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Variability in word learning: Phonological sensitivity and phonological memory

Marnie E. Arkenberg
University of Nebraska at Omaha

VARIABILITY IN WORD LEARNING:

PHONOLOGICAL SENSITIVITY AND PHONOLOGICAL MEMORY

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Marnie E. Arkenberg

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THESIS ACCEPTANCE

Acceptance for the faculty of the Graduate College, University of Nebraska, in partial fulfillment of the requirements for the degree Master of Arts, University of Nebraska at Omaha

Committee

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VARIABILITY IN WORD LEARNING:

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Marnie E. Arkenberg, MA

University of Nebraska, 2001

Advisor: Dr. Brigette O. Ryalls

Presently, investigators believe that variability in children's word learning results from individual differences in one of two separate processes thought to underlie word learning: phonological sensitivity or phonological memory. Traditionally, researchers have viewed differences in children's vocabularies as being the result of differences in either phonological memory or phonological sensitivity. However, there is reason to believe that a different type of relation exists among phonological sensitivity, phonological memory, and vocabulary. The purpose of this investigation was to determine the nature of these relations in preschoolers. Three hypotheses were presented: either phonological memory or phonological sensitivity plays a larger role in word learning, phonological sensitivity and phonological memory both are important variables underlying differences in vocabulary learning, but each variable exerts the bulk of its influence at different points in development, or a mediated relation exists among phonological sensitivity, phonological memory, and word knowledge. Results were in partial support of Hypotheses I and II: a main effect of phonological sensitivity was found, while an age by phonological memory interaction was observed. No support was found for Hypothesis III.

Acknowledgements

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Children face a number of cognitive tasks during the first several years of life. One of these tasks is language learning. Although children must learn a number of different skills to become competent language users, most children acquire language almost effortlessly, and in a relatively short period of time, moving from a state of having little linguistic knowledge to becoming proficient language users in just a few years (Hoff-Ginsberg, 1997). The rate at which children acquire language is generally presented in terms of norms that specify the average age children typically acquire linguistic competencies (Goldberg & Reznick, 1990; Ingram, 1989). In addition, language learning is typically portrayed as a straightforward progression, with individuals following a similar sequence and a similar timetable for each linguistic milestone (Carroll, 1994). In reality, the rate of language learning can vary drastically from child to child with some children developing language very quickly and others lagging behind their peers (Ingram, 1989).

Learning one's language involves becoming competent in a number of subdomains. Children must learn which sounds are important in their native language, they must learn how these sounds combine to make words that follow legal patterns for that language, and they must learn how words are combined in a way that results in grammatical phrases and sentences (Gleitman, 1994). Variability in children's language acquisition may result from differences in children's abilities in any one, or many, of these subdomains (Ingram, 1989). In addition, variability may be the result of individual differences in more general information-processing abilities, such as differences in speed of processing or short-term memory capacity (Ashcraft, 1989). The purpose of the present study was to investigate variability in one subdomain of language acquisition: word learning.

Several investigators have evidenced large variability in vocabulary acquisition and have suggested that these differences are the result of differences in abilities underlying vocabulary learning (Adams & Gathercole, 1996; Gathercole & Baddeley, 1993). From the glut of possible processes thought to underlie word learning, two of these have been emphasized in the current literature and are the subject of the present investigation. These are phonological short-term memory capacity (Baddeley, Gathercole, & Papagno, 1998; Bowey, 1996; Gathercole, & Baddeley, 1990b; Gathercole, Hitch, Service, & Martin, 1997; Lonigan, Burgess, Anthony, & Barker, 1998), and phonological sensitivity (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Bowey, 1996; Braine, 1994; Gathercole & Baddeley, 1990b; Snowling, Chait, & Hulme, 1991; Snowling, Goulandris, Bowlby, & Howell, 1986).

Phonological Memory

Most researchers contend that memory is an important variable in language learning (e.g. Braine, 1994; Gathercole & Baddeley, 1990b). According to Slobin (1973), because spoken language is temporal in nature, memory is a critical prerequisite for its development. Thus, the ability to perceive under temporal conditions is central to a child's ability to comprehend and produce language (Kirchner & Klatzky, 1985). Children must have adequate working memory systems so they can attend to speech input, construct mental representations of this input, recall phonological information stored in long-term memory, and assimilate new phonological information (Gillam, 1997; Gillam, Cowan, & Marler, 1998), tasks imperative for speech production (Adams & Gathercole, 1995; 1996), comprehension (Bowey, 1996; Gathercole & Baddeley, 1989), and novel word learning (Baddeley, Gathercole, & Papagno, 1998; Gathercole & Baddeley, 1989; 1990b; Gathercole, Hitch, Service, & Martin, 1997; Gathercole, Service, Hitch, Adams, & Martin, 1999).

Baddeley (1986) has suggested that the human memory system is ideally constructed for dealing with phonological information in working memory. In his theory, working memory is constructed of three main components: a central executive which performs all mental operations, a visuospatial sketchpad that holds short term iconic information, and a phonological loop consisting of a phonological store that keeps phonological information in queue, and a rehearsal mechanism that keeps this phonological information active. Baddeley, et al. (1998) have suggested that the phonological loop evolved for language learning, specifically the learning of novel words. As phonological information enters short-term memory, a memory trace of this information is stored in the phonological loop. The phonological loop performs both the task of recruiting previously stored phonological information from long-term memory that is used to supplement decoding of novel material, and the task of holding novel phonological information in short-term memory until that information can be incorporated into one's existing long-term phonological store. Word learning is thought to be dependent on the child's ability to hold phonologically intact information until that information can be assimilated into the child's lexical store.

It has been suggested that variability in word learning may result from differences in children's capacity to hold information in the phonological loop. Gathercole and Baddeley and colleagues (Baddeley, et al., 1998; Gathercole & Baddeley, 1990a; 1990b; Gathercole, et al., 1997) suggest that differences in children's rate of vocabulary development can be explained, in part, by differences in their short-term memory capacity, specifically in the capacity of the phonological loop. To illustrate, Adams and Gathercole (1995) examined the association between phonological memory and spontaneous spoken language in normal 3-year-old children. They found that children who produced higher scores on auditory digit span and nonword repetition indices produced significantly more and varied speech output than did preschoolers with lower memory scores. In particular, higher-scoring children tended to have larger expressive lexicons and tended to produce a greater number of words per utterance. The authors suggested that these results clearly indicated an association between phonological memory and expressive vocabulary. In a similar investigation, Gathercole and Baddeley (1990a) looked at the ability to learn familiar or unfamiliar names of toys in children with differing nonword repetition scores. In this study it was found that children who scored lower on the nonword repetition task learned significantly fewer unfamiliar toy names than did children with higher nonword repetition scores. These children did not, however, vary in their ability to learn toys with familiar names. To explain this pattern of results, the authors suggested that phonological memory is not only linked to, but may also assist in the learning of phonologically unfamiliar items. Children with poor phonological memory may be unable to store transient phonological representations of unfamiliar words. Thus, they may have difficulty constructing stable representations of these words to store in long-term memory (Gathercole, Willis, & Baddeley, 1991).

