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Age of Acquisition and Repetition Priming Effects on Picture Naming of Children Who Do and Do Not Stutter

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Abstract

The effects of age of acquisition and repetition priming on picture naming latencies and errors were studied in 22 children who stutter (CWS) and 22 children who do not stutter (CWNS) between the ages of 3;1 and 5;7. Children participated in a computerized picture naming task where they named pictures of both early and late acquired (AoA) words in two consecutive stages. Findings revealed that all children's picture naming latencies and errors were reduced following repetition priming and in response to early AoA words relative to late AoA words. AoA and repetition priming effects were similar for children in both talker groups, with one exception. Namely, CWS benefitted significantly more, in terms of error reduction, than CWNS from repetition priming for late AoA words. In addition, CWNS exhibited a significant, positive association between linguistic speed and measures of vocabulary, but CWS did not. These findings were taken to suggest that the (a) semantic-phonological connections of CWS may not be as strong as those of CWNS, and (b) lexical measures may not be sensitive enough to differentiate CWS from CWNS in lexically-related aspects of language production.

Keywords

Stuttering; Repetition Priming; Age of Acquisition; Picture Naming; Children

Since the 1970's, there has been much theoretical interest in explaining the onset and development of childhood stuttering from a psycholinguistic standpoint (e.g., Howell & Au-Yeung, 2002; Perkins, Kent, & Curlee, 1991; Postma & Kolk, 1993). Consequently, researchers have experimentally examined the speech-language processing systems of children who stutter (CWS), with most efforts centered on phonological and lexical processes. While findings from some studies indicate that CWS may have difficulty with phonological or lexical processing, findings from other studies have not supported this conclusion. These contradictory findings motivate the need for further investigation of language production in CWS. The primary purpose of this study was to assess the connection between semantic and phonological processing systems in CWS by examining the effects of repetition priming for early and late acquired words. To put this study into context, we first review what is currently known about the phonological and lexical processing abilities of CWS and present relevant background information on repetition priming and age-of-acquisition effects on speech production.

Phonological Processing in Children Who Stutter

Melnick, Conture, and Ohde (2003) were among the first to experimentally assess phonological processing in preschool CWS relative to children who do not stutter (CWNS). This was

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accomplished using a picture-word interference task, in which CWS and CWNS named pictures in the absence and presence of related and unrelated phonological primes. The authors measured, among other things, the amount of time it took children to name the pictures (i.e., speech reaction time [SRT]). Results revealed that CWS and CWNS named pictures significantly faster in the related prime condition compared to the no prime and/or unrelated prime condition. Although there were no significant between-group differences in SRT, regression analyses revealed that CWNS exhibited a significant, negative relationship between SRT and “articulatory mastery,” measured using the *Goldman-Fristoe Test of Articulation-2* (GFTA-2; Goldman & Fristoe, 2000), whereas CWS did not. In essence, CWNS who had higher articulatory mastery scores named pictures more rapidly than those with lower articulatory master scores, who tended to name pictures more slowly.

Because CWS did not exhibit an association between SRT and articulatory mastery, the authors concluded that their phonological systems may be less organized or developed relative to CWNS. It is not clear, however, why a lack of association would indicate a less organized phonological system or how their phonological systems might be differentially organized relative to CWNS. Furthermore, no significant differences were found between CWS and CWNS in SRT or phonological priming effects. If CWS did have a less organized/developed system, then they should have had slower SRTs in the absence of a phonological prime (due to difficulties inherent in accessing phonemes in an unorganized system) and, perhaps, benefitted more or less from the presentation of the prime relative to CWNS. Thus, in considering these inconsistent findings, it is perhaps safest to conclude that the findings of Melnick et al. (2003) do not provide strong evidence to suggest that phonological processing in CWS differs from that of CWNS.

Since the publication of Melnick et al. (2003), several other experimental studies of phonological processing have appeared in the literature. Most recently, Byrd, Conture, and Ohde (2007) used a picture-word interference task, where target pictures were preceded by a segmental (the initial segment of the target word) or holistic (the entire target word, except for the initial segment) auditory prime, to examine phonological processing in preschool CWS and CWNS. They found that CWS were significantly faster than CWNS in the earlier developing holistic priming condition, but slower in the later developing segmental priming condition. Byrd et al. took these findings to suggest that CWS may be delayed in their ability to develop a segmental approach to phonological processing. That is, CWS may continue to rely on an earlier developing, less efficient phonological encoding system, in which speech sounds are selected as whole words rather than individual speech sounds. This protracted reliance on holistic processing may, according to the authors, result in fluency breakdowns, particularly as CWS increase their vocabulary size and begin to use longer, more complex utterances.

The notion that CWS may have difficulties with phonological encoding receives further support from studies that have revealed that CWS may be less skilled than CWNS in their ability to retain phonological information in working memory (Anderson, Wagovich, & Hall, 2006; Hakim & Ratner, 2004). Phonological working memory allows one to temporarily store verbal information so that it can be cognitively manipulated for language processing (Adams & Gathercole, 1995; Gathercole & Baddeley, 1993). However, it may also function to support language development (Leonard et al., 2007). For if, as suggested by Leonard et al., a child is unable to retain phonological information in his working memory for a sufficient period of time, then he may have difficulty forming the word's phonological representation. Thus, if CWS have difficulty with phonological working memory, it could potentially impact the integrity of their developing representations, which may make it more difficult for them to engage in segmental processing–a possibility consistent with the findings and speculation of Byrd et al. (2007).

Thus far, findings from several recent studies (Anderson et al., 2006; Byrd et al., 2007; Hakim & Ratner, 2004) support the notion that CWS may have difficulties with phonological encoding. However, in addition to the equivocal findings of Melnick et al. (2003), there is another study by Arnold, Conture, and Ohde (2005), whose findings do not support the above contention. In this study, children were shown pictured objects whose names were either high or low in neighborhood density (the number of phonetically similar sounding words). Results revealed that CWS and CWNS named low density words faster and more accurately than high density words, with no between-group differences observed. The authors concluded that phonological processing is not likely to be a major source of difficulty for CWS. The authors did, however, note several methodological problems with their study, which could have compromised its validity. Thus, these findings and conclusions are, perhaps, best viewed as preliminary.

Lexical Processing in Children Who Stutter

Although most experimental investigations of language production in CWS have focused on phonological processes, several lexical processing studies have recently been conducted. In the first study, Pellowski and Conture (2005) used a semantic priming paradigm, in which SRT was measured in the absence and presence of semantic (related and unrelated) primes, to examine lexical processing in preschool CWS and CWNS. They found that CWS named pictures significantly slower and benefitted less from related primes than CWNS. CWNS also exhibited a significant, negative relationship between receptive vocabulary and SRT in two conditions, whereas CWS did not. The authors concluded, like Melnick et al. (2003), that the lexical processing abilities of CWS may not be as developed or organized as those of their normally-fluent peers.

More recently, Hartfield and Conture (2006) examined the effect of conceptual (i.e., categorical and functional) and perceptual (i.e., physical) primes on picture naming speed and accuracy. Findings revealed that CWS were not only slower to name pictures across all conditions than CWNS, but they also named pictures more rapidly following functionally related primes relative to physically related primes. The authors suggested that the lexicons of CWS may be more conceptually organized (i.e., words are organized by their functional attributes) than their normally-fluent peers, an organizational scheme that tends to be more prominent in early lexical development.

Repetition Priming and Age of Acquisition Effects in Speech Production

It would seem, from the above review, that while there is some evidence to suggest that CWS may have difficulties with phonological or lexical processing, this evidence is, by no means, conclusive. Furthermore, findings from studies of adults who stutter (AWS) have been similarly inconsistent, with some suggesting that the speech-language processing systems of AWS may be slower and/or less accurate than adults who do not stutter (e.g., Newman & Ratner, 2007; Prins, Main, & Wampler, 1997; Sasisekaran & DeNil, 2006) and others reporting no such differences (e.g., Weber-Fox, Spencer, Spruill, & Smith, 2004). Given these uncertainties, further study of the speech-language processing abilities of CWS would appear to be warranted. In the current study, two well-known phenomena–age of acquisition (AoA) and repetition priming effects–associated with lexical access were examined. What follows is a brief review of the literature concerning the effect of these variables on speech production.

Age of Acquisition Effects

It has long been recognized that words acquired early in life tend to be recognized and named faster and more accurately than those acquired later in life (Barry et al., 2001; Barry, Johnston, & Wood, 2006; Brown & Watson, 1987; Carroll & White, 1973; Gerhand & Barry, 1998, 1999b; Morrison & Ellis, 1995). The effect of AoA on word recognition and production has been demonstrated not only in adults, but also in preschool and/or school-aged children using a variety of different tasks (Assink, van Well, & Knuijt, 2003; Garlock, Walley, & Metsala, 2001; Johnson & Clark, 1988; Walley & Metsala, 1990, 1992). Despite the fact that robust effects of AoA have been reported in a variety of different populations and tasks, some researchers have dismissed this effect, suggesting that AoA is another measure of word frequency (Juhasz, 2005). Although some researchers have reported a moderately strong, negative correlation between AoA and word frequency, others have shown that the effects of AoA are much stronger than those of word frequency and they occur even when word frequency has been controlled (see Johnston & Barry, 2006, and Juhasz, 2005, for reviews). Thus, it would appear, as suggested by Catling and Johnston (2005), that the effects of AoA and frequency are relatively "…distinct and independent in nature" (p. 169).

