Contributions of declarative memory and prior knowledge to incidental L2 vocabulary learning

Josiah Murphy,[1] Ryan T. Miller,[2] and Phillip Hamrick[2]
[1] University of Hawai'i at Mānoa | [2] Kent State University

The bulk of second language (L2) vocabulary learning happens incidentally through reading (Rott, 2007; Webb, 2008), but individual differences, such as prior knowledge, modulate the efficacy of such incidental learning. One individual difference that is strongly predicted to play a role in L2 vocabulary is declarative memory ability; however, links between these two abilities have not been explored (Hamrick, Lum, & Ullman, 2018). This study considered declarative memory in conjunction with varying degrees of prior knowledge, since declarative memory may serve a compensatory function (Ullman & Pullman, 2015). L2 Spanish learners completed measures of prior Spanish vocabulary knowledge, declarative memory ability, and incidental L2 vocabulary learning. The results suggest that better declarative memory predicts better immediate learning in general and better vocabulary retention two days later, but only for those with more prior knowledge, consistent with the Matthew Effect previously reported in the literature (Stanovich, 1986).

Keywords: declarative memory, incidental learning, prior knowledge, second language acquisition, vocabulary

Acquiring vocabulary is critical to learning another language, and the majority of second language (L2) vocabulary learning occurs incidentally while learners are attempting to do something else. Much of the vocabulary that language learners know is acquired while reading in the L2 (see Rott, 2007; Webb, 2008). However, the success of incidental vocabulary learning through reading varies among learners, with some learners being capable of more robust incidental vocabulary learning and others lagging behind their peers. For example, there is evidence that having more prior vocabulary can induce a Matthew Effect (see Stanovich, 1986), whereby the 'rich get richer' (p. 380), or in this case those with greater prior

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vocabulary knowledge are better able to learn new vocabulary incidentally while reading (see Pulido, 2003, 2007; Pulido & Hambrick, 2008; Webb & Chang, 2015). There are other individual differences that appear consequential for incidental learning of L2 vocabulary as well. Indeed, recent studies have examined effects of individual differences such as working memory, motivation, age, enjoyment, topic interest and familiarity, first language reading ability, and L2 proficiency and processing experience (see Elgort & Warren, 2014; Koda & Miller, 2018; Lee & Pulido, 2017; Malone, 2018; Papi, 2018; Pulido & Hambrick, 2008; Zhao, Guo, Biales, & Olszewski, 2016). Despite this growing body of research, one individual difference that may be critical for L2 vocabulary – yet has been largely ignored – is declarative memory.

Declarative memory system

The declarative memory system consists of two distinct, yet partially overlapping subsystems (see Renoult, Irish, Moscovitch, & Rugg, 2019): episodic memory and semantic memory. Episodic memory refers to the ability to learn and recall events from one's own life, and includes details of when and where the memory was formed (e.g., a memory of your fifth birthday party). Semantic memory, on the other hand, refers to general knowledge of facts, information, and meaning (e.g., knowing that Columbus is the capital of Ohio). While classical models of memory often proposed a sharp distinction between these two systems, recent research has seen a growing consensus that episodic and semantic memory systems are entangled with one another (see McRae & Jones, 2013; Renoult et al., 2019). Indeed, recall of episodic memories often involves recall of general semantic knowledge (e.g., that birthday cakes have candles on them), and semantic memory is often entangled in experience (e.g., thinking that Columbus is the capital of Ohio may spontaneously trigger an episodic memory of a trip to that city). Some have even proposed models of semantic memory based on instances or episodes (see Jamieson, Avery, Johns, & Jones, 2018). Episodic and semantic memory also appear to play complementary roles in learning, with episodic memory being utilized in initial phases of learning and semantic memory playing a larger role in remembering after consolidation (particularly during sleep; see James, Gaskell, Weighall, & Henderson, 2017).

Interaction between individual differences

These declarative memory systems are also strongly predicted to play specific roles in the mental lexicon according to numerous theories, including the Declarative/Procedural Model of language (see Ullman, 2004, 2014, 2016), the Complementary Learning Systems Model (see Davis & Gaskell, 2009), and the Episodic Lexicon Hypothesis (see Jiang & Forster, 2001; Witzel & Forster, 2012). Their predictions appear plausible because declarative memory and the mental lexicon appear to share common neurocomputational principles (see Ullman, 2007). For example, since episodic memory underlies the learning of arbitrary bits of information and the associations between them, and since semantic memory underlies subsequent storage and processing of those bits of information and associations, then these memory systems should play comparable roles in language; arbitrary bits of information (e.g., how a word sounds and what it refers to) should be initially learned in episodic memory and ultimately (after consolidation and/or practice) come to be represented in semantic memory. This is predicted broadly by both the Declarative/Procedural Model (see Ullman, 2004, 2014, 2016) as well as the Complementary Learning Systems Model (see Davis & Gaskell, 2009).

