Gender differences in adult word learning

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ABSTRACT

In prior work, women were found to outperform men on short-term verbal memory tasks. The goal of the present work was to examine whether gender differences on short-term memory tasks are tied to the involvement of long-term memory in the learning process. In Experiment 1, men and women were compared on their ability to remember phonologically-familiar novel words and phonologically-unfamiliar novel words. Learning of phonologically-familiar novel words (but not of phonologically-unfamiliar novel words) can be supported by long-term phonological knowledge. Results revealed that women outperformed men on phonologically-familiar novel words, but not on phonologically-unfamiliar novel words. In Experiment 2, we replicated Experiment 1 using a within-subjects design, and confirmed gender differences on phonologically-familiar, but not on phonologically-unfamiliar stimuli. These findings are interpreted to suggest that women are more likely than men to recruit native-language phonological knowledge during novel word-learning.

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Individual differences in language acquisition are pervasive and apparent. Some children acquire language faster than others, and some adults acquire a second language with greater alacrity than others. Both biological and social factors, as well as interactions between the two, have been considered as mechanisms underlying individual differences in language acquisition. One biological factor in language development appears to be gender. From a very early age, girls tend to outpace boys in their language development, demonstrating a larger vocabulary as early as at 16 months of age (e.g., Bauer, Goldfield, & Reznik, 2002; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991). The presence of gender differences on linguistic tasks suggests that the mechanisms of language acquisition may be somewhat distinct for males and females. The goal of the present work was to examine gender differences and their underlying mechanisms on one specific linguistic task — novel word learning.

1. Mechanisms of gender differences

Although women have been shown to outperform men on semantic tasks like verbal fluency and synonym-generation (e.g., Herlitz, Airaksinen, & Nordstrom, 1999; Kimura & Harshman, 1984; Loonstra, Tarlow, & Sellers, 2001; Larsson, Lovden, & Nilsson, 2003; Maitland, Herlitz, Nyberg, Backman, & Nilsson, 2004), the presence of gender differences on linguistic tasks is not a uniform finding (see Halpern, 2000 and Kimura, 1999 for reviews). For instance, there have been reports of men outperforming women on linguistic tasks such as the verbal SAT (e.g., Jackson & Rushton, 2006) and verbal intelligence tests (e.g., Quereshi, 1994). Similarly, there have been suggestions that effects of gender on verbal learning tasks become non-significant once age and education levels are taken into account (e.g., Ryan, Kreiner, & Tree, 2008). Moreover, the mechanisms underlying the gender differences on verbal tasks (when they are obtained) are not at all clear, since there is currently no accepted theoretical framework for examining and explaining gender differences in linguistic performance.

In the present study, we examine whether gender differences are present on a word-learning task, and test one account of how gender influences linguistic performance — the Declarative/Procedural Model. This model, proposed by Ullman and colleagues (e.g., Ullman, 2001; 2004; Ullman et al., 2002; 2004; 2008) localizes the female advantage on linguistic tasks to the declarative memory system. The declarative memory system is part of long-term memory, and has extensive storage capacity and longevity. Unlike procedural memory, that underlies acquisition of skill (e.g., learning of implicit rules and sequence, Lewicki, Hill, & Czyzewska, 1992), declarative memory underlies explicit learning and retrieval of information, and is linked to the ability to store and operate knowledge of facts and events (e.g., Mishkin, Malamut, & Bachevalier, 1984). The declarative memory system is tied to semantic knowledge, and has been localized to the hippocampus, (e.g., Mishkin et al., 1984; Schacter & Tulving, 1994; Squire & Knowlton, 2000), whose function is known to be enhanced by estrogen (e.g., Kampen & Sherwin,

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1994; Maki & Resnick, 2000; McEwen, Alves, Bulloch, & Weiland, 1998; Phillips & Sherwin, 1992; Sherwin, 1998; Sherwin, 2003; Woolley & Schwartzkroin, 1998). Ullman and colleagues proposed that it is the superior function of the declarative memory system that underlies the female advantage on linguistic tasks.

In previous work, Ullman and colleagues tested their account of gender differences against lexical retrieval patterns in men and women. Formation of grammatically-complex forms (e.g., producing a past tense for a verb) can be accomplished via the procedural memory system (by computing the past tense for a given bare-stem verb) or via the declarative memory system (by retrieving the past-tense form of the word from memory). In a series of studies, Ullman et al. have shown that women tend to rely on the declarative memory system for retrieving past-tense verb forms, while men tend to rely on the procedural memory for the same task (e.g., Steinhauer & Ullman, 2002; Ullman et al., 2002; Ullman & Estabrooke, 2004). Similarly, women tend to exploit regularities in language to support learning (e.g., Hartshorne & Ullman, 2006) and processing (e.g., Prado & Ullman, 2009) of linguistic information more than men, suggesting their greater reliance on the declarative memory system.

In summary, the Declarative/Procedural Model localizes the female advantage on linguistic tasks to a more efficient declarative-memory system. However, gender differences have also been observed on short-term memory tasks, where linguistic information must be retained for only a brief period of time. For instance, women have been shown to surpass men on digit-span tasks (e.g., Jensen & Reynolds, 1983; Kail & Siegel, 1978), list memory tasks (e.g., Bleecker, Bolla-Wilson, Agnew, & Meyers, 1988; Kramer, Delis, & Daniel, 1988; Trahan & Quintana, 1990), and paired-associate learning tasks (e.g., Ivison, 1977; Youngjohn, Larrabee, & Crook, 1991), although absence of gender differences on verbal learning tasks has also been noted (e.g., Grace, 2000; Parsons et al., 2005). Short-term memory and declarative (long-term) memory have distinct biological bases, cognitive constraints, and functional characteristics (e.g., Brown, 1958; Damasio, Eslinger, Damsio, Van Hoesen, & Cornell, 1985; Millner, Corkin, & Teuber, 1968). The mechanisms previously posited to explain gender differences on short-term memory tasks were not rooted in the Declarative/Procedural Model. Instead, the explanations for gender differences on short-term memory tasks tended to focus on differences in strategy use (e.g., McGuiness, Olson, & Chapman, 1990) and in women's adaption to tasks that require efficient retention of sequences (e.g., Kimura, 1999). However, different explanatory mechanisms for gender differences on long-term and short-term memory tasks may not be necessary, since short-term learning can be supported by the declarative memory system (i.e., long-term knowledge; e.g., Burgess & Hitch, 1999; Gupta & MacWhinney, 1997; Majerus, Poncelet, Van der Linden, & Weekes, 2008). In the current study, we ask whether gender differences can be observed on a short-term memory task like novel word learning, and whether patterns of gender differences, if obtained, would diverge for cases where learning can be supported by long-term linguistic knowledge vs. cases where learning is less likely to rely on long-term linguistic knowledge.

