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Gender Differences in Child Word Learning

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Abstract

In prior work with adults, women were found to outperform men on a paired-associates word-learning task, but only when learning phonologically-familiar novel words. The goal of the present work was to examine whether similar gender differences in word learning would be observed in children. In addition to manipulating phonological familiarity, referent familiarity was also manipulated. Children between the ages of 5 and 7 learned phonologically-familiar or phonologically-unfamiliar novel words in association with pictures of familiar referents (animals) or unfamiliar referents (aliens). Retention was tested via a forced-choice recognition measure administered immediately after the learning phase. Analyses of retention data revealed stronger phonological and referent familiarity effects in girls than in boys. Moreover, girls outperformed boys only when learning phonologically-familiar novel words and when learning novel words in association with familiar referents. These findings are interpreted to suggest that females are more likely than males to recruit native-language phonological and semantic knowledge during novel word learning.

Keywords

word learning; gender differences; phonology; semantics

1. Gender Differences in Child Word Learning

The degree to which a novel word conforms to the properties of known words can influence its learnability. In general, research suggests broad familiarity effects in learning, where novel words that are more familiar in form and/or meaning are retained better than novel words that are less familiar (e.g., Ellis & Beaton, 1993; Service & Craik, 1993; Storkel, 2001). However, women may be more sensitive to such linguistic familiarity effects than men (e.g., Kaushanskaya, Marian, & Yoo, 2011). Although the mechanisms that underlie gender differences in language processing remain controversial, one theoretical framework – the Declarative/Procedural Model – attributes gender differences in language acquisition and processing to women’s superior declarative memory system (Ullman et al., 2001; 2004; 2005; 2008). Thus, women generally tend to outperform men on tasks that engage long-term linguistic knowledge, such as verbal fluency and synonym-generation tasks (e.g., Herlitz et al., 1999; Kimura & Harshman, 1984; Loonstra, Tarlow, & Sellers, 2001; Larsson, Lovden, & Nilsson, 2003; Maitland, et al., 2004).

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In our recent work, we examined gender differences in word-learning within the Declarative/Procedural framework, and demonstrated that women outperformed men on a lexical learning task, but only when the novel words were constructed using native-language phonological categories (Kaushanskaya, Marian, & Yoo, 2011). These findings were interpreted to suggest that when learning can be supported by the declarative memory system, i.e., long-term linguistic knowledge (as is the case for phonologically familiar novel words), women outperform men. The goal of the present study was to examine whether similar gender differences in lexical learning can be observed in childhood. We contrasted learning of phonologically-familiar and phonologically-unfamiliar novel words by children in order to test phonological familiarity effects in novel word learning across genders. We manipulated phonological familiarity categorically by contrasting novel words that were constructed using familiar English phonemes with novel words that incorporated unfamiliar non-English phonemes. We also contrasted the learning of familiar and unfamiliar referents, in order to test semantic familiarity effects in novel word learning across genders. We hypothesized that if gender differences in lexical learning are driven by females' reliance on long-term linguistic knowledge girls would outperform boys only when learning phonologically-familiar and semantically-familiar novel words. We also hypothesized that girls would show stronger phonological and semantic familiarity effects than boys.

1.1. Gender Differences on Linguistic Tasks

The presence of gender differences on linguistic tasks is not a uniform finding. While many previous studies have suggested that adult women tend to outperform adult men on linguistic processing tasks (e.g., Herlitz et al., 1999; Kimura & Harshman, 1984; Loonstra, Tarlow, & Sellers, 2001; Larsson, Lovden, & Nilsson, 2003; Maitland, et al., 2004), a similarly large number of studies documented a lack of differences between adult males and females on language tasks (e.g., Allendorfer et al., 2012; Halpern, 2000; Jackson & Rushton, 2006; Kimura, 1999; Ryan, Kreiner, & Tree, 2008). Similarly, in childhood, some studies show evidence for lack of gender differences on cognitive tasks that include language measures (e.g., Ardila, et al., 2011), while others demonstrate consistent and stable gender differences in language development over the first six years of life (e.g., Bornstein, Hahn, & Haynes, 2004).

Studies that do document gender differences on language measures in childhood generally find that girls outpace boys (e.g., Bornstein, Hahn, & Haynes, 2004; Eriksson, et al., 2012). Gender differences in language acquisition appear very early in life. For example, girls have been shown to outperform boys as early as 6 months of age on measures related to sensory discrimination of speech sounds (e.g., Pivik, Andres, & Badger, 2011). Gender differences in language acquisition are also largely stable, with longitudinal studies showing that when girls outperform boys at the first time point, these advantages generally sustain with age (e.g., Bornstein, Hahn, & Haynes, 2004; Eriksson, et al., 2012). However, patterns of increased gender differences with age (e.g., Bauer, Goldfield, & Reznick, 2002; Bouchard et al., 2009; Dodd et al., 2003; Eriksson, et al., 2012) and of reduced gender differences with age (e.g., Bornstein, Hahn, & Haynes, 2004) have also been reported.