In another study, Gathercole, et al. (1997) examined the association between phonological loop capacity and the rate of learning unfamiliar phonological material in 5-year-olds. In this research, digit-span and nonword repetition scores were obtained, and were correlated with the rates of word-word and word-nonword pair learning. A high degree of association was found between scores on the short-term memory tasks and the rate of learning word-nonword pairs. This relation was not found for word-word pairs, suggesting that the learning of new words is independent of learning of familiar word pairs, and that this learning is constrained by the capacity of the phonological loop. Children make use of both new information held in the phonological loop and any existing information stored in long-term memory (Snowling, et al., 1986). When existing knowledge is not available to aid in new word learning, then children must rely on the phonological loop alone. Long-term storage of unfamiliar sound structures (phonologically unfamiliar words) is dependent on the representations of these sound structures in the phonological loop. The phonological loop, then, is critical in maintaining intact phonological information for the construction of more permanent mental representations (Baddeley, et al., 1998). This theory implies that the ability to learn new words is constrained by the ability to hold intact phonological information in the phonological loop until that information is ready for long-term storage. Decay or degradation of this phonological information can inhibit word learning because information stored in long-term memory will consist of inaccurate representations

(Adams & Gathercole, 1996). Thus, any information recruited from long-term memory to aid in the learning of phonologically novel items will be of little use and children will need to rely on the phonological loop alone. Furthermore, if novel information exceeds the capacity of the phonological loop, some information pertinent to forming accurate phonological representations will be unavailable, thus hampering the acquisition of new lexical items (Gathercole & Baddeley, 1990b). These findings, then, suggest that the rate of vocabulary acquisition is dependent on one's phonological loop capacity.

Phonological Sensitivity

Phonological short-term memory capacity may not be the only factor involved in the learning of new words. Several investigators contend that phonological sensitivity also plays a major role in word acquisition (Bowey, 1996; Snowling, et al., 1986; 1991). Stanovich (1992) defines phonological sensitivity as sensitivity to speech sounds. This ability is thought to arise from perceiving the speech of one's native language (Fowler, 1991). That is, knowledge of the sound patterns used in one's language is gained through linguistic experience. It is the sensitivity to phonological structure gained through perceiving the speech of one's native language that allows for word learning (Werker & Tees, 1999). Word learning is thought to require the ability to identify and store the sounds, and units of sound, important in one's language. Myers, et al. (1996) suggest that the ability to segment words from fluent speech depends on children's knowledge of the sounds and sound structure important in one's language. Jusczyk (1993) has developed a model, called the Word Recognition and Phonemic Structure Acquisition Model, to account for these tasks. In this model it is proposed that as speech enters the auditory system, children perform a preliminary analysis on this input to extract basic properties from the signal. These properties are weighted in terms of their importance in determining meaningful distinctions in the child's native language, with weighting amounting to directing attention to certain properties in the speech signal. The resulting weighting scheme that develops is appropriate only for that language for which that scheme was derived. The weight assigned to different acoustic properties changes as children gain experience with their native language (Eilers & Oller, 1976; Nittrouer, Manning, & Meyer, 1993), moving from initial emphasis on dynamic properties to emphasis on the acoustic features of the signal that are most informative for making phonemic discriminations. The result of this refinement of phonemic categories is increased phonemic sensitivity. In other words, featural refinement affords the ability to make more accurate discriminations between phonemes with similar but distinct sound units (Archangeli, 1988; Bird & Bishop, 1992; Gierut, 1996).

It has been posited that the ability to discriminate phonological units accurately may play a role in word learning (Snowling, et al., 1986). As children gain experience with their native language, they are developing a database of frequently occurring and acceptable sounds and phonetic combinations for that language (Jusczyk & Hohne, 1997). This knowledge is thought to enable children to construct stable representations of new words by allowing them to infer whether an unfamiliar sound pattern can be a word in their language (Gathercole, et al., 1997). Jusczyk, Luce, and Charles-Luce (1994) have shown that sensitivity to the phonological structure of one's native language is, in fact, an important factor in word learning. These authors demonstrated that young children favor listening to phonological combinations familiar in one's native language over phonological combinations that are unfamiliar. In their study, 9-month-old children were presented with either nonwords with phonological combinations familiar in their native language, or nonwords with unfamiliar phonological combinations. Using a head turn preference procedure, it was shown that infants clearly preferred listening to nonwords with familiar phonological combinations, as evidenced by significantly longer fixation times for nonwords with familiar phonology compared to nonwords with unfamiliar phonological combinations. The authors concluded that even young children appear to prefer speech that contains phonologically familiar information, that infants have learned some sounds and sound combinations are more important in one's native language than are others, and that this phonological information can serve as a basis for what children will consider as possible words in their language (Jusczyk, et al., 1993). Gathercole, Frankison, Pickery, and Peaker (1999) extended this work by investigating the recall of unfamiliar lexical items with either high frequency or low-frequency phonological combinations in 7- and 8-year-olds. They found significantly better recall for nonwords containing high-frequency phonological combinations compared to nonwords with low-frequency combinations. In sum, phonological knowledge appears to plays an important role in the learning of new lexical items.

Researchers have also suggested that individual differences in vocabulary acquisition may arise due to differences in the underlying representations of phonologically familiar lexical units (Gathercole, et al., 1991; Gathercole, Willis, Emslie, & Baddeley, 1992; Snowling, et al., 1991). Unfortunately, while this suggestion has been proposed, it has not been fully tested. Preliminary work is suggestive that this contention may be a plausible one however. To illustrate, Bowey (1996) has performed some research investigating the role of phonological sensitivity on individual differences in vocabulary learning. In her research, Bowey investigated the relation between phonological memory and vocabulary learning, and phonological sensitivity and vocabulary learning, in normally developing 5-year-olds. Using the traditional nonword repetition task to assess phonological memory capacity, and a rhyming task to measure phonological sensitivity, she found that both phonological sensitivity and phonological memory contributed a significant proportion of the variance in receptive vocabulary. That is, each factor added additional explained variance above and beyond age. These results suggest that phonological sensitivity can explain some of the variance in school-age children's vocabularies. Gathercole, et al. (1991), however, found conflicting evidence in their study of 7- and 8-year-old children; in their investigation phonological sensitivity did not account for a significant proportion of the variance in the learning of nonwords. One possibility for the discrepancy between these studies is that phonological sensitivity may exert the majority of its influence on vocabulary learning at an earlier point in development. That is, the discrepancy between these studies could be the result of having used children of different ages, and hence different linguistic abilities. Jusczyk and colleagues' work described above suggests that phonological sensitivity is an important factor in word learning in very young children, implying that differences in phonological sensitivity may serve to account for a significant proportion of the variance between young children's lexicons.

Individual Differences: Phonological Memory or Phonological Sensitivity

The above research indicates that both differences in phonological sensitivity and phonological memory may account for some of the variance in vocabulary knowledge. The nature of the relation between these variables, however, remains unclear. For example, some researchers have argued phonological memory is more important for word learning than is phonological sensitivity. To refresh, in their study investigating the contribution of phonological memory and phonological sensitivity on the ability to learn novel names of familiar objects, Gathercole et al. (1991) observed that after controlling for general intelligence, nonword repetition scores contributed more unique variance to novel word learning than did scores on a rhyme oddity task, suggesting that phonological memory plays a larger role in novel word learning than does phonological sensitivity. Other researchers contend that both phonological sensitivity and phonological memory account for the variability in vocabulary acquisition, but that neither variable provides a unique contribution above and beyond the other. For example, in a study aimed at replicating the results of Gathercole et al. (1991), Bowey (1996) found no significant difference in the amount of variance explained by phonological memory and phonological sensitivity.

