an informed consent form.

3.3. Research instruments

3.3.1. Serial nonword recognition task (phonological short-term memory)

There are several ways to assess the phonological store of working memory, and tasks such as nonword repetition, rhyme detection, word span (e.g., Avons, Wragg, Cupples, & Lovegrove, 1998) or digit span, serial nonword recall, and serial nonword recognition (e.g., Gathercole, Service, Hitch, Adams, & Martin, 1999; Gathercole et al., 2001) have been put forward. Assessing students' PSTM by means of different measures was not feasible within the time constraints of this study. Therefore, the decision was made to use a serial nonword recognition task, in which a list of nonwords of varying lengths is presented, followed by the presentation of a second list with the same items in either the same or a different order. Participants have to judge immediately after listening to a list whether the order of a sequence of nonwords is identical or different. A serial nonword recognition task was chosen for different reasons. Firstly, participants do not have to repeat the nonwords out loud, so there are no articulatory processes involved. In this way, a poor or unclear pronunciation does not affect the results and the task may provide a relatively pure measure of the phonological store (Baddeley, 2003; Gathercole et al., 2001), compared with serial recall or nonword repetition. Since earlier studies have shown serial nonword recognition to correlate strongly with serial nonword recall (Hummel & French, 2016; Majerus, Poncelet, Elsen, & van der Linden, 2006; Skrzypek & Singleton, 2013), it was not deemed necessary to add a recall task to the procedure.

The design of the serial nonword recognition task was based on Gathercole et al. (2001). To start, a collection of 160 monosyllabic pronounceable Dutch nonwords was assembled, using Wuggy, a multilingual pseudoword generator (Keuleers & Brysbaert, 2010). This algorithm generates pseudowords that follow a given language's phonotactics. An L1 (Dutch) non-word task was used to ensure that the differences in performance between participants reflect the differences in their PSTM, rather than their knowledge of the phonological regularities of L2 German (O'Brien et al., 2007).

From this pool of 160 nonwords, a four-item practice list was created. The practice list contained two identical and two different trials. For the nonword recognition task, the stimulus set consisted of 144 nonwords. Twenty-four pairs of nonword lists were developed: eight pairs of lists containing five items (see Appendix A), eight pairs of six items and eight pairs of seven items. All nonwords within a list had different vowel sounds and consonants were phonologically as distinctive as possible. For each list length of the eight pairs of lists, there were four identical and four different lists. For the identical lists, the same nonwords were presented in the same order. For the different lists, the nonwords were the same, but the order of two of the items in the set was changed in the second presentation. The changed pair within each list was distributed randomly across participants, and initial and final nonwords never changed position. The pairs of lists in each list length were also selected at random by a computer program that was designed for this purpose.

3.3.2. Sight translation

To test students' knowledge and uptake of German collocations, a short German video-recording was selected and transcribed. In the transcript of the video-recording, a text of 231 words, 17 collocations (see Appendix B) were selected as target items. The video-recording was selected for three reasons, the first being authenticity. As it was taken from Deutsche Welle, Germany's public international broadcaster, the collocations used in the video-recording were part of authentic German spoken discourse. According to Nesselhauf (2003), collocations in a classroom context "should be both undoubtedly acceptable and frequent in a neutral register and any special register that is of use to the learner" (Nesselhauf, 2003, p. 238). Secondly, the content was relevant to the topic of the class, which was "alternative family forms", and very suitable for a classroom discussion. Thirdly, the video-recording took less than three minutes and was thus sufficiently short to keep students interested.

In the current study, collocations were identified on the basis of two criteria: 1) consisting of a two-to-three word syntagmatic unit and 2) appearing in

at least one of the two existing German collocation dictionaries (in which a combination of a frequency-based and a phraseological approach was adopted): *Feste Wortverbindungen des Deutschen: Kollokationenwörterbuch für den Alltag* (Häcki Buhofer, Dräger, Meier, & Roth, 2014) and *Wörterbuch der Kollokationen im Deutschen* (Quasthoff, 2011).

