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Effects of Perceptual and Conceptual Similarity in Lexical Priming of Young Children Who Stutter: Preliminary Findings

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Abstract

The purpose of this study was to investigate the influence of conceptual and perceptual properties of words on the speed and accuracy of lexical retrieval of children who do (CWS) and do not stutter (CWNS) during a picture-naming task. Participants consisted of 13 3- to 5-year-old CWS and the same number of CWNS. All participants had speech, language, and hearing development within normal limits, with the exception of stuttering for CWS. Both talker groups participated in a picture-naming task where they named, one at a time, computer-presented, black-on-white drawings of common age-appropriate objects. These pictures were named during four auditory priming conditions: (a) a *neutral* prime consisting of a tone, (b) a word prime *physically* related to the target word, (c) a word prime *functionally* related to the target word, and (d) a word prime *categorically* related to the target word. Speech reaction time (SRT) was measured from the offset of presentation of the picture target to the onset of participant's verbal speech response. Results indicated that CWS were slower than CWNS across priming conditions (i.e., neutral, physical, function, category) and that the speed of lexical retrieval of CWS was more influenced by functional than perceptual aspects of target pictures named. Findings were taken to suggest that CWS tend to organize lexical information functionally more so than physically and that this tendency may relate to difficulties establishing normally fluent speech and language.

Keywords

STUTTERING; SEMANTIC PROCESSING; LEXICAL RETRIEVAL; SEMANTIC PRIMING; LEXICAL PRIMING; CHILDREN; SPEECH REACTION TIME

Lexical Priming of Young Children Who Stutter

Recent empirical studies of children (e.g., Anderson & Conture, 2004; Byrd, Conture, & Ohde, 2006; Melnick, Conture, & Ohde, 2003; Pellowski, Conture, Anderson, & Ohde, 2001; Pellowski & Conture, 2005) as well as adults who stutter (e.g., Cuadrado & Weber-Fox,

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2003; Weber-Fox, 2001; Weber-Fox, Spencer, Cuadrado, & Smith, 2003; Weber-Fox, Spencer, Spruill, & Smith, 2004) suggest that the speech-language planning of these individuals may be subtly different. In particular, lexical/semantic skills appear less than typical for young children who stutter (CWS; Pellowski & Conture, 2005). For example, Pellowski and Conture reported that CWS exhibit slower speech reaction times (SRTs) than children who do not stutter (CWNS) in response to semantically-related primes (e.g., hearing "cat" just before naming a picture of "dog"). Consistent with these experimental findings, critical review (see Conture, 2001, p. 25, Appendix 3) of at least seven empirical studies of the receptive vocabulary abilities of CWS indicated that in four of these seven studies, CWS scored significantly lower than CWNS on tests of receptive vocabulary. Likewise, others have reported depressed expressive vocabulary in CWS in comparison to CWNS although both talker groups (CWS and CWNS) presented vocabulary skills within the range of normal (Ratner & Silverman, 2000; Silverman & Ratner, 2002). Based on these findings, it appears possible that lexical retrieval, encoding, and even storage may differ between CWS and CWNS.

Levelt's (1989) model of speech-language planning and production provides a basis for empirical examination of lexical access and retrieval (see Indefrey & Levelt, 2000, 2004; Levelt, 1989; Levelt, Roelofs & Meyer, 1999, for additional detailed coverage of this model). This model divides the complex process of speech-language planning and production into three inter-related subsystems or processing components: (1) the conceptualizer, (2) the formulator and (3) the articulator. Briefly, the *conceptualizer*, among various tasks, conceives the speaker's intention and selects the necessary information needed to realize and express the speaker's intention. The output of this processing component is described by Levelt as the "preverbal message" (Levelt, 1989, p10). The preverbal message, in turn, serves as input to the next processing component, that is, the *formulator*, which receives elements or fragments of the preverbal message, with the output of the formulator described as the phonetic or articulatory plan. This plan, in turn, serves as input to the *articulator*, which then executes the phonetic plan by means of the coordinated activities of the respiratory, laryngeal, and supralayrngeal systems.