Another possible scenario is that phonological memory and phonological sensitivity exert the majority of their influence at different points in language development. To some extent there is evidence suggesting such a relation. For instance, in a longitudinal study, Gathercole, et al. (1992) investigated the causal underpinnings of the relation between phonological memory and vocabulary development. These authors compared the relation between children's ability to learn new lexical items and their previous vocabulary knowledge, or their phonological memory, as measured by nonword repetition in 4-, 5-, 6-, and 8-year-olds, using cross-lagged partial correlations. The authors found that for 4- and 5-year-olds phonological memory best predicted the learning of new vocabulary items, while for 6- and 8-year-olds previous vocabulary knowledge was a better predictor of new word leaning. The authors explained these results by suggesting that age-related changes in phonological memory capacity are responsible for individual differences in vocabulary learning in 4- and 5-year-old children. However, as phonological loop capacity reaches mature levels, differences in this underlying ability decrease, and individual differences in vocabulary acquisition can no longer be best described in terms of differences in phonological memory capacity. That is, as children age, there is an increasing shift in the ability to describe individual differences in vocabulary acquisition in terms of differences in previously stored lexical information rather than in terms of phonological loop capacity. It is suggested by this finding that there is a shift in the amount of influence exerted by different variables at different points in language learning. This research, coupled with Jusczyk and colleague's work indicating that phonological sensitivity is an important variable in word learning in very young children, not only suggests that phonological sensitivity may be important for word learning in young children, but also lends to the suggestion that there might be a developmental trend in the effects of phonological sensitivity on word learning, and that the relations among phonological memory, phonological sensitivity, and word learning may change over time.

Finally, other research is suggestive of perhaps a different type of relation among phonological loop capacity, phonological sensitivity, and vocabulary knowledge. Phonological memory and phonological sensitivity may not be separate subsystems at all, but rather, a mediational relation may exist among these variables. While researchers have not systematically examined this possibility, this type of relation is quite feasible. For example, Gathercole, Baddeley, and colleagues have consistently used a nonword repetition task to investigate the effects of phonological memory capacity and phonological sensitivity on word learning (Bowey, 1996; Snowling, et al., 1991). In studies that have used this method, the authors have consistently found that while phonological memory capacity explained a significant proportion of the variance in word learning, phonological sensitivity did not (Baddeley, et al., 1998; Adams & Gathercole, 1995; Gathercole & Baddeley, 1990a; 1990b; Gathercole, et al., 1997). In mediated relations, only the variable that exerts direct influence on the criterion variable is seen as contributing a unique proportion of the variance in explaining that dependent variable. In terms of phonological sensitivity and phonological memory on individual differences in vocabulary development, one would expect that if phonological memory does mediate phonological sensitivity, then phonological memory would explain a significant proportion of the variance in vocabulary development while phonological sensitivity would not, but that phonological sensitivity would predict a significant proportion of the variance in phonological memory. As evidenced above, research has supported the former part of this claim: phonological memory does account for some of the variance in vocabulary development. The latter claim has yet to be tested. However, Snowling, et al.

(1991) have hinted at this type of relation. They claim that traditional methods for examining phonological memory rely on children's phonological sensitivity. That is, performance on nonword repetition tasks depends on adequate speech perception and adequate construction of phonological representations as well as sufficient short-term memory capacity. Snowling, et al. suggest that differences in any one of these domains can result in poor memory performance, and that the role of phonological memory in vocabulary acquisition may be affected by phonological knowledge; short-term retention of words may depend on the recollection of previously stored, intact, phonological, lexical, and semantic representations. In particular, familiarity with the phonetic structure of words in one's native language may be especially salient to the formation and retention of adequate phonological representations of new words with familiar units in short-term memory (Gathercole & Baddeley, 1993; Gathercole, et al., 1992). Bowey (1996) has also suggested that phonological sensitivity is an important factor underlying vocabulary acquisition, and that differences in phonological memory capacity may simply be a reflection of some more underlying differences in children's sensitivity to phonological structure. Thus, one conclusion from these claims is that phonological memory may, in fact, have a mediating effect on phonological sensitivity.

In sum, a number of possibilities exist concerning the relation among phonological memory, phonological sensitivity, and vocabulary learning. It may be that either phonological memory or phonological sensitivity provides the major crux in explaining variance in children's word learning, that each of these variables is more important than the other at different points of time in the continuum of word learning, or that phonological memory mediates the relation between phonological sensitivity and word learning. The purpose of the current investigation, then, was to attempt to uncover the most likely relation among phonological sensitivity, phonological memory, and vocabulary learning by systematically investigating these claims in turn.

Current Study

While, previous research has indicated phonological sensitivity and phonological memory are factors important in accounting for the variability in children's rate of vocabulary learning, the nature of the relation among these variables is unknown. The goal of the current study was to delineate the specific nature of the relation among phonological memory, phonological sensitivity, and word learning in children between the ages of 3 and 5, the point in development at which children are testable, and children's lexicons are blossoming. Children's scores on a nonword repetition task used to assess phonological memory, and a rhyme-oddity task used to measure phonological sensitivity served as predictors in a number of hierarchical regression analyses. The total number of words children know defined as the addition of raw scores from an expressive vocabulary and a receptive vocabulary test served as the criterion.

The evidence presented above provided a theoretical foundation for presenting three specific hypotheses about the nature of the relation among these variables:

Hypothesis I. One proposed relation is that both phonological sensitivity and phonological memory are important in explaining individual differences in word learning, but either phonological sensitivity or phonological memory accounts for more of the variance accounted for in vocabulary knowledge than does the other. Support for this scenario would have been garnered if both variables had accounted for a significant proportion of the variance in word knowledge, but that one variable accounted for a significantly greater proportion of the variance in word learning than did the other, with this relation holding across age. Because separate researchers have implicated both variables as important in explaining individual differences in word learning it was difficult to provide a directional hypothesis. This relation is presented in Figure 1.

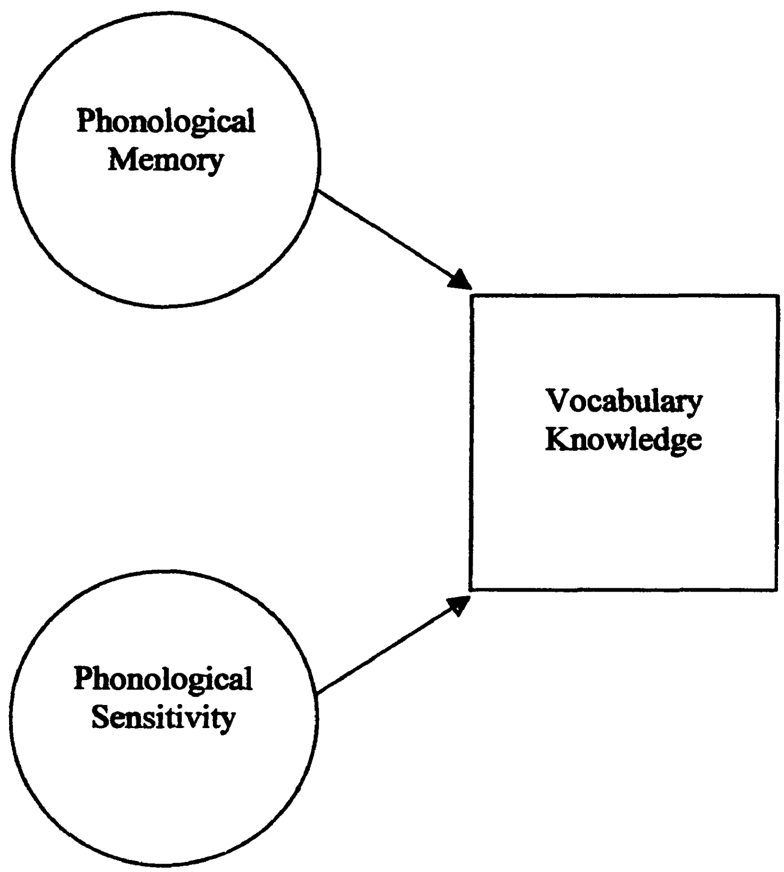

Figure 1. Proposed relation among phonological sensitivity, phonological memory, and vocabulary knowledge proposed in Hypothesis I.