Another topic of interest centers on the locus of the AoA effect in picture naming. Picture naming involves three main processing stages: object recognition, semantic activation, and lexical access (Humphreys, Riddoch, & Quinlan, 1988; Snodgrass & McCullough, 1986; Wheeldon & Monsell, 1992). In brief, after a familiar pictured object is perceptually analyzed, the object's stored visual (or structural) representation is activated during *object recognition*. During *semantic activation*, the visual representation activates the object's stored semantic representation, which represents its functional (i.e., what it can do, what it is for) and relational (e.g., associates, category) properties. After recognizing and comprehending the object, respectively, the stored lexical phonology of the object's name is activated during *lexical access*. Most language processing models assume that lexical access is a two-step process, involving the selection and retrieval of the lemma, a word's semantic and syntactic specifications, and lexeme, a word's phonological representation (Dell, 1986; Levelt, Roelofs, & Meyer, 1999). Following lexical access, the name of the object is finally articulated.

Theoretically, AoA could be localized to any of the three processing stages or during articulatory planning. There would appear to be limited support for AoA having its effect during object recognition or articulation (Chalard & Bonin, 2006; Johnston & Barry, 2006). Evidence for a semantic locus has been equivocal, as some researchers have failed to find AoA effects in semantic tasks (Chalard & Bonin, 2006; Izura & Ellis, 2004; Morrison, Ellis, & Quinlan, 1992), whereas others have reported such effects (Brysbaert, Van Wijnendaele, & De Deyne, 2000; Johnston & Barry, 2005). Given these inconsistencies in findings, it would appear, as suggested by Chalard and Bonin (2006), that the most likely locus of the AoA effect is at the stage of lexical access (cf. Barry et al., 2001; Gerhand & Barry, 1998, 1999a, 1999b; Ellis & Lambon Ralph, 2000; Izura & Ellis, 2002; Morrison, Hirsh, Chappell, & Ellis, 2002). More specifically, AoA effects presumably result from differences in the strength of the connection between semantic and phonological processing levels or between semantic-lemma or lemma-lexeme levels (Barry, Johnston, & Wood, 2006; Bonin, Barry, Méot, & Chalard, 2004; Catling & Johnston, 2005; Chalard & Bonin, 2006; Ellis & Lambon Ralph, 2000; Monaghan & Ellis, 2002; Zevin & Seidenberg, 2002).

Repetition Priming Effects

Repetition priming is the phenomenon whereby the time it takes to name a pictured object (i.e., SRT) or the number of errors produced is reduced due to its prior presentation (Barry et al., 2001; Barry, Johnston, & Wood, 2006; Durso & Johnson, 1979; Johnson, Paivio, & Clark, 1996; Mitchell & Brown, 1988). That is, if a pictured object is presented twice within a given time frame, it is typically processed more efficiently (faster and with fewer errors) the second time it is presented than the first (Ellis & Ellis, 1998). Although repetition priming has primarily been studied in adults, it has also been examined in children (Lorsbach, Sodoro, & Brown, 1992; Nakamura et al., 2006). For example, Lorsbach et al. examined repetition priming in school-aged children with and without language or learning disabilities using a picture naming task. As expected, children in both groups named pictures significantly faster in the second presentation relative to the first. However, children with language or learning disabilities benefitted significantly more from repetition priming than children without these disabilities. The authors did not proffer an explanation for this latter finding, but they did suggest that floor effects may have reduced the priming effects for children without language or learning disabilities. This is based on the fact that the naming latencies of children without language or learning disabilities were significantly faster than those of children with disabilities, giving them less room for improvement in the second presentation.

As with AoA effects, researchers have been interested in determining the processing stage at which repetition priming effects are localized. While any of the aforementioned picture naming stages could serve as the locus (Barry et al., 2001; Francis, Augustini, & Sáenz, 2003; Monsell, Matthews, & Miller, 1992; Wheeldon & Monsell, 1992), most episodic memory, task-specific learning, semantic, phonological, and articulation accounts have been ruled-out, leaving lexical access as the likely locus (Barry et al., 2001; Belke, Meyer, & Damian, 2005; Griffin & Bock, 1998; Hernandez & Reye, 2002; Monsell, Matthews, & Miller, 1992; Wheeldon & Monsell, 1992). In particular, repetition priming is presumed, like AoA, to strengthen the connection between semantic and phonological representations (Barry et al., 2001; Belke et al., 2005; Hernandez & Reye, 2002; Monsell, Matthews, & Miller, 1992; Wheeldon & Monsell, 1992, 1994). This account is further supported by the finding that AoA and repetition priming interact, with repetition priming for naming late AoA pictures tending to be greater than for early AoA pictures (Barry et al., 2001; cf. Francis et al., 2003; Hernandez & Reye, 2002). This interaction suggests a common locus: at some point during the process of mapping a semantic representation onto a word's phonological representation (Barry et al.). Accordingly, late AoA words presumably have weaker connections than early AoA words, making them more likely to benefit from repetition (Hernandez & Reye, 2002).

The Present Study

To date, experimental investigations of language processing in CWS have examined whether stuttering could be related to difficulties with the formation, storage, or retrieval of phonological (lexeme) or lexical (lemma) representations (e.g., Byrd et al., 2007; Hartfield & Conture, 2006; Pellowski & Conture, 2005). However, perhaps the source of difficulty is not in the encoding of phonological or lexical representations, but rather in the mapping of semantic representations onto phonological representations (i.e., the connection between representational levels). As will be recalled, once a word's semantic representation has been activated, activation will spread to the word's lemma and then its lexeme during lexical access. Activation spreading is presumed to occur through excitatory connections from semantic to lemma to lexeme levels, with the strength of these connections determined by experience and learning (Dell, Chang, & Griffin, 1999; Dell, Schwartz, Martin, Saffran, & Gagnon, 1997; Schwartz, Dell, Martin, Gahl, & Sobel, 2006). Thus, a word's lemma and lexeme could be fully formed and easy to access, but the connection or pathway to retrieving these representations could be weak, increasing the amount of time and energy needed for word processing (Harley & Bown, 1998; Morrisette & Gierut, 2002).

One way to examine the strength of semantic-phonological connections in CWS and CWNS is to use a picture naming paradigm in which AoA is manipulated with repetition priming, as these effects would appear to be reasonably localized to the connection between semantic and phonological representations. Hence, the purpose of this study is to investigate the effect of repetition priming for early and late AoA words on picture naming latencies and errors in CWS and CWNS. It is anticipated that if CWS have less developed or weaker semantic-phonological connections, then they will, compared to CWNS, produce slower SRTs and more errors during the picture naming task, and respond differently to AoA and repetition priming effects.

Method

Participants

Participants were two groups of 22 children (N = 44) between the ages of 3;1 and 5;7 (years; months) who do and do not stutter. All children were native speakers of American English with no history of neurological, speech-language (other than stuttering), hearing, or intellectual problems per parent report and examiner observation/testing. Children were identified for participation in this study by their parents who had heard about it through an advertisement in a local parent magazine (“Indy Child”), and referrals from speech-language pathologists, other parents, or preschools in the south-central Indiana area.

Group Matching Procedure—CWS were matched to CWNS by age (± 4 months), gender (8 girls, 14 boys per group), and family socioeconomic status (SES). CWS had a mean age of 52.68 months (SD = 8.70) and CWNS had a mean age of 52.73 months (SD = 7.66), a non-significant difference, $t(42) = -0.02$, $p = .98$. Family SES was measured using Hollingshead's Index of Social Position (Myers & Bean, 1968), which is based on paternal educational and occupation (all resided in a two-parent household). Participants were matched according to their Hollingshead Classification Level, with 3 children in each group having a Level I classification, 6 Level II, 7 Level III, 5 Level IV, and 1 Level V. CWS had a mean social position score of 31.82 (SD = 14.00; Hollingshead classification III) and CWNS a mean of 33.82 (SD = 14.95; Hollingshead classification III), a non-significant difference, $t(42) = -0.46$, $p = .65$.

Group Classification Criteria—Children participated in a conversational interaction for group (CWS or CWNS) classification purposes. Children and their parent(s) interacted with each other for 20 to 30 minutes while seated at a small table with age-appropriate toys. A 300-word sample was obtained for each child and analyzed for frequency of part-word and single-syllable repetitions, sound prolongations, blocks, and tense pauses. Most CWS produce these disfluency types more often than CWNS (Yairi & Ambrose, 1992, 1999, 2005). Stuttering severity was measured for CWS using the *Stuttering Severity Instrument-3* (SSI-3; Riley, 1994).

