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A comparison of homonym and novel word learning: the role of phonotactic probability and word frequency*

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ABSTRACT

This study compares homonym learning to novel word learning by three- to four-year-old children to determine whether homonyms are learned more rapidly or more slowly than novel words. In addition, the role of form characteristics in homonym learning is examined by manipulating phonotactic probability and word frequency. Thirty-two children were exposed to homonyms and novel words in a story with visual support and learning was measured in two tasks: referent identification; picture naming. Results showed that responses to homonyms were as accurate as responses to novel words in the referent identification task. In contrast, responses to homonyms were more accurate than responses to novel words in the picture-naming task. Furthermore, homonyms composed of common sound sequences were named more accurately than those composed of rare sound sequences. The influence of word frequency was less straightforward. These results may be inconsistent with a one-to-one form–referent bias in word learning.

INTRODUCTION

Homonyms are words that have one phonological form but two distinct meanings. For example, the word *bank* can refer to a 'financial institution' or 'the edge of land by a river.' In this paper, the focus is on pre-literate children so spelling differences will be ignored (i.e. homonyms with one

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spelling, like *bank*, and homonyms with distinct spellings, like *bear/bare*, will be treated as similar problems for word learning by pre-literate children). It is generally assumed that the mental representation of a homonym consists of a single LEXICAL REPRESENTATION of the word form and two SEMANTIC REPRESENTATIONS, one for each meaning (e.g. Beveridge & Marsh, 1991; Backscheider & Gelman, 1995). Homonyms present an interesting challenge for theories of word learning because learning a secondary meaning of a homonym differs fundamentally from learning a novel word. In homonym learning, the child has already learned the lexical representation of the word form (e.g. *bank*) and a semantic representation of one referent (e.g. 'financial establishment'). When the secondary meaning is encountered (e.g. *bank* paired with the meaning 'edge of land by a river'), the child must create a new semantic representation of the novel referent and develop an association between this semantic representation and the already existing lexical representation of the known form. In contrast, when learning a novel word, a child must create a lexical representation of the novel word form and a semantic representation of the novel referent as well as develop an association between these two newly created representations. The impact of this difference between homonym learning and novel word learning is controversial.

One view is that homonyms are learned more slowly than novel words. This view is often formally stated as a preference for unique mappings, specifically a one-to-one mapping between lexical and semantic representations (e.g. Slobin, 1973; Markman, 1989). It is then hypothesized that words that violate this preference, such as homonyms, are learned more slowly than words that do not violate this preference, namely novel words, because the child requires additional evidence or cues to override this preference for unique mappings to learn the appropriate form–referent pairing. In support of this hypothesis, previous studies demonstrate that three- to four-year-old children have difficulty alternating between primary and secondary meanings of homonyms, frequently failing to select the contextually appropriate meaning; however, children this young are able to demonstrate knowledge of both meanings of a homonym in tasks that minimize cognitive demands or provide greater support for the contextually appropriate interpretation (e.g. Beveridge & Marsh, 1991; Backscheider & Gelman, 1995; Doherty, 2000). Thus, preschool children appear to have an emerging awareness that words can have more than one meaning but have difficulty utilizing this information in less supportive language processing tasks. This ability to independently alternate between meanings of a homonym or identify a contextually appropriate meaning of a homonym appears to improve with age (e.g. Beveridge & Marsh, 1991; Doherty, 2000). Turning to more direct studies of word learning, when given similar exposure to the secondary meaning of a homonym vs. a novel word, three- to nine-year-old children are less accurate in providing a correct interpretation of the homonym than the novel word (Mazzocco, 1997; Mazzocco, Myers, Thompson & Desai, 2003; Doherty, 2004). When providing an interpretation of the homonym, children in this age range tend to select a meaning that is consistent with the primary meaning of the homonym rather than the new meaning. This pattern of performance suggests difficulty in creating a new and accurate semantic representation of the secondary meaning of homonyms. Taken together, this empirical evidence provides support that children have difficulty alternating between meanings of homonyms and are slower to learn secondary meanings of homonyms than to learn novel words.

The second view is that homonyms are learned more rapidly than novel words. This view is based primarily on naturalistically collected production evidence from children at the earliest stages of word learning. Case studies provide evidence that children learning their first 50 words will sometimes demonstrate preferences for certain phonological patterns. These preferences appear to guide word learning with children more rapidly learning words consistent with the preferred phonological pattern (e.g. Vihman, 1981; Stoel-Gammon & Cooper, 1984; Velleman & Vihman, 2002). In fact, it has been reported that children will sometimes change from a correct production of a target word to an incorrect production that is consistent with their phonological preferences (see Vihman, 1981 for review). In addition, it has been argued that some children rapidly expand the diversity of semantic representations at the expense of the diversity of lexical representations (e.g. Stoel-Gammon & Cooper, 1984). These data suggest that children may collect, rather than avoid, homonyms because homonymy eases the demands of word learning by reducing the amount of new information that must be represented in the mental lexicon. That is, children need only create a new semantic representation and an association between this new semantic representation and an existing lexical representation, rather than create a new semantic representation, a new lexical representation, and a corresponding association between the two. It is important to note that homonyms in this line of research are usually words that are not homonyms in the target language but are homonyms in the child's system because target sound contrasts are collapsed in the child's surface production; however, it is easy to see the extension of these concepts to learning a secondary meaning of an adult homonym. As in the young child, homonyms of the target language would reduce the number of new representations that need to be created when compared to the number of new representations that need to be created to learn a novel word.

One reason for these two discrepant views of the effect of homonymy on word learning may relate to the types of representations that are tapped by the measures of word learning used in each study. Specifically, studies that provide evidence that homonyms are learned more slowly than novel words have focused primarily on receptive tasks that emphasize the semantic representation. In these studies, the child listens to a brief story with no visual support and then is asked to select the appropriate interpretation of the homonym or novel word from a field of pictures. In this case, hearing the homonym may activate the child's known lexical representation of the homonym and this, in turn, should activate the newly created semantic representation of the secondary meaning. A similar scenario is hypothesized for novel word learning where hearing the novel word should activate the newly created lexical representation, leading to activation of the newly created semantic representation. Thus, for both types of words, the child's response choice should reflect learning of a new semantic representation. Results show that children are less accurate selecting the appropriate meaning of the homonym than the novel word when both the primary or original meaning of the homonym and the new secondary meaning are presented as possible responses (Mazzocco, 1997; Mazzocco *et al.*, 2003; Doherty, 2004). In contrast, children are equally accurate selecting the appropriate meaning of the homonym and the novel word when only the secondary meaning of the homonym and other foils are presented as possible responses (Doherty, 2004). This pattern suggests that children are equally able to create a semantic representation of a secondary meaning of a homonym or a new meaning of a novel word, but they may have trouble activating or selecting the correct semantic representation of a homonym when both the primary and secondary meanings are presented as response choices.