Hypothesis II. An alternative hypothesis was that both phonological memory and phonological sensitivity are important contributors to word learning, but the amount of influence exerted by either variable is dependent on linguistic savvy. Based on previous research, it was suggested that phonological sensitivity would account for a significantly larger proportion of the variance in vocabulary knowledge for young preschool-age children, that is children with less linguistic experience, while for older preschoolers phonological memory would account for a significantly greater proportion of the variance in vocabulary. This relation is presented in Figure 2.

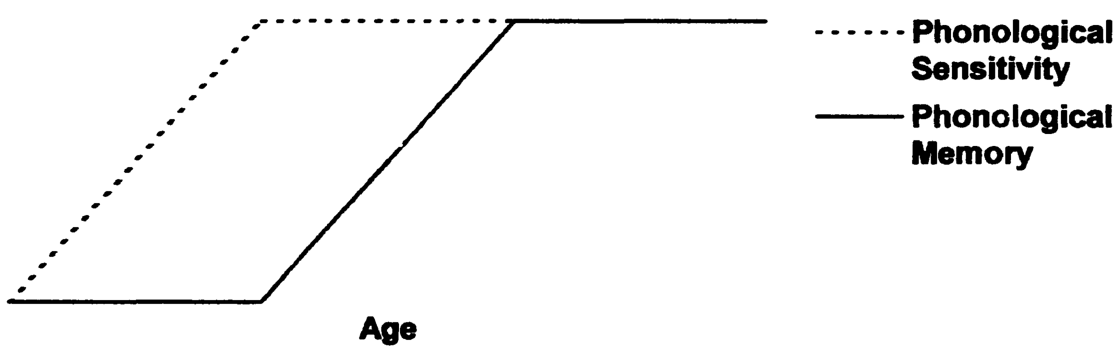

Figure 2. Proposed developmental relation among phonological sensitivity, phonological memory, and vocabulary knowledge proposed in Hypothesis II.

Hypothesis III. If at any age phonological sensitivity did not account for a significant proportion of the variability in word learning above and beyond the effect of phonological memory in any of the above analyses, then it was possible that the third type of proposed relation might exist: that phonological memory mediates the relation between phonological sensitivity and word learning. A finding that the amount of influence by phonological sensitivity and/or phonological memory changes across age would have also suggested a possible mediational relation between these variables. Further support would have been garnered by a collaborative finding that phonological memory did account for a significant proportion of the variance accounted for in vocabulary knowledge while phonological sensitivity did not, but that phonological sensitivity accounted for a significant proportion of the variance in phonological memory. This relation would support the claim that differences in word learning cannot be explained solely by differences in phonological memory. Differences in phonological memory result, in part, due to differences in underlying phonological sensitivity. A pictorial of this relation is presented in Figure 3.

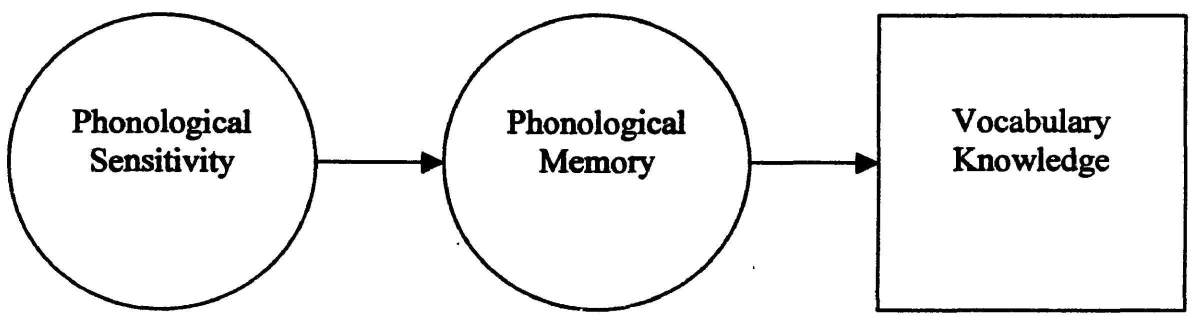

Figure 3. Proposed mediated relation among phonological sensitivity, phonological memory, and vocabulary knowledge proposed in Hypothesis III.

METHOD

Participants

A total of 68 normally developing children recruited from local childcare centers participated, with normal development defined as having never been seen by a physician, school psychologist, or other practitioner for a cognitive impairment. Of these children, one refused to participate on any tests requiring a verbal response, and one child became ill during the testing session. Because they had incomplete data these cases were dropped from the analyses. In addition, initial screening of the data revealed two cases with extreme vocabulary scores, with one child who had an extremely low score, and one who had an extremely high score. Upon inspection of these children's background information it was found that the child with a very low vocabulary score had a familial history of developmental delays and the precocious youngster was the only child currently enrolled in Kindergarten. These children likely had differential language exposure that resulted in deviation of their scores from the mean of the sample. Thus, because these children did not appear to represent the rest of the sampling distribution they were dropped from the analyses. Deletion of these participants resulted in a final count of 64 participants. Of these children mean participant age was 4 years, 0 months. Roughly half of these children were boys (30) and half were girls (34).

Analyses from Hypothesis II required categorization of children by age. Because language development occurs quickly in preschool children, several grouping we desired in order to capture potential developmental trends. Thus, children were grouped into four 6-month intervals: children ages 3 to 3 ½, 3 ½ to 4, 4 to 4 ½, and 4 ½ to 5. Table 1 presents mean age and standard deviations for these groups, and the number of boys and girls within each group.

Table 1.

Number of Subjects, Number of Girls and Boys, and Descriptive Statistics for Each Age Group.

		Sex		Age in Months			
Group	n	Girls	Boys	Min	Max	M	SD
1	16	8	8	35	41	37.56	2.22
2	16	11	5	42	48	44.88	2.00
3	16	9	7	49	54	51.75	1.81
4	16	6	10	55	61	57.81	1.97

To ensure that sex was not playing an integral role in subsequent results, a one-way analysis of variance was performed. This analysis revealed no sex difference and no interaction between sex and age in terms of vocabulary (for both, $F < 1$, NS), suggesting that the number of boys and girls in each age group was not significantly different, and that sex differences were not responsible for any subsequent differences in vocabulary among the age groups.

Equipment

A Marantz model PMD222 portable cassette recorder and Sony HF90 voice quality normal bias cassette were used to record and play stimuli for the Test of Nonword Repetition and the rhyme-oddity detection task.