The transcript of the video-recording was translated into Dutch, which served as the basis of a sight translation exercise in which the 17 target items were elicited. In this kind of task, students read the text in the L1 and translate it out loud in the L2. A sight translation was chosen because of the participants' familiarity with the task and because of its productive character.

3.3.3. Productive vocabulary test

The students were administered the productive vocabulary test for German, developed by the Institute for Test Research and Test Development, in cooperation with the Herder-Institute Leipzig and the University of Leipzig. The vocabulary levels of German (1000, 2000, 3000, 4000 and 5000) are based on the frequency lists developed from the Herder/BYU-corpus (Jones, Tschirner, Goldhahn, Buchwald, & Ittner, 2006). Participants have to fill in the blanks, for instance, *In dem Dorf steht eine alte K_____ → Kirche*. To pass a test level, participants need 14 correct responses on a total of 18.

3.3.4. Receptive vocabulary test

To test students' receptive vocabulary, the German version of the LexTALE test (Lemhöfer & Broersma, 2012) was given as a paper and pencil test. LexTALE is a lexical decision task, consisting of 60 items (40 words and 20 nonwords), where participants have to indicate for each item whether it is an existing German word or not. The final scores consist of the percentage of correct responses, corrected for the unequal proportion of words and nonwords in the test by averaging the correct percentages for words and nonwords. The score is calculated according to the following formula: $((\text{number of words correct}/40 \times 100) + (\text{number of nonwords correct}/20 \times 100)) / 2$.

3.4. Procedure

3.4.1. Data collection procedure

The study was conducted in a German oral proficiency course, and a pre-test post-test design was adopted. Before the start of the course, participants were tested on their PSTM by means of a serial nonword recognition task. Each student

was tested individually in a quiet room at the university and the nonwords were presented aurally through a pair of headphones. A computer-generated voice was used to sound out the nonwords at a rate of approximately one item every 750 ms. Between the first and the second presentation of a list, there was an interval of 1.5s. Immediately after listening to each set of lists, participants had to decide whether or not the two lists were the same, pressing [y] for the same order, and [n] for a different order. They were told that they would listen to each set only once. In order to familiarize themselves with the task, participants started with the four-item practice trial and continued with the eight five-item lists, followed by the eight six-item lists, and finally the eight seven-item lists. The total number of correct responses was automatically saved by the program for each participant and the task took about 15 minutes.

In the third week of a 12-week course, students watched a German video-recording about “alternative family forms” to familiarize themselves with the topic that they would discuss later. They were invited to give their opinions about the content of the video-recording, to provide an oral summary and to engage in a sight translation, from Dutch into German, which took them about five minutes. Before watching the video-recording, students were not told that they would have to translate the transcript of the video later. This task was considered the pre-test. After one month, in week seven of the course, the video-recording was shown again and an unannounced post-test (i.e., the same sight translation used in the pre-test containing 17 target collocations) was administered to the students.

Two weeks later, two additional tests, a standardized productive and receptive vocabulary test, were given to control for the vocabulary knowledge of the participants. Participants were given 25 minutes to complete the productive test, 5 minutes to complete the LexTALE.

3.4.2. Classroom activities

During the 10 instruction hours between pre-test and post-test, the learners were exposed to several authentic, German listening materials, especially video-recordings. The course provided opportunities for both incidental and intentional learning. Incidental learning was fostered through regular exposure to German video-recordings, communicative interaction with the tutor (a native-speaker of German), and reading activities. The intentional activities consisted, for example, of screening the recordings for collocations and writing them down. Students were later invited to recycle these collocations in classroom discussions. Sometimes, students received pages with useful and frequent collocations that they could use during the discussion rounds in class. Finally, the tutor engaged in oral exercises in which students had to mimic the tutor or repeat frequent word combinations.

For the purpose of the study it has to be pointed out that the 17 target collocations were not addressed during the intentional learning activities.

3.4.3. Scoring

Following O'Brien et al. (2007), a weighted score was calculated for PSTM, because it is more challenging to memorize seven items than five or six. Correct answers at the five-item list were scored with five points, correct answers at the six-item list with six points and correct answers at the seven-item list with seven points, with a maximum weighted score of 144.