Children who stutter: To be classified as a CWS, children were required to (a) exhibit three or more of the aforementioned disfluency types per 100 words of conversational speech; (b) receive a total score of 11 or above on the SSI-3 (8 CWS were classified as “mild,” 11 “moderate,” and 3 “severe”); and (c) have parent(s) who were concerned about their speech disfluency. CWS had an average parent-reported time since stuttering onset of 15.73 months (SD = 8.50), as measured using the “bracketing” procedure of Yairi and Ambrose (1992; cf. Anderson, Pellowski, Conture, & Kelly, 2003).

Children who do not stutter: To be classified as a CWNS, children had to exhibit less than three of the aforementioned disfluency types per 100 words of conversational speech and have no parental concern about their speech disfluency.

Procedures

Children were tested in the Speech Disfluency Laboratory in two separate sessions, lasting 45 to 90 minutes. Both sessions were conducted in a quiet room to minimize ambient noise in the environment. In the first session, children participated in the parent-child interaction (described above) and completed four speech-language tests and a hearing screening. In the second session, children participated in a computerized picture naming task (described below), as well as several other tasks unrelated to the present investigation. The conversational interaction and picture naming task were videotaped using two color video cameras (EV1-D30), Unipoint AT853 Rx Miniature Condenser Microphone, and Panasonic DVD/HD video recorder (DMR-HS2).

Speech-Language Tests and Hearing Screening—To participate, children were required to score no lower than one standard deviation below the mean on four norm-referenced speech-language tests to ensure that their speech (other than stuttering) and language skills were typically developing. The speech-language tests, which were administered after the conversational interaction, included: (a) *Peabody Picture Vocabulary Test-III* (PPVT-III; Dunn & Dunn, 1997), a measure of receptive vocabulary; (b) *Expressive Vocabulary Test* (EVT; Williams, 1997), a measure of expressive vocabulary; (c) Spoken Language subtest of the *Test of Early Language Development-3* (TELD-3; Hresko, Reid, & Hammill, 1999), a measure of receptive and expressive language skills; and (d) "Sounds-in-Words" subtest of the GFTA-2, a measure of speech sound articulation.

All children received standard scores of 85 (one standard deviation below the mean) or higher on all four speech and language tests. Nevertheless, as a group, CWS (PPVT-III: M = 111.68, SD = 10.39; EVT: M = 113.91, SD = 11.33; TELD-3: M = 115.86, SD = 14.48; GFTA-2: M = 106.05, SD = 10.46) scored lower than CWNS on each of the four standardized tests (PPVT-III: M = 113.45, SD = 11.97; EVT: M = 117.82, SD = 8.97; TELD-3: M = 119.95, SD = 11.11; GFTA-2: M = 110.27, SD = 8.54). These differences were not statistically significant, with p-values ranging from .15 to .60. Each child's hearing was screened, following the speech-language testing, using bilateral pure tone testing at 20dB SPL for 500, 1000, 2000, and 4000 Hz (American Speech-Language-Hearing Association, 1990) to ensure that hearing was within normal limits. All participants passed the hearing screening.

Picture Naming Task—Children participated in a computerized picture naming task, consisting of two common random sets of pictures, similar in design to Barry et al. (2001). Children named each picture depicted on the computer screen and the length of time in which it took the child to name the picture was recorded, along with the number and type of errors produced. The stimulus materials, experimental design, response coding, and exclusion of participants are described below.

Stimulus materials: Stimulus materials consisted of 44 pictures of simple object–20 experimental, 20 filler, and 4 practice pictures–from Snodgrass and Vanderwart (1980). The experimental pictures consisted of 10 early AoA words (e.g., fish, hand) and 10 late AoA words (e.g., heart, zebra; see Appendix). AoA was determined using the objective "75% rule" values reported by Morrison, Chappel, and Ellis (1997). These AoA values are based on data collected from 280 children between the ages of 2;6 and 10;11 (years; months) during a picture naming task, in which most of the pictures were derived from the Snodgrass and Vanderwart corpus. Morrison and colleagues defined AoA as the mean age (in months) at which 75% of the children in a particular age group were able to correctly name the pictured word. For example, items that were named correctly by 75% of children who were 54 to 59 months of age range were assigned a mean AoA value of 56.5 months. The authors reported that the AoA values obtained using the objective "75% rule" were highly correlated with subjective AoA ratings and curve-fitted estimates of AoA, which indicates that they are a reliable and valid estimate of the age in which words tend to be acquired. In the present study, early and late AoA words were selected to be in keeping with the age of the participants. Thus, the late AoA words had to be among those that most preschool children would be able to name, but late enough that they would be maximally different from those acquired earlier in life. Early AoA words had a mean acquisition rating of 23.01 months (SD = .63, Range = 22.1 - 23.4 months), while late AoA words had a mean acquisition rating of 49.30 months (*SD* = 4.73, Range = 44.5 - 56.5 months), a statistically significant difference, $t(18) = -17.41$, $p < .001$.

The 10 early and 10 late AoA words were closely matched by word frequency, name agreement, concept familiarity, word length, and visual complexity to ensure that they were otherwise comparable in linguistic and visual complexity (see Table 1). Values for word frequency (the number of times a given word occurs in a language as expressed per million) were initially based on the adult written American English counts of Kučera and Francis (1967). After log-transforming the word frequency values to normalize the distribution, an independent samples *t*-test revealed no significant difference in word frequency between the early and late AoA words using this database, $t(18) = -.13$, $p = .90$. Because this database was derived from the adult lexicon, this measure was also cross-validated with the kindergarten spoken American English counts of Kolson (1960; e.g., Garlock, Walley, & Metsala, 2001). One late acquired word (zebra) did not appear in this database and, thus, the mean frequency value for late AoA words was based on 9 instead of 10 words. As revealed in Table 1, the mean word frequency value (and standard deviation) for early AoA words was higher than the mean value for late AoA words using this database, but this difference was not statistically significant, $t(17) = 1.00$, $p = .33$. Thus, regardless of which database is used to calculate word frequency, the early and late AoA words would appear to be comparable in word frequency, a claim further substantiated by a significant, positive correlation between values in both databases ($r = .54$, $p = .02$).

All other matching variables, whose values are shown in Table 1, were based on the normative values of Cycowicz, Friedman, Snodgrass, and Rothstein (1997). The Cycowicz et al. normative values for name agreement (the percentage of children who named a picture with its most common name), concept familiarity (how well known a pictured word is), word length (number of phonemes associated with a pictured word), and visual complexity (how complex a pictured word is) are based on the responses of kindergarten children to the Snodgrass and Vanderwart (1980) pictures. Independent samples *t*-tests revealed no significant difference between the early and late AoA words in any of these variables, with *p*-values ranging from .67 to .91.

Experimental design: Pictures were randomly organized into two sets of 30 pictures with no semantically or phonologically related words positioned next to each other and one filler picture per every one or two experimental pictures. Filler pictures were included in each picture set to reduce the predictability of repetition. The first picture set consisted of the 20 experimental pictures and 10 filler pictures. The second picture set consisted of the same 20 experimental pictures, but 10 different filler pictures. Children were seated in front of a computer and given the following directions: "This is a picture naming game. You will see some pictures on the computer screen and you need to name the pictures as fast as you can. We are going to practice first, so you can see how the game is played." Thus, the children began the experiment with four practice trials to ensure that they understood the task, and then they named the first set of pictures (Stage I). Each picture was displayed for 2,000 ms, with an inter-stimulus interval of 2,500 ms. A five minute break occurred after Stage I, and then the participants named the second set of pictures (Stage II). The presentation of the two picture sets was counterbalanced across children.

The picture naming task was generated using E-Prime v.1.1 software by Psychology Software Tools, Inc (PST). A PST Serial Response Box, which has a microphone and voice key that permits SRT data collection, was directly connected to the computer. The latency of the child's picture naming response (i.e., SRT) was measured in milliseconds from the onset of the pictured object to the onset of the child's verbal response. SRT data were recorded onto the computer via the E-Prime software program, while the children's verbal responses were recorded on the

DVD recorder. The main dependent variables were SRT and number of errors in response to the experimental pictures. SRT and error data from the practice and filler pictures were not analyzed.

Coding of responses: Children's responses to the experimental words in Stages I and II were accurate if they corresponded to the expected target response or if they were a synonym of the target response (e.g., *bunny for rabbit*).[1] All other responses were deemed errors, as described below, and excluded from the SRT analyses (see Table 2). Errors were divided into two types: child and other errors (cf. Melnick et al., 2003). Child-related errors (i.e., errors resulting from the child's behavior) included semantic, blocked, fluency, phonologic, and determiner errors, whereas other errors (i.e., errors that were not child-related) included technical errors and outliers.