Materials

Criterion Measure

The addition of raw scores from two standardized measures of vocabulary knowledge was used to estimate the number of words children know and served as the criterion variable in this study. The Peabody Picture Vocabulary Test- Third Edition (PPVT-III: Dunn & Dunn, 1997) and the Expressive Vocabulary Test (EVT: Williams, 1997) were used to assess receptive vocabulary and expressive vocabulary respectively. These tests have been normed and validated for preschool-age children using the same population, with samples matching those reflected by the 1994 U.S. census in terms of gender, race and ethnicity, region, and socioeconomic status. Additionally, both measures have been extensively field-tested and have been cited as being culturally sensitive (Williams, 1997; Williams & Wang, 1997). Finally, each measure has been found to have moderate to high reliability and appear to be valid measures of children's vocabulary. Investigations assessing the reliability of the PPVT-III have yielded alpha coefficients of .92 to.98 for internal consistency and .86 to .97 for split-half reliability, and correlation coefficients of .91 to .94 for test-retest reliability, and .88 to .96 for alternate-form reliability (Williams & Wang, 1997). Reliability assessment of the EVT has yielded alpha coefficients of .90 to .98 for internal consistency, .83 to .97 for split-half reliability, and .77 to .90 for test-retest reliability (Williams, 1997). Studies investigating criterion-related validity of the PPVT-III and the EVT suggest moderate to high correlations with other measures of oral language. For example, correlation coefficients of .60 and .82 were observed between the PPVT-III and the oral language subscale One Word Language Scale (OWLS), and the

EVT and OWLS. Investigations using the verbal subscale of the Weschler Intelligence Scale for Children suggest similar findings, with coefficients of .72 and .92 for the PPVT-III and EVT respectively (Williams, 1997, Williams & Wang, 1997). In general, then, these measures have been found to be highly stable, valid measures of receptive and expressive vocabulary in preschool-age children.

Predictor Measures

Scores from two measures, one assessing phonological sensitivity, and one assessing phonological memory, served as prediction factors. Stimuli for both tasks were prerecorded on an audio cassette, and were spoken by a female American English speaker.

Phonological sensitivity. The ability to distinguish a word that does not rhyme from a series of words containing rhymes is regarded as a form of phonological sensitivity (Adams, 1990; Carroll, 1994; Stanovich, 1992). Rhyme-oddity tasks have been determined to assess phonological sensitivity reliably, and numerous investigators have successfully used variations of the rhyme-oddity task with preschool-age children (Bowey, 1996; Gathercole, et al., 1992; Kirtley, Bryant, MacLean, & Bradley, 1989; Lonigan, et al., 1998). To determine children's phonological sensitivity a slightly modified version of a widely used rhyme-oddity detection task developed by Maclean, Bryant, & Bradley (1987) was employed. Modifications to this test included the addition of two items, increasing the total number of items from 13 to 15. A copy of this task can be found in Appendix A. This task has been shown to measure phonological sensitivity reliably in children as young as 2 (Lonigan, et al., 1998). The procedure for this task includes presenting three words, each accompanied by a picture, and having the child point to and/or say the word that does not rhyme with the others (or alternatively saying the words and/or pointing to the two pictures that do rhyme). The use of pictures insures that the task is measuring phonological sensitivity alone rather than phonological sensitivity and phonological memory. For the present study these pictures were color clipart images presented on white cardstock.

Phonological memory. A 15-item nonword repetition task used by Adams and Gathercole (1995), which extends the Test of Nonword Repetition (Gathercole, Willis, Baddeley, & Emslie, 1994) so that it is applicable to 3-year-old children, was used to assess phonological memory. The Test of Nonword Repetition is a normed test of phonological memory. This test has been used extensively to assess children's phonological memory and is regarded as being a highly reliable measure of phonological memory (Dollanghan, Biber, & Campbell, 1995; Gathercole, et al., 1998). A copy of this task can be found in Appendix B.

Procedure

All testing was conducted in a quiet room located at the childcare center. Each child was tested during one session approximately 45 minutes in length. To begin, the child was brought to the testing room by one of the childcare employees and was introduced to the investigator. The child was given adequate time to acclimate to the investigator prior to the onset of any of the experimental tasks. In addition, the investigator and the child engaged in free play for a few minutes in an effort to establish rapport. Testing procedures began when the child seemed adequately at ease with the investigator and the test environment.

During testing the child and the investigator sat opposite each other. Administration of the PPVT-III and EVT was conducted according to the administration procedures in the relevant testing manual. Because standardization of the PPVT-III and the EVT entailed assessment of children on the PPVT-III prior to the EVT, the PPVT-III was administered immediately prior to the EVT in this study.

The rhyme-oddity detection task and the Test of Nonword Repetition followed the administration of the EVT. Because there was no a priori reason to administer one of these tasks before the other, administration of the tests was counterbalanced across participants. Presentation of stimuli for these measures was administered via a cassette recorder to ensure consistency in the presentation of stimulus items. Items for the nonword repetition task were recorded in random order. Instructions to the child were the same as those found in MacLean, et al. (1987) and Gathercole, et al. (1994).

Analysis

To test Hypotheses I and II a hierarchical regression was performed, with chronological age entered in the first step, phonological sensitivity and phonological memory entered next, and the centered interaction terms (Aiken & West, 1991) between age and phonological memory, age and phonological sensitivity, and age, phonological sensitivity and phonological memory entered last. Because the purpose of this investigation was theoretical rather than applied in nature, it was appropriate to include only those variables relevant for theoretical interpretation (Tabachnick & Fidell, 2001).

Thus, because the interaction between phonological sensitivity and phonological memory was unimportant in the context of Hypothesis II it was excluded from the analysis. To determine the unique contribution of phonological sensitivity and of phonological memory, two additional regression analyses were run: one with age and phonological memory entered first, and phonological sensitivity entered in the second step, and another with age and phonological sensitivity entered first, and phonological memory entered second. The test of Hypothesis III entailed examination of the zero-order correlation between phonological memory and phonological sensitivity. This was performed via Pearson product-moment correlation. Partial correlation between these variables was also conducted with the effects of age eliminated. All analyses were performed using SPSS for Windows, version 9.0.

Results and Discussion

The purpose of the present research was to determine the nature of the relation among phonological memory, phonological sensitivity, and vocabulary knowledge in young children, that is, to determine how differences in phonological memory and differences in phonological sensitivity affect individual differences in children's rate of vocabulary acquisition. Based on previous research, a number of hypotheses about the nature of the potential relations among these variables were posited: either phonological memory or phonological sensitivity might play a greater role in vocabulary learning than the other, both phonological memory and phonological sensitivity might be important variables in word learning, but the extent of influence by either variable might depend upon a child's current level of linguistic competency, or there might exist some type of mediated relation among phonological sensitivity, phonological memory, and vocabulary knowledge.

Descriptive Statistics

Evaluation of the assumptions underlying correlation and multiple regression was performed. All variables were found to be homoscedastic and normally distributed, and the relations among the dependent variable and the independent variables were linear. Thus, subsequent analyses were performed without concern about the viability of interpretation of the resulting statistics.

Descriptive statistics revealed a mean vocabulary score of 89.20 items (SD = 20.19). In addition, mean items correct for the rhyme oddity task and the Test of Nonword Repetition were 6.81 (SD = 3.42) and 11.09 (SD = 2.79) respectively. Table 2 shows means and standard deviations for vocabulary scores, items correct on the rhyme oddity task, and items correct for the Nonword Repetition task, broken down by group.

Table 2.

Means and Standard Deviations for Number of Items Correct for Vocabulary, the Nonword Repetition Task (NWRT), and the Rhyme-Oddity Task (ROT) for Each Age Group.

	Vocabulary		NWR		RO	
Age	M	SD	M	SD	M	SD
3 – 3 ½	68.25	15.44	9.00	3.01	4.63	1.82
3 ½ - 4	86.25	14.87	11.19	2.95	5.94	2.67
4 – 4 ½	94.19	15.58	12.13	2.13	6.56	2.78
4 ½ - 5	108.13	11.11	12.06	1.91	10.13	3.63

Table 3.

Means, Standard Deviations, and Mean Standard Scores for the Peabody Picture Vocabulary Test (PPVT) and the Expressive Vocabulary Test (EVT) for Each Age.