There is overwhelming support for connections between declarative memory and vocabulary learning, but the bulk of the empirical data come from either child first language (see Hamrick, Lum, & Ullman, 2018) or neuropsychological and neuroimaging studies. These latter studies have, for example, linked damage in hippocampal and medial temporal lobe structures to impaired word learning, but with spared knowledge of known words (see Kensinger, Ullman, & Corkin, 2001). Likewise, neuroimaging studies have reported that learning and retention of novel words heavily recruit the hippocampus during early learning and a distributed semantic memory network after consolidation (see Breitenstein et al., 2005; Takashima, Bakker, van Hell, Janzen, & McQueen, 2017).

It is important to keep in mind, though, that these neural substrates are involved in other cognitive processes outside the declarative memory (e.g., spatial cognition), leaving open the possibility that vocabulary learning recruits these neural substrates because it relies on some other, non-memory-based mechanism (see Hamrick et al., 2018). A compelling way to address this issue is to employ behavioral individual difference measures. For example, if a series of standard measures of declarative memory are systematically correlated with a series of vocabulary measures, then it is likely that they share a common underlying mechanism, and if the declarative memory measures are non-verbal, then it is likely to be a non-linguistic memory mechanism (Hamrick et al., 2018). Importantly, such behavioral relationships have been shown between declarative memory and vocabulary in child first language (L1) acquisition (as well as both declarative and procedural memory and grammar in both child L1 and adult L2 acquisition), but there remains a critical gap in studies measuring individual differences in declarative memory and L2 vocabulary (Hamrick et al., 2018).

In fact, we know of only one study to have measured the contributions of declarative memory to vocabulary learning in adult L2 learners. Using an individual differences design, Hamrick, Graff, and Finch (2019) examined L2 word learning using a modified paired-associate style task with pseudowords to control for prior knowledge. In that study, it was found that episodic memory abilities predicted word learning on the day of learning, but not two days later. These findings are consistent with the Complementary Learning Systems Model, which predicts initial, but not necessarily subsequent, involvement of the episodic system in word learning; however, they are not consistent with the Episodic L2 Hypothesis, which predicts that L2 lexical representations remain episodic over time. However, there are at least two reasons to doubt these conclusions from Hamrick et al. (2019). First, that study employed pseudowords (to control for prior knowledge), but those pseudowords obeyed phonotactics of English (the L1 of the participants); therefore, the words could have been assimilated into their L1 mental lexicons after a night of sleep, in which case episodic memory would not play a role in subsequent testing. Second, that study employed no measure of semantic memory abilities, so any claim that the learned pseudowords might have been retained in a semantic memory system were speculative at best.

Motivation

Although strongly predicted to play important roles in L2 vocabulary development, existing research has not clarified the role of individual differences in episodic or semantic memory in that process. Moreover, the existing research on this topic has relied on word learning tasks that are overly artificial. Therefore, the aim of this study was to explore the role of individual differences in episodic and semantic memory in L2 vocabulary that are learned in a more naturalistic context (e.g., incidental learning while reading). Because prior experience in the L2 may alter the rate at which new information is learned (i.e., the Matthew Effect), we also examined the role of prior L2 vocabulary knowledge. Indeed, we predicted that prior knowledge may even interact with declarative memory abilities, with one compensating for a lack of the other.

Research questions

This study had two primary research questions:

1. Do individual differences in episodic or semantic memory abilities predict incidental L2 vocabulary learning while reading?
2. If these predictive effects exist, are they modulated by prior L2 vocabulary knowledge?

Method

Participants

Thirty-nine native speakers of American English who were undergraduate students at a large, Midwestern university were recruited for voluntary participation in the study. Twenty-six of the participants were female and thirteen were male, and they had a mean age of 19.2 years ($SD = 1.34$). The participants were determined to have a comparable level of Spanish proficiency according to their placement by WebCAPE, a widely used computerized foreign language placement assessment initially developed at Brigham Young University, into sections of an intermediate-level Spanish course. The participants had different instructors but the same coordinator, used the same curriculum materials, and were on the same semester schedule for instruction. Thus, the Spanish as a foreign language input and course requirements were the same for all participants. None of the participants needed physical or time accommodations.