One account of gender differences in language acquisition, the Declarative/Procedural model, posits that gender differences in language acquisition are rooted in how language is *used* by males vs. females. This model, proposed by Ullman and colleagues (2001; 2004; 2005; 2008) localizes the female advantage on linguistic tasks to the declarative memory system. Unlike procedural memory, which underlies acquisition of skill, 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, et al., 1984; Squire et al., 2004). The declarative memory system has been localized to the medial temporal lobe, and includes the hippocampus (e.g., Mishkin, et al., 1984; Schacter & Tulving, 1994; Squire & Knowlton,

2000) as well as other connected areas such as the entorhinal, the perirhinal and the parahippocampal cortex (e.g., Squire & Knowlton, 2000). The hippocampus in particular has been the focus of the work on gender differences in language processing because the function of the hippocampus is known to be enhanced by estrogen (e.g., Kampen & Sherwin, 1994; Maki & Resnick, 2000; McEwen et al., 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 ensues as the result of higher estrogen levels in females) that underlies the female advantage on linguistic tasks. In their work, Ullman and colleagues tested this account of gender differences by examining lexical retrieval in men vs. women and found that women tended to rely on the declarative memory system for retrieving past-tense verb forms, while men tended to rely on the procedural memory for the same task (e.g., Steinhauer & Ullman, 2002; Ullman et al., 2002; Ullman & Estabrooke, 2004). Similarly, women tended 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 did, suggesting their greater reliance on the declarative memory system.

The Declarative/Procedural account of gender differences on linguistic processing tasks has also been supported by studies testing memory for lexical information. For instance, women have been shown to outperform men on 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., Iverson, 1977; Youngjohn, Larrabee, & Crook, 1991). Short-term learning can be supported by the declarative memory system (i.e., long-term knowledge; Burgess & Hitch, 1999; Gupta & MacWhinney, 1997; Majerus et al., 2008). Therefore, gender differences on these learning and short-term memory tasks are likely rooted in the same mechanisms that yield gender differences in language-processing tasks. That is, women's superior long-term memory function is likely to support retention of new linguistic information, thus yielding gender differences on short-term memory tasks. Crucially, such gender differences would only be observed on learning and memory tasks when the to-be-retained information *can* be supported by the long-term memory system.

In accordance with the Declarative/Procedural framework, women are likely to outperform men on learning tasks only when learning familiar linguistic information – information that can activate the linguistic representations in the long-term (declarative) memory. In our recent study, we demonstrated precisely this familiarity-based constraint on gender differences in word learning (Kaushanskaya, Marian, & Yoo, 2011). We contrasted the learning of phonologically-familiar and of phonologically-unfamiliar novel words, where the phonologically-familiar novel words were constructed using native-language phonemes, while the phonologically-unfamiliar novel words were constructed using non-native phonemes. We found that women accurately retained a larger number of phonologically-familiar novel words than men, but that men and women showed comparable retention rates for the phonologically-unfamiliar novel words. We therefore concluded that women were better able than men to rely on their long-term knowledge of native-language phonology during novel word-learning, and thus, showed superior retention of the phonologically-familiar novel words.

In the current study, we asked whether similar gender differences in novel word learning would be observed in children. Because it is possible that gender differences on linguistic tasks expand with age (e.g., Bauer, Goldfield, & Reznick, 2002; Bouchard et al., 2009; Dodd et al., 2003; Eriksson, et al., 2012), the finding of gender differences in adult word-learning does not necessarily imply similar differences in childhood. In addition to examining possible gender differences in word-learning in childhood, we were also

interested in 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. We therefore manipulated the familiarity of the novel words, both with regards to their phonology and with regards to their meanings.

1.2 Familiarity Effects in Novel Word Learning

The work on word-learning is largely consistent in demonstrating that the higher the degree to which the novel words conform to the properties of known words, the better able the learners are to retain them. The vast majority of studies examining familiarity effects in novel word-learning focused on learners' familiarity with the forms associated with the novel words. Generally, words that are more phonologically familiar are retained better than words that are phonologically unfamiliar (e.g., Ellis & Beaton, 1993; Gathercole, Willis, Emslie, & Baddeley, 1991; Service, 1992; Service & Craik, 1993; Papagno, Valentine, & Baddeley, 1991; Papagno & Vallar, 1992; Storkel, 2001). In previous studies, phonological familiarity has generally been conceptualized in terms of phonotactic probability (i.e., the frequency with which phonemes cooccur in the language) and/or in terms of phonological neighborhood size (i.e., the degree to which a word is phonologically-similar to other words in the language), and depending on whether phonotactic probability or neighborhood density has been used, somewhat distinct patterns of findings have been obtained.