- **a.** *Semantic errors:* child's response did not correspond to the expected target response (e.g., child says “ear” in response to the picture of the nose; see German and Newman, 2004, for a similar description of semantic errors as they pertain to children's word finding skills),
- **b.** *Blocked errors:* child either failed to respond or responded with “I don't know” or “What's that?” (cf. German & Newman, 2004),
- **c.** *Fluency errors:* child's response contained a speech disfluency (e.g., “uh… fish” or “m-m-m-mouse”),
- **d.** *Phonologic errors:* child's response contained a phonological error (e.g., /fɑg/ or /fwɑg/ for /frɑg/; cf. German & Newman, 2004),
- **e.** *Determiner errors:* child added the words “and” or “a” prior to the response (e.g., “a bow” or “and a cow”),
- **f.** *Technical errors:* an extraneous noise (e.g., tongue click, inhalation, etc.) triggered the voice key or the child did not speak loudly enough to trigger the voice key,
- **g.** *Outliers:* child's response was more than two standard deviations above or below the mean of all participant responses for a given stage (see Ratcliff, 1993).

Children's verbal responses to the experimental words were recorded by the author and a trained graduate student during the experiment. Any discrepancies in the online recordings of the author and graduate student (< 5% of the data were discrepant) were resolved by subsequently viewing the child's DVD recording to verify the response.

Exclusion of participants: Of 61 initial participants, 17 children (8 CWS, 9 CWNS) had to be excluded from participation because (a) they refused to fully partake in the picture naming experiment (2 CWS, 5 CWNS), (b) they failed to receive a standard score of 85 or higher on one or more speech-language test(s) (2 CWS, 0 CWNS), or (c) more than half of their responses to the experimental words in Stage I or II were errors (4 CWS, 4 CWNS). After removing all errors (see Table 2), the remaining 22 CWS had 293 (66.6%) useable responses in Stage I and 300 (68.2%) in Stage II (a maximum of 440 responses possible in each stage), while the 22 CWNS had 283 (64.3%) useable responses in Stage I and 304 (69.1 %) in Stage II.

[1]Synonyms were considered to be acceptable if both the target and synonym were comparable in AoA. Of the 1180 total useable, accurate responses across both talker groups and conditions, 95 (8%) were accepted as synonyms of the target response.

Results

The purpose of this study was to assess lexical access in CWS versus CWNS by examining the effects of repetition priming for early and late AoA words. The first step towards this aim was to calculate, for each child, mean SRT and error data for the 20 experimental words in Stages I and II. This data was subsequently analyzed, using analyses of variance (ANOVA) techniques, to determine whether CWS and CWNS differed in the speed and accuracy of picture naming in response to AoA and repetition priming. Correlational analyses were also conducted to examine the relationship between SRT and vocabulary for both CWS and CWNS.

Chronological age was a between-subjects variable for SRT and error analyses, as repetition or AoA effects could potentially differ between younger (e.g., 3-year-old) and older (e.g., 5-year-old) preschool children. In this way, older children would have more opportunities for repeated exposures to words than younger children simply by virtue of having lived for a slightly longer period of time. This could, in turn, influence their susceptibility to the effects of repetition or AoA. An additional motivation for including chronological age as a between-subjects variable is that some investigators have found differences between younger and older preschool CWS and CWNS using similar experimental paradigms (e.g., Byrd et al., 2007). In the present study, children were divided into two chronological age groups using a median split value of 54 months, with one group consisting of children equal to or less than 54 months of age (14 CWS; 12 CWNS; *M* = 47.2 months, *SD* = 5.19) and the other consisting of children equal to or greater than 55 months of age (8 CWS; 10 CWNS; *M* = 60.6 months, *SD* = 3.77).

SRT Analyses

SRT data was analyzed using a mixed-model ANOVA with stage (I or II) and AoA (early or late) as within-subjects variables and talker group (CWS or CWNS) and age group (≤ 54 months or ≥ 55 months) as between-subjects variables. Significant effects were followed-up with post-hoc analyses. Bonferroni adjustments were applied, where appropriate, to maintain Type I error at .05. Partial eta square (partial eta^2) is reported as an effect size measure for each statistical comparison, with a partial eta^2 of .14 representing a "large" effect, .06 a "medium" effect, and .01 a "small" effect (Cohen, 1988).

Within-Subjects Effects for SRT

Stage: The ANOVA revealed a significant main effect of stage, with children naming pictures more rapidly in Stage II (*M* = 1105.82 ms, *SD* = 166.48) than Stage I (*M* = 1170.85 ms, *SD* = 160.85), F (1, 40) = 8.01, p = .007, partial eta^2 = .17. There was no significant stage x talker group interaction effect, F (1, 40) = .03, p = .87, partial eta^2 = .001, indicating that repetition priming effects (i.e., the difference in SRT between Stages I and II) were similar for both CWS (*M* difference = 66.05 ms, *SD* = 133.58) and CWNS (*M* difference = 64.02 ms, *SD* = 140.56). The interaction effects between stage and age group, F (1, 40) = .70, p = .41, partial eta^2 = .02, and stage, talker group, and age group, F (1, 40) = .59, p = .45, partial eta^2 = .01, also failed to reach significance. These findings indicate that while preschool children's picture naming latencies were reduced as a result of their prior presentation, there were no differences between CWS and CWNS in repetition priming effects.

AoA: The ANOVA revealed a significant main effect of AoA, such that children named early AoA words (*M* = 1110.07 ms, *SD* = 157.35) more rapidly than late AoA words (*M* = 1166.60 ms, *SD* = 162.54), F (1, 40) = 8.95, p = .005, partial eta^2 = .18. There were no significant interaction effects between AoA and talker group, F (1, 40) = .08, p = .78, partial eta^2 = .002, AoA and age group, F (1, 40) = .001, p = .98, partial eta^2 = .00, and AoA, talker group, and age group, F (1, 40) = .52, p = .47, partial eta^2 = .01. As expected, findings revealed that children named early acquired words more rapidly than late acquired words.

Stage and AoA: There was no significant interaction effect between stage and AoA, F (1, 40) = 2.70, p = .11, partial eta^2 = .06. However, subsequent analyses revealed that repetition priming effects were, in fact, significant for late AoA words (M difference = 84.36 ms, SD = 182.22), t(43) = 3.07, p = .004, partial eta^2 = .07, but not early AoA words (M difference = 45.7 ms, SD = 165.60), t(43) = 1.83, p = .07, partial eta^2 = .18. There was also no significant interaction effect between stage, AoA, and talker group, F (1, 40) = .64, p = .43, partial eta^2 = .02 (Figure 1). On a descriptive basis, CWS named late AoA words, on average, about 92.5 ms (SD = 139.84) faster in Stage II than Stage I, while CWNS were 76.2 ms (SD = 219.75) faster. CWS and CWNS also benefitted, descriptively-speaking, from repetition for early AoA words, but this benefit was smaller (CWS: M= 39.56 ms, SD = 168.66; CWNS:M= 51.86, SD = 166.22).

The ANOVA further revealed a significant interaction for stage, AoA, and age group, F (1, 40) = 4.29, p = .04, partial eta^2 = .10 (Figure 2), but not stage, AoA, talker group, and age group, F (1, 40) = .96, p = .33, partial eta^2 = .02. To further examine the significant interaction, independent and paired samples t-tests (Bonferroni corrected) were used to analyze stage and AoA effects by age group. Between-group analyses revealed that children 54 months of age or younger (n= 26) named early and late AoA words consistently slower than children 55 months of age or older (n = 18) in both stages, with all p-values ≤ .01 (partial eta^2 = .13 to .39). Paired samples t-tests also revealed that children who were less than or equal to 54 months of age named early AoA words significantly faster, by about 86.33 ms (SD= 159.39), in Stage II than Stage I, t(25) = 2.76, p = .01, partial eta^2 = .23, but for children aged 55 months or older, the 12.96 ms (SD= 160.75) difference was not statistically significant,t(17) = −0.34, p = .74, partial eta^2 = .007. In contrast, for late AoA words, the 71.86 ms (SD= 184.28) difference between Stage I and II for children aged 54 months or younger was not statistically significant, t(25) = 1.99, p = .06, partial eta^2 = .14, but the 102.41 ms (SD= 182.92) difference for children aged 55 months or older was significant, t(17) = 2.38, p = .03, partial eta^2 = .25, even after Bonferroni correction. These results indicate that older preschool children significantly benefitted from repetition priming in response to late AoA words, whereas younger preschool children benefitted more from the effects of repetition for early AoA words.

Between-Subjects Effects for SRT—Although the main effect for talker group did not reach significance, F (1, 40) = 2.03, p = .16, partial eta^2 = .05, the main effect for age group was significant, F (1, 40) = 23.94, p < .001, partial eta^2 = .37. In particular, children who were 54 months of age or younger named pictures, on average, more slowly (M= 1210.72 ms, SD = 126.29) than children 55 months of age or older (M= 1033.78 ms, SD = 114.54). There was no significant interaction effect between talker group and age group, F (1, 40) = .43, p = .52, partial eta^2 = .01.