Materials

Measure of prior knowledge

Participants' prior knowledge of Spanish L2 vocabulary was assessed via the Spanish Vocabulary Levels Test (SVLT; Chandler, 2017). Participants were given twenty minutes to complete each portion of this paper-and-pencil assessment, though few needed the full time. The receptive portion was a multiple-matching format similar to the original Vocabulary Levels Test by Nation (1990), with a cluster of six words in a column on the left and three meanings in a column on the right. Participants were asked to match each meaning in the right-hand column with a word from the left-hand column. There were 105 items (35 clusters) equally distributed across five tiers of word frequency. The expressive portion of the SVLT was similar in format to Laufer and Nation's (1999) vocabulary-size test of controlled productive ability. Participants were asked to read sentences and complete partial word prompts by writing in the rest of the truncated vocabulary item that made sense for the sentence context. This task included 90 items equally distributed across five tiers of frequency.

Measure of incidental vocabulary learning ability

Participants' ability to learn L2 vocabulary incidentally was assessed using materials from Pulido (2003, 2007, 2009). Participants were given five minutes to read two paragraphs about familiar situations: shopping for groceries and visiting a doctor's office. Each paragraph was written in intermediate level Spanish and contained eight pseudowords in each text (a total of 16 pseudowords). The pseudowords, designed to resemble actual Spanish words in form and sound, replaced words that are frequently associated with the scenarios (see Pulido, 2003 for the methods used to create the passages and pseudowords). To increase the likelihood that learning would be incidental, pseudowords were not textually enhanced, and participants were not instructed to learn words nor told that there would be a vocabulary-related task afterward.

After participants finished reading the two paragraphs, they returned the paper with the paragraphs and then immediately completed two pencil-and-paper tasks. A word form recognition task (WFRT) asked participants to read a list of 32 pseudowords on a page and circle *YES* or *NO* to indicate whether the words were familiar. Sixteen of the pseudowords had appeared in the paragraphs participants had just read, while the other sixteen pseudowords (also from Pulido, 2003, 2007, 2009) were distractors that had not appeared in the texts. Participants were given up to five minutes to complete this task. Participants then completed a word meaning recognition task (WMRT) in which they read a list of the same 32 Spanish pseudowords and indicated the meaning of each by circling the best definition from among four choices. Sixteen of those items appeared in the paragraphs participants had read, while the other sixteen were unfamiliar. Participants were given up to five minutes to complete this second task.

Measure of episodic memory ability

Participants' episodic memory abilities were assessed via the Continuous Visual Memory Test (CVMT; Trahan & Larrabee, 1988). This task assesses ongoing recognition of abstract designs not found in nature or established art. Participants sat at a desktop computer and were instructed to respond as quickly and accurately as they could to the prompts. Participants were given two seconds to view an abstract design and then asked to indicate whether it was *old* or *new*; seven *old* items repeated seven times each (49 total trials) in an interspersed way among

63 distractor *new* items (Figure 1) that only occurred once each, for a total of 112 items.

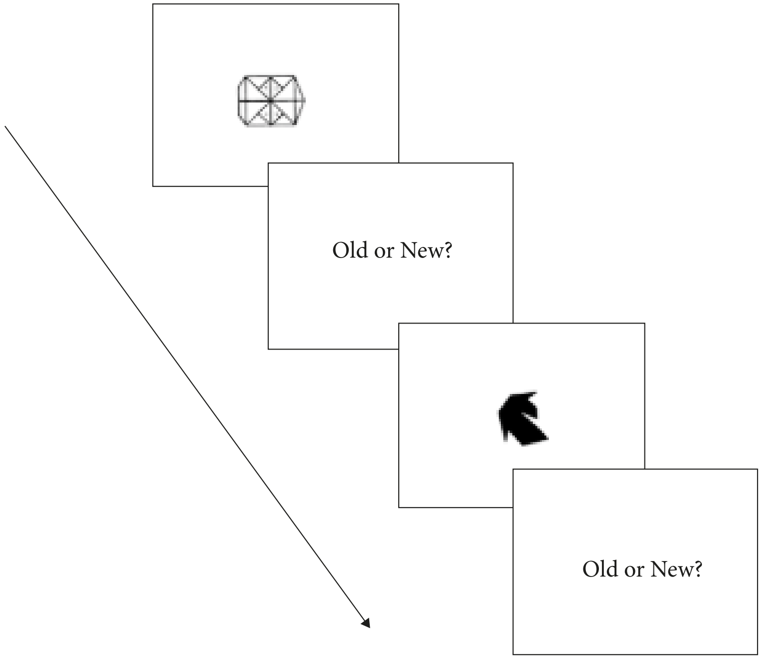

Figure 1. Continuous visual memory task (CVMT; Trahan & Larrabee, 1988)