In contrast, studies documenting an advantage for homonyms in word learning generally rely on tasks emphasizing lexical representations. In particular, studies showing that young children may collect homonyms are based on production evidence (e.g. spontaneous speech samples), where children are observed to produce the same form for a variety of referents. While suggesting a potential homonym advantage in production, these naturalistic observations have not directly compared homonym learning to novel word learning. This is an important comparison for the homonym debate. In a production task, seeing the referent is thought to activate the child's new semantic representation and this, in turn, should activate the corresponding lexical representation. The child's response should provide evidence of the status of the lexical representation. For homonym learning, the lexical representation is known. In contrast, the lexical representation of a novel word must be learned. Therefore, it is possible that homonyms would be responded to more accurately than novel words in a task emphasizing lexical representations, such as picture naming. One goal of the current study was to examine this potential variation in the homonym effect across tasks by comparing homonym and novel word learning in a task emphasizing semantic representations and a task emphasizing lexical representations.

An additional goal of the current study was to examine how form characteristics influence the learning of homonyms vs. the learning of novel words. Two form characteristics were of interest: phonotactic probability and word frequency. PHONOTACTIC PROBABILITY refers to the likelihood of a sound sequence being present in a given language (Field, 2004) and is frequently determined through analysis of a word corpus (e.g. dictionary). Previous studies have shown that phonotactic probability influences novel word learning. In particular, novel words composed of common sound sequences are learned more rapidly than those composed of rare sound sequences, and this effect has been observed in tasks emphasizing semantic representations and tasks emphasizing lexical representations (Storkel, 2001, 2004*a*). While there is evidence documenting the effect of phonotactic probability on novel word learning, it is unclear whether phonotactic probability would influence homonym learning. On the one hand, phonotactic probability may not influence homonym learning because semantic characteristics may be more dominant than form characteristics and because the form of the word is known. That is, the conflict between the known primary meaning and the novel secondary meaning may overshadow any effects of form. On the other hand, phonotactic probability may influence homonym learning because it may facilitate the initial recognition that the form is known and may facilitate the child's ability to hold form and semantic information in working memory to create accurate and detailed representations in long-term memory. Here, the effect of phonotactic probability on homonym learning would be expected to parallel that observed in novel word learning (i.e. a common sound sequence advantage). The examination of phonotactic probability may provide evidence of the role of form characteristics in homonym learning.

WORD FREQUENCY refers to the number of times a given word form occurs in a spoken or written corpus (Field, 2004). Word frequency influences language processing with high frequency words generally being produced or recognized more accurately and more rapidly than low frequency words (e. g. Oldfield & Wingfield, 1965; Landauer & Streeter, 1973). This effect of word frequency on language processing has been instantiated in processing models through differences in various aspects (e.g. threshold, weights) of the lexical representation of higher vs. lower frequency words, suggesting that the quality of a lexical representation may be dependent on the frequency of the word form (e.g. Dell, 1986; Norris, 1994). The influence of word frequency on homonym learning has not been explored previously. At the heart of this issue is whether the quality of the lexical representation of a homonym, as indexed by frequency, has any effect on homonym learning. On the one hand, frequency may have no effect on homonym learning. That is, learning a secondary meaning of a homonym may be slower or faster than learning a novel word, regardless of the frequency of the homonym. Here, having a lexical representation in long-term memory may influence the word learning process, no matter the quality of that representation. On the other hand, word frequency may influence homonym learning. Specifically, the difference between the rate of learning of a secondary meaning of a homonym and the rate of learning of a novel word may vary by frequency. For example, high frequency words may show a larger difference and low frequency words may show a smaller difference or no difference. In this scenario, the quality of the lexical representation in long-term memory may influence homonym learning. Taken together, examination of word frequency in homonym learning will determine whether the quality of a known lexical representation alters the effect of homonymy on learning.

The goal of this study was to clarify the effect of homonymy on word learning by examining learning in two tasks, one emphasizing semantic representations and one emphasizing lexical representations, and by examining the influence of the form characteristics of phonotactic probability and word frequency on the homonym effect. To address these issues, three- and four-year-old children were exposed to stimuli in a story. Learning of the stimuli was examined in both a referent identification task, a task emphasizing semantic representations, and in a picture-naming task, a task emphasizing lexical representations. The stimuli were known words paired with a novel secondary meaning (i.e. homonyms) and novel words paired with a novel referent (i.e. novel words). The known and novel words varied in phonotactic probability (common vs. rare). The known words also varied in word frequency.

Our predictions are as follows. First, if homonyms are avoided in learning due to a preference for a one-to-one form-referent mapping, then we would expect children to learn the known words more slowly than the novel words. In contrast, if homonyms facilitate learning due to a decrease in the amount of information to be learned, then we expect children to learn known words more rapidly than novel words. Second, it is further expected that the difference between known and novel word learning may vary by task. For the task emphasizing semantics (i.e. referent identification), known words may be learned at the same rate as novel words because both types of words involve the creation of a new semantic representation. In contrast, in the task emphasizing lexical representations, known words may be learned more rapidly than novel words because learning a secondary meaning of a known word does not involve the creation of a new lexical representation, whereas novel word learning does. Third, phonotactic probability may have no effect on homonym learning because semantic characteristics may be more critical than form characteristics. A second possibility is that phonotactic probability will influence homonym learning because form characteristics may affect recognition and retention of the form. Here, a common sound sequence advantage is predicted in keeping with past studies. Finally, the difference in rate of learning between known and novel words may be the same regardless of the word frequency of the known word, indicating that the influence of homonymy on word learning is not dependent on the quality of the lexical representation of the known word. Alternatively, the difference in rate of learning between known and novel words may vary by word frequency, indicating that the influence of homonymy on word learning may be dependent on the quality of the lexical representation of the known word.

METHODS

Participants

Thirty-two children, aged 3;4 to 5;0 ($M=4;1$, S.D.$=6$ months), participated. Children were monolingual, native speakers of American English with no history of speech, language, hearing, or cognitive disorder by parent report. Normal phonological and vocabulary development was confirmed through standardized testing. Mean performance was at the 71st percentile (S.D.$=20$, range 27–98) on the *Goldman-Fristoe Test of Articulation-2* (GFTA-2, Goldman & Fristoe, 2000), the 67th percentile (S.D.$=16$, range 23–92) on the *Peabody Picture Vocabulary Test-3* (PPVT-3, Dunn & Dunn, 1997), and the 75th percentile (S.D.$=17$, range 23–98) on the *Expressive Vocabulary Test* (EVT, Williams, 1997). In addition, correct articulation of the auditory stimuli, described below and in Table 1, was assessed using a stimuli naming task. In this task, production of the known word stimuli was elicited through picture naming. If the child did not spontaneously name the picture, a production was elicited in imitation. Production of the novel word stimuli was elicited through imitation. All children correctly articulated the known and novel word stimuli. Receptive knowledge of the primary meaning of the known word stimuli was assessed in a picture pointing task. In this task, children were shown a set of three pictures and asked to point to the picture corresponding to the known word stimuli. All children accurately identified the known word stimuli, verifying that the stimuli were known.