Error Analyses

Nonparametric statistics were used to examine within (stage and AoA) and between-group (talker and age group) differences in the number and types of child-related errors produced during the picture naming task. Nonparametric statistics were used to analyze the error data, as preliminary analyses revealed that the data violated the normality assumption and attempts to power transform the data failed to correct the distribution. The Pearson's correlation coefficient (r) statistic is reported as an index of effect size, with .50 representing a “large” effect, .30 a “medium” effect, and .10 a “small” effect (Cohen, 1988, 1992).

Within-Subjects Effects for Number of Child-Related Errors

Stage: A Friedman's ANOVA by ranks indicated that CWS produced significantly more naming errors in Stage I (M rank = 1.75) than Stage II (M rank = 1.25), $\chi^2(1, n = 22) = 6.37$, p = .01, r = .56. The repetition priming effect was largely restricted to those who were 55 months or age or older, as the difference in the number of naming errors between Stages I and

II was significant for CWS in this age range (Stage I: *M* rank = 1.94; Stage II: *M* rank = 1.06), χ^2(1, *n* = 8) = 7.00, *p* = .008, *r* = .98, but not for those who were 54 months of age or younger (Stage I: *M* rank = 1.64; Stage II: *M* rank = 1.36), χ^2(1, *n* = 14) = 1.33, *p* = .25, *r* = .26. While CWNS also produced fewer naming errors in Stage II (*M* rank = 1.43) than Stage I (*M* rank = 1.57), this difference was not statistically significant, χ^2(1, *n* = 22) = .53, *p* = .47, *r* = .00. In general, these findings indicate that CWS, particularly those who are older, produced significantly fewer child-related errors following the effect of repetition, whereas the same was not true for CWNS.

AoA: A Friedman's ANOVA by ranks revealed a significant effect of AoA, such that both CWS, χ^2(1, *n* = 22) = 13.76, *p* < .001, *r* = .85, and CWNS, χ^2(1, *n* = 22) = 8.00, *p* = .005, *r* = .63, produced fewer naming errors on early AoA words (CWS: *M* rank = 1.11; CWNS: *M* rank = 1.23) relative to late AoA words (CWS: *M* rank = 1.89; CWNS: *M* rank = 1.77). The effect of AoA, however, was largely restricted to children younger than or equal to 54 months of age, as the difference in errors between early and late AoA words was significant for CWS, χ^2(1, *n* = 14) = 14.00, *p* < .001, *r* = .98, and CWNS, χ^2(1, *n* = 12) = 6.40, *p* = .01, *r* = .77, who were 54 months of age or less, but not for those who were 55 months of age or older (CWS: χ^2[1, *n* = 8] = 1.29, *p* = .26, *r* = .33; CWNS: χ^2[1, *n* = 10] = 2.00, *p* =.16, *r* =.43). Thus, findings reveal that children, particularly those who are younger, named early AoA words with significantly fewer child-related errors than late AoA words.

Stage and AoA: A Friedman's ANOVA by ranks indicated that the number of naming errors varied significantly across stage and AoA for CWS, χ^2(3, *n* = 22) = 24.68, *p* < .001, *r* = .85, and CWNS, χ^2(3, *n* = 22) = 16.92, *p* = .001, *r* = .74 (Figure 3). For CWS, follow-up Wilcoxon signed-ranks tests (Bonferroni corrected) indicated that repetition priming effects (i.e., the difference between the number of errors produced in Stages I and II) were significant for late AoA words (*M* difference = .82, *SD* = 1.62), *z* = −2.08, *p* = .04, *r* = −.44, but not early AoA words (*M* difference = .55, *SD* = 1.50), *z* = −1.60, *p* = .11, *r* = −.34. Analyses further revealed that the significant repetition priming effect for late AoA words was generally restricted to CWS who were 55 months of age or older (*M* difference = 1.38, *SD* = 1.69), *z* = −2.04, *p* = .04, *r* = −.72, but not CWS who were 54 months of age or younger (*M* difference = .50, *SD* = 1.56), *z* = −1.09, *p* = .28, *r* = −.29. Although the overall stage x AoA interaction was significant for CWNS, follow-up tests failed to reveal any significant repetition priming effects for early (*M* difference = .36, *SD* = 1.22), *z* = −1.41, *p* = .16, *r* = −.30, and late AoA words (*M* difference = .41, *SD* = 1.47), *z* = −1.38, *p* = .17, *r* = −.29. These findings indicate that CWS, particularly those who are older, produced fewer child-related errors on late AoA words as a result of their prior presentation, whereas the same was not true for CWNS.

Between-Subjects Effects for Number of Child-Related Errors—A Kruskal-Wallis analysis of variance revealed no significant difference between CWS (*M* rank = 23.61) and CWNS (*M* rank = 21.39) in the total number of errors produced in the picture naming task, χ^2 (1, *N* = 44) = .33, *p* = .56, *r* = .00. There was also no significant difference between children 54 months of age or younger (*M* rank = 25.71) and those 55 months of age or older (*M* rank = 18.64) in the total number of errors across all stimulus items, χ^2 (1, *N* = 44) = 2.78, *p* = .10, *r* = .25. Analyses of the interaction between talker and age group failed to reveal any significant differences in the number of errors between CWS and CWNS who were less than or equal to 54 months of age, χ^2 (1, *n* = 26) = .05, *p* = .82, *r* = .00 (CWS: *M* rank = 13.18; CWNS: *M* rank = 13.88), and those who were 55 months of age or older, χ^2 (1, *n* = 18) = 1.57, *p* = .21, *r* = .27 (CWS: *M* rank = 11.25; CWNS: *M* rank = 8.10). There were also no significant differences between CWS and CWNS in the number of errors produced by stage, AoA, and age group, with *p*-values ranging from .10 to .99 (*r* = .25 to 00). These findings indicate that children in both talker and age groups were comparable in terms of the number of total child-related errors produced during the picture naming task.

Within- and Between-Subjects Effects for Types of Child-Related Errors—A Friedman's ANOVA by ranks revealed a significant variation in child-related error types (semantic, blocked, fluency, phonologic, and determiner) for both CWS and CWNS in Stage I, $\chi^2(4, n = 22) = 20.23$ and 21.01, respectively, $p < .001$, $r = .85$, and Stage II, $\chi^2(4, n = 22) = 25.25$ and 26.25, respectively, $p < .001$, $r = .85$. As shown in Table 2, semantic errors were, on a descriptive basis, the most common type of error produced by CWS and CWNS in each stage, followed by fluency errors for CWS and blocked errors for CWNS. With respect to AoA, neither CWS, $\chi^2(4, n = 22) = 3.35$, $p = .50$, $r = .00$, nor CWNS, $\chi^2(4, n = 22) = 7.19$, $p = 13$, $r = .32$, exhibited a significant variation in error types for early AoA words, but error types significantly varied in response to late AoA words, $\chi^2(4, n = 22) = 29.79$ and 29.07, respectively, $p < .001$, $r = .85$. With respect to this latter finding, semantic errors were, again, the most common error type produced by CWS and CWNS when naming late AoA words, followed by blocked and fluency errors for CWS and blocked errors for CWNS. Finally, Kruskal-Wallis analyses of variance revealed no significant differences in the number of errors produced by type between talker and/or age groups, with p-values ranging from .08 to .92 ($r = .26$ to 00). In sum, these findings indicate that the types of child-related errors significantly varied within stages and for late AoA words, with the most common error type being semantic in nature.

Correlational Analyses of Speech Reaction Time and Lexical Measures— Bivariate correlation analyses were conducted for each talker group between SRT for early and late AoA words in each stage and three of the four formal tests administered in the first session (PPVT-III, EVT, and TELD-3). As will be recalled, the PPVT-III and EVT measure receptive and expressive vocabulary, respectively. The TELD-3 is an overall measure of spoken language development; it assesses syntax and morphology, as well as expressive and receptive vocabulary (Hresko et al., 1999).

For CWS, there were no significant correlations between SRT (for early and late AoA words in Stages I and II) and the EVT ($p = .59$ to .94), PPVT-III ($p = .26$ to .96), and TELD-3 ($p = .45$ to .95). For CWNS, significant, positive correlations were found between SRT in Stage I for early AoA words and the EVT ($r = .51$, $p = .01$), SRT in Stage I for late AoA words and the PPVT-III ($r = .44$, $p = .04$), and SRT in Stage II for late AoA words and the EVT ($r = .45$, $p = .04$). All correlations between SRT and the TELD-3 were significant and positive for CWNS (Early AoA, Stage I: $r = .57$, $p = .005$; Late AoA, Stage I: $r = .63$, $p = .002$; Early AoA, Stage II: $r = .45$, $p = .04$; Late AoA, Stage II: $r = .53$, $p = .01$). All other correlations for CWNS between SRT and both the EVT and PPVT-III were not statistically significant, with p-values ranging from .08 to .41. These findings indicate a relationship between SRT for early and late AoA words both before and after the effects of repetition and vocabulary for CWNS, but not CWS.