2. Short-term memory and long-term knowledge

A number of memory models posit a relationship between the short-term memory processes and the long-term memory system (e.g., Acheson & MacDonald, 2009; Allen & Baddeley, 2009; Baddeley, Gathercole, & Papagno, 1998; Baddeley, 2010; Burgess & Hitch, 1999; Gupta & MacWhinney, 1997; Just & Carpenter, 1992; Majerus et al., 2008). Effects of long-term memory on learning are supported by studies demonstrating that lexical and semantic characteristics associated with the native language can influence short-term memory function (e.g., Duyck, Szmalec, Kemps, & Vandierendonck, 2003; Hanten & Martin, 2001; Hulme, Maughan, & Brown, 1991; Martin & Saffran, 1999). Similar influences rooted in native-language phonological knowledge have also

been shown to affect phonological short-term memory (e.g., De Jong, Seveke, & Van Veen, 2000; Gathercole & Baddeley, 1990; Masoura & Gathercole, 1999; Papagno, Valentine, & Baddeley, 1991). In general, retention of novel words that fit the native-language (L1) phonological structure is facilitated compared to novel words that diverge from native-language phonology (e.g., Ellis & Beaton, 1993; Gathercole, Willis, Emslie, & Baddeley, 1991; Service;, 1992; Service & Craik, 1993; Papagno & Vallar, 1992; Rogers, 1969; Storkel, 2001). The facilitation effects associated with familiar phonology are due to the involvement of long-term memory in the learning process. When the novel word is phonologically-familiar (i.e., fits the native-language phonological structure), a learner can rely on the established long-term knowledge associated with the native language to process the novel word form. This conceptualization of novel word learning offers an opportunity to test the Declarative/Procedural account of gender differences in language processing against short-term memory tasks. Because learning of phonologically-familiar items (but not of phonologically-unfamiliar items) involves the long-term (i.e., declarative) memory system, women should be more likely to outperform men when learning phonologically-familiar novel words rather than when learning phonologically-unfamiliar novel words.

The suggestion that gender differences on short-term memory tasks may be attributable to the involvement of the long-term memory system has been previously made by Kramer, Delis, Kaplan, and O'Donnell (1997). Kramer et al. (1997) examined serial position effects on a list recall task, and found that girls recalled more items from the primary and middle regions of the list than boys. Kramer et al. argued that reliance on short-term memory yields recency effects, while reliance on long-term memory tends to yields primacy effects. Therefore, the female advantage on the items in the primary region of the list suggested that girls relied on long-term memory during the retrieval process more than boys. However, while the female advantage on verbal memory tasks may be linked to women's reliance on long-term memory, this mechanism has not yet been directly tested. The goal of the present work was to examine whether the female advantage on short-term phonological memory tasks can be localized to the declarative memory system. In Experiment 1, we tested the differences between men and women on a word-learning task, where phonological familiarity of novel words was manipulated between subjects. In Experiment 2, we replicated Experiment 1 using a within-subjects design in order to ensure that the findings obtained in Experiment 1 were not due to between-group confounds.

3. Experiment 1

In Experiment 1, we examined (1) whether gender differences would be revealed on a word-learning task, and (2) whether gender differences would be due to women's greater reliance on long-term memory during learning. To that end, men and women were compared on their ability to learn phonologically-familiar vs. phonologically-unfamiliar novel words. Encoding of phonologically-familiar novel words is more likely to rely on long-term phonological knowledge than encoding of phonologically-unfamiliar novel words. If the female advantage on short-term verbal memory tasks is rooted in their reliance on long-term memory, then gender differences should be more apparent for phonologically-familiar novel words than for phonologically-unfamiliar novel words. Furthermore, we tested participants' memory for novel words immediately after learning and one week after initial learning has taken place in order to examine long-term maintenance of novel words and longevity of phonological-familiarity effects in word-learning across genders.

3.1. Method

3.1.1. Design

The study followed a 3-way mixed design, with gender (male vs. female) and phonological overlap (phonologically-familiar vs.

phonologically-unfamiliar novel words) as between-subjects independent variables, and testing session (immediate vs. delayed) as a within-subjects independent variable. Dependent variables intended to capture the success of vocabulary learning included recall accuracy and recognition accuracy. Responses were coded as 1s (if correct) or zeros (if incorrect). Therefore, the dependent variable was categorical in nature and binomially distributed.

3.1.2. Participants

Sixty-eight participants were tested, 34 men and 34 women. All participants were monolingual native speakers of English. Within each gender group, half of the participants learned phonologically-familiar novel words, and half of the participants learned phonologically-unfamiliar novel words, yielding 17 participants per gender/phonological-overlap sub-group. We chose to manipulate phonological familiarity as a between-subjects variable in order to minimize practice effects (retrieval of novel words in one condition may have heightened participants' ability to retrieve words in the other condition). Further, phonological familiarity was manipulated as a between-subjects variable in order to make the task more ecologically valid. When participants learned phonologically-familiar novel words, the situation was similar to learning synonyms in one's native language. When participants learned phonologically-unfamiliar novel words, the situation was similar to learning new words in a foreign language. All participants (male and female) were recruited from the undergraduate student population of Northwestern University, and were randomly assigned to either the phonologically-familiar or the phonologically-unfamiliar condition. In order to ensure that the groups were comparable in demographic characteristics, participants were matched for age and years of education across the four sub-groups. In addition, participants were matched for their performance on vocabulary and memory measures. See Table 1 for participant characteristics across the four sub-groups.

3.1.3. Materials

Two artificial phonemic inventories constructed by Kaushanskaya and Marian (2008) were used in the current study. These phonemic inventories consist of 8 sounds. An artificial language based on 8 sounds (4 vowels and 4 consonants) has been shown to be suitable for examining how incidental phonotactic learning can influence subsequent short-term memory performance (Majerus, Van der Linden, Mulder, Meulemans, & Peters, 2004). Eight English phonemes were used to construct the artificial phonologically-familiar inventory: four vowels (/ɑ/, /ɛ/, /i/, and /u/) and four consonants (/f/, /n/, /t/, and /g/). To create the phonologically-unfamiliar inventory, four English phonemes in the phonologically-familiar inventory were replaced with non-English phonemes. Specifically, vowels /i/ and /u/ were replaced by non-English vowels /ɨ/ and /y/, respectively, while consonants /t/ and /g/ were replaced by non-English consonants /ʈ/ and /χ/, respectively. Forty-eight monosyllabic and disyllabic phonologically-familiar novel words and matching forty-eight monosyllabic and disyllabic phonologically-unfamiliar novel words were created.

The phonotactic probability for the phonologically-familiar novel words was calculated using the Phonotactic Probability calculator (e.g., Vitevitch & Luce, 2004). The phonologically-familiar novel words had an average phonotactic probability of 1.14 ($SE = 0.06$) and an average biphone frequency of 1.00 ($SE = 0.003$). A male native speaker of English who was extensively trained on all pronunciations recorded both the phonologically-familiar and the phonologically-unfamiliar stimuli.

Each novel word was paired with its English "translation". All 48 English translations referred to concrete, highly imageable objects with frequent English names. The 48 translation pairs are listed in Appendix A. The English words that served as translation equivalents were selected based on the frequency of use (calculated using Francis & Kucera, 1982), with the majority of translations falling within high frequency ranges. We also obtained concreteness ratings for each English word using the MRC Psycholinguistic Database. These values were acquired from the Gilhooly and Logie (1980), Paivio, Yuille, and Madigan (1968), and Toglia and Battig (1978) norms, which were based on adults' ratings of each word for concreteness on the 100–700 point-scale, where lower values reflected more abstract status. The English translations were on average 4.53 letters in length ($SE = 0.52$), with an average of 47.79 per million frequency of use ($SE = 56.24$), and an average concreteness ratings of 582.80 ($SE = 34.71$). None of the non-words was similar to its English translations in either phonology or orthography.