Auditory stimuli

All legal consonant–vowel–consonant (CVC) combinations in American English were created and served as the potential stimuli pool. Stimuli were selected from this pool manipulating two independent variables: familiarity

TABLE 1. *Form and referent characteristics of the word learning stimuli*

Known		Novel						
Common	Rare	Common	Rare	Category	Referent 1	Referent 2	Referent 3	Referent 4
koʊm	gus	baɪn	fig	Candy Machine	Red candy + 1 chute (created)	Blue candy + 2 chutes (created)	Yellow candy + 1 chute (created)	Green candy + 1 chute (created)
sʌn	geɪm	bɪm	daʊs	Pet	Green gerbil + 2 antenna (DeBrunhoff, 1981)	Purple mouse-bat (Mayer, 1992)	Yellow frog-bat (Mayer, 1992)	Orange elephant mouse (Mayer, 1992)
bɛd	fud	kɪt	gim	Horn	Orange trumpet bell pointing down (Geisel & Geisel, 1954)	Yellow hand-held tuba (Geisel & Geisel, 1954)	Red saxophone pointing down (Geisel & Geisel, 1954)	Blue oboe pointing upward (Geisel & Geisel, 1954)
boʊt	dɔg	seɪd	gʌd	Toy	Punch toy (Geisel & Geisel, 1958)	Cork gun (Geisel & Geisel, 1958)	Punch arrow (Geisel & Geisel, 1958)	Marshmallow sprayer (Geisel & Geisel, 1958)

(known vs. novel word) and phonotactic probability (common vs. rare sound sequence). Familiarity was defined using the *MacArthur Communicative Development Inventory*, a 680 word parent checklist intended for use with children aged 1;4–2;6 (CDI, Fenson, Dale, Reznick, Thal, Bates, Hartung, Pethick & Reilly, 1993) and the *Hoosier Mental Lexicon*, a corpus based on a 20 000 word dictionary (HML, Nusbaum, Pisoni & Davis, 1984). Known stimuli were those that appeared in the CDI and novel stimuli were those that did not appear in the CDI or HML. Thus, known stimuli consisted of real words that were likely to be familiar to children in the age range tested, and this was verified in the picture pointing task (see above). The learning of a new meaning for the known stimuli parallels learning of a secondary meaning for a target homonym. Novel stimuli were sound sequences that were not likely to be real words for children or adults (i.e. nonwords). Learning the novel stimuli is similar to learning a new word that is not a homonym.

Phonotactic probability was computed for each CVC in the stimuli pool using a corpus (i.e. HML) and algorithm that have been used in past studies of word learning (Storkel, 2001, 2004*a*). Two measures were computed: (1) the sum of the positional segment frequencies of each sound in the CVC; (2) the sum of the biphone frequencies of the two pairs of sounds in each CVC (i.e. CV and VC). Positional segment frequency was computed for each sound in the CVC using a computer programme that searched the HML to identify all the words containing a given sound in a given word position and to identify the words containing any sound in a given word position. The log word frequency of the former were summed and divided by the sum of the log word frequency of the latter. For example, for initial /b/, the sum of the log frequency of all the words in the HML containing an initial /b/ was divided by the sum of the log frequency of all the words in the HML containing any phoneme in initial position. Positional segment frequency was calculated for each phoneme in the CVC in this way and then summed. Calculation of the biphone frequency was similar, except that sound pairs rather than single sounds were used. Detailed examples of these calculations can be found in Storkel (2004*b*). The inclusion of word frequency in these calculations yields a token based measure of phonotactic probability. Free access to the phonotactic probability programme is available online at http://www.people.ku.edu/%7Emvitevit/PhonoProbHome.html. The CVC pool was then divided into common and rare categories based on a median split.

The final CVCs were selected to preserve phonological diversity among the stimuli in the same condition because phonologically similar items may slow learning. An attempt was made to match phonemes across the known and novel stimuli so that the main difference between these two categories was familiarity (known vs. novel). Selected stimuli are shown in Table 1.

TABLE 2. *Phonotactic probability, neighbourhood density, and word frequency for the stimuli in each condition*

	Known	Novel
	Mean positional segment frequency sum (S.D.)	
Common	0·1894 (0·0347)	0·2007 (0·0378)
Rare	0·1061 (0·0166)	0·1118 (0·0196)
	Mean biphone frequency sum (S.D.)	
Common	0·0084 (0·0023)	0·0075 (0·0028)
Rare	0·0021 (0·0005)	0·0020 (0·0006)
	Mean neighbourhood density (S.D.)	
Common	15 (2)	16 (2)
Rare	7 (2)	5 (1)
	Mean log word frequency (S.D.)	
Common	1·70 (0·62)	0
Rare	1·68 (0·73)	0

Mean positional segment frequency sums and mean biphone frequency sums are shown in Table 2 for each condition. As can be seen from Table 2, common sound sequences had higher positional segment frequency sums and higher biphone frequency sums than rare sound sequences. Positional segment frequency and biphone frequency were similar for known and novel words. In addition, the common and rare known words were matched in log word frequency based on a written corpus of adult language (Kucera & Francis, 1967) and sampled a range of frequencies (raw frequency range 4–147 occurrences per 1 million words). These adult frequency counts accorded well with several child spoken frequency counts (kindergarten children Kolson, 1960; first grade children Moe, Hopkins & Rush, 1982). Finally, phonotactic probability reportedly is correlated with neighbourhood density (e.g. Storkel, 2004*b*). Neighbourhood density refers to the number of words that differ from a given word by a one phoneme substitution, addition, or deletion (Luce & Pisoni, 1998). Neighbourhood density was computed for the stimuli based on the HML. As expected, common sound sequences had more neighbours than rare sound sequences, and this was similar across known and novel words.

Visual stimuli

The selected CVCs were paired with unusual objects that were adapted from children's stories or invented. The objects are described in Table 1. Objects were chosen from the same semantic category in sets of four in an attempt to equate semantic and conceptual factors across the four familiarity and phonotactic probability conditions (Storkel, 2004*a*). Pairing of CVCs with objects was counterbalanced across participants.

Exposure story

Two story narratives and accompanying pictures were created to provide a context for exposure to the CVC stimuli (Storkel, 2004*a*). Story narratives are provided in the appendix. Familiarity was blocked by story such that each story contained either eight known words (four high probability and four low probability) or eight novel words (four high probability and four low probability). Assignment of known vs. novel words to story 1 vs. story 2 was counterbalanced across participants as was order of story administration. Each story consisted of three story episodes. In the first episode, each of the eight assigned stimuli occurred once. In the second episode, each of the eight assigned stimuli occurred three times. The third episode also provided three occurrences of each stimulus. Thus, the number of cumulative exposures across each episode is 1 (first episode), 4 (second episode), and 7 (third episode). Each episode began with a brief introduction that provided the name of the characters and the location, and identified the routine that would occur in the episode (e.g. hiding objects). Then, each episode incorporated the novel objects in the routine, providing exposure to the CVC-object pairs. Semantically related items were presented simultaneously, and the exposure sentences for each item were virtually identical to control syntactic and conceptual factors across the levels of the independent variables. Finally, each episode concluded with a brief statement about the outcome of the routine to introduce a consistent delay between exposure and test. A female speaker recorded four versions of each of the two story narratives to accomplish the appropriate counter-balancing of CVC-referent pairings.