Discussion

Within the past few years, investigators have begun to examine the phonological and lexical processing abilities of CWS and CWNS to determine if stuttering could be related to limitations in the ability to engage in these processes (e.g., Hakim & Ratner, 2004; Pellowski & Conture, 2005). In the present study, the goal was not to examine phonological or lexical encoding per se, but rather the connection between semantic and phonological processing components. To accomplish this goal, children participated in a picture naming task, in which they named pictures of early and late AoA words in two consecutive stages. The resulting data was then analyzed to determine whether CWS and CWNS differed in the speed and/or number of errors produced during the task, as well as the relationship between SRT and vocabulary. What follows is a discussion of the main findings from these analyses.

AoA and Repetition Priming Effects

Findings revealed that AoA and repetition priming had a significant influence on picture naming latencies and errors in preschool CWS and CWNS. More specifically, children's picture naming latencies and errors were reduced following the effect of repetition and in response to early AoA words relative to late AoA words. In addition, children named pictures depicting late AoA words significantly faster following repetition priming, whereas repetition priming effects on picture naming speed and errors were not significant for early AoA words. These findings are consistent with previous studies in suggesting that (a) words acquired earlier in life are named faster and with fewer errors than those acquired later in life, (b) words are processed faster and with fewer errors after having had prior experience with the word, and (c) words acquired later in life benefit more from repetition than those acquired earlier in life (e.g., Barry et al., 2001; Brown & Watson, 1987; Garlock et al., 2001; Lorsbach et al., 1992). These findings establish the effectiveness and validity of the materials and procedures used to manipulate lexical access in this study.

Findings further revealed that AoA and repetition priming effects on picture naming latencies and errors were relatively similar for CWS and CWNS, with one exception. Namely, CWS exhibited significantly fewer naming errors, particularly in response to late AoA words, following repetition priming, whereas the same was not true for CWNS. As previously indicated, AoA and repetition priming effects are presumed to result from modifications in the strength of the connection between semantic and phonological representational levels or, perhaps, between semantic-lemma or lemma-lexeme levels (Barry et al., 2001; Belke et al., 2005; Catling & Johnston, 2005; Ellis & Lambon Ralph, 2000; Hernandez & Reye, 2002; Wheeldon & Monsell, 1992; Zevin & Seidenberg, 2002). Connection strength is presumably stronger for early AoA words, weaker for late AoA words, and enhanced following repetition. According to some theorists, early AoA words have stronger connections, because they are learned when the brain is most responsive to learning (see Johnston & Barry, 2006, for review). As a result of this increase in responsiveness or plasticity, early AoA words are more likely to become ingrained in the system, making them easier to access. Responsiveness to learning (i.e., brain plasticity) presumably declines over time, which is why it is more difficult for late AoA words to establish strong semantic-phonological connections (Johnston & Barry, 2006). If the connections are more tenuous for late AoA words, then the scope for further decreasing the speed or accuracy of access following repetition priming will be greater (Hernandez & Reye, 2002; cf. Barry et al., 2001). In contrast, if early AoA words are already easy to access, given that their connections are more entrenched, then there will be less scope for further decreasing speed or accuracy following repetition priming.

If AoA and repetition priming effects are due to modifications in the strength of semantic-phonological connections during lexical access, as suggested above, then the fact that CWS benefitted more, in error reduction, than CWNS from repetition priming for late AoA words suggests that their connections may not be quite as firmly established as those of CWNS. These words would be more vulnerable to errors or other disruptions, as a result. This speculation should be considered tentative and preliminary, given that there were otherwise no significant differences between CWS and CWNS. In considering these latter findings, it is tempting to speculate that whatever weaknesses, if any, CWS have in the strength of their semantic-phonological connections may simply be a “side-effect” of less specified (i.e., detailed) semantic, lexical, or phonological representations. Accordingly, words with more specified semantic, lexical, or phonological representations tend to be used more frequently in language, making them stronger and more ingrained (e.g., Anderson, 2007; cf. Garlock et al., 2001;

Metsala & Walley, 1998). In contrast, words with less specified representations tend to be used less frequently, resulting in more tenuous connections. Thus, if the representations of CWS are less specified, then the connection between representational levels may be more indirectly affected, which might account for the fact that CWS and CWNS were otherwise comparable on the picture naming task.

Chronological age did not have a major impact on the speed of picture naming in response to AoA and repetition priming, but it did influence the interaction between the two factors. In particular, younger preschool children named pictures depicting early and late AoA words more slowly than older preschool children both before and after repetition priming. Younger children also named early AoA words significantly faster following repetition priming, whereas the opposite occurred for older children–that is, they named late AoA words significantly faster following repetition. Chronological age did not have a significant influence on the number of errors produced, although younger children named early AoA words with significantly fewer errors than late AoA words.

Perhaps the most obvious explanation for these age-related findings is that the lexicons of younger preschool children are not as developed as those of older preschool children, because they have had fewer opportunities for repeated exposures to words–both early and late acquired–due to their age. This would presumably result in slower picture naming latencies. Younger preschool children would also benefit more from repetition priming for early AoA words than older preschool children, because semanticphonological connections are not likely to be as strong, giving them more room for improvement. Younger preschool children would also likely benefit less from repetition priming for late AoA words, as these connections may be too loosely or newly established, making them less responsive to priming. By comparison, older preschool children would benefit less from repetition priming for early AoA words, because these words are already highly established, giving them less scope to further decrease speed. They would, however, have a greater scope for decreasing speed for late AoA words, as these words are likely stronger than those of younger preschool children, making them susceptible to priming, but still not completely developed. Thus, they would have plenty of room to further decrease the speed with which they name these late AoA words.

Relationship Between Speech Reaction Time and Vocabulary Measures

Findings revealed that CWNS who scored higher on standardized measures of vocabulary named pictures more slowly than those who scored lower on these measures and vice versa. However, no such relationship existed for CWS. The finding of a positive relationship between SRT and the lexical measures for CWNS is surprising, as one might expect children with higher vocabulary scores to name pictures more rapidly (i.e., SRT decreases) than those with lower vocabulary scores. This expectation is based, in part, on findings from other studies, in which significant, negative correlations have been found between SRT and various speech-language measures for CWNS (Melnick et al., 2003; Pellowski & Conture, 2005). One possible explanation for these findings is that CWNS with larger vocabularies experience more lexical competition than those with smaller receptive vocabulary sizes (see Cutting & Ferreira, 1999; Levelt et al., 1999 regarding lexical competition in models of speech-language production). Accordingly, CWNS with larger vocabularies may have more difficulty efficiently and effectively accessing appropriate lexical items or forming stronger connections in a system that has more vocabulary entries to choose from, resulting in slower naming latencies. In contrast, lexical competition would presumably be less for CWNS with smaller vocabularies, as they have fewer lexical items to compete for selection during lexical access and/or their connections may be more firmly established, enabling them to name pictures more rapidly.

The fact that present findings contradict those of Melnick et al. (2003) and Pellowski and Conture (2005) in terms of the direction of the association for CWNS may be wholly or partially attributed to the methodological differences in these studies. As will be recalled, Melnick et al. and Pellowski and Conture used picture-word interference tasks to examine whether CWS have difficulties with the selection or retrieval of lexemes and lemmas, respectively. The SRT data obtained from these tasks were later correlated with a measure of sound production (i.e., GFTA-2; Melnick et al.) and receptive and expressive vocabulary (i.e., PPVT-III and EVT; Pellowski & Conture). In the present study, however, a picture naming task with no auditory interference was used to “tap-into” the semantic-phonological connection, with the resulting SRT data correlated with the PPVT-III, EVT, and TELD-III. Thus, it seems reasonable to suggest that differences in the conditions in which SRT data were obtained or the types of speech-language measures used across studies could have contributed to the differences in the direction of the association.

Despite differences in findings between the present study and those of Conture and colleagues (Melnick et al., 2003; Pellowski & Conture, 2005) in the direction of the association, these studies are consistent in finding that CWNS exhibited associations between SRT and speech-language measures, whereas CWS did not. These latter findings had been interpreted to suggest that CWS may have less organized or developed phonological (Melnick et al.) or lexical (Pellowski & Conture) systems than CWNS. In the present study, findings are interpreted to suggest that the lexical measures (EVT, PPVT-III, TELD-3) are simply not sensitive enough to differentiate CWS from CWNS in lexically-related aspects of language production. As will be recalled, there were no significant differences between CWS and CWNS on any of the aforementioned lexical measures or in SRT for early and late AoA words both before and after the effects of repetition priming. Thus, given that CWS and CWNS were comparable in their performance on these measures, but SRT was significantly correlated with lexical measures for CWNS, but not CWS, suggests that some other factor inherent in these measures may have contributed to the association. This factor, however, whatever it is, is seemingly not as apparent or functionally different in CWS.