We have used these stimuli extensively in previous work to examine effects of cross-linguistic phonological overlap on mapping novel phonological words onto their orthographic representations (e.g., Kaushanskaya & Marian, 2008); to test the effects of bilingualism on word learning (e.g., Kaushanskaya & Marian, 2009a,b); and to examine the effects of rehearsal differences on novel-word retention (e.g., Kaushanskaya & Yoo, 2011). These prior studies indicated that monolingual speakers of English perceive phonologically-unfamiliar novel words to be markedly different from English words, find these words more difficult to pronounce than phonologically-familiar novel words; and rate them lower on the scale or being a likely English word than phonologically-familiar novel words.

3.1.4. Procedure

3.1.4.1. Vocabulary learning.
Participants heard the novel word pronounced twice over the headphones, and saw its written English translation on the computer screen. Participants were instructed to repeat the novel word and its English translation out loud three times. Each pair was presented twice during the learning phase. Learning was self-paced.

3.1.4.2. Vocabulary testing.
During recall testing, participants heard the novel word and pronounced its English translation into a microphone. During recognition testing, participants heard novel words over headphones and chose the correct English translations from five alternatives listed on the computer screen. Of the five alternatives,

Table 1
Background information for men and women learning phonologically-familiar vs. phonologically-unfamiliar novel words in Experiment 1.

	Men		Women		F-test
	Phonologically familiar	Phonologically unfamiliar	Phonologically familiar	Phonologically unfamiliar	
N	17	17	17	17	
Age	21.00 (1.92)	22.72 (1.16)	21.77 (1.16)	22.76 (1.57)	$p = 0.75$
Years of education	15.40 (0.58)	16.00 (0.54)	15.15 (0.54)	15.68 (0.54)	$p = 0.95$
PPVT-III (percentile)	90.25 (2.63)	89.12 (2.55)	85.18 (2.55)	89.65 (2.55)	$p = 0.28$
EVT (percentile)	93.88 (2.47)	95.71 (2.40)	89.82 (2.40)	92.34 (2.40)	$p = 0.89$
Digit span (percentile)	79.63 (4.03)	81.77 (3.91)	82.06 (3.91)	77.18 (3.91)	$p = 0.38$
Nonword repetition (percentage correct)	65.80 (0.30)	57.80 (0.30)	66.30 (0.30)	64.10 (0.30)	$p = 0.44$

Note: The values in parentheses represent standard errors. The *p* values represent the results of univariate analyses of variance with group as an independent between-subjects variable with 4 levels (men/phonologically-familiar; men/phonologically-unfamiliar; women/phonologically-familiar; and women/phonologically-unfamiliar).

one answer was correct, two answers were translations of other novel words on the list, one answer was an English word that was semantically related to the correct answer, and one answer was an unrelated English word not previously presented. Participants' memory for novel words was tested using the recall and the recognition measures immediately after learning and after a one-week delay. Because recall and recognition of English words (rather than recall and recognition of newly-learned words) was tested, the current study was able to examine phonological familiarity effects in word-learning while at the same time avoiding confounds associated with the fact that phonologically-unfamiliar sequences are also more difficult to pronounce. Phonological familiarity effects obtained in the current paradigm would thus suggest a clear reliance on native-language phonological knowledge, rather than be an outcome of easier articulation associated with phonologically-familiar information.

3.1.4.3. Assessment of phonological memory and vocabulary knowledge.
To ensure equal levels of vocabulary knowledge and phonological memory across the four sub-groups, all participants were administered standardized assessment measures of vocabulary knowledge and phonological memory. Phonological memory was measured using the digit-span and the nonword repetition subtests of the *Comprehensive Test of Phonological Processing* (*CTOPP*, Wagner, Torgesen, & Rashotte, 1999). Native-language vocabulary knowledge was measured receptively and expressively using the *Peabody Picture Vocabulary Test* − Third Edition (Dunn & Dunn, 1997) and the *Expressive Vocabulary Test* (Williams, 1997), respectively.

3.1.5. Analyses

Recall and recognition accuracy data were each analyzed using a generalized linear mixed effects model for binomially distributed outcomes where the accuracy data were transformed using the logit function (mixed logit model from now on). In such a model, the log (or logit) odds of being correct are examined against the factors in the model. In the current study, we modeled logit odds of recalling or recognizing the correct English translations as a function of gender and phonological familiarity (modeled as between-subjects factors) and of testing session (modeled as a repeated factor).

3.2. Results

3.2.1. Recall data

A mixed logit model yielded significant main effects of phonological familiarity and testing session, as well as a significant three-way interaction among gender, phonological familiarity, and testing session (see Table 2). All two-way interactions were also significant.

To identify the locus of the interaction, two types of follow-up analyses were conducted. First, to examine whether men and women performed differently on the two types of novel words, recall accuracy data were modeled separately for phonologically-familiar and phonologically-unfamiliar novel words with gender as the fixed factor. These analyses revealed that for phonologically-familiar novel words, women outperformed men both immediately after learning (B coefficient $= 1.16$, $SE = 0.27$, $Wald$ $Z = 4.30$, $p < 0.0001$) and after a 1-week delay (B coefficient $= 0.98$, $SE = 0.23$, $Wald$ $Z = 4.26$, $p < 0.0001$). However, for phonologically-unfamiliar novel words, women and men demonstrated comparable accuracy rates during both immediate recall (B coefficient $= 0.23$, $SE = 0.28$, $Wald$ $Z = 0.82$, $p = 0.40$) and delayed recall (B coefficient $= 0.15$, $SE = 0.29$, $Wald$ $Z = 0.52$, $p = 0.61$).

Second, to examine whether phonological familiarity exerted different influences in men vs. women, recall accuracy data were modeled separately for men and women, with phonological familiarity as the fixed factor. These analyses revealed that women were more accurate at recalling English translations for phonologically-familiar novel words than for phonologically-unfamiliar novel words, both

Table 2
Summary of the fixed effects in the mixed logit model for Experiment 1.

Predictor	Coefficient B	SE	Wald Z	p value
Recall data				
Intercept	1.79	0.18	9.94	<0.001
Gender	0.15	0.29	0.52	=0.61
Phonological familiarity	0.70	0.25	2.80	<0.01
Session	0.65	0.10	6.50	<0.001
Gender × phonological familiarity	0.84	0.37	2.27	<0.05
Gender × session	0.38	0.16	2.38	<0.05
Phonological familiarity × session	0.61	0.17	3.59	<0.001
Gender × phonological familiarity × session	0.56	0.26	2.15	<0.05
Recognition data				
Intercept	0.38	0.14	2.71	<0.01
Gender	0.10	0.21	0.48	=0.62
Phonological familiarity	0.54	0.24	2.25	<0.05
Session	0.33	0.16	2.06	<0.05
Gender × phonological familiarity	0.70	0.34	2.06	<0.05

during immediate testing (B coefficient $= 1.30$, $SE = 0.28$, $Wald$ $Z = 4.64$, $p < 0.0001$), and during delayed testing (B coefficient $= 0.70$, $SE = 0.25$, $Wald$ $Z = 2.80$, $p < 0.01$). However, men demonstrated comparable accuracy rates for phonologically-familiar and phonologically-unfamiliar novel words, both during immediate testing (B coefficient $= 0.09$, $SE = 0.27$, $Wald$ $Z = 0.33$, $p = 0.73$) and during delayed testing (B coefficient $= 0.14$, $SE = 0.27$, $Wald$ $Z = 0.52$, $p = 0.60$). See Figure 1 for the visual representation of the data.