Measure of word learning

Learning was assessed at five test points: 0 cumulative exposures (i.e. prior to story exposure), 1 cumulative exposure (i.e. following story episode 1), 4 cumulative exposures (i.e. following story episode 2), 7 cumulative exposures (i.e. following story episode 3), and 1 week post-exposure ($M=7$ days, S.D. $=2$ days, range $=2$–14 days). At each test point, children completed two measures of learning: referent identification and picture naming.

In the referent identification task, the child was shown three pictures of novel objects presented in the story. The child then heard one of the stimuli played over speakers and was asked to point to the picture that corresponded to the auditory stimulus. The picture choices included the target referent, a semantically related referent, and an unrelated referent. The position of the foils was randomized. Responses were scored as correct or incorrect.

In the picture-naming task, the child was shown a picture of one of the objects and was asked to name it. Responses were audio recorded, phonetically transcribed, and scored. A response was scored as correct if it contained two of the three target phonemes in the correct order.

Procedures

Each child participated in four sessions. The first session consisted of the GFTA-2, the stimuli naming probe, the stimuli picture pointing probe, and a hearing screening (ASHA, 1997). The second session consisted of administration of the first story and associated measures of learning. The third session consisted of post-exposure testing of the first story and administration of the second story and associated measures of learning. The fourth session consisted of second story post-exposure testing and administration of the PPVT-3 and the EVT.

For the word learning task, all auditory stimuli were presented via a laptop computer and table top speakers set at a comfortable listening level. Baseline testing was conducted for each stimulus prior to story exposure. For the referent identification task, children were told 'I am going to play you some words we are going to hear in our story. I want you to try to guess which picture goes with the word.' Pictures of sets of three objects were then displayed on a computer screen and an auditory stimulus was played. Children pointed to an object on the computer touch screen using a stylus. The computer recorded and scored the response. Then, the picture-naming task was administered. Children were told, 'I want you to try to guess the names of these pictures.' Pictures of each object were then displayed. For both tasks, the order of presentation of the items was determined by experimental control software (i.e. Direct RT).

After completing baseline testing, the child listened to the first story episode. Again, a software programme controlled the presentation of the auditory and visual stimuli. The introductory scene was always administered first, and the concluding scene was always administered last. The order of presentation of the remaining scenes was randomized by the computer. Following completion of the first story episode, the referent identification and picture-naming tasks were re-administered. The instructions to the child were modified from encouraging the child to guess to encouraging the child to remember the items from the story. The child then listened to the second story and completed the referent identification and picture-naming tasks again, following the same procedures. Finally, the third story episode was administered, followed by the referent identification and picture-naming tasks. The entire word learning procedure was completed in approximately 30 minutes. Throughout the procedure, children received stickers and verbal praise to encourage attention to the task.

Administration of the 1-week post-exposure referent identification and picture-naming tasks and the second story followed these same procedures.

TABLE 3. *Mean proportion correct (with standard errors in parentheses) in the referent identification and picture-naming tasks for each familiarity by phonotactic probability by exposure condition*

	Referent identification				Picture naming			
	Known words		Novel words		Known words		Novel words	
	Common	Rare	Common	Rare	Common	Rare	Common	Rare
1	0·43 (0·05)	0·43 (0·04)	0·51 (0·05)	0·38 (0·04)	0·20 (0·05)	0·09 (0·02)	0·07 (0·02)	0·03 (0·01)
4	0·51 (0·05)	0·38 (0·05)	0·48 (0·04)	0·48 (0·05)	0·23 (0·05)	0·16 (0·04)	0·05 (0·02)	0·05 (0·02)
7	0·44 (0·04)	0·44 (0·05)	0·52 (0·06)	0·48 (0·06)	0·30 (0·05)	0·23 (0·05)	0·05 (0·02)	0·02 (0·01)
post	0·47 (0·04)	0·47 (0·05)	0·53 (0·05)	0·50 (0·05)	0·38 (0·05)	0·27 (0·05)	0·09 (0·03)	0·08 (0·03)
Mean	0·46 (0·05)	0·43 (0·05)	0·51 (0·05)	0·46 (0·05)	0·28 (0·05)	0·18 (0·04)	0·07 (0·02)	0·04 (0·02)

RESULTS

Reliability

Reliability was computed for 22% of the participants. Mean consonant-to-consonant transcription reliability was 94% (S.D. = 2) for known words (i.e. GFTA-2, stimuli naming probe, and picture naming responses) and 93% (S.D. = 6) for novel words (i.e. stimuli naming probe and picture naming responses). Mean scoring reliability for picture naming was 98% (S.D. = 2). Mean procedural reliability for administration of the word learning task was 100% (S.D. = 0·4).

Participant analysis

A preliminary report of a subset of the findings from the participant analysis has been previously published (Storkel & Young, 2004). The analysis below was based on a larger sample size (i.e. 32 vs. 28) and provides a more detailed analysis of the full data set.

For each child, proportion of correct responses was computed for each measure of word learning in each familiarity by phonotactic probability by exposure condition. Table 3 shows the group means by condition. Data were analysed using a four-way ANOVA: (2) measure (referent identification vs. picture naming) × (2) familiarity (known vs. novel word) × (2) phonotactic probability (common vs. rare sound sequence) × (4) exposure (1 vs. 4 vs. 7 vs. 1-week post).

The main effect of measure was significant, $F(1, 31) = 398{\cdot}29$, $p < 0{\cdot}0001$, $\eta_p^2 = 0{\cdot}93$. Proportion correct was higher in the referent identification task

($M = 0{\cdot}46$, S.D. $= 0{\cdot}28$, SE $= 0{\cdot}05$) than in the picture-naming task ($M = 0{\cdot}14$, S.D. $= 0{\cdot}23$, SE $= 0{\cdot}04$). This is expected because the referent identification task uses a three-alternative forced-choice format whereas the picture-naming task uses an open response format. Therefore, the potential to guess the correct response in the referent identification task is higher than in the picture-naming task.

The main effect of familiarity was significant, $F(1, 31) = 5{\cdot}97$, $p < 0{\cdot}05$, $\eta_p^2 = 0{\cdot}16$. Children responded more accurately to known words ($M = 0{\cdot}34$, S.D. $= 0{\cdot}29$, SE $= 0{\cdot}05$) than to novel words ($M = 0{\cdot}27$, S.D. $= 0{\cdot}31$, SE $= 0{\cdot}05$). Thus, homonyms appeared to be learned more readily than novel words, consistent with the findings from very young children.