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Findings from several recent studies (Anderson et al., 2006; Hakim & Ratner, 2004) provide a preliminary basis for speculation regarding the possible nature of this “mediating factor.” These studies revealed that CWS are less successful in their ability to correctly repeat two- and three-syllable nonwords than their normally fluent peers, suggesting that CWS may have difficulty retaining phonological information in working memory. The ability to accurately repeat nonwords has consistently been shown to be associated with vocabulary development (see Gathercole, 2006, for review). Given the apparent relationship between nonword repetition and vocabulary development, it is suggested that phonological working memory may have mediated the association between SRT and the lexical measures observed in this study. Accordingly, the fact that CWS did not exhibit this association may then be interpreted to reflect the difficulties they reportedly have with phonological working memory.

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The finding that all correlations between the TELD-3 and SRT were significant for CWNS further supports the notion that phonological working memory may have mediated the observed association. As will be recalled, the TELD-3 captures a variety of expressive/receptive language skills beyond the single-word level and, thus, is likely to be more dependent on working memory demands or processes than the PPVT-III and EVT. Thus, if working memory mediates the relationship between SRT and the lexical measures, and the TELD-3 is more dependent on working memory skills, then the fact that the TELD-3 was more consistently related to SRT than the PPVT-III and EVT in CWNS can be more readily explained.

Conclusion and Future Directions

The main question in this study was whether CWS differ from CWNS in processes associated with the mapping of semantic representations onto phonological representations. The findings that emerged did not provide a conclusive answer to this question. While there was some evidence to suggest that the semantic-phonological connections of CWS may not be as strong as those of CWNS, the performances of CWS and CWNS were otherwise comparable. Thus, it was suggested that any weaknesses CWS have, if any, in their semantic-phonological connection strength may indirectly reflect the degree of specificity in the representations themselves. This conclusion was based on the notion of a reciprocal link between representation specificity and connection strength, such that more specified representations tend to have stronger connections and vice versa. Nevertheless, it seems relatively safe to say that semantic-phonological connections are probably not a major source of difficulty for CWS. Rather, any difficulties CWS have with speech-language production may be more related to lexical or phonological encoding (e.g., Byrd et al., 2007; Hartfield & Conture, 2006), morphosyntactic construction (e.g., Anderson & Conture, 2004), or a combination of processes (Anderson, 2007; Anderson & Byrd, in press).

The present finding of a significant relationship between linguistic speed and lexical measures for CWNS, but not CWS would seem to warrant further exploration. In particular, the notion that the observed association for CWNS may have been mediated by phonological working memory could be tested in future research by examining the relationship between linguistic speed and measures of verbal working memory, such as the nonword repetition task. If working memory was driving the association observed in the present study, then one would expect to find significant differences or, perhaps, dissociations between CWS and CWNS in the relationship between linguistic speed and measures of verbal working memory.

In addition to the conceptual issues noted above, there are several methodological issues that may warrant consideration. The first issue has to do with the removal of responses with phonological errors for the SRT analyses. Responses containing phonological errors had been removed, because (a) it was assumed that the error reflected non-normal processes, and (b) the practice of removing phonological errors from data corpora is common-place in picture naming studies (e.g., Arnold, Conture, & Ohde, 2005; German & Newman, 2004; Pellowski & Conture, 2005). On the other hand, one might argue that these non-adult-like productions are not errors, but rather part and parcel of the child's lexicon–at least from the child's point-of-view. Although few responses were removed for this reason (see Table 2), the utility of this practice may warrant further consideration in future studies of this nature.

The second issue has to do with the age of the participants. The advantage of using preschool CWS as participants is that they are closer to the median age of onset of stuttering, which is approximately 30 to 38 months of age (Yairi & Ambrose, 2005). As they age, children who continue to stutter tend to develop more negative feelings and attitudes about themselves and their stuttering, increase their level of awareness, and produce more avoidance behaviors and tense physical struggles or body movements during stuttering (Guitar, 2006). With the advent of these behaviors, it becomes more difficult to determine if any differences between older children, adolescents, or adults who stutter and their normally-fluent peers are associated with the actual cause of stuttering or to other factors associated with, for example, the use of compensatory behaviors or psychological reactions (see Yairi, 1993). Thus, preschool CWS represent an ideal population in which to study, because one can examine factors that may be present during the time in which stuttering typically develops and do so with potentially less interference from factors associated with more advanced stuttering.

One disadvantage, however, of using preschool children as participants is that it can be difficult to design experimental studies that children of this age range can reliably perform. In the present study, it was especially challenging to find early and late AoA words that would be maximally distinct from one another in mean AoA and still be among those that most children would be likely to name. Young children also tend to be highly variable in vocabulary acquisition, such that it was possible that some of the younger participants (or, perhaps, even some of the older children) may not have acquired some late AoA words, while others may have acquired words whose mean AoA exceeds their chronological age. The former case is less of an issue, because if the child didn't know the word, then that response would have been excluded from the data corpus. The second case, however, may be more problematic, but then again, perhaps, less so if one considers that even if a child had acquired a late AoA word that exceeded his/her chronological age, that word should still be named more slowly or less accurately than those that had been acquired earlier in life.

The pattern of findings in this study further substantiates the validity of the experimental design for, as expected, children named early AoA words significantly faster than those acquired later in life, and younger children named both early and late AoA words significantly slower than the older children. It may be interesting, however, to replicate this study with school-aged children as participants, as this may lessen, although not eliminate, issues related to potential mismatches in the age at which an individual actually acquires a word and the acquisition age of the word based on normative data. On the other hand, using school-aged CWS as participants is not without its problems, given the increased likelihood that their data may be “contaminated” by other factors associated with advanced stuttering. For example, a child may name a word more slowly not because its semantic-phonological connection is weak, but rather because he has developed fears associated with the word's phonemes or the word itself.

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Appendix

List of Early and Late Acquired Experimental Words

Word	Early Acquired	Late Acquired
1	Table	Heart
2	Fish	Piano
3	Rabbit	Drum
4	Hat	Nose
5	Cow	Belt
6	Hand	Bell
7	Lion	Bow
8	Mouse	Glove
9	Airplane	Chicken
10	Frog	Zebra

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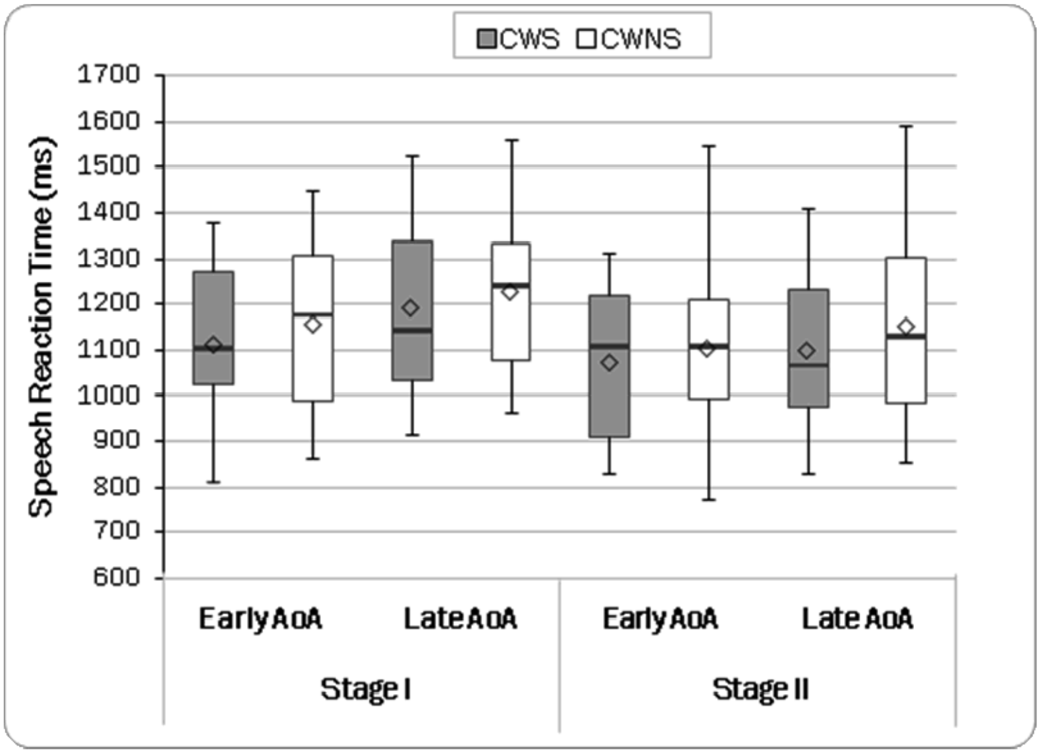

Figure 1.
Boxplot of SRT for early and late AoA words in Stages I and II for CWS (n = 22) and CWNS (n = 22) between the ages of 3;1 and 5;7 (years;months). The horizontal line in each box represents the value of the median; the diamond-shaped marker represents the value of the mean.