3.2.2. Recognition data

A mixed logit model on recognition accuracy data yielded significant main effects of phonological familiarity and testing session, as well as a significant two-way interaction between gender and phonological familiarity (see Table 2).

To parallel the analyses of recall data, two types of follow-up analyses were conducted on the recognition data. First, to examine whether men and women perform differently on the two types of novel words, recognition accuracy data were modeled separately for phonologically-familiar and phonologically-unfamiliar novel words with gender as the fixed factor. These analyses revealed that for phonologically-familiar novel words, women outperformed men both immediately after learning (B coefficient $= 1.00$, $SE = 0.31$, $Wald$ $Z = 3.23$, $p < 0.01$) and after a 1-week delay (B coefficient $= 0.80$, $SE = 0.26$, $Wald$ $Z = 3.08$, $p < 0.01$). However, for phonologically-unfamiliar novel words, women and men demonstrated comparable accuracy rates during both immediate recall (B coefficient $= 0.03$, $SE = 0.22$, $Wald$ $Z = 0.14$, $p = 0.90$) and delayed recall (B coefficient $= 0.10$, $SE = 0.21$, $Wald$ $Z = 0.48$, $p = 0.62$).

Second, to examine whether phonological familiarity exerted different influences in men vs. women, recognition accuracy data were modeled separately for men and women, with phonological familiarity as the fixed factor. These analyses revealed that women were more accurate at recognizing English translations for phonologically-familiar novel words than for phonologically-unfamiliar novel words, both during immediate testing (B coefficient $= 0.93$, $SE = 0.31$, $Wald$ $Z = 3.00$, $p < 0.01$), and during delayed testing (B coefficient $= 0.54$, $SE = 0.24$, $Wald$ $Z = 2.25$, $p < 0.05$). However, men demonstrated comparable recognition accuracy rates for phonologically-familiar and phonologically-unfamiliar novel words, both during immediate testing (B coefficient $= 0.09$, $SE = 0.23$, $Wald$ $Z = 0.39$, $p = 0.68$) and during delayed testing (B coefficient $= 0.16$, $SE = 0.24$, $Wald$ $Z = 0.67$, $p = 0.51$).

3.3. Discussion

The goal of Experiment 1 was to test the utility of the Declarative/Procedural Model of gender differences for explaining performance on a
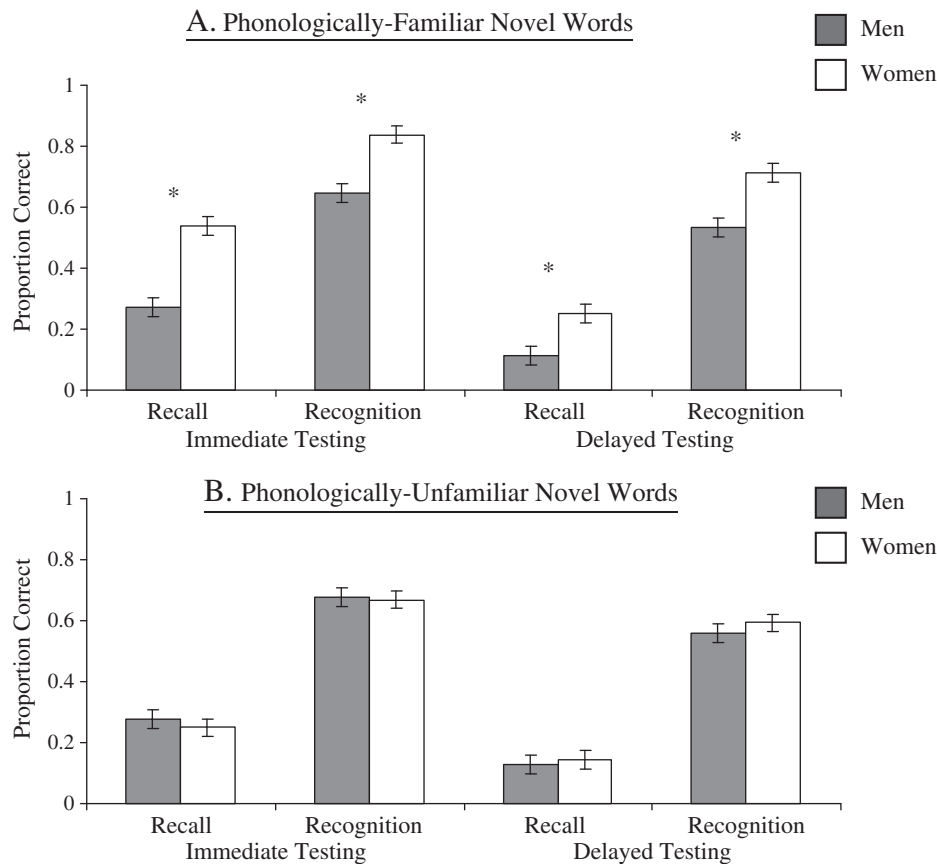
A. Phonologically-Familiar Novel Words

B. Phonologically-Unfamiliar Novel Words

Fig. 1. Male vs. female performance on phonologically-familiar novel words (panel A) and phonologically-unfamiliar novel words (panel B) in Experiment 1.

short-term memory task like word-learning. Since the Declarative/ Procedural Model localizes the female advantages on verbal tasks to women's greater reliance on the declarative memory system, we reasoned that women would be more likely to outperform men when learning phonologically-familiar novel words, but not when learning phonologically-unfamiliar novel words. The findings confirmed this hypothesis. Women outperformed men when learning phonologically-familiar novel words that fit the English phonological structure. Conversely, women and men performed similarly when learning phonologically-unfamiliar novel words that diverged from the English phonological structure. Because phonologically-familiar (but not phonologically-unfamiliar) novel words can be supported by native-language phonological knowledge, the findings suggest that women's superior performance was rooted in their greater reliance on the native-language phonological knowledge during the learning process.

Comparing women's and men's performance across the immediate and the delayed testing sessions for phonologically-familiar novel words revealed that gender differences were comparable during immediate and during delayed retrieval. Similarly, for phonologically-unfamiliar novel words, there was no female advantage at either immediate or delayed testing. These findings suggest that gender differences at the retrieval stage (either immediate or delayed) are likely a reflection of the more robust *encoding* of novel verbal information in women compared to men. When the configuration of novel material matches that of the material stored in the long-term memory system, the encoding of the novel material is more robust in females, yielding superior retrieval performance both at immediate and at delayed testing. Conversely, when the configuration of novel material does not match long-term knowledge, the encoding process relies on the same mechanisms in men and women, yielding comparable retrieval performance both at immediate and at delayed testing. Although Experiment 1 did not yield differences in the

strength of phonological familiarity or gender effects across the two testing sessions, it should be noted that in the current word-learning paradigm, participants learned all novel word-English word pairs, and then were tested on the retention of all the stimuli. Since the sequence of stimulus presentation was randomized for both the learning and the testing phase across participants, it is impossible to specify the length of time between the presentation of one particular novel word and its subsequent retrieval. Therefore, the gross distinction between immediate and delayed retrieval of the stimuli relative to the time of encoding made in the current work should be followed-up with studies where the temporal characteristics of the stimulus presentation at encoding and retrieval are more finely manipulated.