For the sight translation, the audio recordings of the participants were analyzed with a focus on the translation of the target collocations. Students got one point for a correct rendering of the collocation in German, and zero points for an unacceptable collocation or no response. The maximum score was 17, as the audio recording contained a total number of 17 target items. The productive vocabulary test was scored dichotomously: one point for a correct word – zero for an erroneous word, and the receptive vocabulary test was scored according to the LexTALE measure *average % correct*, as described in Lemhöfer and Broersma (2012).

4. Results

The aim of this study was to see whether students' PSTM is related to their uptake of German collocations during incidental learning in class and whether this relationship is affected by students' German productive or receptive vocabulary size.

Table 1 Descriptive statistics of the test scores for the PSTM, pre-test, post-test, gain score and productive and receptive vocabulary size test

Variable (total possible)	<i>N</i>	Minimum	Maximum	<i>M</i>	<i>SD</i>
PSTM (144)	20	46.0	120.0	92.4	18.0
pre-test (17)	20	5.0	12.0	8.0	1.9
post-test (17)	20	5.0	12.0	8.4	2.2
gain score (17) (post-test minus pre-test)	20	-4.0	4.0	.4	2.3
productive vocabulary (18)	18	10.0	14.4	12.5	1.3
receptive vocabulary (100)	18	57.5	81.3	67.9	6.7

The descriptive statistics with the minimum and maximum scores, means and standard deviations are presented in Table 1. PSTM scores range from 46 to 120, out of 144; recall scores for the collocations range from 5 to 12, out of 17; the difference between pre-test and post-test scores ranges from -4 to +4, productive vocabulary size ranges from 10 to 14.4, out of 18; and receptive vocabulary size from 57.5% to 81.3%. Most of the variation in the dataset is found in students' PSTM.

Table 2 shows the Pearson correlation coefficients for PSTM and the other measures, namely the gain score between pre-test and post-test and the productive and receptive vocabulary size. PSTM was significantly correlated with the gain score ($p = .016$), with productive vocabulary size ($p = .038$) and with receptive vocabulary size ($p = .004$). Productive vocabulary size also correlated significantly with receptive vocabulary size ($p = .007$).

Table 2 Pearson correlation coefficients among PSTM, gain score and productive and receptive vocabulary size

Variables	PSTM	gain score	prod. voc.	rec. voc.
1. PSTM ($N = 20$)	-			
2. gain score ($N = 20$)	.531*	-		
3. productive voc. ($N = 18$)	.493*	.364	-	
4. receptive voc. ($N = 18$)	.640**	.216	.614**	-

* $p < 0.05$ ** $p < 0.01$

In summary, the results presented here reveal that PSTM is related to students' receptive and productive vocabulary size. We also observe a significant correlation between PSTM and students' uptake of collocations. However, since a correlational design only allows conclusions about the existence of relationships, a hierarchical multiple regression was conducted to investigate whether PSTM can be considered a predictor for the uptake of collocations and whether productive and receptive vocabulary size are intervening variables. Prior to the hierarchical multiple regression, the relevant assumptions of this analysis were tested and these assumptions (e.g., linear relationship, normal distribution of the data, no multicollinearity) were met.

A three stage hierarchical multiple regression was conducted with the gain score as the dependent variable, PSTM and both vocabulary size measures as independent variables. The score for productive vocabulary size was the first variable entered, followed by receptive vocabulary size and then PSTM. The analysis revealed that at stage one, productive vocabulary accounted for 13% of the variation in the gain score, but did not contribute significantly to the regression model, $F(1,17) = 2.45$, $p = 0.14$. Adding receptive vocabulary size did not give a change in R^2 or in significance, $F(2,17) = 1.15$, $p = 0.34$. Finally, the addition of PSTM to the regression model explained an additional 30% of the variation in gain score and this change in R^2 was significant, $F(3,17) = 3.52$, $p = 0.04$. When all three independent variables were included in stage three of the regression model, neither productive nor receptive vocabulary size were significant predictors of the gain score. The most important predictor was PSTM, which uniquely explained 30% of the variation. The best fitting model for predicting the gain in uptake of collocations is a linear combination of the three predictors together ($R = .656$, R^2

= .430, $F(3,17) = 3.52$, $p = .04$), which accounted for 43% of the variance in the gain score. A summary of the results is presented in Table 3.