When phonological familiarity is conceived in terms of neighborhood size, studies generally yield learning advantages for phonologically-familiar novel words, i.e. for novel words from dense neighborhoods (e.g., Storkel, Armbruster, & Hogan, 2006, but see Storkel & Lee, 2011). Conversely, when phonological familiarity is conceived in terms of phonotactic probability, some studies have observed learning advantages for novel words with lower phonotactic probability (e.g., Gray & Brinkley, 2011; Gray, Brinkley, & Svetina, 2012; Storkel, 2009; Storkel, Armbruster, & Hogan, 2006; Storkel & Lee, 2011). Thus, the effects of phonological familiarity when phonological familiarity is manipulated *within* a single linguistic system are somewhat contentious. Therefore, in the present study, we manipulated phonological familiarity in a categorical manner, so that phonologically-familiar novel words clearly overlapped with the phonological system of the native language, while phonologically-unfamiliar novel words clearly included non-native language phonology. This manipulation of phonological familiarity has always yielded learning advantages for phonologically-familiar novel words (e.g., Kaushanskaya, Marian, & Yoo, 2011; Kaushanskaya & Yoo, 2011; Kaushanskaya, Yoo, & Van Hecke, 2013; Morra & Camba, 2009) and therefore was more likely to be sensitive to the effects of gender than phonotactic probability or neighborhood density.

Phonological familiarity effects in learning are often construed to reflect an interaction between short-term memory mechanisms and long-term memory mechanisms (e.g., Burgess & Hitch, 1999; Gathercole & Baddeley, 1990). While the capacity of the short-term memory system is limited, long-term memory (i.e., stored lexical knowledge associated with the native language) can support the maintenance of information in the phonological short-term memory, provided that this information overlaps in form with the stored lexical knowledge. A number of studies that have demonstrated the positive effects of higher phonotactic probability and neighborhood density in novel word learning have attributed these to the relative ease associated with maintaining phonologically-familiar items in short-term memory because of the ability to rely on the long-term memory system (e.g., De Jong, Seveke, & Van Veen, 2000; Gathercole and Baddeley, 1990; Gathercole, Willis, Emslie, & Baddeley, 1991; Masoura & Gathercole, 1999; Papagno, Valentine, & Baddeley, 1991). A similar argument could be made for semantic familiarity effects in learning.

There have been very few studies of lexical learning where the familiarity of the referent was manipulated, and these studies have yielded somewhat conflicting findings. Work by Gray et al. (Gray & Brinkley, 2011; Gray, Brinkley, & Svetina, 2012) revealed learning advantages associated with unfamiliar objects vs. familiar objects, especially when children were required to name the objects at testing. Conversely, the only study to date that manipulated referent familiarity on a word-learning task with adults observed better retention of the novel words when these were taught in association with familiar referents (e.g., Barcroft & Sunderman, 2008). Given the sparse and conflicting nature of prior work on referent familiarity, we followed the same logic that drove our predictions with regards to phonological familiarity effects when posing the hypothesis with regards to referent familiarity effects. Specifically, we hypothesized that long-term semantic knowledge would scaffold the encoding of familiar referents, but not the encoding of unfamiliar referents, thus yielding superior learning in the context of familiar vs. unfamiliar referents.

1.3 The Current Study

In the current study, we examined whether gender differences would be revealed on a word-learning task in children, and whether gender differences would be due to girls' greater reliance on long-term memory. To that end, boys and girls were compared on their ability to learn phonologically-familiar vs. phonologically-unfamiliar novel words in association with familiar vs. unfamiliar referents.

The phonologically-familiar (+P) novel words contained phonemes that were all part of the English inventory (the native language for all participants), and the phonologically-unfamiliar (−P) novel words contained some phonemes that were not part of the English phonemic inventory (i.e., they were perceptually different from any phoneme in English). This type of phonological-familiarity manipulation has been successful in engendering phonological-familiarity effects in adult learners (e.g., Kaushanskaya, Marian, & Yoo, 2011; Kaushanskaya & Yoo, 2011; Kaushanskaya, Yoo, & Van Hecke, 2013). Morra and Camba (2009) took a similar phoneme-replacement approach to examine phonological familiarity effects in children's word-learning and found more successful retention of phonologically-familiar novel words than of phonologically-unfamiliar novel words. We manipulated the familiarity of the referents by contrasting acquisition of novel words in association with familiar referents (+R, pictures of familiar animals such as squirrel, lion, etc.) vs. unfamiliar referents (−R, pictures of unfamiliar aliens). This manipulation ensured that in both referent conditions, learners were exposed to meaningful categories (animals and aliens).

We reasoned that encoding of familiar novel words (either in phonology or in semantics) would be more likely to rely on long-term lexical-semantic knowledge than encoding of unfamiliar novel words. If the female advantage on lexical learning tasks is rooted in women's reliance on long-term memory, then gender differences should be more apparent for phonologically-familiar novel words than for phonologically-unfamiliar novel words. Similarly, gender differences should be more apparent for the novel words learned in association with familiar referents than unfamiliar referents.