Within the formulator processing component, the speaker is thought to access and retrieve information from their mental lexicon. Such access and retrieval takes time, of course, and as previously shown (Pellowski & Conture, 2006), the speed or latency of this access/retrieval process appears to differ between CWS and CWNS. Thus, speed of these processes would seem to be a salient variable to consider when assessing lexical access and retrieval in CWS and CWNS. In attempts to estimate a speaker's speed or latency of accessing and retrieving information from their mental lexicon, researchers have measured SRT (e.g., Pellowski & Conture, 2005; Schreuder, Flores d'Arcais, & Glazenborg, 1984). Furthermore, measurement of SRT allows the experimenter to assess the speaker's production of the retrieved information. Of course, any exploration of children's lexical retrieval skills also requires consideration of underlying developmental processes.

Development of Lexical/Semantic Processing and Its Measurement

Review of the development of lexical/semantic processing skills (e.g., Clark, 1973; Flores d'Acrais, Schreuder, & Glazenborg, 1985; Gentner, 1978; Nation & Snowling, 1999; Nelson, 1974a; Schreuder, Flores d'Arcais, & Glazenborg, 1984; Tomikawa & Dodd, 1980), highlights the fact that the exact nature and sequence of events involved with the development of lexical retrieval in young children are still less than certain. What is relatively more certain is that during development of semantic abilities, young children process various properties of objects, for example, physical properties (e.g., size, shape), in ways not yet fully understood.

Newman and German (2002) as well as Cycowicz, Friedman, Rothstein, and Snodgrass (1997) noted the importance of categorical, perceptual, and physical properties of objects to

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the semantic development and lexical retrieval abilities of young children. It seems reasonable to suggest, therefore, that interaction between the properties of objects *and* the child's abilities to conceptually organize these properties contributes to the development of their lexical retrieval abilities. Therefore, perceptual as well as conceptual properties of objects (in this case, target pictures to be named) seem particularly relevant for the study of lexical retreival of CWS.

In brief, *perceptual* processing is typically thought to involve lexical concepts/words that are semantically related to one another due to shared perceptual or physical attributes/properties (Flores d'Arais et al., 1985; Gentner, 1978; Schreuder et al., 1984; Tomikawa & Dodd, 1980). In contrast, *conceptual* processing is typically thought to involve nonphysical attributes of objects or pictures (Flores d'Arais et al., 1985; Gentner, 1978; Schreuder et al., 1984) such as categorical or functional features.

Lexical Priming Paradigm

Although several experimental methods might be used to assess the influence of perceptual and conceptual properties of objects on speed and efficiency of lexical retrieval, a lexical priming paradigm (e.g., McNamara & Holbrook, 2003; Pellowski & Conture, 2005) seems particularly useful. This paradigm allows for experimental manipulation of the time course or speed of covert linguistic planning processes that lead to participants' overt speech language production. The procedure permits the experimenter to pair auditory lexical representation with visual lexical representation of the target picture rather than solely relying on the written form of the target word (Nation & Snowling, 1999). Such priming methods have been used successfully to evaluate wide-ranging aspects of semantic and lexical processing in normally fluent adults as well as children who stutter (e.g., Bowles & Poon, 1985; Moss, McCormick, & Tyler, 1997; Nation & Snowling, 1999; Pellowski & Conture, 2005; Plaut & Booth, 2000; Schreuder et al., 1984).

One important consideration in priming experiments is the development of targets and primes that appropriately reflect the relationship(s) under consideration. For example, in theory, a target word immediately preceded by a functionally-related prime (e.g., prime = "bat" and target word = "ball") should trigger faster identification and naming when compared to a target preceded by a functionally-unrelated prime (e.g., prime = "bat" and target = "chair"; Bowles & Poon, 1985; McNamara, 1992; Moss et al., 1997).

In general, the aforementioned lexical priming paradigm can be used to assess children's speech reaction times (SRTs) as well as errors associated with naming of target pictures. Specifically, just prior to children naming the target pictures, children can be exposed to auditory primes that are (a) *physically* -, (b) *categorically* - or (c) *functionally* - related to the target pictures (see Table 1 for description and examples of primes). As mentioned above, categorical, functional and physical properties of objects are thought to be salient to the development of lexical access and retrieval in young children (Flores d' Arcais et al., 1985;Moss et al., 1997;Newman & German, 2002;Cycowicz et al., 1997). For example, Schreuder and colleagues (1984) measured speech reaction times of participants after their exposure to *perceptually*- or *conceptually*-based primes. However, Schreuder et al.'s findings were based on college students, whose lexical retrieval skills are essentially *established*; therefore, their results cannot be easily extrapolated to preschool children, whose lexical retrieval abilities are still *being acquired*.