Measure of semantic memory ability

Participants' semantic memory abilities were assessed via the Camel and Cactus Test (CCT; Bozeat, Lambon Ralph, Patterson, Garrard, & Hodges, 2000). Participants sat at a desktop computer and were instructed to answer the prompts as quickly and accurately as they could. This task assesses semantic association knowledge by prompting participants with a target concept and then asking them to choose from among four options that has an associative relationship with the target concept. All target concepts and response choices were presented as illustrated pictures. For example, a picture of a nail would appear at the top of the screen, with four mechanical tools below (see Figure 2); the participants should choose the *hammer* as the closest semantic match to the *nail*. The CCT included 64 total items.

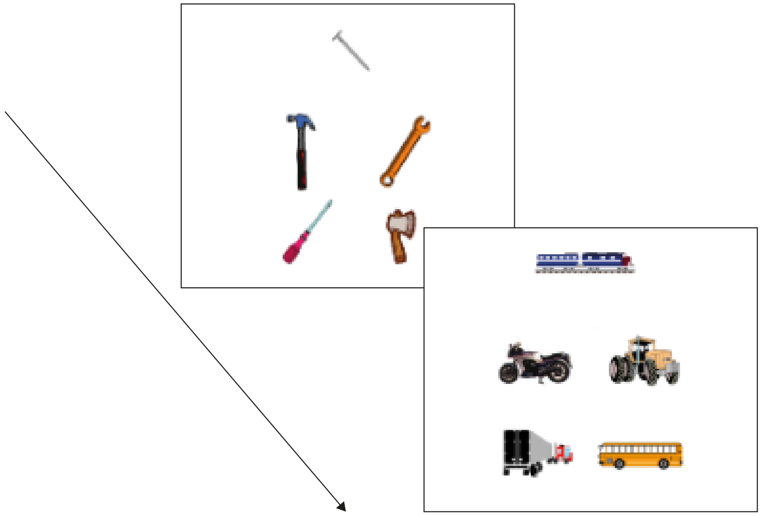

Figure 2. Camel and Cactus Task (CCT; Bozeat et al., 2000)

Procedure

Data were collected in multiple sessions in the same building and on the same days participants attended Spanish class. At Time 1 (Monday or Tuesday), participants completed a biodata survey including information about their language experience, such as when they began learning another language(s), from whom, and in what contexts. Then the participants' prior knowledge was assessed via receptive and expressive portions of the SVLT. Following this, the participants were exposed to novel vocabulary (pseudowords) while reading short passages in Spanish. Then they completed the WFRT and the WMRT. Only after completing these tasks were participants notified there would be additional tasks to complete two days later; this prevented them from actively memorizing any of the materials during initial learning or testing. At Time 2 (two days later, on Wednesday or Thursday), participants completed the WFRT and the WMRT again (items were re-randomized). In a third session within two weeks of Time 1, participants completed the two computerized declarative memory measures, the CVMT and the CCT.

Data analyses

The predictor variables (CCT, CVMT, and SVLT) were checked for normality and collinearity. The CCT was the only non-normal predictor and was arcsinesquare root transformed to achieve normality. The CVMT was scored using *d′* as a sensitivity index in a binary choice task (see Wickens, 2002). Correlations between the predictor variables (Table 1) were not statistically significant, with the exception of the large correlation between the two subtests of the SVLT.

Table 1. Pearson's correlations between predictor variables

Predictor variables	1	2	3	4
1. CCT Semantic memory				
2. CVMT Episodic memory	−0.086			
3. SVLT Subtest 1	0.024	0.187		
4. SVLT Subtest 2	0.042	0.243	0.767*	

Note. * Statistically significant at $p < .05$

Given this collinearity, a Principal Component Analysis with varimax rotation was conducted to look for one underlying factor. A single principal component explained 88% of the variance in the two subtests of the SVLT; the standardized score for each participant from this component was used as each participant's SVLT score in all subsequent analyses. The three predictor variables (CCT, CVMT, and SVLT) were centered via z-score transformation.

Logistic multilevel modeling was conducted in R (R Core Team, 2015) using the lme4 package (see Bates, Machler, Bolker, & Walker, 2015). CCT, CVMT, and SVLT performance were fixed effects, while trial-level accuracy on the WFRT and WMRT was the outcome variable. The random effects structure was cross-classified by subject and item, allowing for generalization across subjects and items in the study. We followed a similar model building procedure as in Hamrick and Pandza (2020). First, forward stepwise testing of random slopes for fixed effects by subject were conducted. Where random slopes significantly improved model fit, they were retained; otherwise, they were not included. This was followed by backward stepwise testing of fixed effects for models with more than one fixed effect in order to arrive at the model of best fit. This overall procedure is aimed at developing the best fitting, yet most parsimonious, model of the data.