2. Method

2.1. Participants

Sixty-nine children between the ages of 5 and 7 were tested. Of these, 39 were boys and 30 were girls. All children were monolingual speakers of English, with no speech, language, cognitive, hearing, or vision impairments, per parents' reports. Boys and girls were randomly assigned to learn either the phonologically-familiar novel words (+P) or the phonologically-unfamiliar novel words (−P). Thus, the two between-subjects independent

variables in this study – the gender of the participants (boys vs. girls) and phonological familiarity (+P vs. –P novel words) were crossed, yielding four groups of children.

2.1.1 Standardized testing—Each child was administered an extensive battery of language and cognitive tests. Receptive English vocabulary skills were measured using the Peabody Picture Vocabulary Test III (*PPVT-III*; Dunn & Dunn, 1997), and expressive English vocabulary skills were measured using the Picture Vocabulary Subtest of the *Woodcock-Johnson III Tests of Achievement*, Form A (Woodcock, McGrew, & Mather, 2001). Children's short-term memory was measured using the Memory for Digits (forward digit-span) and the Nonword Repetition subtests of the Comprehensive Test of Phonological Processing (*CTOPP*; Wagner, Torgesen, & Rashotte, 1999). Children's working memory was measured using Numbers Reversed (backward digit-span) Subtest of the Woodcock Johnson III Tests of Cognitive Abilities. The Visual Matrices subtest of the Kaufman Brief Intelligence Test, Second Edition (KBIT-2; Kaufman & Kaufman, 1990) was administered as a measure of children's nonverbal intelligence. The precise values associated with participants' linguistic and cognitive performance can be found in Table 1. The 2×2 Anovas with gender (boys vs. girls) and phonological familiarity (+P vs. –P) as the between-subjects variables were used to compare the groups on these linguistic and cognitive measures. The Anovas did not yield either a main effect of gender or a main effect of phonological familiarity; nor did the two variables interact (all p values > 0.1). We therefore conclude that the children in the four groups (+P boys; –P boys; +P girls; –P girls) did not differ with regards to performance on the English language tasks, the non-linguistic cognitive measures, and the phonological memory measures.

2.2 Materials

2.2.1 Auditory Stimuli—Phonologically-familiar (+P) novel words were selected from a set of nonword stimuli developed by Gupta et al. (2004). The nonwords in this database are controlled for phonological properties, and come in sets that are equated for consonant-onset characteristics and neighborhood density. For our task, we chose 8 pairs of bi-syllabic English pseudowords that all followed a CVCVC syllable structure. The pairs were matched on length, stress patterns, and phonotactic probability. Non-parametric analyses were used to confirm the precise matching of the two lists of the auditory stimuli. The Related-Samples Wilcoxon Signed Rank Tests indicated that the two lists of nonwords did not differ in phoneme frequency ($p = 0.67$), biphone frequency ($p = 0.48$), or in acoustic length in milliseconds ($p = 0.26$). Phonologically-unfamiliar (–P) stimuli were constructed by modifying the 8 pairs of nonwords selected for the +P condition to include non-English phonemes. Five non-English consonants (/ /, /t/, /d/, /z/, /r/) and four non-English vowels (/i/, /y/, /o:/, /ja/) replaced English consonants and vowels in the phonologically-familiar words. The number of non-English phonemes per word was matched across the pairs of words in each of the two lists of novel words. See Appendix A for the full list of the auditory stimuli used in the current study.

The female speaker chosen to record the stimuli was a native speaker of English, with no working knowledge of any other language. Prior to the recording session, she was extensively trained on the pronunciation of all the novel words. All the stimuli were recorded in a soundproof booth at a 20kHz sampling rate and were normalized to 70dB amplitude using Praat (Boersma & Weenink, 2013). They were also edited to match in duration and intensity. These auditory stimuli were piloted as part of a larger set of auditory stimuli containing 48 items with ten monolingual English-speaking adults. Pilot participants listened to each nonword (with presentation of +P and –P novel words blocked and order of block presentation counterbalanced across participants), and were asked to rate each novel words on a Likert scale where 1 was equal to “does not sound like a possible English word”

and 7 was equal to “sounds like a possible English word.” The eight –P stimuli were rated as significantly less “English-sounding” ($M = 2.14$, $SD = 1.45$) than the eight +P stimuli ($M = 6.21$, $SD = 2.24$) used in the present study, $p < 0.01$.

2.2.2. Visual Stimuli—Eight pictures of familiar animals were chosen from the International Picture Naming Database (Székely et al., 2004) for the familiar-referent (+R) task. Eight pictures of unfamiliar aliens were chosen from the Gupta et al. (2004) database for the unfamiliar-referent (–R) task. The alien stimuli developed by Gupta et al. (2004) were designed to represent a meaningful category with each individual exemplar having no preexisting individual name. The original database included 144 alien stimuli that were constructed to vary along three dimensions: head shape, appendage type, and number of arms. The 8 alien pictures we selected were chosen to be maximally distinct from each other (i.e., any two pictures did not share more than one attribute). All visual stimuli were black-and-white pictures that were matched in size, shading and thickness of lines.