The main effect of familiarity was qualified by a significant interaction with measure, $F(3, 31) = 12{\cdot}12$, $p < 0{\cdot}01$, $\eta_p^2 = 0{\cdot}28$. *Post hoc* comparisons showed that responses to known words ($M = 0{\cdot}44$, S.D. $= 0{\cdot}27$, SE $= 0{\cdot}05$) were similar in accuracy to responses to novel words ($M = 0{\cdot}49$, S.D. $= 0{\cdot}28$, SE $= 0{\cdot}05$) in the referent identification task, $F(1, 31) = 0{\cdot}76$, corrected $p > 0{\cdot}70$, $\eta_p^2 = 0{\cdot}02$. In contrast, responses to known words ($M = 0{\cdot}23$, S.D. $= 0{\cdot}27$, SE $= 0{\cdot}05$) were significantly more accurate than responses to novel words ($M = 0{\cdot}05$, S.D. $= 0{\cdot}12$, SE $= 0{\cdot}02$) in the picture-naming task, $F(1, 31) = 25{\cdot}08$, corrected $p < 0{\cdot}01$, $\eta_p^2 = 0{\cdot}45$. Thus, the homonym advantage was only observed in picture naming, not in referent identification.

The main effect of phonotactic probability was significant, $F(1, 31) = 12{\cdot}43$, $p < 0{\cdot}01$, $\eta_p^2 = 0{\cdot}29$. Children responded more accurately to common sound sequences ($M = 0{\cdot}33$, S.D. $= 0{\cdot}31$, SE $= 0{\cdot}05$) than to rare sound sequences ($M = 0{\cdot}28$, S.D. $= 0{\cdot}30$, SE $= 0{\cdot}05$). This finding parallels those of past studies of preschool children, where a common sound sequence advantage has been observed in both referent identification and picture naming (Storkel, 2001, 2004*a*).

The main effect of exposure was significant, $F(3, 93) = 6{\cdot}24$, $p < 0{\cdot}01$, $\eta_p^2 = 0{\cdot}17$. *Post hoc* comparisons showed that responses at the 1-week post test ($M = 0{\cdot}35$, S.D. $= 0{\cdot}31$, SE $= 0{\cdot}05$) were significantly more accurate than responses following one exposure ($M = 0{\cdot}27$, S.D. $= 0{\cdot}28$, SE $= 0{\cdot}05$), $p < 0{\cdot}05$. The difference between 1-week post ($M = 0{\cdot}35$, S.D. $= 0{\cdot}31$, SE $= 0{\cdot}05$) and four exposures ($M = 0{\cdot}29$, S.D. $= 0{\cdot}30$, SE $= 0{\cdot}05$) approached significance, $p < 0{\cdot}07$. Taken together, response accuracy generally increased as the number of cumulative exposures increased.

No other two-way, three-way, or four-way interactions were significant, all Fs $< 2{\cdot}20$, all ps $> 0{\cdot}09$, all $\eta_p^2 < 0{\cdot}07$.

Developmental differences

The participants in this study represented a relatively wide range of ages (i.e. 40–60 months) and language abilities (i.e. percentile ranks 23rd–98th percentile on standardized language tests), suggesting the possibility that age or language ability may modify the effects of the independent variables under study. To explore this possibility, linear regression was used to examine whether age or test performance predicted the observed effects.

Mean differences in proportion correct were computed to describe the following significant main effects and interactions: measure (referent identification – picture naming), familiarity (known words – novel words), referent identification familiarity (referent identification known words – novel words), picture naming familiarity (picture naming known words – novel words), and phonotactic probability (common – rare). Note that familiarity was examined by collapsing across measures of word learning as well as separately for each measure of learning because the previously described participant analysis yielded both a main effect of familiarity as well as a significant interaction with measure. The main effect of exposure was not explored further because this effect is not central to the experimental questions. Mean difference scores were computed by first calculating the difference between the two relevant conditions when matched on other variables and then computing the mean of these differences. To illustrate, for the main effect of measure, proportion correct on the PICTURE NAMING MEASURE for high probability known words following one exposure was subtracted from proportion correct on the REFERENT IDENTIFICATION MEASURE for high probability known words following one exposure. Additional differences were computed by systematically changing familiarity, phonotactic probability, and exposure, yielding 16 difference scores. Then, the mean of these 16 difference scores was calculated. The method was similar for the other main effects and interactions.

Five backward linear regression analyses were performed (measure, familiarity, referent identification familiarity, picture naming familiarity, and phonotactic probability). In each analysis, chronological age in months, GFTA-2 raw score, PPVT-3 raw score, and EVT raw score were entered as potential predictors of the mean difference score. Only one regression analysis yielded a significant result: picture naming familiarity. Chronological age was the only significant predictor of the difference between known and novel words in picture naming, $t = 2.35$, $p < 0.05$, $r^2 = 0.16$. Figure 1 shows a scatter plot of the picture naming familiarity difference scores by chronological age in months. Positive difference scores indicate that naming of known words was more accurate than naming of novel words (i.e. homonym advantage). Scores of 0 indicate no difference, marked in the figure by a dashed reference line. Negative scores indicate that naming of known words was less accurate than naming of novel words (i.e. homonym disadvantage). The difference between known words and novel words increased as age increased, indicating that older children showed a larger homonym advantage than younger children. Follow-up regression analyses

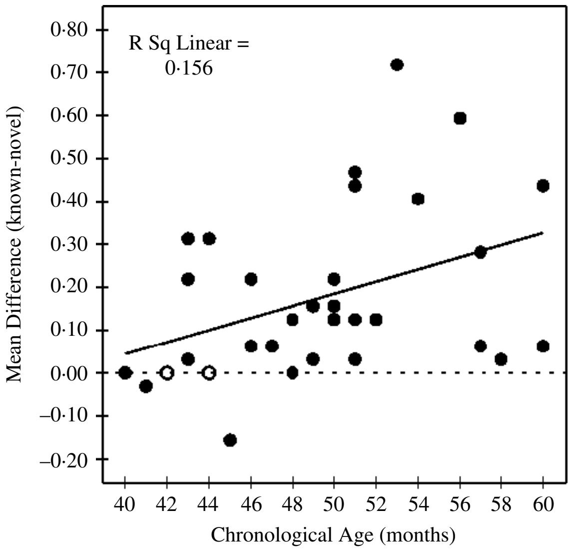

Fig. 1. Mean difference between proportion correct for the known words and proportion correct for the novel words in the picture-naming task as a function of chronological age. Positive scores indicate that naming of known words was more accurate than naming of novel words. Scores of 0 indicate no difference, marked here with a dashed reference line. Negative scores indicate that naming of known words was less accurate than naming of novel words. Open circles indicate the two children who were 0% accurate for all stimuli in the picture-naming task (i.e. floor effect).

showed that naming accuracy of known words increased as age increased, $t=2{\cdot}37$, $p<0{\cdot}05$, $r^2=0{\cdot}16$, whereas naming accuracy of novel words was relatively constant across age, $t=0{\cdot}14$, $p>0{\cdot}80$, $r^2=0{\cdot}001$.

Although the size of the homonym advantage increased with age, it is important to note that the majority of the children (26 of 32) showed a homonym advantage (i.e. positive difference score). Only 4 of the 32 children named known words and novel words with equal accuracy (i.e. difference score = 0), and two of these children failed to name any stimuli correctly (i.e. floor effect). Moreover, only 2 of the 32 children exhibited a homonym disadvantage (i.e. negative difference score). Thus, the majority of children in this age range learned homonyms more readily than novel words.