The threshold for outlier removal was set to > 2.5 standard deviations (*SD*) from the mean. When analyzing the CVMT results, one participant was excluded because their score was more than −3.0 *SD* from the mean. When analyzing the WFRT (Time 1 and Time 2), two participants were excluded because their scores were more than −2.5 *SD* from the group mean due to having marked every answer *NO*. And when analyzing the WMRT (Time 1 and Time 2), one participant was excluded because their score was more than −2.5 *SD* from the group mean.

Results

Form recognition

Group-level accuracy on the word form recognition task (WFRT) at Time 1 (M = 54.06%, SD = 8.36%, SE = 1.18%) and Time 2 (M = 54.14%, SD = 12.50%, SE = 1.84%) was generally low. To examine whether declarative memory and prior vocabulary knowledge predicted form recognition performance, separate models were built for Time 1 and Time 2. In each case, we examined fixed effects of episodic memory (CVMT), semantic memory (CCT), and prior vocabulary knowledge (SVLT), as well as their interactions. The results of the best fitting, most parsimonious, multilevel model of form recognition accuracy at Time 1 revealed a significant effect of semantic memory abilities and a marginally non-significant effect of prior vocabulary knowledge, in that better semantic memory and prior knowledge predicted better form recognition performance at Time 1 (AIC = 1753.0, BIC = 1789.7; Table 2).

Table 2. Best fitting model for the word form recognition task (WFRT) at Time 1 with semantic memory and prior vocabulary knowledge as fixed effects

Fixed effects	**Estimate**	***SE***	***z*-value**	***Pr*(>|*z*|)**
Intercept	0.2276	0.18878	1.206	0.228
Prior vocabulary knowledge	0.13101	0.07933	1.651	0.0986
Semantic memory	0.11724	0.05896	1.989	0.0467
Random effects	**Variance**	***SD***	**Correlation**	
Participant (Intercept)	0	0		
Item (Intercept)	1.01978	1.0098		
*z*VLT	0.07573	0.2752	0.88	

The results are somewhat different at Time 2, where the best multilevel model revealed a significant interaction between episodic memory abilities and prior vocabulary knowledge, whereby better episodic memory abilities facilitated form recognition but only for those participants with more prior vocabulary knowledge (AIC = 1439.5, BIC = 1469.5; Table 3).

Table 3. Best fitting model for the form recognition task at Time 2 with episodic memory and prior vocabulary knowledge as fixed effects

Fixed effects	**Estimate**	***SE***	***z*-value**	***Pr*(>|*z*|)**
Intercept	0.22321	0.13221	1.688	0.09134
Prior vocabulary knowledge	0.02033	0.07750	0.262	0.79304
Episodic memory	−0.11130	0.09166	−1.214	0.22468
PVK × EM	0.23831	0.08146	2.926	0.00344
Random effects	**Variance**	***SD***	**Correlation**	
Participant (Intercept)	0.000	0.000		
Item (Intercept)	0.409	0.6403		

Visual inspection of the data (Figure 3)[1] suggests that better episodic memory abilities may have even been somewhat detrimental to those with lower prior vocabulary knowledge scores.