	PPVT			EVT		
Age	M	SD	Standard Score*	M	SD	Standard Score*
3 – 3 ½	31.94	12.27	95	36.31	4.42	107
3 ½ - 4	45.69	13.13	100	40.56	4.05	105
4 – 4 ½	50.56	10.82	96	43.63	7.78	100
4 ½ - 5	62.63	5.02	100	45.50	8.69	97

*Standard scores are based on a distribution with a mean of 100 and a standard deviation of 15 points.

Means, standard deviations, and mean standard scores for the Peabody Picture Vocabulary Test and the Expressive Vocabulary Test are presented in Table 3.

Hypothesis I

Previous research has suggested that both phonological memory and phonological sensitivity may be important factors in children's word learning. However, there is continued contention about the contribution of each variable to the development of a child's burgeoning lexicon. Several researchers suggest that while both phonological sensitivity and phonological memory are important in explaining individual differences in word learning, either phonological sensitivity or phonological memory accounts for more of the variance in vocabulary knowledge than does the other. To test this hypothesis age, phonological sensitivity, and phonological memory were entered into a stepwise regression analysis, with age being entered into the equation first, and phonological sensitivity and phonological memory entered together in a second block. This procedure allowed examination of the effect of phonological sensitivity and phonological memory while accounting for any variability in vocabulary due to age. Results showed that together age, phonological sensitivity, and phonological memory account for 53% of the variance in young children's vocabulary knowledge, where $F(3, 61) = 22.80$, $p = .001$. The source table for this analysis is presented in Table 4.

Table 4.

Source Table for Hierarchical Regression for Hypotheses I and II.

Step		SS	df	MS	F	p
1	Regression	14036.61	1	14036.61	54.26	.000
	Residual	16297.95	63	258.70		
	Total	30334.55	64			
2	Regression	16035.35	3	5345.12	22.802	.000
	Residual	14299.20	61	234.41		
	Total	30334.55	64			
3	Regression	17021.33	6	2836.89	12.36	.000
	Residual	13313.22	58	229.54		
	Total	30334.55	64			

Note: Step 1 variables entered: age; Step 2 variables entered: phonological memory, phonological sensitivity; Step 3 variables entered: age x phonological memory, age x phonological sensitivity, age x phonological memory x phonological sensitivity.

Of these contributors, age was the largest ($\underline{R}^2 = .46$), as evidenced in Table 5.

Table 5.

Regression Coefficients for Hypotheses I and II.

Step		B	SE	β	t	p
1	Constant	.78	12.31		.06	.95
	Age	1.86	.25	.68	7.37	.00
2	Constant	4.37	12.80		.34	.73
	Age	1.27	.31	.47	4.05	.00
	PM	1.18	.75	.15	1.59	.12
	PS	1.68	.68	.27	2.46	.02
3	Constant	8.64	16.05		.54	.59
	Age	1.29	.32	.47	4.08	.00
	PM	.76	.92	.10	.83	.41
	PS	1.52	.86	.24	1.76	.08
	Age x PM	-.20	.11	-.19	-1.85	.07
	Age x PS	.13	.09	.16	1.47	.15
	Age x PM x PS	-.002	.04	-.06	-.45	.65

Note. PM is phonological memory; PS is phonological sensitivity.

However, the combination of phonological sensitivity and phonological memory did account for a significant proportion of the variability in children's lexicons above and beyond age: 7% of the variability in vocabulary knowledge was contributed by these variables, $\underline{F\Delta}(2, 61) = 4.26$, $\underline{p} = .02$. Examination of the regression coefficients (see

Table 5) revealed phonological sensitivity to be the only significant factor within this duo (β = .27, t = 2.46, p = .02).

Partial correlations confirmed this result by showing no reliable relation exists between vocabulary and phonological memory when the effects of age are controlled, but when the same situation occurs for vocabulary and phonological sensitivity a significant moderate association remains (r = .29, p = .02). Based on these results, a general conclusion regarding the viability of phonological sensitivity, but not phonological memory, appears warranted. Only phonological sensitivity appears to contribute to word learning throughout the preschool years.

To determine the amount of unique contribution provided by phonological sensitivity a second regression analysis was run, with age and phonological memory entered in the first step and phonological sensitivity entered next. A significant R^2 of .05 was observed, where $F\Delta$ (1,61) = 6.04, p = .02, suggesting phonological sensitivity accounts for 5% of the variability in vocabulary acquisition in young children. This amount of explained variance is quite a contribution given the overwhelming contribution of age alone. Thus, while phonological sensitivity contributes only 5% overall, that variance becomes more meaningful in light of the fact that age contributes a whopping 46%. Thus, with respect to the remaining variance, 54%, nearly 10% of that is the unique contribution of phonological sensitivity. To determine whether differences in phonological memory were partially responsible for differences in vocabulary knowledge beyond the effects of age and phonological sensitivity, another regression analysis was performed, this time with age and phonological sensitivity entered into the analysis first and phonological memory entered afterwards. This scenario did not result in a significant change in F for the second step, suggesting that the amount of unique variance contributed by phonological memory is not enough to overcome the effects of age and phonological memory.

The pattern of the results from these analyses suggests that only phonological sensitivity plays a significant role in vocabulary knowledge of young children throughout the preschool years, lending additional support to Bowey's (1996) contention that phonological sensitivity is indeed an important component in explaining the variability in children's word learning. In this study the ability to recognize words that rhyme was the index of phonological sensitivity. The ability to recognize rhymes as such requires a child to segment words into their component parts and then categorize these parts on the basis of shared sounds (Maclean, et al., 1987). Sensitivity to these different phonological units allows for proficiency in tasks, such as rhyming, that require the recognition and segmentation of phonological elements in words. The foundation of these skills rests in a child's previous capability to learn the sound structure important in one's native language; an inability to properly segment fluent speech, or to devise a weighting scheme appropriate for one's language would result in a failure to recognize that words contain similar segments because that child's database would contain either phonemically inaccurate or phonologically unsegmented information insufficient for both the ability to detect rhymes and to learn new lexical items. Children who are slow to learn words may not yet have mastered these prerequisite abilities needed to become proficient in their native language. In other words, they may lack adequate phonological sensitivity.

That these results indicate phonological sensitivity contributes a significantly greater proportion of the variance in word learning than does phonological memory suggests that variability in word learning can be best explained by differences in children's ability to either recognize or use discriminative phonological information rather than simply being able to hold that information, intact, in one's short-term phonological store. However, the finding that phonological sensitivity has an effect on word learning in preschool children overall, does not preclude the fact that the influence of this variable or phonological memory may change over time. That is, that a main effect exists for phonological sensitivity but not phonological memory tells us only that, in general, phonological sensitivity is the principle contributor between these factors if age is taken to be a constant. This outcome does not adequately address the possibility of a developmental role for phonological sensitivity or phonological memory in children's word learning. The test of this suggestion was the aim of Hypothesis II.

Hypothesis II

The extent of influence of phonological sensitivity and phonological memory may vary according to a child's linguistic competence. That is, it is possible that the contribution of one or the other variable may increase or decrease as a child gains linguistic experience. This question is an important one given the discord that has resulted from seemingly contradictory findings by different researchers in terms of which variable is more important. This dissension might be reconcilable if support is found for this hypothesis. In fact, both variables may be valuable in explaining individual differences in word learning, but the influence of each variable may be allocated according to the timetable that an individual child's lexical learning follows. There is an abundance of research suggesting that phonological sensitivity is an important variable underlying the learning of new words. However, much of this research has focused on children much younger than those seen in investigations of the impact of phonological memory on word learning. The use of children of different ages in studies investigating these two variables has resulted in a cacophony of research findings with no cohesive framework. The failure to discover this architecture may reside in the fact that, to date, researchers have simply neglected to simultaneously investigate the effects of these variables developmentally in children who are at the height of language learning. Support for Hypothesis II would help to delineate the progression of word learning in children by showing that there may in fact exist a developmental trend in the processes underlying lexical development, and that both phonological memory and phonological sensitivity concurrently play tangible roles in a child's ability to learn new vocabulary items, although perhaps at different times.