The data regarding the pictures’ visual complexity were collected from 32 monolingual adult speakers of English. Visual complexity ratings were collected based on a procedure established by Snodgrass and Vanderwart (1980) that was successfully used to index visual complexity by a number of previous studies (e.g., Alario & Ferrand, 1999; Forsythe, Mulhern, & Sawey, 2008; Himmanen, Gentles, & Sailor, 2003). Each participant was asked to rate the visual complexity of each picture (animal and alien) on a scale from 1 (very simple) to 7 (very complex). The 16 pictures used in the present study were rated as part of a larger piloting procedure that was done on 48 pictures (24 animals and 24 aliens). Participants were instructed to rate the complexity of the drawing itself (rather than the real-life correlate it represented) based on the amount of detail and the intricacy of lines in the picture. Animal and alien pictures were presented in separate blocks, with order of pictures in a block randomized for each participant, and order of block presentation counterbalanced across participants. While overall, the set of 24 animal pictures was rated as less visually complex than the set of 24 alien pictures (see Kaushanskaya, Joo, & Van Hecke, 2013 for details), the 16 pictures chosen for the present study were selected because they were the ones most closely matched in visual complexity. That is, the 8 animal pictures ($M = 3.94$, $SD = 1.17$) and the 8 alien pictures ($M = 4.23$, $SD = 0.92$) used in the present study did not differ in their visual complexity ratings, $p = 0.29$.

2.3 Procedure

2.3.1 Teaching Phase—In both the +P and the –P groups, children learned 8 novel words paired with familiar referents (animals), and 8 novel words paired with unfamiliar referents (aliens) in two different sessions scheduled at least one week apart. The presentation of animals vs. aliens was blocked. The order of presentation (animals vs. aliens first) was counterbalanced across participants; similarly, novel-word lists were counterbalanced across participants (i.e., half of the participants learned list A in association with animals and list B in association with aliens, and half of the participants did the reverse). For all learning trials, children heard the novel word twice, and saw the corresponding picture in the middle of the computer screen. The picture remained on the screen for 6 seconds. Children were directed to remember which words went with which pictures.

2.3.2 Testing Phase—Immediately after the learning phase, the children were tested on their memory for the novel words. Children were presented with an array of four pictures (animals or aliens), and were instructed to pick the picture that corresponded to the novel word. The distracters in the forced-choice recognition task included two stimuli that have been presented in the learning phase, and one novel stimulus that has never been presented

to the children. The position of the correct picture on the display varied randomly across trials. Children were instructed to match the correct picture to the novel word as quickly as possible. The accuracy on the forced-choice recognition task was indexed by proportion of correctly identified pictures out of the total of 8 trials. Reaction times were also collected, and were averaged across all the correctly identified items for each participant and for each referent condition.

2.4 Analyses

Recognition accuracy data and RT data were analyzed separately using $2 \times 2 \times 2$ Mixed Anovas, with gender (boys vs. girls) and phonological familiarity (+P vs. -P) as between-subjects independent variables, and referent familiarity (+R vs. -R) as a within-subjects independent variable. Follow-up comparisons were conducted both within the gender groups and across the gender groups.

3. Results

3.1 Omnibus Anovas

The $2 \times 2 \times 2$ Anova for recognition accuracy yielded a significant two-way interaction between gender and referent familiarity, ($F(1, 61) = 3.92, p = 0.05, \eta^2 = 0.06$), and a significant two-way interaction between gender and phonological familiarity ($F(1, 61) = 3.33, p < 0.05, \eta^2 = 0.30$). No other main effects or interactions were detected. The $2 \times 2 \times 2$ Anova for reaction times yielded a main effect of referent familiarity ($F(1, 61) = 3.46, p < 0.05, \eta^2 = 0.06$), with shorter RTs for the familiar referents ($M = 4670.65$ ms, $SE = 285.94$) than for the unfamiliar referents ($M = 5546.83, SE = 421.87$). No other main effects or interactions were revealed. Therefore, the follow-up analyses were conducted for the recognition accuracy measure only.

Two sets of follow-up comparisons were performed in order to identify the loci of the interactions in the accuracy data. First, we examined whether there were differences in how boys and girls responded to phonological familiarity (collapsed across familiar and unfamiliar referents) and to referent familiarity (collapsed across phonologically-familiar and unfamiliar novel words). Second, we examined whether there were gender differences for each of the word-learning performance measures.

3.1.1 Analyses within gender groups—Paired-samples *t*-tests were used to examine referent familiarity effects in boys and in girls. The accuracy data were collapsed across the +P and the -P conditions. For boys, the referent familiarity effect was not statistically-significant, ($t(36) = 0.41, p = 0.67, \eta^2 = 0.05$). That is, boys recognized the novel words for familiar referents ($M = 0.35, SE = 0.04$) and for unfamiliar referents ($M = 0.37, SE = 0.04$) with equal accuracy. In contrast, for girls, a significant referent familiarity effect was found, ($t(27) = 2.58, p < 0.05; \eta^2 = 0.20$). Girls recognized the novel words for familiar referents ($M = 0.45, SE = 0.04$) with higher accuracy than for unfamiliar referents ($M = 0.33, SE = 0.04$).