Items analysis

The participant analysis provided evidence of a significant effect of familiarity on picture-naming performance. To determine whether this homonym advantage was modified by word frequency, an items analysis

TABLE 4. *Known words that were significantly more accurate than their phonotactic probability- and semantically-matched novel word counterparts*

Exposures	Common	Rare
0		
1		
4		
7	Boat (72) Sun (112)	Dog (75)
Post	Boat (72) Sun (112)	Food (147)
Never significantly greater than matched novel word	Comb (6) Bed (127)	Goose (4) Game (123)

was completed for the picture-naming data. Performance for each known word was compared to performance for the corresponding novel word that was matched in phonotactic probability and semantic category. The relevant comparisons can be derived from the previous description of the stimuli shown in Table 1. For example, responses to the known common sound sequence /koʊm/, which was paired with a candy machine referent, were compared to the responses to the novel common sound sequence /baɪn/, which also was paired with a candy machine referent. These comparisons were completed for each exposure using McNemar's test and Bonferroni correction for multiple comparisons across exposures (i.e. five comparisons for each item). Table 4 shows the known words that were significantly more accurate than their novel word counterparts at each exposure as well as those words that were never significantly more accurate than their novel word counterparts. The word frequency of each known word is shown in parentheses (Kucera & Francis, 1967).

For the common sound sequences, the known words *boat*, with a frequency of 72, and *sun*, with a frequency of 112, were significantly more accurate than their matched novel word counterparts at the 7 exposure and post-exposure tests. In contrast, the lowest frequency known word *comb*, frequency of 6, and the highest frequency known word *bed*, frequency of 127, were never significantly more accurate than the matched novel words. Thus, for common sound sequences, mid frequency known words showed a homonym advantage, whereas low and high frequency known words did not show a homonym advantage. The same pattern was observed when the data were analysed using child spoken frequency counts (Kolson, 1960; Moe *et al.*, 1982).

For the rare sound sequences, the known words *dog*, frequency of 75, and *food*, frequency of 147, were significantly more accurate than their matched novel word counterparts at 7 exposures and post-exposure respectively. In contrast, performance for the known word *goose*, frequency of 4, and the known word *game*, frequency of 123, was never significantly different from the matched novel words. Thus, for rare sound sequences, mid-low and high frequency known words showed a homonym advantage, whereas low and mid-high frequency known words did not show a homonym advantage. The same pattern was observed when the data were analysed using child spoken frequency counts (Kolson, 1960; Moe *et al.*, 1982).

To summarize, the relationship between the frequency of the known word and a significant homonym advantage in word learning was not all-or-none. The lowest frequency known words *comb* and *goose* did not show a homonym advantage, suggesting that low frequency words may not induce a facilitory effect of homonym learning. However, higher frequency words (i.e. *bed* and *game*) also failed to show a homonym advantage, indicating that higher frequency alone does not guarantee a facilitory effect of homonym learning. This pattern indicates that a certain frequency may be necessary to induce a homonym advantage (i.e. frequency >6), but crossing this frequency threshold may not be sufficient to ensure a homonym advantage.

DISCUSSION

The primary goal of this study was to examine the effect of homonymy on word learning when learning was measured using a task that emphasized semantic representations (i.e. referent identification) vs. a task that emphasized lexical representations (i.e. picture naming). A secondary goal was to investigate the role of form characteristics in homonym learning by examining the effects of phonotactic probability and word frequency. Results showed that children learned known words and novel words at an equivalent rate when learning was measured by a referent identification task, whereas known words were learned more rapidly than novel words (i.e. homonym advantage) when learning was measured by a picture-naming task. The size of this homonym advantage in picture naming increased as age increased. In addition, phonotactic probability influenced learning with common sound sequences being learned more rapidly than rare sound sequences. Finally, the influence of word frequency was less clear. A homonym advantage was not observed for the lowest frequency known words, suggesting that there may be a word frequency threshold for inducing this effect; however, higher frequency known words also failed to show a homonym advantage, indicating that word frequency may not be the only factor governing the homonym advantage. The implications of each these findings will be considered.

Familiarity

The findings of this study help to reconcile previous controversy concerning the effect of homonymy on word learning. Studies that measure word learning in tasks that emphasize referent learning find a disadvantage for homonym learning as compared to novel word learning when both meanings of the homonym are presented as response choices (Mazzocco, 1997; Mazzocco *et al.*, 2003; Doherty, 2004). The results of this study replicate those of Doherty (2004) by demonstrating that this disadvantage for homonym learning in receptive tasks is minimized or eliminated when only one meaning of a homonym is presented as a response choice. Furthermore, the current study also measured word learning in an expressive task emphasizing lexical representations and found an advantage for homonym learning over novel word learning.

Taken together, these findings suggest that difficulty with homonyms is not likely due to a preference for a one-to-one mapping between form and meaning. If children did prefer unique mappings, then we would expect a consistent negative effect of homonymy across word learning tasks because this bias would always be operative. Instead, the effect of homonymy varies depending on how word learning is measured. The disadvantage for homonym learning reported in previous studies may be attributable to task demands with poor performance only being observed in tasks that require inhibition of the primary meaning of the homonym. Moreover, the ability to alternate between meanings of a homonym appears to improve with age and is correlated with the ability to perform other complex tasks (e.g. Doherty, 2000). Thus, the previously reported homonym disadvantage appears to be related to the ability to alternate between old vs. new semantic representations and/or task complexity, rather than to an inherent preference for a one-to-one mapping between form and meaning.

These findings are consistent with the hypothesis that there is less new information to be learned for homonyms than for novel words. Learning a homonym requires the creation of a new semantic representation and associating that new semantic representation with a known lexical representation. In contrast, learning a novel word requires the creation of a new semantic representation and associating the new semantic representation with a newly created lexical representation. Thus, both types of words require creation of a new semantic representation. This similarity yields equivalent performance in tasks where performance is dependent on the new semantic representation. In contrast, learning a homonym does not require creation of a lexical representation, whereas learning a novel word does. This difference yields a homonym advantage in tasks where performance is dependent on the known (i.e. homonym) vs. new lexical representation (i.e. novel word).

What remains to be learned is whether a homonym disadvantage, no effect, or a homonym advantage would be observed in naturalistic word learning. That is, do children frequently encounter both meanings of a homonym at the same time? Others have argued that it is unlikely that children would encounter both meanings of a homonym in tandem because the two meanings are not likely to be appropriate in the same context (Kohn & Landau, 1990; Doherty, 2004). Likewise, when both meanings are present, parents tend to supply additional information to help children differentiate the two meanings of the homonym (Kohn & Landau, 1990). Given this, we predict that in naturalistic learning there would be no difference between learning the secondary meaning of a homonym and learning a novel word in receptive tests emphasizing semantic representations and that there would be an advantage for homonym learning over novel word learning in expressive tests emphasizing lexical representations. This hypothesis warrants further investigation.

Developmental differences

Visual inspection of the scatter plot provided evidence that the majority of children in this study exhibited a homonym advantage for measures of word learning emphasizing lexical representations (i.e. picture naming). Only a minority of children showed no difference between homonym and novel word learning or a homonym disadvantage. Our finding of a homonym advantage also is consistent with studies of young children learning the first 50 words where children appear to alter production of novel words to create homonyms. Thus, the homonym advantage appears to be relatively consistent across this age range.