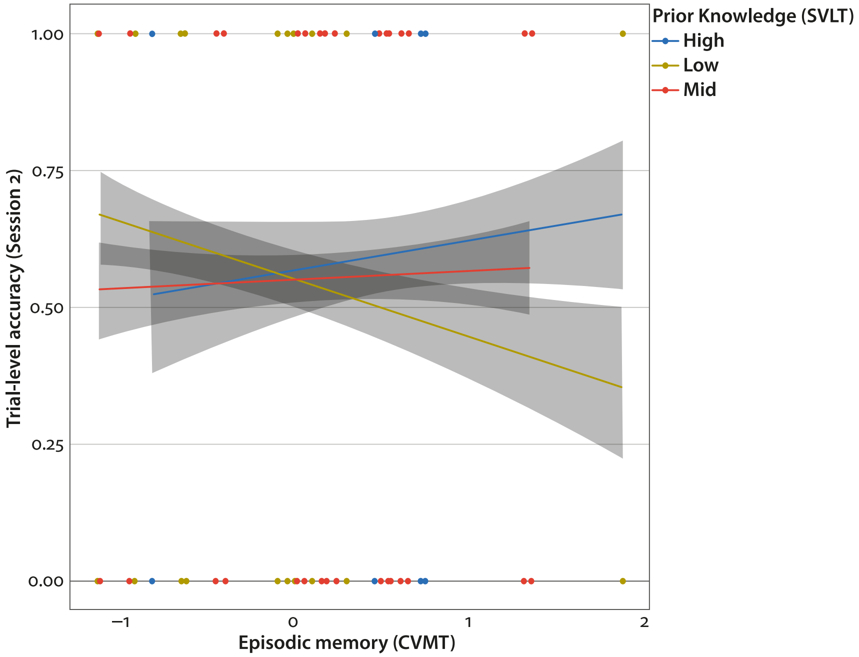

Figure 3. Accuracy in the word form recognition task (WFRT) at Time 2 as a function of episodic memory abilities (CVMT score) and prior vocabulary knowledge (SVLT score) in the best-fitting model

1. The SVLT scores were split into three groups only for the purpose of graphing the interactions in Figures 1 and 2. That is, such splitting was only done for visualization. All statistical analyses used continuous predictor values for the SVLT.

Meaning recognition

Group-level accuracy on the word meaning recognition task (WMRT) at Time 1 (*M*=32.14%, *SD*=11.12%, *SE*=1.59%) and Time 2 (*M*=32.20%, *SD*=12.22%, *SE*=1.80%) were also generally low, but departed from chance performance (25% in this task) more so than in the WFRT. To examine whether declarative memory and prior vocabulary knowledge predicted word meaning recognition performance (WMRT), separate models were built for WMRT accuracy at Time 1 and Time 2. As with the word form recognition multilevel models, we examined fixed effects of episodic memory (CVMT), semantic memory (CCT), and prior vocabulary knowledge (SVLT), as well as their interactions.

The results of the best fitting, most parsimonious, multilevel model of meaning recognition accuracy at Time 1 revealed only a significant effect of episodic memory abilities (*AIC*=737.0, *BIC*=754.7; Table 4).

Table 4. Best fitting model for the word meaning recognition task at Time 1 with episodic memory as a fixed effect

Fixed effects	**Estimate**	***SE***	***z*-value**	***Pr*(>|*z*|)**
Intercept	−0.8634	0.1894	−4.559	< 0.0001
Episodic memory	0.3838	0.1206	3.182	0.00146
Random effects	**Variance**	**SD**	**Correlation**	
Participant (Intercept)	0.0000	0.0000		
Item (Intercept)	0.4262	0.6529		

At Time 2 (Figure 4), meaning recognition was better predicted by the interaction of both prior vocabulary knowledge and semantic memory abilities (*AIC*=703.5, *BIC*=734.0; Table 5).

Similar to the interaction for form recognition at Time 2, this interaction suggests that better memory abilities – in this case, semantic memory abilities – predict better meaning retention, but the effect is primarily for those with better prior vocabulary knowledge. Individual differences in semantic memory appeared not to be linked to performance for those with lower prior vocabulary knowledge. It is worth noting that this best fitting, most parsimonious model also includes a non-significant term for episodic memory, which may be indicative of a small or non-robust effect for this predictor at Time 2.