Independent-samples *t*-tests were used to examine phonological familiarity effects in boys and in girls. The accuracy data for these analyses were collapsed across the +R and the -R conditions. For boys, the phonological familiarity effect was not statistically significant, ($t(37) = 0.31, p = 0.76, \eta^2 = 0.01$). That is, boys recognized phonologically-familiar novel words ($M = 0.37, SE = 0.04$) and phonologically-unfamiliar novel words ($M = 0.39, SE = 0.05$) with equal accuracy. In contrast, for girls, a significant phonological familiarity effect was found, ($t(28) = 1.92, p = 0.05, \eta^2 = 0.12$). Girls recognized phonologically-familiar

novel words ($M = 0.46$, $SE = 0.05$) with higher accuracy than phonologically-unfamiliar novel words ($M = 0.35$, $SE = 0.04$).

3.1.2 Analyses across gender groups—Independent-samples t -tests were used to contrast boys and girls on each of the word-learning conditions of interest. Collapsing across referents, girls demonstrated higher recognition accuracy than boys on the phonologically-familiar novel words, $t(33) = 2.33$, $p < 0.05$, $p^2 = 0.14$ but not on the phonologically-unfamiliar novel words, $t(33) = 0.76$, $p = 0.45$, $p^2 = 0.02$. Collapsing across levels of phonological familiarity, girls demonstrated higher recognition accuracy than boys for the novel words paired with familiar referents, $t(65) = 1.97$, $p = 0.05$, $p^2 = 0.10$, but not of novel words paired with unfamiliar referents, $t(62) = 1.07$, $p = 0.29$, $p^2 = 0.02$.

4. Discussion

In previous studies both with children (e.g., Bornstein, Hahn, & Haynes, 2004; Eriksson, et al., 2012), and with adults (e.g., Herlitz et al., 1999; Kimura & Harshman, 1984; Loonstra, Tarlow, & Sellers, 2001; Larsson, Lovden, & Nilsson, 2003; Maitland, et al., 2004), females have been shown to outperform males on linguistic tasks that involve activation of the information stored in long-term memory. 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 et al., 2002; 2004; 2005). In our prior work with adults, we demonstrated that the Declarative/Procedural account of gender differences in language processing can also apply to dynamic learning tasks (Kaushanskaya, Marian, & Yoo, 2011). We showed that women outperformed men when learning phonologically-familiar novel words, but not when learning phonologically-unfamiliar novel words. We argued that the female advantage on this short-term memory task was driven by women's ability to more efficiently access linguistic information in long-term memory. That is, women were able to rely on their long-term knowledge of native-language phonology more than men. As a result, they demonstrated superior retention of information that could be supported by native-language knowledge. In the present study, we examined whether similar gender differences would be obtained in children, and tested whether semantic as well as phonological familiarity effects in learning would be sensitive to gender differences. Our findings suggest three noteworthy patterns. First, gender differences in word learning can be observed in children as young as 5–7 years of age. Second, girls outperform boys on word-learning tasks only when these involve learning of familiar information. That is, the female advantage on word-learning tasks is constrained to situations where long-term knowledge of the language can support learning. And third, phonological and semantic familiarity effects appear to be stronger in girls than in boys.

Prior research has rarely examined gender differences in language skills along the age span. Yet, documenting different patterns of performance in males and females at a particular time point does not necessarily mean that these gender differences are developmentally stable. In childhood, just as in adulthood, the presence of gender differences in language is not a consistent finding, with some work documenting robust and lasting gender differences in children (e.g., Bornstein, Hahn, & Haynes, 2004), and other work showing no gender differences (e.g., Ardila, et al., 2011). Further, patterns of gender differences may shift with age. For example, some studies have documented expanding gender differences in language with age (e.g., Bauer, Goldfield, & Reznick, 2002; Bouchard et al., 2009; Dodd et al., 2003; Eriksson, et al., 2012). Thus, it was possible that the superior female performance on the word-learning task we have found in our previous study with adults (Kaushanskaya, Marian, & Yoo, 2011) would not generalize to children. The present study confirmed the presence of gender differences on word-learning tasks in childhood, in children as young as 5–7 years of age. Although such crosssectional data do not necessarily imply that gender differences in

word learning are stable throughout the developmental period into adulthood, the findings of this study do confirm that the female advantage for word-learning tasks appears fairly early in life.