Based on previous research by Jusczyk and colleagues, Gathercole and colleagues, and others, it was predicted that if a developmental relation exists, then the direction of change would most likely be as follows: phonological sensitivity would contribute much to the variability in word learning early in children's linguistic careers, while phonological memory would contribute a greater proportion of the variability in children's vocabularies later in development. Examining the contribution of the interaction between age and phonological memory and age and phonological sensitivity irrespective of the unique contribution of these variables alone, allowed for investigation of this hypothesis. It was reasoned that partial support for Hypothesis II would be garnered if the amount of unique contribution of the interaction between age and phonological sensitivity, age and phonological memory, or age, phonological sensitivity, and phonological memory was greater than that provided by the terms contained within the interaction variables.

To test this hypothesis, centered interaction terms for age and phonological sensitivity and age and phonological memory, and the three-way interaction of age, phonological memory, and phonological sensitivity were entered into the regression equation after entry of each of these variables alone. With the addition of these variables the overall amount of variance accounted for in vocabulary knowledge increased from 53% to 56%, $F(6, 58) = 12.36$, $p = .00$, although the change in F was not significant. (See Table 6.)

Table 6.

Change Statistics for Hierarchical Regression for Hypotheses I and II.

Step	R^2	$R^2 \Delta$	$F\Delta$	df	p
1	.46	.46	54.26	1, 63	.00
2	.53	.067	4.26	2, 61	.02
3	.56	.03	1.43	3, 58	.24

Note: Step 1 variables entered: age; Step 2 variables entered: phonological memory, phonological sensitivity; Step 3 variables entered: age x phonological memory, age x phonological sensitivity, age x phonological memory x phonological sensitivity.

To determine which terms were reliably contributing to the overall effect of the regression coefficients for these factors were examined. Contrary to expectations the beta weight for the age by phonological sensitivity interaction was not significant. However, the main effect of phonological sensitivity remained ($\beta = .24$, $t = 1.76$, $p = .08$), although the loss of degrees of freedom from the inclusion of additional variables resulted in only marginal significance. Phonological sensitivity can be best described as a force important in explaining differences in word learning throughout children's preschool years rather than at any point in development, be it early or late. The rhyme oddity task used in this experiment and others requires children to have developed skills related to accurate decomposition of fluent speech, such as phoneme identification, as well as the ability to recognize, compare, and manipulate important structural units contained within rhyming units. Thus, several subsystems appear to be involved in the ability to detect words that rhyme. Phonological sensitivity is generally defined as the sensitivity to the structure of language, and a conscious ability to detect, combine, and manipulate different sizes of sound units, including phonemic, syllabic, and onset/rhyme awareness. Clearly a number of different aspects of language learning are contained under this heading. Proficiency in these subdomains follows a developmental progression, with phoneme discrimination preceding the ability to recognize different phonemes contained within syllables, the ability to map phonemic contrasts onto stored lexical units and the ability to manipulate phonemic units contained within syllabic or lexical items (Ferguson & Farwell, 1975; Hoff-Ginsberg, 1997; Jusczyk, 1993; Menyuk, Menn, & Sibler, 1986; Sander, 1972). The rhyme-oddity task may reflect differences in any of these subdomains of children's phonological awareness at different points in children's language development. Which of these abilities are the critical components of word learning at different ages is beyond the scope of this investigation; however, this question is important in light of the results obtained here. The lack of an age by phonological sensitivity effect may be the result of tapping into several subsytems within phonological awareness rather than assessing sensitivity to speech sounds per se. Thus, it is possible that phonological sensitivity is important for young children, but that the task used to assess this ability obscured potential results. Clearly this is a conundrum that future research will need to address.

Inspection of the standardized beta weights revealed a marginally reliable trend towards a composite effect of age and phonological memory on the variability in children's word learning, $\beta = -.19$, $t = -1.85$, $p = .07$. Because interaction effects are notoriously elusive in multiple regression (Pedhazer, 1982), because there was a relatively low study N and thus some loss of power was anticipated, and because this result is theoretically important, multiple comparisons through the use of bivariate correlations were performed to delineate the ages in which these potential interactions were occurring. Bivariate correlations between phonological memory and vocabulary for each category revealed the strongest and most reliable relation for the youngest children ($r = .41$, $p = .11$.). While the probability of obtaining this finding based on chance alone is higher than traditionally desirable, this correlation is the strongest and most reliable of those presented for the different groups. Thus, it is suggested that phonological memory may play a larger role in lexical acquisition early in development rather than at a later stage. For the youngest children phonological memory accounted for 17% in vocabulary knowledge, while for older children phonological memory did not appear to play a role in lexical development. Table 7 provides correlations for each group for comparison purposes.

Table 7.

Pearson Product-Moment Correlation Coefficients and Respective Probability Values for the Relation Between Vocabulary and Phonological Memory for Each Age Group.

Age	R	p
3 – 3 ½	.41	.11
3 ½ - 4	.08	.77
4 – 4 ½	-.03	.92
4 ½ - 5	.11	.70

The finding that phonological memory appears to play a larger role in vocabulary acquisition for younger rather than older children is somewhat contrary to expectations, but is important nevertheless. Low scores on the Test of Nonword Repetition are thought to represent an inability to maintain unfamiliar phonological information in the phonological loop. The learning of new lexical items appears to rely, in part, on the ability to maintain unfamiliar phonological patterns in the phonological loop until previously stored lexical information can be recruited to aid in the process of assimilation of that new word (Adams & Gathercole, 1996). If novel information exceeds the capacity of the phonological loop, some information pertinent to forming accurate phonological representations will be unavailable, thus hindering the acquisition of new lexical items (Gathercole & Baddeley, 1990b). For young children, then, the critical component of word learning may reside in their ability to simply keep new information intact while searching for potentially relevant information, such as whether or not that phonological string has been encoded previously. There is an abundance of evidence to suggest that memory capacity improves during early childhood as the result of increases in speed of processing (Kail, 1991; 1993; Kail & Park, 1994; Kail & Salthouse, 1994; Hitch, Halliday, & Littler, 1989; 1993; Hitch, Halliday, Schaafstal, & Heffernan 1991). Thus, it is a real possibility that phonological memory does indeed play a role early in lexical learning, but that the demands placed on the phonological loop are no longer cumbersome as the speed with which information can be recruited increases (Kail & Park, 1994), as the development of mature coding strategies (for example, the ability to store, for example, more than one phoneme, syllable, or word, in one chunk) emerges (Chi, 1976; 1977), and as a child's underlying network of semantic representation expands (Chi & Ceci, 1987; Chi & Koeske, 1983; Schneider, Gruber, Gold, & Opwis, 1993). Children who operate without capacity limitations are able to recruit information from long-term storage, as well as hold information, intact, in the phonological loop. Thus, information recalled from long-term storage will match that information held in the short-term store so that this information will be stored in the correct phonological form. Upon hearing that item again, the recruitment process will result in a match of this heard word and the representation previously stored. In other words, that vocabulary item will have been acquired. This finding fits nicely with the results of Gathercole, et al.'s (1992) investigation of the relation between children's ability to learn new lexical items and their previous vocabulary knowledge, and their phonological memory. In that study the authors found that for young preschoolers phonological memory was a better predictor of new word learning than was previous vocabulary knowledge as well, while the opposite pattern was found for older children, suggesting age-related changes in phonological memory capacity may be responsible for individual differences in vocabulary learning in preschoolers. Thus, while the results of this investigation are marginally significant, other researchers have found similar results, providing support for the contention that a developmental trend may exist for the impact of phonological memory on lexical acquisition, and that low power may have played an integral role in the failure to identify a significant age by phonological memory interaction in this investigation. This theory, however, contains the assumption that phonologically unfamiliar information has been accurately segmented and decoded in the first place, and that the representation of this new information has made it, intact, to long-term memory. In other words, it might be that phonological sensitivity underlies phonological memory. This hypothesis was addressed by Hypothesis III.