The gender differences obtained in Experiment 1 replicate previous findings of female advantages on verbal learning tasks, and suggest that these advantages may be rooted in women's greater reliance on the long-term (declarative) memory system during learning. The surprising finding was that phonological familiarity effects were obtained only in women, but not in men. That is, women demonstrated higher accuracy rates for phonologically-familiar novel words than for phonologically-unfamiliar novel words. However, men's performance did not appear to be sensitive to phonological familiarity effects. The presence of familiarity effects in the female data strongly indicates that our manipulation of phonological familiarity was successful. Therefore, it is unlikely that the lack of phonological familiarity effects in the male data can be attributed to our methodological choices. While there have been indications that male students may be less motivated to learn a foreign language in school than female students (e.g., Dornyei, 1994; Williams, Burden, & Lanvers, 2002), a study of Canadian male and female students learning French showed that despite differences in motivation to learn French, the actual levels of French mastery did not differ between male and female students (e.g., Kissau, 2006). Furthermore, in the current study, men and women did not differ in their ability to learn phonologically-unfamiliar novel words — a

situation that approximates second-language acquisition more than learning phonologically-familiar novel words.

It is tempting to interpret these findings as suggesting that previously-reported phonological familiarity effects may, in fact, be specific to women. In the present work, the overall analyses where male and female recall data were analyzed together yielded a main effect of phonological familiarity was obtained. Only after gender was factored into the analyses was it obvious that the main effect of phonological familiarity was driven by women. However, the between-subjects design of Experiment 1 necessarily weakens the findings. Although we were careful to match men and women on variables known to influence word-learning performance, including levels of education, English vocabulary knowledge, and phonological memory, it is possible that other factors, like non-verbal intelligence did differ among the four groups. In order to ensure that the findings of Experiment 1 were not spurious, we conducted Experiment 2, where we replicated Experiment 1, but as a within-subjects design.

4. Experiment 2: within-subjects replication

Results of Experiment 1, while largely conclusive regarding gender differences for phonologically-familiar, but not phonologically-unfamiliar novel words, also yielded an unexpected finding regarding phonological familiarity effects. We found that while women clearly showed the well-established advantages associated with phonologically-familiar novel words, men failed to show such advantages. However, because phonological familiarity was manipulated between-subjects, two different groups of men learned phonologically-familiar and phonologically-unfamiliar novel words. While we assigned men to the two learning conditions randomly, and the two groups of men did not differ with respect to demographic characteristics or to performance on native-language vocabulary and phonological memory measures, the very fact of between-subject manipulation coupled to an unexpected lack of phonological familiarity effects demanded a replication. Therefore, Experiment 2 was designed to replicate Experiment 1, but with phonological familiarity manipulated within-subjects. Since time of testing (immediate vs. delayed) did not play an important role in either the differences between women and men, or in the differences between phonologically-familiar and phonologically-unfamiliar novel words, we omitted this manipulation from Experiment 2. However, we administered measures of non-verbal cognition (non-verbal IQ and visual memory) to all participants in order to ensure that gender differences on the word-learning task, if obtained, could not be attributed to general differences in cognitive levels between men and women.

4.1. Method

4.1.1. Design

The study followed a 2-way mixed design, with gender (male vs. female) as a between-subjects independent variable and phonological overlap (phonologically-familiar vs. phonologically-unfamiliar novel words) as a within-subjects independent variable. Dependent variables intended to capture the success of vocabulary learning included recall accuracy and recognition accuracy. As in Experiment 1, in Experiment 2, all responses were coded as 1s (if correct) or zeros (if incorrect).

4.1.2. Participants

Forty participants were tested, 20 men and 20 women. All participants were monolingual native speakers of English. Men and women were matched for age and years of education. The following standardized measures were administered to all participants: Peabody Picture Vocabulary Test-III (to index English receptive vocabulary knowledge), the digit-span and nonword repetition sub-tests of the CTOPP (to index short-term phonological memory), the backward digit span sub-test of the Woodcock Johnson Tests of Achievement-II (to index phonological working memory), and the matrices sub-test
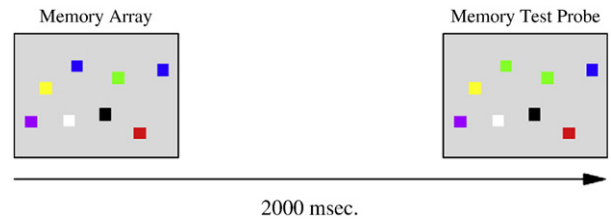

Fig. 2. Example of displays for the visual short-term memory task in Experiment 2.

of the Kaufman Brief Intelligence Test (to index non-verbal IQ). In addition, we measured the participants' visual short-term memory using the Colored Squares Task. This task was introduced by Luck and Vogel (1997) to measure visual short-term memory, and its utility for indexing visual memory capacity has been replicated by a number of studies (e.g., Cowan & Morie, 2007). On this task, participants view a visual display that contains colored squares for 500 ms, and after a 2-second delay, are presented with another visual display. The task is to decide whether the second display is identical to the first display. On half of the trials, the two displays are identical. On the other half of the trials, the second display differs from the first display in that one of the squares changed color. We constructed displays where the number (n) of colored squares varied from 4 to 12, with 32 trials for each of the n values (Fig. 2). Participants were instructed to press one key when the two displays were the same and a different key when the two displays were different. Comparisons between the two groups indicate comparable levels of performance on all these measures except for the non-verbal IQ test, on which men outperformed women (see Table 3). This difference in non-verbal IQ (with men outperforming women) has been demonstrated by a number of previous studies (e.g., on the Raven's Progressive Matrices; DeShon, Chan, & Weissbein, 1995; Vigneau & Bors, 2008), and was therefore not surprising. Since this difference would act against our predicted direction of gender differences on the experimental task (we hypothesized that women would outperform men on word learning), this discrepancy in non-verbal IQ scores between men and women provides an even more stringent test of our hypothesis.

4.1.3. Materials

Phonologically-familiar and phonologically-unfamiliar novel words used in Experiment 1 were also used in Experiment 2. Because

Table 3
Background information for men and women in Experiment 2.

	Men	Women	t-test
Age	23.46 (1.42)	22.77 (0.37)	$p = 0.72$
Years of education	15.71 (0.90)	15.09 (0.41)	$p = 0.54$
PPVT-III (percentile)	81.00 (4.80)	71.26 (4.38)	$p = 0.13$
Digit span (percentile)	76.95 (4.99)	70.26 (5.31)	$p = 0.37$
Nonword repetition (percentile)	37.21 (4.01)	33.47 (3.20)	$p = 0.47$
Backwards digit span (percentile)	95.28 (1.97)	96.95 (1.02)	$p = 0.45$
K-BIT visual matrices sub-test (percentile)	67.79 (5.61)	46.26 (3.57)	$p = 0.003^*$
Visual short-term memory task (n = 4 conditions)	0.96 (0.01)	0.98 (0.01)	$p = 0.23$
Visual short-term memory task (n = 6 conditions)	0.78 (0.03)	0.85 (0.03)	$p = 0.10$
Visual short-term memory task (n = 8 conditions)	0.77 (0.04)	0.83 (0.02)	$p = 0.20$
Visual short-term memory task (n = 10 conditions)	0.66 (0.02)	0.68 (0.02)	$p = 0.43$
Visual short-term memory task (n = 12 conditions)	0.67 (0.02)	0.69 (0.02)	$p = 0.57$