Why did the girls in the present study outperform the boys on the word-learning tasks, but only when learning phonologically-familiar novel words, and only when learning novel words in association with familiar referents? Although the Declarative/Procedural account is just one theoretical framework within which gender differences have been considered, it appears to parsimoniously account for the current findings. The Declarative/Procedural Model proposed by Ullman (2001; 2004; 2005; 2008) suggests that females have a more efficient declarative system than males, and are thus better able to exploit regularities and patterns in a language than men (e.g., Hartshorne & Ullman, 2006; Prado & Ullman, 2009). Although this account has previously been applied primarily to linguistic tasks that involve the *processing* of information, we have demonstrated that it can also apply to linguistic tasks that involve the *learning* of novel information (Kaushanskaya, Marian, & Yoo, 2011). Acquisition of new linguistic information occurs in the context of prior knowledge, and it is well established that short-term memory can be supported by the declarative memory system (i.e., long-term knowledge; Burgess & Hitch, 1999; Gupta & MacWhinney, 1997; Majerus et al., 2008). Therefore, findings of female advantages on short-term memory tasks such as 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., Iverson, 1977; Youngjohn, Larrabee, & Crook, 1991) can be accounted for by positing that women are more apt than men to rely on their long-term knowledge during short-term memory tasks.

The present study provides strong evidence that gender differences on linguistic learning tasks can only be observed when the to-be-retained information can be supported by the long-term memory system. Girls outperformed boys on the experimental word-learning task only when the retention of the novel words could be scaffolded by native-language phonological knowledge or by native-language semantic knowledge. Boys and girls performed identically on the word-learning conditions that involved unfamiliar semantic or unfamiliar phonological information, likely because neither group could rely on long-term knowledge of the native language to support learning. This finding is congruent with previous work on gender differences in the verbal memory domain, which 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). The novel finding here is that the knowledge of native-language phonology and of native-language semantics can bootstrap learning, and does so more strongly in females than in males.

Because boys and girls did not differ on the measure of non-verbal intelligence and on demographic characteristics that may have impacted word-learning performance (such as chronological age and socioeconomic status), it is unlikely that gender differences observed in this study are a result of between-group confounds. Even more strikingly, gender differences on the word-learning task were observed despite the fact that the groups did not differ on measures of native-language knowledge. This finding strongly suggests that superior female performance on word-learning tasks is a result of a dynamic, possibly strategic mechanism, whereby females can draw on their knowledge of the native language for the purposes of learning more successfully than men. Previous studies that have examined gender differences in verbal memory performance use have suggested that women may rely on semantic (e.g., Kramer et al., 1997) and phonological (e.g., Koren, Kofman, & Berger, 2005) clustering strategies during verbal retrieval tasks more so than men. Perhaps a similar strategic mechanism is at work in the present study, where girls are more likely to

use their long-term linguistic knowledge to strategically boost their retention of familiar novel words than boys. Whatever the explanation, it appears that gender differences on the word-learning task are not the result of females' superior knowledge of the native language, but rather the result of their superior ability to *utilize* this knowledge. It is this ability that yields stronger phonological and semantic familiarity effects in women than in men.

Prior studies suggest that superior retention of phonologically-familiar items on short-term memory tasks is indicative of long-term memory involvement in the learning process (e.g., Gathercole, 1995; Gathercole et al., 1991). Although the advantages associated with phonological familiarity have not been consistently observed on novel word learning tasks, the conflicting findings appear to be largely limited to studies where phonological familiarity is manipulated through phonotactic probability (e.g., Gray & Brinkley, 2011; Gray, Brinkley, & Svetina, 2012; Storkel, 2009; Storkel, Armbruster, & Hogan, 2006; Storkel & Lee, 2011). When phonological familiarity is manipulated through neighborhood density (e.g., Storkel, Armbruster, & Hogan, 2006) or through integration of non-native phonology (e.g., Morra & Camba, 2009), it is generally found to benefit learning. In our study, we manipulated phonological familiarity in a highly overt and categorical manner, such that phonologically-unfamiliar novel words clearly could *not* be native-language words, either in terms of their lexical or sublexical properties. It is therefore not surprising that we observed a positive effect of phonological familiarity, with better performance on phonologically-familiar novel words. 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. However, because we observed such phonological familiarity effects in girls only, the current work refines existing evidence regarding the benefits of phonological familiarity for word learning (e.g., Ellis & Beaton, 1993; Gathercole, Willis, Emslie, & Baddeley, 1991; Service, 1992; Service & Craik, 1993; Papagno, Valentine, & Baddeley, 1991; Papagno & Vallar, 1992; Storkel, 2001), and suggests that phonological familiarity benefits women more than men. This finding of stronger phonological familiarity effects in girls is highly congruent with our prior study with adults (Kaushanskaya, Marian, & Yoo, 2011).