A caveat to this claim of a consistent homonym advantage across ages is that the homonym advantage appeared to increase over the 3;4–5;0 period due to an improvement in homonym learning in the face of relatively stable novel word learning. This improvement in homonym learning can not be attributed to changes in the ability to create new semantic representations. Any change in the ability to create a new semantic representation should affect homonyms and novel words equivalently because learning of both types of words requires the formation of a new semantic representation. One remaining difference between homonyms and novel words is that the lexical representation is known for homonyms but unknown for novel words. Thus, changes in known lexical representations may lead to changes in homonym learning but not novel word learning. In fact, it has been suggested previously that children's lexical representations may change from holistic to segmentally detailed during this age range (e.g. Metsala & Walley, 1998; Storkel, 2002). If true, this change in lexical representations may have consequences for homonym learning in that known segmentally detailed lexical representations, as hypothesized for older children, may have a stronger influence on word learning than known holistic lexical representations, as hypothesized for younger children.

Phonotactic probability

Phonotactic probability appeared to influence homonym learning, suggesting that form characteristics can affect word learning even when the form is known. This effect of form characteristics could occur either during learning or during testing of learning. During learning of the homonym, phonotactic probability may facilitate recognition of the known lexical representation or may facilitate retention of the form in working memory (e.g. Gathercole, Frankish, Pickering & Peaker, 1999; Vitevitch & Luce, 1999). Facilitation of either of these processes would allow greater resources to be devoted to creating a new semantic representation and an association between this semantic representation and the existing lexical representation. Phonotactic probability could also facilitate performance in the picture-naming task used to measure word learning. Vitevitch, Armbruster & Chu (2004) demonstrated that reaction times in picture naming were faster for common known sound sequences than rare known sound sequences. In this way, phonotactic probability may facilitate performance in the naming task. It is also possible that phonotactic probability may have affected both learning and picture naming. Further study is needed to more fully understand the specific mechanism accounting for this common sound sequence advantage in homonym learning.

Word frequency

The influence of word frequency on homonym learning was less straightforward. For both common and rare sound sequences, the lowest frequency known words were never significantly more accurate than their phonotactic-probability- and semantically-matched novel word counterparts. This suggests that the known lexical representation of very low frequency words may not facilitate word learning, and thus learning of these words may be highly similar to learning of novel words. The lexical representation of these lowest frequency words may not be as stable, detailed, or accessible as that of words with higher frequency, resulting in minimal facilitation in homonym learning relative to novel word learning. Counter to this claim, several relatively higher frequency words also were never significantly more accurate than their matched novel word counterparts. Therefore, the lack of a difference between homonym learning and novel word learning can not be solely attributable to word frequency effects. One tentative hypothesis is that a certain level of word frequency may be necessary to induce a homonym advantage but may not be sufficient to guarantee a homonym advantage. Further exploration of the influence of word frequency on homonym learning is warranted based on these preliminary findings.

CONCLUSION

Results of this study provide evidence that homonym learning is similar to novel word learning when learning is measured by tasks emphasizing semantic representations. In contrast, homonym learning appears to facilitate word learning when learning is measured by tasks emphasizing lexical representations. This homonym advantage in expressive tasks was observed for the majority of the participants, but the size of the homonym advantage increased with age. This increase in the difference between homonym and novel word learning appeared to be attributable to improved performance for homonym learning, indicating that age-related changes in lexical representations may account for developmental changes in homonym learning. Moreover, phonotactic probability influenced homonym learning. It was hypothesized that phonotactic probability may affect the recognition of the known lexical representation and/or the retention of the form in working memory during learning, or could affect the retrieval of the lexical representation during testing. Word frequency results indicated that very low frequency words may not produce a homonym advantage, although further investigation is warranted in this area because the relationship between word frequency and the homonym advantage was not straightforward.

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APPENDIX

STORY 1 SCRIPT

Episode 1

[Picture 1] Mom and dad were at work. Big brother had to take care of little sister. Little sister was crying. Big Brother said, 'I'll take you to the park if you stop crying.'

[Picture 2] Big Brother said, 'We can go to the candy machines at the park. My favourite is the *candy 1 word*.' Little Sister said, 'My favourite is the *candy 2 word*.' [Picture 3] Little Sister asked, 'Can we bring some toys?' Big Brother said, 'Yes, I'm bringing my *toy 1 word*.' Little Sister said, 'I'm bringing my *toy 2 word*.' [Picture 4] Big Brother said, 'We can play music at the park. I'm taking my *horn 1 word*.' Little Sister said, 'I'm taking my *horn 2 word*.' [Picture 5] Little Sister asked, 'What about the pets?' Big Brother said, 'We'll take them with us. I'll get *pet 1 word*.' Little Sister said, 'I'll get *pet 2 word*.'

[Picture 6] 'Let's go!' said Big Brother. 'Yeah!' said Little Sister. They ran all the way to the park. What will they do at the park?

Episode 2

[Picture 1] Big Brother and Little Sister were swinging. Big Brother said, 'I can go higher than you!' Big Brother went very high. Little Sister said, 'I can go higher than that.' Big Brother pushed her very high.

[Picture 2] Little Sister said, 'I can play music louder than you.' Big Brother said, 'No you can't. Listen to me blow my *horn 1 word*.' He blew his *horn 1 word*. 'See how loud my *horn 1 word* is?' Little Sister said, 'Oh, yeah? Listen to me blow my *horn 2 word*.' She blew her *horn 2 word*. 'See how loud my *horn 2 word* is?' [Picture 3] Big Brother said, 'I can eat more candy than you.' Big Brother ran to the *candy 1 word*. He got candy from the *candy 1 word*. He stuffed all the candy from the *candy 1 word* in his mouth. 'Can you eat that much?' Little Sister ran to the *candy 2 word*. She got candy from the *candy 2 word*. She stuffed all the candy from the *candy 2 word* in her mouth. Then, they got more candy for later. [Picture 4] Little Sister said, 'I can make our pets do more tricks than you.' Big Brother said, 'Uh-uh.' Big Brother made *pet 1 word* do tricks. He made *pet 1 word* roll-over. He made *pet 1 word* jump up and down. Next, it was Little Sister's turn. Little Sister made *pet 2 word* do tricks. She made *pet 2 word* roll-over. She made *pet 2 word* jump up and down. [Picture 5] Big Brother said, 'I can hit more rocks with my toy than you.' Big Brother set up the rocks. Big Brother got out his *toy 1 word*. He pointed the *toy 1 word* at the rocks. He hit a rock with his *toy 1 word*. Little Sister put the rock back. Little Sister got out her *toy 2 word*. She pointed the *toy 2 word* at the rocks. She hit a rock with her *toy 2 word*.

[Picture 6] Big Brother looked at his watch. 'It's time to go home.' They walked home hand in hand. What will they play when they get home?

Episode 3

[Picture 1] Big Brother and Little Sister were playing hide n' seek in the back yard. Little Sister was hiding. Big Brother was trying to find her. 'Where's Little Sister?' There she is, behind the tree!