Note: The values in parentheses represent standard errors. The p values represent the results of an independent-samples t-test with group (men vs. women) as an independent between-subjects variable. Significant differences between men and women at $p < 0.05$ are marked with an asterisk.

the original stimulus set was designed as two lists of matched novel word/English translation pairs (Kaushanskaya & Yoo, 2011), these stimuli were ideally suited for the within-subjects manipulation of phonological familiarity undertaken in Experiment 2. The 48 phonologically-familiar novel words (paired with their translations) were split into two lists of 24. The two lists of phonologically-familiar non-words were matched for length, syllabic structure, and phonotactic probability, including sum of phoneme frequencies ($M1 = 1.14$, $SE = 0.06$; $M2 = 1.14$, $SE = 0.05$), and sum of biphone frequencies ($M1 = 1.00$, $SE = 0.003$, $M2 = 1.00$, $SE = 0.004$). The two lists of English words were matched for length ($M1 = 4.53$ letters, $SE = 0.52$; $M2 = 4.53$ letters, $SE = 0.52$), frequency of use ($M1 = 47.79$, $SE = 56.24$; $M2 = 51$, $SE = 63.98$), concreteness ($M1 = 578.38$, $SE = 35.71$; $M2 = 587.21$, $SE = 33.70$), imageability ($M1 = 593.58$, $SE = 30.15$; $M2 = 597.08$, $SE = 20.06$), and familiarity ($M1 = 547.50$, $SE = 35.84$; $M2 = 560.67$, $SE = 32.81$) ratings.

The two lists of novel word/English translation pairs in the phonologically-unfamiliar condition were balanced on the number of unfamiliar phonemes across the two lists (although strict pair-by-pair matching was not possible, it was also unnecessary since each participant learned only one list of phonologically-unfamiliar and phonologically-familiar novel words).

4.1.4. Procedure

Each participant learned a set of phonologically-familiar and a set of phonologically-unfamiliar novel words. The 24 novel words and their translations were blocked by phonological familiarity, and were taught in two different sessions that were scheduled one week apart. The order of learning (phonologically-familiar first or phonologically-unfamiliar first) was counterbalanced across participants. Moreover, list (A or B) was also counterbalanced across participants. The learning and testing procedures were exact replications of Experiment 1 procedures.

4.1.4.1. Cognitive and linguistic assessment. All participants were administered standardized assessment measures of vocabulary knowledge, phonological memory, and non-verbal IQ, and a measure of visual memory.

4.1.5. Analyses

Because Experiment 2 was designed with specific a-priori hypotheses in mind, we examined gender differences for phonologically-familiar and phonologically-unfamiliar novel words separately. We also examined differences between phonologically familiar and phonologically-unfamiliar novel words for men vs. women.

4.2. Results

4.2.1. Recall data

To examine whether men and women performed differently on two types of novel words, recall accuracy data were modeled separately for phonologically-familiar and phonologically-unfamiliar novel words with gender as the fixed factor. These analyses revealed that women outperformed men for phonologically-familiar novel words (B coefficient $= 0.48$, $SE = 0.24$, Wald $Z = 2.00$, $p < 0.05$), but not for phonologically-unfamiliar novel words (B coefficient $= 0.31$, $SE = 0.32$, Wald $Z = 0.97$, $p = 0.32$). See Fig. 3 for the visual representation of the data.

To examine whether phonological familiarity exerted different influences in men vs. women, recall accuracy data were modeled separately for men and women, with phonological familiarity as a repeated factor. These analyses revealed that both men and women were more accurate at recalling English translations for phonologically-familiar novel words than for phonologically-unfamiliar novel words. However, the phonological familiarity effect was stronger for women (B coefficient $= 0.49$, $SE = 0.16$, Wald $Z = 3.06$, $p = 0.003$), than for men (B coefficient $= 0.33$, $SE = 0.15$, Wald $Z = 2.20$, $p = 0.03$). It is important to note, however, that the interaction between gender and phonological familiarity was not significant in the overall model (see Table 4).

4.2.2. Recognition data

To examine whether men and women performed differently on two types of novel words, recognition accuracy data were modeled separately for phonologically-familiar and phonologically-unfamiliar novel words with gender as the fixed factor. These analyses revealed that women outperformed men for phonologically-familiar novel words (B coefficient $= 0.67$, $SE = 0.28$, Wald $Z = 2.39$, $p = 0.02$), but not for phonologically-unfamiliar novel words (B coefficient $= 0.16$, $SE = 0.27$, Wald $Z = 0.59$, $p = 0.55$).

To examine whether phonological familiarity exerted different influences in men vs. women, recognition accuracy data were modeled separately for men and women, with phonological familiarity as a repeated factor. These analyses revealed that women were more accurate at recognizing English translations for phonologically-familiar novel words than for phonologically-unfamiliar novel words (B coefficient $= 0.43$, $SE = 0.17$, Wald $Z = 2.53$, $p = 0.01$). However, men demonstrated comparable recognition accuracy rates for phonologically-familiar and phonologically-unfamiliar novel words (B coefficient $= 0.09$, $SE = 0.12$, Wald $Z = 0.75$, $p = 0.43$). Importantly, the interaction between gender and phonological familiarity was significant in the overall model (see Table 4).
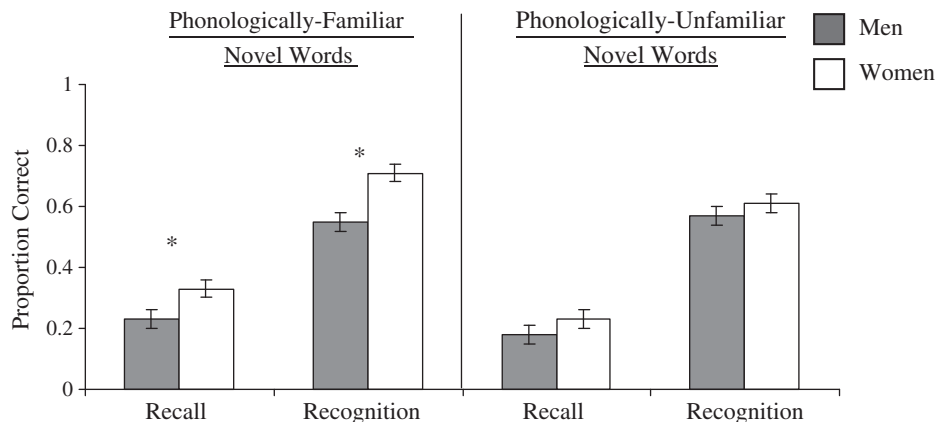

Fig. 3. Male vs. female performance on phonologically-familiar and phonologically-unfamiliar novel words in Experiment 2.

Table 4
Summary of the fixed effects in the mixed logit model for Experiment 2.