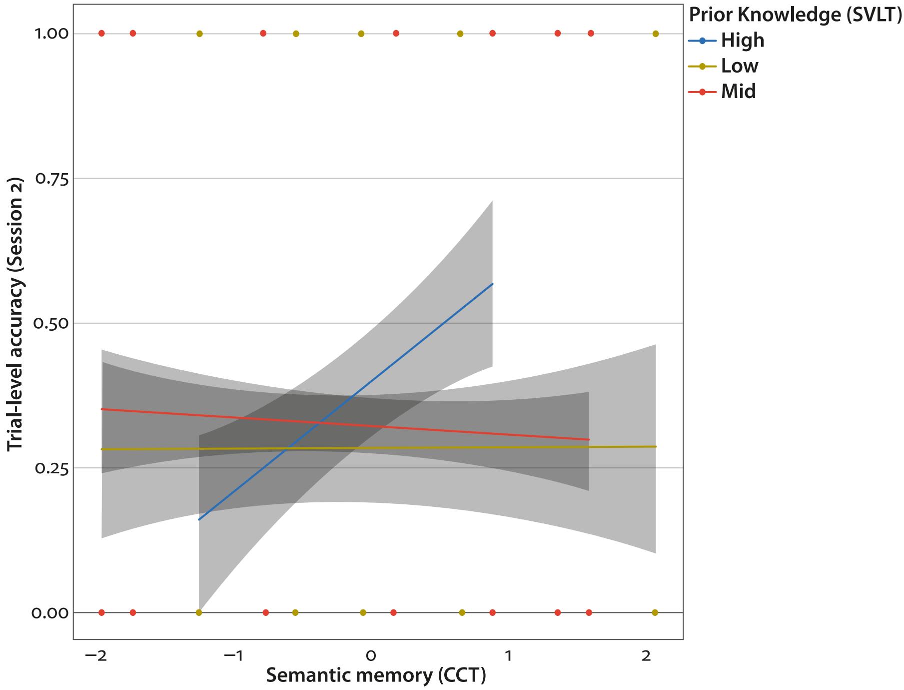

Figure 4. Accuracy in the meaning recognition task at Time 2 as a function of semantic memory abilities (CCT score) and prior vocabulary knowledge (SVLT score) in the best-fitting model

Table 5. Best fitting model for the word meaning recognition task at Time 2 with episodic memory and prior vocabulary knowledge as fixed effect

Fixed effects	**Estimate**	***SE***	***z*-value**	***Pr*(>|*z*|)**
Intercept	−0.85575	0.17539	−4.879	< 0.001
Prior vocabulary knowledge	0.10457	0.09947	1.051	0.293
Semantic memory	0.15786	0.09953	1.586	0.113
Episodic memory	0.17398	0.14457	1.203	0.229
PVK × SM	0.22689	0.11420	1.987	0.047
Random effects	**Variance**	***SD***	**Correlation**	
Participant (Intercept)	0.0000	0.0000		
Item (Intercept)	0.3380	0.5813		

Discussion

Effects of declarative memory abilities

The results indicate that declarative memory abilities were predictive of L2 vocabulary development, both at Time 1 and Time 2 (two days later). Importantly, by Time 2 the role of individual differences in declarative memory were modulated by prior L2 vocabulary knowledge. In both the WFRT and WMRT, better declarative memory abilities resulted in greater retention only for those participants with larger L2 vocabularies. This finding provides another layer to our understanding of the Matthew Effect. In this case the rich not only get richer because of their prior knowledge, but also because of their better declarative memory abilities.

Despite the coherence to this finding, the data do reveal some unexpected findings. Perhaps most notable is the inconsistent role of episodic and semantic memory abilities at different points in time. In the WFRT, semantic memory was predictive of performance at Time 1, but episodic memory (in interaction with prior L2 vocabulary) was predictive at Time 2. This pattern was reversed in the WMRT, with episodic memory playing a larger role at Time 1 and semantic memory playing a larger role at Time 2. Importantly, this finding is not straightforwardly predicted by any existing model.

Fit to theoretical models

In brief, the Complementary Learning Systems Model (see Davis & Gaskell, 2009) predicts roles for both episodic and semantic memory systems in word learning, with the former playing a critical role in initial learning of a word and the latter playing a larger role with the consolidation (e.g., after a period of sleep). The Episodic L2 Hypothesis (see Jiang & Forster, 2001; Witzel & Forster, 2012) argues that L2 lexical representations are episodic in nature, which at least implies a reduced or impoverished role in L2 for the broader semantic memory system that is thought to underlie the L1 mental lexicon. The Declarative/Procedural Model (see Ullman, 2016) strongly predicts associations between declarative memory and L2 vocabulary but stops short of explicitly assigning certain parts of word learning to either episodic or semantic memory. Inasmuch as all three models claim links between aspects of declarative memory and L2 vocabulary, the present results are consistent with all three. However, no model predicts the full pattern of results found here.

The results from the WMRT are consistent with the predictions from the Complementary Learning Systems Model in that initial performance on the WMRT was predicted by episodic memory abilities, while subsequent performance two days later was predicted by semantic memory abilities, particularly for those with a larger prior vocabulary. This pattern of findings, including the Matthew Effect at Time 2, are predicted by the Complementary Learning Systems model (see Davis & Gaskell, 2009; James et al., 2017). However, the results of the WFRT are not consistent with the Complementary Learning Systems Model. The effect of episodic memory at Time 2 in the WFRT is consistent with the Episodic L2 Hypothesis, but the effect of semantic memory at Time 1 in that task is not. Although our present findings do not follow directly from existing theoretical predictions, the mixed involvement of both episodic and semantic memory in word learning and retention is consistent with neuroimaging data that show more complex dynamic relationships between vocabulary learning and the episodic and semantic memory systems over learning and consolidation (see Takashima et al., 2014, 2017). For example, Takashima et al. (2017) found that the amount of semantic information associated with a given word was associated with differential involvement of episodic and semantic systems over the course of learning. The complexity of our findings, especially with regards to word form recognition performance, may reflect such hidden variables.