Table 3 Summary of the hierarchical multiple regression analysis

	<i>B</i>	<i>SE B</i>	<i>B</i>	<i>P</i>
Step 1				
Constant	-8.24	5.58		.16
Productive vocabulary	.69	.44	.36	.14
Step 2				
Constant	-8.12	6.48		.23
Productive vocabulary	.71	.58	.37	.24
Receptive vocabulary	-.00	.11	-.01	.97
Step 3				
Constant	-4.71	5.59		.41
Productive vocabulary	.49	.49	.26	.34
Receptive vocabulary	-.14	.11	-.40	.19
PSTM	.10	.04	.72	.02

$R^2 = .13$ for Step 1; $\Delta R^2 = -.00$ for Step 2; $\Delta R^2 = .30$ for Step 3

5. Discussion

The aim of the present study was to investigate the relationship between students' PSTM and their uptake of German collocations in a classroom-based context, in which the target collocations were encountered incidentally through listening. Two main findings emerged: (1) the mean uptake of collocations was small, and (2) PSTM was the best predictor of the uptake of collocations. Productive and receptive vocabulary size did not predict students' uptake of collocations.

Descriptive statistics indicated that students' PSTM showed most variation. The variation in the other variables is rather small and can be explained by the fact that participants of this study share more or less the same proficiency level for German and have a similar vocabulary size. In general, the mean uptake of collocations was poor. If we look at the individual scores, we see that some students picked up a few collocations, while others did not. A couple of students even regressed on the post-test. Two causes can be put forward to explain the meager uptake of collocations. First, students only watched the video-recording three times. It has been widely demonstrated that successful vocabulary acquisition is determined by a large number of encounters with words (e.g., Nation, 2001). However, watching the video-recording more than three times would have been unrealistic given the classroom context. Even in a situation in which watching the same recording six times or more were possible, the number of ten repetitions that was suggested by Webb (2007) as a minimal number of encounters to acquire new words would not have been reached. Second, students were exposed to the targets through listening, and the focus was on meaning, not on form.

The main research question, however, was to determine the influence of PSTM and vocabulary size on the gains of collocation during incidental exposure in a classroom context. The correlations which were attested are in line with other studies which also observed correlations between PSTM and vocabulary size (e.g., Gathercole & Baddeley, 1989; Papagno et al., 1991) and between PSTM and collocational gain (Skrzypek & Singleton, 2013).

The results of the regression analysis demonstrated that the most important predictor was PSTM, which significantly explained 30% of the variation in students' gain scores (RQ1). Students' productive or receptive vocabulary size alone did not predict their acquisition of collocations significantly (RQ2), although the three variables together explained 43% of the variance. This result seems to confirm that individual differences in PSTM capacity do not only determine the acquisition of L2 vocabulary (e.g., Masoura & Gathercole, 2005; Service & Kohonen, 1995; Speciale et al., 2004) and grammar (e.g., Ellis & Sinclair, 1996), but also the efficiency with which phrases or nativelike selections (Bolibaugh & Foster, 2013; Ellis & Sinclair, 1996; Foster et al., 2014) and collocations (Skrzypek & Singleton, 2013) are acquired in different foreign languages.

The finding that students' receptive or productive vocabulary size alone could not predict the uptake of collocations is rather surprising because of the importance of vocabulary size in language proficiency. However, Schmitt et al.'s (2004) study on the acquisition of formulaic sequences was also characterized by a lack of correlation between the formulaic sequence gain scores and the vocabulary size scores of the participants (although the measurement for the productive knowledge of the FS was different, with cloze and C-test test formats being used). Schmitt and colleagues suggested that "the relationship between size of the 'individual word lexicon' and the 'formulaic sequence lexicon' is not straightforward" (Schmitt et al., 2004, p. 64), an observation which seems to apply to this study too.