The finding of stronger semantic familiarity effects in the female data lends credence to the hypothesis that women may rely on their long-term language knowledge more than men during novel word learning. In general, manipulations of referent familiarity have been rare in prior research. One previous study that attempted such a manipulation with adults (Barcroft & Sunderman, 2008) revealed superior learning of novel vocabulary in association with familiar objects rather than unfamiliar objects. However, at least two prior studies conducted with children have observed the opposite pattern of results, with better retention of novel words learned in association with unfamiliar objects than familiar objects (Gray & Brinkley, 2011; Gray, Brinkley, & Svetina, 2012). Although the gender of the children tested in Gray et al. studies is unknown, it is fruitful to entertain the possibility that their findings may have been driven by a predominantly male sample (given the fact that they tested children with Specific Language Impairment, which has a higher incidence in males, e.g., Bishop, 1997; Tomblin, Hardy, & Hein, 1991). Therefore, future studies examining semantic familiarity effects would benefit from considering gender as a crucial variable. Based on the current findings, we propose an account of referent-familiarity effects that is similar to the one used to explain phonological familiarity effects. That is, long-term knowledge of native-language semantics would support the learning of novel words when these map onto familiar semantic representations, but not when they map onto semantic representations that have no correlates in the native language semantic system. This mechanism would benefit females more than males given the females' higher reliance on the long-term memory system during language processing and language learning tasks.

To conclude, the theoretical Declarative/Procedural model of gender differences in language abilities attributes enhanced female performance on linguistic tasks to women's superior declarative memory system. This account has previously been applied to explain female advantages on word-learning tasks in adults. The current study aimed to examine the utility of this account for explaining word-learning performance in children. Our main hypothesis was that girls would outperform boys on the word-learning tasks only when learning involved familiar linguistic information, because only then could the declarative memory system (where long-term linguistic knowledge is stored) scaffold learning. The findings support this hypothesis. Girls were found to outperform boys only when learning phonologically-familiar novel words, and only when the novel words were learned in association with familiar referents. We therefore conclude that the female advantages on word-learning tasks are rooted in girls' superior ability to dynamically access long-term linguistic representations (both phonological and semantic) in the declarative memory when engaging in short-term learning.

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Appendix

Phonologically-Familiar and Phonologically-Unfamiliar Novel Words

	Phonologically-Familiar	Novel Words	Phonologically-Unfamiliar	Novel Words
	List A	List B	List A	List B
1	b moʊg	tɪm k	bo:mo:	tjmo:k
2	taɪn f	gæb k	tjɪn f	jab k
3	pataɐb	t b n	pytæb	tɛbo:n
4	koʊnoʊv	k daɪl	ko:no:v	kydɪl
5	gætik	bit s	jaɪtik	biɪɪzɪ
6	k nit	kerfem	ko:niɪ	kjaɪjan
7	tikis	boʊnid	tɛkizɪ	bo:niɪ
8	d sin	pɛɪt l	dɔ:zɪn	pjaɪo:l

Highlights

- We examine gender differences in children's word learning.
- We found superior performance in girls for novel words.
- We found superior performance in girls for words paired with familiar referents.
- No gender differences were found when novel words involved unfamiliar information.
- Findings indicate that girls make greater use of long-term knowledge to support short-term learning than boys.

Figure 1.

Recognition accuracy for boys vs. girls in each word-learning condition (+P+R; +.P-R; -P+R; and -P-R). Data for phonologically-familiar novel words are presented in Panel A. Data for phonologically-unfamiliar novel words are presented in Panel B. The dashed line represents performance at chance levels (0.25), and asterisks mark conditions where recognition accuracy statistically exceeded chance ($p < 0.05$).

Table 1
Background Information for Girls and Boys in Phonologically-Familiar vs. Phonologically-Unfamiliar Conditions

	Boys		Girls		F-test
	Phonologically Familiar	Phonologically Unfamiliar	Phonologically Familiar	Phonologically Unfamiliar	
N	21	18	15	15	
Age	6.33 (0.19)	6.54 (0.20)	6.35 (0.22)	6.67 (0.22)	$p = 0.76$
Maternal Years of Education	18.76 (0.61)	17.06 (0.66)	19.07 (0.72)	17.73 (0.72)	$p = 0.79$
KBIT-2	102.48 (2.85)	106.28 (3.08)	111.67 (3.38)	108.53 (3.38)	$p = 0.28$
PPVT-III	118.24 (2.92)	122.94 (3.15)	122.20 (3.45)	118.87 (3.45)	$p = 0.22$
Picture Vocabulary	106.05 (2.41)	110.61 (2.60)	110.07 (2.85)	107.53 (2.85)	$p = 0.19$
Digit Span	11.24 (0.55)	11.28 (0.60)	11.20 (0.65)	10.13 (0.65)	$p = 0.37$
Nonword Repetition	10.95 (0.50)	10.94 (0.52)	11.87 (0.57)	10.87 (0.57)	$p = 0.36$
Numbers Reversed	104.38 (2.51)	105.17 (2.72)	109.00 (2.97)	108.47 (2.97)	$p = 0.82$

Note: The means for standardized measures represent Standard Scores, while values in parentheses represent Standard Errors. The p values represent the significance of an interaction between Gender (boys vs. girls) and Phonological Familiarity (+P vs. -P) yielded by 2×2 Anovas. In all analyses, the main effect of Gender and the main effect of Phonological Familiarity were not statistically significant (all p values > 0.1).