In addition to revealing complex patterns of links between episodic and semantic memory and L2 vocabulary, the findings of this study also suggest that learners who have a larger L2 vocabulary get a "boost" if they have better declarative memory abilities relative to learners with smaller L2 vocabularies. That is, those with a relatively smaller L2 lexicons had more limited initial learning and later recall of new L2 vocabulary, regardless of their declarative memory abilities, and those with a relatively larger L2 lexicon performed better on both initial learning and later recall, particularly if they had better declarative memory abilities.

While there is no existing theoretical account that neatly explains the full range of results reported here, we do propose the following explanations of the findings in the WMRT. First, we propose that episodic memory mediates the associations built between a word form and its (approximate) meaning (hence the predictiveness of episodic memory for WMRT at Time 1). Second, we propose that semantic memory is predictive of WMRT task performance at Time 2 specifically for those with larger prior L2 vocabularies because those participants who have a wealth of existing knowledge are more readily able to engage in neocortical (i.e., semantic) learning and consolidation (James et al., 2017).

The findings of the WFRT are more difficult to reconcile with any available theoretical position. Although it is possible that episodic memory contributions to WFRT performance at Time 2 could be due to a general tendency for L2 word forms to be represented episodically (Witzel & Forster, 2012), it is unclear why episodic memory would not be predictive at Time 1, and semantic memory be predictive instead. This finding could represent a problem for current theoretical models; however, given that it has only been reported in this data set, and given that so little work has been done on the topic, such a strong conclusion is likely unwarranted. More data – and more specific theoretical predictions – on the exact function of episodic and semantic memory in learning both word meaning and word form are needed.

Limitations

Several limitations warrant consideration in interpreting our data. First, the fact that this study measured the very complex cognitive phenomena of episodic memory and semantic memory with a single measure of each means that any relationships found (or not found) in the data could be a byproduct of the tasks chosen, rather than genuine properties of the underlying memory systems. Consequently, different measures of episodic or semantic memory abilities might yield a different pattern of results. Future research should incorporate a wider variety of verbal and non-verbal measures in order to address this issue, as well as consider other mediating cognitive abilities such as working memory.

Second, it is also possible that our prior knowledge measures were indirect measures of memory. For example, perhaps participants who have a larger prior vocabulary do so because they have better memory abilities. If this is so, then by measuring prior vocabulary we could have been indirectly measuring declarative memory abilities, thereby making it difficult to interpret the results in any straightforward way.

Finally, this study is limited in how we assessed word learning. Learning and knowing a word involves much more than simple form recognition and meaning recognition over the course of a couple of days, and, although most vocabulary must be learned under incidental conditions, there are certainly plenty of instances of explicit and intentional word learning that could lead to different patterns of results. More longitudinal and rich data examining relationships between declarative memory and L2 vocabulary development will provide a clearer picture to inform theories of the mental lexicon and the roles of individual differences in modulating it. Studies that employ other learning conditions and manipulations of the amount of lexical semantic information associated with the to-be learned words are all warranted.

Conclusion

This study sought to address the lack of research on the role of declarative memory abilities in incidental learning of L2 vocabulary, as well as the moderating effects of prior L2 vocabulary knowledge. It was designed to mimic natural L2 vocabulary learning conditions such as incidentally encountering new vocabulary while reading realistic narratives, which is how the preponderance of vocabulary is acquired. Prior knowledge of the L2 was measured receptively and expressively according to widely accepted vocabulary assessment tasks. The delayed post-tests were administered with enough time to allow for consolidation from episodic memory to semantic memory. Memory assessments included both episodic and semantic tasks.

Results suggests that declarative memory abilities, both episodic and semantic, contribute to word learning and retention two days after exposure. The exact nature of the contribution from declarative memory is moderated by participants' prior knowledge, but only regarding retention. These complex interactions between declarative memory abilities, prior language experience, and learning/retention of new words call for further investigation of existing theoretical predictions.

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Address for correspondence

Josiah Murphy
University of Hawai'i at Mānoa
Linguistics Department
1890 East-West Rd.
Honolulu, Hawaii 96822
USA

murphyj2@hawaii.edu

Co-author information

Ryan T. Miller
Kent State University
English Department

rmill129@kent.edu

Phillip Hamrick
Kent State University
Language and Cognition Research Lab
English Department

phamric1@kent.edu