Hypothesis III

A final hypothesis is that phonological memory and phonological sensitivity are not separate variables at all, but rather, one ability underlies the other. It is the influence of the underlying ability that results in explained variance by the mediated variable. It was predicted that if this type of relation exists, phonological sensitivity would underlie phonological memory. Several researchers have suggested that nonword repetition tasks require adequate phonological sensitivity, as well as adequate phonological memory, for sufficient performance (Bowey, 1996; Snowling, et al., 1991), and that it may in fact be difficulties in the area of phonological sensitivity that result in poor performance on nonword repetition tasks rather than difficulties within the realm of phonological memory per se.

Support for this prediction was not found. Results from the analyses for Hypothesis I revealed that rhyme-oddity scores do account for a significant proportion of the variability in the number of words children know over and above any contribution by age or phonological memory. In addition, while the zero-order correlation between phonological sensitivity and phonological memory revealed a possible significant correlation between these variables, where $r = .22$, $p = .08$, even this marginal correlation disappeared when the effect of age was controlled, with the resulting partial correlation being essentially zero ($r = -.0032$. $p = .98$), thus eliminating even the possibility that a mediational relation exists in the unpredicted direction. Hence, support for the hypothesis that a mediated relation exists between phonological memory and phonological sensitivity was not garnered; support for Hypothesis III was not found. It seems reasonable to expect that the ability to segment phonemes from fluent speech correctly might underlie phonological memory. Phonological memory is only as good as the units that make it to the short-term store. If these units have been incorrectly segmented in the first place, then one would expect that word learning might be inhibited, not because of faults in the memory system but because the units were never correct in the first place. One reason why a mediated relation was not identified may be the result of the test used to assess phonological sensitivity. The rhyme-oddity task may be measuring many processes contained under the heading of phonological sensitivity, such as the ability to manipulate and compare phonemic units as well as the ability to identify these units within syllables initially. Thus, inaccuracies by children may result from deficits in processes other of than phonological sensitivity and phonological memory. Examination of a hypothesis by a task measuring too many aspects of phonological sensitivity would surely obscure any effect of one of the involved subprocesses, hence eliminating any chance of identifying a mediated relation based on that one ability alone. A better test of this hypothesis might be to examine phonological sensitivity using a task that measures only sensitivity to phoneme discrimination or phoneme identification, such as a task investigating minimal pairs. Future research should address this possibility.

General Conclusions

In general, results from this study suggest that both phonological sensitivity and phonological memory are important factors underlying word learning and that individual differences in these factors appear to be partially responsible for individual differences in children's ability to learn new words. Phonological memory appears to be important in accounting for variability in lexical acquisition early in children's linguistic careers, while different aspects of phonological sensitivity may play a role in word learning throughout the preschool years. In addition, it does not appear that any type of mediated relation exists among phonological memory, phonological sensitivity and vocabulary acquisition; however, the lack of a mediated relation may be the result of the test used in this study to examine phonological sensitivity (the rhyme-oddity task). This task may tap into processes that develop later in children's language learning, such as the ability to manipulate and compare phonemic items within syllables, as well as the early developing ability to distinguish among different phonemes.

The findings from this study are valuable from a number of different perspectives. From an experimental and general interest perspective, these results can aid in the ability to understand why such large individual differences in the rate of vocabulary acquisition exist, and assist in the understanding of the processes that may underlie children's learning of new words and the relation between these processes. In addition, the clear delineation of the relation among phonological memory, phonological sensitivity, and individual differences in vocabulary knowledge may serve to reconcile the seemingly contradictory evidence that has been observed in research investigating vocabulary learning, and may provide for a foundation for future research. In the past, researchers have disagreed about the factors and extent of these factors in terms of their relation with word learning. These data show that phonological memory and phonological sensitivity are important, and that the lack of a significant relation among these factors in some studies does not preclude a meaningful influence, but rather, may simply be the result of the influence of linguistic experience. Thus, discrepant results should not be viewed as contradictory, but complimentary in that they highlight the processes important at a specific period in language development.

These results are also valuable from a clinical perspective. First, they will help to identify the possible functions underlying some language difficulties. While these results cannot and will not provide the whole story about why individual variability in word learning occurs, they can at least tell us the possible role of two potential underlying factors, and should serve to facilitate the elimination of the definitional hurdles that plague the diagnosis of children with differing language problems. The current problem of categorizing children based on their specific language impairment has seeped into the experimental world. Research on children with specific language impairments is often performed with groups of children whose linguistic competencies differ wildly. By identifying potential areas of underlying functioning in language learning, more conclusive definitions of different types of language-impaired children can be formed, resulting in more controlled research programs, and ultimately leading to a clearer understanding of what goes wrong in children who have difficulty learning language, and a clearer understanding of which potential treatments for children with language learning difficulties might be most beneficial.

It is important to note that phonological sensitivity and phonological memory are only two of a multitude of factors that may underlie individual differences in vocabulary performance. To begin to develop a rich explanation of variability in word learning these other factors will surely need to be addressed. For example, whether a child interprets phonological segments analytically or holistically may be a key element of the timing in children's word learning. Nelson and Lucariello (1985) suggest vocabulary development is dictated, in part, by children's tendency to organize experiences in terms of whole events or their component parts. Children's predisposition to use not-yet-mastered vocabulary items may also play a role in lexical development. It appears that some children approach word learning cautiously and are less likely to adopt new words without a clear understanding of their phonology. Other children are more exploratory in their use of unfamiliar phonological items and are more likely to produce words that have not been fully mastered (Ferguson & Farwell 1975). In addition, the extent of a child's underlying semantic network may also play a role in how quickly and/or adequately children assimilate new lexical items into their preexisting semantic network (Ashcraft, 1989).

Thus, a slew of factors beyond those addressed here may play potentially important roles in word learning and may influence or be influenced by other variables. Thus, the relations among phonological sensitivity, phonological memory, and many others need to be assessed in further studies in order to develop a greater understanding of the process of word learning in young children.

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Appendix A

Modified Rhyme-Oddity Task.

Task Items

Sail	Nail	Boot
Pig	Mat	Bat
Cat	Hat	Bell
Fish	Dish	Book
Peg	Cot	Leg
Bus	Arm	Farm
Sand	Cup	Hand
Hen	Car	Pen
Gun	Sun	Tap
Wall	Dog	Ball
Paw	Boat	Goat
Duck	Hill	Pill
Sock	Hay	Tray
Toy	**Boy**	**Door**
Clock	**Girl**	**Block**

Note: Nonrhyming words are underlined. Additional items are in bold print.

Appendix B

Nonword Repetition Task.

	Number of syllables		
	One	**Two**	**Three**
Nonword items	Grall	Rubid	Brastering
	Nate	Diller	Dopelate
	Mot	Grindle	Kannifer
	Plird	Bannock	Tumperine
	Tull	Pennet	Parrazon