Predictor	Coefficient B	SE	Wald Z	p value
Recall data				
Intercept	1.21	0.24	5.04	<0.001
Gender	0.31	0.32	0.97	=0.32
Phonological familiarity	0.49	0.16	3.06	<0.01
Gender × phonological familiarity	0.16	0.22	0.73	=0.46
Recognition data				
Intercept	0.46	0.19	2.42	<0.05
Gender	0.16	0.27	0.59	=0.55
Phonological familiarity	0.43	0.17	2.53	<0.05
Gender × phonological familiarity	0.51	0.20	2.55	<0.05

4.3. Experiment 2 discussion

The goal of Experiment 2 was to replicate the findings of Experiment 1. In a within-subjects design, where phonological familiarity was manipulated within groups, we have shown that women outperformed men when learning phonologically-familiar novel words, but not when learning phonologically-unfamiliar novel words. These findings are all the more reliable, given that in Experiment 2, we administered measures of non-verbal cognition to all participants. Men and women in Experiment 2 demonstrated equal levels of performance on the visual short-term memory task, thus ensuring that women were not overall better learners than men, and that the female advantage was in fact specific to the *verbal* learning task. Even more notably, men actually outperformed women on the visual matrices sub-test of the K-BIT — the test measuring non-verbal IQ. The female advantages on the word-learning task were therefore obtained despite men's higher level of non-verbal intelligence. Thus, we are confident in the presence of the female advantage on the word-learning task used in the current study, and we suggest that this advantage can be attributed to women's greater reliance on long-term linguistic knowledge during learning.

Experiment 1 revealed an unexpected finding regarding the phonological familiarity effects, with men not benefiting from phonological familiarity during learning. In Experiment 2, we used a within-subjects manipulation to examine phonological familiarity effects. Women clearly demonstrated phonological familiarity effects in both the recall and the recognition data, and showed higher retention accuracy for phonologically-familiar than for phonologically-unfamiliar novel words. Men also demonstrated phonological familiarity effects, but only in the recall data and not in the recognition data. Moreover, the phonological familiarity effects in the female recall data were larger than in the male recall data. Thus, Experiment 2 partially replicated the findings of Experiment 1 regarding phonological familiarity. It appears that while both men and women benefit from phonological familiarity during learning, women benefit significantly more than men. This suggests that both men and women can access long-term linguistic knowledge during learning, but that women tend to do so to a greater extent than men. This result is especially noteworthy because participants did not have to produce novel words at retrieval. Instead, retrieval was tested by asking participants to recall or to recognize the English translations associated with novel words. Despite this, phonologically-familiar novel words were retrieved with higher accuracy, suggesting that articulation of a novel word is not necessary to produce a phonological familiarity effect.

5. General discussion

Previous work has shown that women tend to outperform men on a range of linguistic tasks, including lexical retrieval and semantic fluency tasks (e.g., Herlitz et al., 1999; Kimura & Harshman, 1984; Loonstra et al., 2001; Larsson et al., 2003; Maitland et al., 2004) as well as phonological

memory tasks (e.g., Bleecker et al., 1988; Halpern, 2000; Jensen & Reynolds, 1983; Kail & Siegel, 1978; Kimura, 1999; Kramer et al., 1988; Trahan & Quintana, 1990). One neurocognitive mechanism that has been implicated as the root of these gender differences is a more efficient declarative memory system in women (e.g., Ullman, 2004; Ullman et al., 2002). While this appears to be a reasonable hypothesis for explaining women's superior performance on semantic tasks, the involvement of the declarative memory system in influencing women's performance on short-term memory tasks has not been directly tested. The goal of the present work was to examine whether men and women would perform differently on a word-learning task and to directly test whether gender differences could be attributed to the involvement of the declarative (long-term) memory. Our prediction was that if the female advantage on short-term memory tasks were due to women's recruitment of the declarative memory system, then women would outperform men when learning phonologically-familiar novel words, but not when learning phonologically-unfamiliar novel words. The findings confirmed this hypothesis. In both Experiment 1 and Experiment 2, women consistently outperformed men when learning phonologically-familiar novel words that fit the English phonological structure. Conversely, women and men performed similarly when learning phonologically-unfamiliar novel words that diverged from the English phonological structure. Because phonologically-familiar (but not phonologically-unfamiliar) novel words can be supported by native-language phonological knowledge, the findings suggest that women's superior performance was rooted in their ability to recruit native-language phonological knowledge during the learning process.

Previous work in the verbal memory domain has suggested that the female advantage on verbal memory tasks like list-memory may be due to women's reliance on the long-term memory system during learning (e.g., Kramer et al., 1997). Our findings support this hypothesis, and provide explicit evidence for the role of the declarative memory system in performance on short-term-memory tasks. In view of our findings, it can be speculated that previous demonstrations of gender differences on short-term memory tasks like the digit-span task and the list-memory tasks (e.g., Kail & Siegel, 1978; Kramer et al., 1988) may have been also due to the involvement of declarative memory. Memory for linguistic information that is familiar to the learner (like digit names, familiar words, etc.) is likely to rely on native-language (i.e., long-term) knowledge (e.g., De Jong, Seveke, & Van Veen, 2000; Gathercole & Baddeley, 1990; Masoura & Gathercole, 1999; Papagno et al., 1991). Therefore, performance on a short-term memory task like the list-memory task is likely to draw on a learner's native-language lexical–phonological knowledge. Our findings indicate that the declarative memory system is likely the underlying mechanism of gender differences not only for the linguistic tasks that explicitly rely on the long-term memory system (e.g., synonym generation task) but also for the linguistic tasks that engage the long-term memory system for the learning process (e.g., list-memory task).

It is important to note that acquisition of phonological information per se can be accomplished implicitly (e.g., Chamber, Onishi, & Fisher, 2003), and sensitivity to phonemic regularities in one's native language appears early in life (e.g., Jusczyk, Friederici, Wessels, Svenkerud, & Jusczyk, 1993), presumably without the involvement of the declarative memory system in the acquisition process. Therefore, the lower sensitivity to phonological familiarity in males may be reflective of their decreased ability to rely on implicit phonological cues in the input. This interpretation is less likely however, in light of the existing evidence suggesting that representations of the acquired phonological patterns must be encoded in long-term memory in order to be useful for subsequent language processing (e.g., Houston & Jusczyk, 2003), and that the knowledge regarding the distribution of phonemes in one's native language is part of the long-term memory system (e.g., Messer, Leseman, Boom, & Mayo, 2010; Roodneys, 2009). Thus, recent models of short-term memory explicitly posit that

improved performance on repeated short-term memory tasks is rooted in long-term learning (Burgess & Hitch, 2006), and experimental work in this area firmly indicates that superior short-term retention of phonologically-familiar items than of phonologically-unfamiliar items is indicative of long-term memory involvement in the learning process (e.g., Gathercole, 1995; Gathercole & Adams, 1994; Gathercole et al., 1991). For example, Gathercole (1995) showed that phonological memory span measures were more predictive of nonword repetition performance when the to-be-repeated nonwords were rated low on "wordlikeness" than when the nonwords were rated high on "wordlikeness". The interpretation of the findings was that repetition of wordlike nonwords is supported by long-term lexical–phonological knowledge, while repetition of nonwordlike stimuli depends solely on the function of the short-term memory system. It appears then, that while acquisition of native-language phonological information can occur implicitly and without the involvement of the declarative memory system, the ability to draw upon lexical–phonological knowledge when processing novel phonological information reflects the relationship between short-term memory and long-term memory systems. Therefore, we attribute the phonological familiarity effects in the current study to learners' ability to rely on native-language lexical–phonological knowledge when learning phonologically-familiar novel words, but not when learning phonologically-unfamiliar novel words.