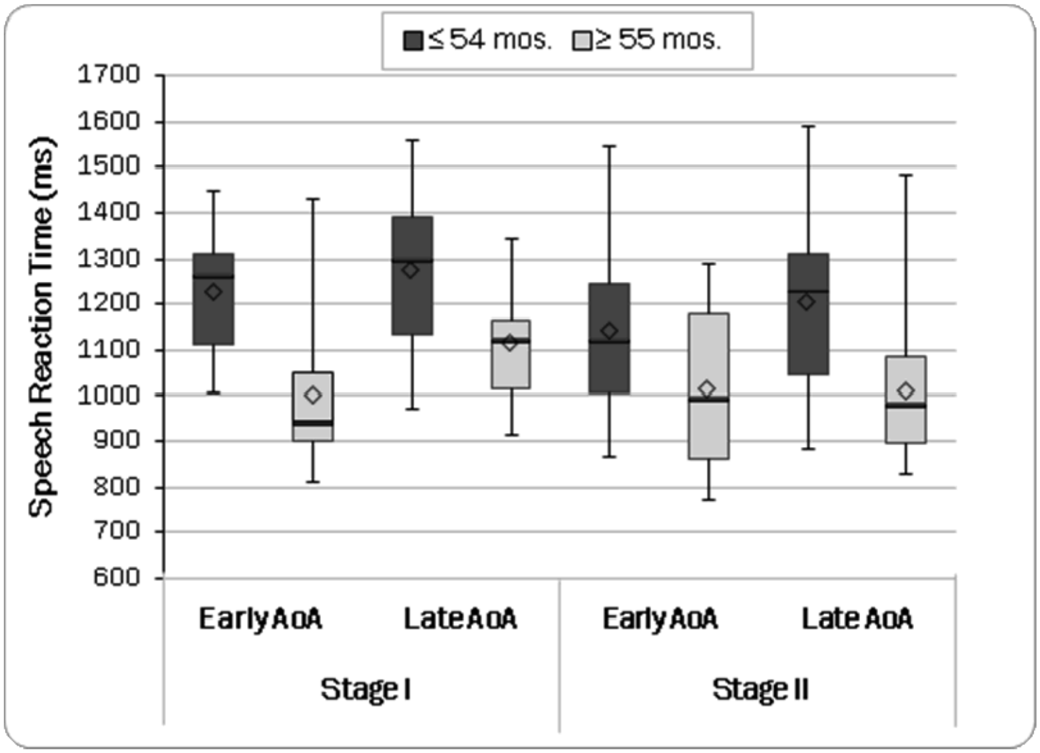

Figure 2.
Boxplot of SRT for early and late AoA words in Stages I and II for children 54 months of age or younger (n = 26) and 55 months of age or older (n = 18). The horizontal line in each box represents the value of the median; the diamond-shaped marker represents the value of the mean.

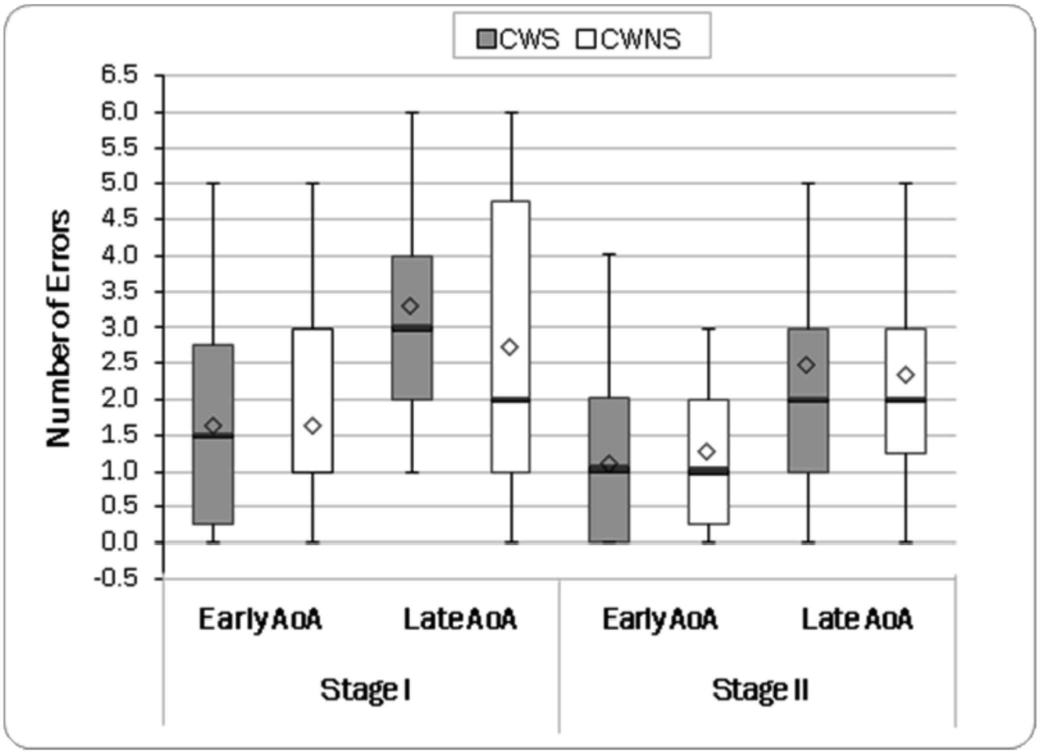

Figure 3.

Boxplot of the number of errors for early and late AoA words in Stages I and II for CWS (*n* = 22) and CWNS (*n* = 22) between the ages of 3;1 and 5;7 (years;months). The horizontal line in each box represents the value of the median; the diamond-shaped marker represents the value of the mean.

List of Early and Late Acquired Experimental Words

Word	Early Acquired	Late Acquired
1	Table	Heart
2	Fish	Piano
3	Rabbit	Drum
4	Hat	Nose
5	Cow	Belt
6	Hand	Bell
7	Lion	Bow
8	Mouse	Glove
9	Airplane	Chicken
10	Frog	Zebra

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Table 1

Mean (Standard Deviation) Characteristics of the 10 Early and 10 Late Acquired Experimental Words

Characteristic	Early AoA	Late AoA
AoA (months)	23.0 (0.6)	49.3 (4.7)
Name Agreement (%)	89.2 (10.4)	86.4 (15.4)
Word Frequency		
Kučera and Francis (1967)	37.7 (58.8)	35.8 (51.4)
Kolson (1960)	168.1 (185.9)	64.3 (36.6)
Concept Familiarity	2.8 (0.5)	2.7 (0.4)
Word Length (in phonemes)	3.9 (1.4)	3.8 (1.0)
Visual Complexity	3.1 (0.9)	3.1 (1.0)

Table 2

Number (Percent) of Error Types for All Picture Naming Responses in Stages I and II by Participant Group (CWS, CWNS) and Age of Acquisition (Early, Late)

	Children Who Stutter			
	Stage I		Stage II	
Error Types	**Early AoA**	**Late AoA**	**Early AoA**	**Late AoA**
Semantic	6(11.3)	33(35.1)	7(12.7)	27(31.8)
Blocked	7(13.2)	14(14.9)	3(5.5)	7(8.2)
Fluency	13(24.5)	12(12.8)	7(12.7)	9(10.6)
Phonological	5(9.4)	5(15.3)	6(10.9)	6(7.1)
Determiner	5(9.4)	8(8.5)	1(1.8)	5(5.9)
Technical	12(22.6)	13(13.8)	26(47.3)	19(22.4)
Outliers	5(9.4)	9(9.6)	5(9.1)	12(14.1)
COLUMN TOTAL	53(18.5)	94(32.8)	55(19.2)	85(29.6)
	Children Who Do Not Stutter			
Semantic	8(11.6)	27(30.7)	8(14.5)	26(32.1)
Blocked	8(11.6)	15(17.0)	6(10.9)	16(19.8)
Fluency	9(13.0)	9(10.2)	4(7.3)	5(6.2)
Phonological	8(11.6)	5(5.7)	8(14.5)	3(3.7)
Determiner	3(4.3)	4(4.5)	2(3.6)	1(1.2)
Technical	24(34.8)	20(22.7)	18(32.7)	18(22.2)
Outliers	9(13.0)	8(9.1)	9(16.4)	12(14.8)
COLUMN TOTAL	69(23.5)	88(30.0)	55(18.8)	81(27.6)

Note. CWS = Children who stutter; CWNS = Children who do not stutter; AoA = Age of Acquisition. The percent value (in parentheses) for each error type is calculated per total number of column errors. For each participant group, the percent value (in parentheses) for each column total is calculated per total number of errors.