6. Limitations and future research

Although the results of this study point to a significant beneficial influence of PSTM on the acquisition of collocations, further empirical research is needed due to the small sample of participants ($N = 20$), the limited number of target items ($N = 17$) and the short period of time between pre-test and post-test. With only one post-test, it should also be taken into account that the effect of PSTM on the acquisition of collocations was only measured over the course of one month, and that the design does not allow conclusions about the relationship between PSTM and the long-term retention of the targets.

Another concern is that, since PSTM was measured by a serial nonword recognition task, we cannot discount the possibility that other tasks measuring PSTM could

lead to different results. The same applies for the productive measurement of the targets: it was measured by a sight translation task, which involves a complex cognitive process, requiring students to read, anticipate, translate and speak simultaneously. A different productive test (for example a gap-fill-exercise) could have yielded different uptake scores and receptive tests would have provided interesting information on learners' degree of comprehension of the target collocations.

Although our focus was on the relationship between PSTM and the incidental uptake of collocation during listening activities in class, future research should also consider the potential effect of intentional learning activities. Furthermore, as PSTM, productive and receptive vocabulary size together explained only 43% of the variance between students, 57% of the variance remained unrevealed. Therefore, other cognitive and other ID variables, which have been shown to affect language acquisition, such as intelligence, personality and motivation (e.g., Biedroń & Pawlak, 2016) should be taken into account as well.

7. Conclusion

Despite the limitations of this study, and although the mean gain score was small, it was shown that PSTM can be considered as a predictor for the acquisition of collocations through incidental learning. From the gain scores in this study, it is clear that listening activities without further structural elaboration or focus on form do not suffice to acquire collocations, especially not for students with lower PSTM capacity. Listening and reading activities should therefore be accompanied by focus on form exercises. Students could read the transcript while listening, with the collocations put in bold typeface, for example, and these collocations could become integrated in a collocation-focused exercise (such as a gap-fill exercise) afterwards. More research into the specific learning gains of different pedagogical techniques is needed to gain insight into the efficacy of these techniques for learners with lower PSTM capacity.

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Appendix A

Five-item lists (8)

Item lists	Item lists repeated	Answer
A. prons, skaalf, bloekt, tielp, leemd	A. prons, skaalf, bloekt, tielp, leemd	YES
B. hoefs, zeum, jolks, maaff, vielp	B. hoefs, zeum, jolks, maaff, vielp	YES
C. mijds, reemd, grank, ziffs, hong	C. mijds, grank, reemd, ziffs, hong	NO
D. zoucht, kimf, poeds, steut, voofd	D. zoucht, kimf, poeds, steut, voofd	YES
E. sleng, drolks, haik, wimf, broogd	E. sleng, drolks, wimf, haik, broogd	NO
F. keemd, paaist, zigh, hoosts, doefs	F. keemd, zigh, paaist, hoosts, doefs	NO
G. baik, graap, jodt, nanz, twiffs	G. baik, graap, nanz, jodt, twiffs	NO
H. mong, ralks, licst, vuijn, paaff	H. mong, ralks, licst, vuijn, paaff	YES

Appendix B

German target collocations used in the study with their Dutch and English translation

großer Wunsch	grote wens	a big wish
einen Wunsch erfüllen	een wens vervullen	to fulfill a wish
eigene Familie	eigen familie	own family
befreundetes Paar	beviend koppel	befriended couple
lesbisches Paar	lesbisch Koppel	lesbian couple
Angaben machen	gegevens verstrekken	to provide details
sich beteiligen an (der Erziehung)	aan de opvoeding bijdragen	to participate in (the education)
im Hintergrund bleiben	op de achtergrond blijven	to stay in the background
(ein) Kind zeugen	een kind verwekken	to conceive a child
Freunde sein	vrienden zijn	to be friends
Liebe brauchen	liefde nodig hebben	to need love
es gibt Kritik an	er is kritiek op	there is criticism towards
das Wohl der Kinder (/des Kindes)	het welzijn van de kinderen	the child's best interest
in Gefahr (sehen)	in gevaar (zien)	(to see) a danger
gleichgeschlechtliche Paare	koppels van hetzelfde geslacht	same-sex couples
negative Erfahrung(en)	negatieve ervaringen	negative experience(s)
Erfahrungen machen/sammeln	ervaringen hebben	to gain experience