[Picture 2] Big Brother said, 'Let's hide our pets. I'll hide *pet 1 word*. Don't make any noise *pet 1 word*. I bet you won't be able to find *pet 1 word*!' Little Sister looked and looked. 'Here he is!' Little Sister said, 'I'll hide *pet 2 word*. Don't make any noise *pet 2 word*. I bet you won't be able to find *pet 2 word*!' Big Brother looked and looked. 'I found him.' [Picture 3] Little Sister said, 'Let's hide the horns.' Big Brother blew the *horn 1 word*. Then, he hid the *horn 1 word* behind a rock. Where's the *horn 1 word*? 'I see it!' said Little Sister. Little Sister blew the *horn 2 word*. Then, she hid the *horn 2 word* behind a tree. Where's the *horn 2 word*? 'I got it!' said Big Brother. [Picture 4] Big Brother said, 'Let's hide the toys.' Big Brother looked for a place to hide his *toy 1 word*. He found a good hiding place for his *toy 1 word*. No one will be able to find the *toy 1 word*. Little Sister looked and looked. She yelled, 'Here it is!' Little Sister looked for a place to hide her *toy 2 word*. She found a good hiding place for her *toy 2 word*. No one will be able to find the *toy 2 word*. Big Brother looked and looked. He yelled, 'Here it is!' [Picture 5] Little Sister said, 'Let's eat our leftover candy before mom and dad come home.' Big Brother got his candy from the *candy 1 word*. He ate all his candy from the *candy 1 word*. 'Mmm,' he said, 'the candy from the *candy 1 word* is really good.' Little Sister got her candy from the *candy 2 word*. She ate all her candy from the *candy 2 word*. 'Mmm,' she said, the candy from the *candy 2 word* is really good.'

[Picture 6] Just then mom and dad came home. 'It's time to come inside now,' said mom. 'We need to make dinner.' Little Sister cried again.

STORY 2

Episode 1

[Picture 1] Mary and Joe crocodile were getting ready to go to school. Today was a big day. It was show & tell day. Joe couldn't decide what to bring for show & tell. Mary said, 'I'll help!'

[Picture 2] Mary said, 'We can stop at the candy machines on the way to school. My favourite is the *candy 4 word*.' Joe said, 'My favourite is the *candy 3 word*.' [Picture 3] Joe asked, 'Can we bring some toys.' Mary said, 'Yes, I'm bringing my *toy 4 word*.' Joe said, 'I'm bringing my *toy 3 word*.' [Picture 4] Mary said, 'We can play music at show & tell. I'm taking my *horn 4 word*.' Joe said, 'I'm taking my *horn 3 word*.' [Picture 5] Joe asked, 'What about our pets?' Mary said, 'We'll take them with us. I'll get *pet 4 word*.' Joe said, 'I'll get *pet 3 word*.'

[Picture 6] 'Let's go!' said Mary. 'Yeah!' said Joe. They climbed in the car to go to school. What will happen at show and tell?

Episode 2

[Picture 1] Mary and Joe were at school. It was time for show & tell. Mary said, 'All the kids are going to like my show & tell things better than yours.' Joe said, 'No they won't. The kids will like what I brought better than what you brought.' Mary said, 'Well we'll see about that.'

[Picture 2] Joe said, 'I can play music very loud.' Mary said, 'So can I. Listen to me blow my *horn 4 word*.' She blew her *horn 4 word*. 'See how loud my *horn 4 word* is?' Joe said, 'Oh, yeah? Listen to me blow my *horn 3 word*.' He blew his *horn 3 word*. 'See how loud my *horn 3 word* is?' [Picture 3] Mary said, 'I have the best candy.' Mary pulled out her candy from the *candy 4 word*. 'See my candy from the *candy 4 word*.' She stuffed all the candy from the *candy 4 word* in her mouth. Joe said, 'Mine is better than that.' Joe pulled out his candy from the *candy 3 word*. 'See my candy from the *candy 3 word*.' He stuffed all the candy from the *candy 3 word* in his mouth. [Picture 4] Joe said, 'My pet does more tricks than yours.' Mary said, 'Uh-uh.' Mary made *pet 4 word* do tricks. She made *pet 4 word* roll-over. She made *pet 4 word* jump up and down. Next, it was Joe's turn. Joe made *pet 3 word* do tricks. He made *pet 3 word* roll-over. He made *pet 3 word* jump up and down. [Picture 5] Mary said, 'I can hit more rocks with my toy than you.' Mary set up the rocks. Mary got out her *toy 4 word*. She pointed the *toy 4 word* at the rocks. She hit a rock with her *toy 4 word*. Joe put the rock back. Joe got out his *toy 3 word*. He pointed the *toy 3 word* at the rocks. He hit a rock with his *toy 3 word*.

[Picture 6] Show & tell was over. All the kids had a really great time. Mary was mad at Joe so she hid all the things Joe brought for show & tell. Joe was mad at Mary so he hid everything Mary brought. Will Mary and Joe be able to find all the things they brought for show & tell?

Episode 3

[Picture 1] School was over and it was time to go home. Mary and Joe couldn't find all the things they brought for show & tell. Where are all the fun things they brought from home?

[Picture 2] Mary said, 'Where are the pets? I can't find *pet 4 word*. Please make some noise *pet 4 word*. I hope I am able to find *pet 4 word*.' Mary looked and looked. 'Here he is!' Joe said, 'I can't find *pet 3 word*. Please make some noise *pet 3 word*. I hope I am able to find *pet 3 word*.' Joe looked and looked. 'I found him!' [Picture 3] Joe said, 'What happened to the horns?' Mary said, 'Where's my *horn 4 word*?' She found the *horn 4 word* behind a rock. Mary blew the *horn 4 word*. She was so glad she found it. Joe said, 'Where's my *horn 3 word*?' He found the *horn 3 word* behind a tree. He blew the *horn 3 word*. Joe was happy he found it. [Picture 4] Mary said, 'Where are the toys?' Mary looked and looked for her *toy 4 word*. Where would be a good hiding place for the *toy 4 word*? 'I hope I can find the *toy 4 word*.' Mary looked very hard. She yelled, 'Here it is!' Joe looked and looked for his *toy 3 word*. Where would be a good hiding place for the *toy 3 word*? 'I hope I can find the *toy 3 word*.' Joe looked very hard. He yelled, 'Here it is!' [Picture 5] Joe asked, 'What happened to the candy?' Mary looked for her candy from the *candy 4 word*. She said, 'The candy from the *candy 4 word* is really good. Oh, no! I ate all my candy from the *candy 4 word*.' Joe looked for his candy from the *candy 3 word*. He said, 'The candy from the *candy 3 word* is really good. Oh, no! I ate all my candy from the *candy 3 word*.'

[Picture 6] Just then mom and dad drove up. 'It's time to go home now,' said mom. 'How was show & tell?' Mary and Joe agreed, it was great!

(*Note*.) Story order (1 vs. 2) was counterbalanced across participants. Within a story episode, the order of presentation of pictures 2–5 and the corresponding narrative was randomized by a computer and experimental control software (Direct RT).