The current work augments existing evidence regarding the benefits of phonological familiarity for word learning (e.g., Ellis & Beaton, 1993; Gathercole et al., 1991; Service, 1992; Service & Craik, 1993; Papagno et al., 1991; Papagno & Vallar, 1992; Storkel, 2001). Here, we compared men and women on their ability to learn phonologically-familiar and phonologically-unfamiliar novel words. In Experiment 1, phonological familiarity effects were obtained only for women, and no phonological familiarity effects were obtained in the male data. Experiment 2 was conducted to ensure that the lack of differences in the male data in Experiment 1 was not due to confounds associated with between-subjects manipulation. Within-subjects manipulation of Experiment 2 did reveal phonological familiarity effects in the male data, but these were less robust than in women, and nonexistent in the recognition data. Thus, the results of Experiment 2, where phonological familiarity was manipulated within-subjects, are quite convincing in showing that while women benefit from phonological familiarity across the board, men only benefit from phonological familiarity when confronted with a rather difficult retrieval task (i.e., recall). However, the finding that men's performance was less sensitive to phonological familiarity than women's performance demands further investigation. While the effect was partially replicated in two experiments, because the two experiments used identical sets of stimuli and an identical learning procedure, it is possible that the patterns of findings are specific to the particular materials and the learning paradigm. For example, in the current study, phonological familiarity was manipulated through replacing English phonemes with phonemes that do not exist in English. Moreover, the procedure we adapted to test participants' retention of the novel words did not test the memory for the novel words directly and instead tested participants' memory for the English meanings associated with the novel words. This method was chosen in order to sidestep the unavoidable confounding of articulation and phonological factors in the production of phonologically-unfamiliar stimuli. Specifically, had we required participants to produce the novel words at testing, the lower production accuracy for phonologically-unfamiliar novel words (if obtained) could be due to both (a) decreased ability to rely on native-language lexical–phonological knowledge and (b) lack of articulation practice with producing non-English phonemes. Because gender differences have been obtained in studies of speech production (e.g., Labov, 1990; 2001; Namy, Nygaard, & Sauerteig, 2002), it was especially important to ensure that production demands would be equalized across conditions (phonologically-familiar vs. phonologically-unfamiliar) and genders (men vs. women). By requiring participants to produce English words at testing, we were able to control for differences in production-difficulty associated with phonologically-unfamiliar vs. phonologically-unfamiliar novel words. The inevitable outcome of that was that retention of the novel words was not indexed directly. Further work will need to instantiate a learning paradigm where the phonological familiarity effects in novel word learning are assessed directly, by requiring learners to retrieve the novel words at testing. This can be accomplished through examining phonological familiarity in a more graded manner, for example, through manipulating phonotactic probability and/or phonological neighborhood density of the stimuli. It is possible that with such manipulation, the strength of phonological familiarity effects would be greater than those observed in the current study, and would diminish the gender-differences in word learning obtained here.

It is important to note that in addition to the Declarative/Procedural account of gender differences on verbal tasks, other theories of gender differences may also be relevant to the current findings. For example, attempts to link the female advantage on language tasks to neural mechanisms have shown that language is represented more bilaterally in women than in men (e.g., Cousin, Perrone, & Baciou, 2009; Ikezawa et al., 2008; Kansaku, Yamaura, & Kitazawa, 2000; Phillips et al., 2000; Shaywitz et al., 1995; Tremblay et al., 2007), that men have higher synaptic density than women in the temporal neocortex (e.g., Alonse-Nanclares, Gonzalez-Soriano, Rodriguez, & DeFelipe, 2008), and that females may rely on a supramodal language network during linguistic processing independent of stimulus modality while males tend to process information in modality-specific cortical regions (e.g., Burman, Bitan, & Booth, 2007). These neuroanatomical gender differences point to the possibility that gender differences on language tasks may be tied to distinct neurocognitive mechanisms recruited by women vs. men for linguistic processing other than the declarative/procedural distinction (e.g., Steinhauer & Ullman, 2002; Ullman et al., 2002; Ullman & Estabrooke, 2004). It is also possible that men and women differ in other respects that contribute to the gender differences observed on verbal learning tasks. For example, there have been reports of gender differences in self-regulation and self-discipline, with women generally outperforming men (e.g., Duckworth & Seligman, 2006; Matthews, Ponitz, & Morrison, 2009). It is therefore possible that an alternative explanation for the results of the current study is that women outperformed men because they were better able to regulate their attention to the task at hand. However, this explanation seems less likely given the fact that gender differences were specific to the phonologically-familiar novel words. Yet, it is important to keep in mind that possible attentional differences between men and women (as well as differences between men and women that arise as a result of socialization of gender roles in the American culture, e.g., Bem, 1981) may in fact interact with the linguistic properties of the stimuli to yield gender effects such as those observed in the present study.

To conclude, the mechanisms of gender differences in language acquisition have been suggested to involve the declarative memory system. The current study indicates that gender differences on phonological memory tasks, just like gender differences on lexical and semantic retrieval tasks, may be driven by women's reliance on the declarative memory system. However, on phonological memory tasks, the involvement of the declarative memory system is constrained by the overlap between the material being acquired and the information stored as part of long-term knowledge. The mechanism responsible for the female advantage when learning phonologically-familiar novel words therefore appears to be highly flexible and dynamic in nature, and is likely based on the active recruitment of representational structures (long-term memory) during the encoding of verbal information.

Acknowledgments

Appendix A. Non-word and English word pairings (2 matched lists of 24 pairs)

List A			List B		
Phonologically-familiar non-words	Phonologically-unfamiliar non-words	English translations	Phonologically-familiar non-words	Phonologically-unfamiliar non-words	English translations
tuf	tʏf	Cube	gɑf	χɑf	Plum
gɛf	χɛf	Hockey	nɑf	nɑf	Zipper
iguf	iχyf	Boss	ufɑg	yfɑχ	Cape
ɛgun	ɛχyn	Lawn	ɑgut	ɑχyʈ	Rope
ɛtug	ɛʈyχ	Insect	ɛfun	ɛfyn	Sunset
utɑf	yʈɑf	Cigar	itug	iʈyχ	Elbow
ɛfit	ɛfiʈ	Ocean	ɑgɛt	ɑχɛʈ	Sugar
itun	iʈyn	Lawyer	ɑtuf	ɑʈyf	Liquor
unɛf	ynɛf	Leg	igan	iχan	Sky
tugi	ʈyχi	Rain	fɑgu	fɑχy	Song
figɑ	fiχɑ	Sunburn	nafi	nafi	Laundry
funɑ	fynɑ	Bucket	guta	χyʈa	Rocket
gitu	χiʈy	Hammer	futa	fyʈa	Locker
fitu	fiʈy	Cement	nɛgi	nɛχi	Infant
fɛti	fɛʈi	Chicken	gɛna	χɛna	Stomach
gɑfun	χɑfyn	Sign	gifɛt	χifɛʈ	Park
nigɛf	niχɑf	Envelope	tɑguf	ʈɑχyf	Magazine
gituf	χʈyf	Mouth	nagut	naχyʈ	Teeth
tɑfun	ʈɑfyn	Morning	nɛgif	nɛχif	College
nɑfit	nɑfiʈ	Book	tagun	ʈaχyn	Road
nɛfg	nɛfɑχ	Beach	nitug	niʈyχ	Coast
futin	fyʈin	Storm	gatɛn	χaʈɛn	Cloud
fanɛt	fanɛʈ	Rose	fitan	fitan	Ship
nutig	nyʈiχ	Flame	figɛn	fiχɛn	Steam

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