Besides *speed* of lexical retrieval, assessment of *errors* in picture naming can also provide insight into children's lexical retrieval processes. By assessing the frequency of these naming errors, it is possible to assess whether slower speech reactions times for one or both talker groups might be merely due to more inaccurate naming. This relation - commonly referred to as a speed-accuracy tradeoff (SAT) - is often considered in studies measuring reaction time, because it has been argued that individuals have the ability to mentally control their SAT which, in turn, can affect their ability to accurately process information (see Rinkenauer, Osman, Ulrich, Muiller-Gethmann, & Mattes, 2004; Ulrich, Muller-Gethmann, & Mattes, 2004).

General Purpose/Hypotheses Tested

We speculated, based on others’ as well as our own research (e.g., Pellowski & Conture, 2005), that lexical access and retrieval are less than well-developed and/or organized in preschool-age CWS. As a consequence of this disorganization, CWS may have greater difficulty retrieving lexical items so that they can be mapped onto appropriate word forms.

Thus, it was the general purpose of this study to use an experimental priming paradigm to examine the physical, categorical, and functional aspects of semantic processing in preschool children who do and do not stutter during a picture-naming task. Specifically, we sought to further test the hypothesis that CWS and CWNS differ subtly relative to lexical retrieval.

The *a priori* hypothesis was that both groups of preschool children, regardless of talker group, would exhibit faster SRTs when naming pictures preceded by physically-related primes than categorically- or functionally-related primes (see Cycowicz, Freidman, Rothstein, & Snodgrass, 1997). Moreover, based on previous findings of the lexical skills of children who stutter (e.g., Pellowski & Conture, 2005; Ratner & Silverman, 2000; Silverman & Ratner, 2002), it was hypothesized the CWNS will appear more mature in their lexical retrieval by exhibiting faster speech reaction times in each conditions when compared to CWS. Lastly, it was hypothesized that picture-naming errors would not differ significantly between CWS and CWNS.

Method

Participants

Participants consisted of 13 preschool children who stutter (CWS) and 13 preschool children who do not stutter (CWNS), all of whom were native speakers of American English. All children participated in a series of studies through the Vanderbilt University Developmental Stuttering Research Project (with none of these 26 participants involved with Pellowski & Conture’s, 2005, study of lexical priming in young CWNS and CWS).

Participants were between the ages of 3;0 and 5;7 (CWS: $M = 49.77$, $SD = 9.95$; CWNS: $M = 52.85$, $SD = 9.17$) with no statistically significant between-group difference ($t\,[24] = -.820$, $p = .42$) in chronological age. The CWS group consisted of 10 boys and 3 girls, and the CWNS group consisted of 5 boys and 8 girls. All participants were paid volunteers referred to the Vanderbilt Bill Wilkerson Center by their parents, speech-language pathologists, daycare, preschool, or school personnel. None of the 26 children had received formal/structured intervention for stuttering or any other communication disorder prior to participation in this study. Also, participants had no known or reported hearing, neurological, developmental, academic, intellectual, or emotional problems. This study’s protocol was approved by the Institutional Review Board at Vanderbilt University, Nashville, Tennessee. For each of the 26 participants, parents signed an informed consent, and their children assented.

Excluded participants—From an initial group of 18 CWNS, 2 participants were excluded because one or more of their standardized test scores were below the 16^{th} percentile criterion. Of the remaining 16 CWNS, three additional participants were excluded because more than 35% of their naming responses were considered errors in at least one of the four priming conditions. From an initial group of 22 CWS, 7 participants were excluded because one or more of their standardized test scores were below the 16^{th} percentile criterion. Of the remaining

15 CWS, two additional participants were excluded because more than 35% of their naming responses were considered errors in at least one of the four priming conditions.

Classification

Children who stutter (CWS)—A child was considered a CWS if he or she (a) exhibited three or more stuttering-like disfluencies (SLD; i.e., sound/syllable repetitions, monosyllabic whole-word repetitions, sound prolongations, inaudible sound prolongations) per 100 words of conversational speech (based on a 300-word sample; Bloodstein, 1995; Conture, 2001; Yairi & Ambrose, 1992) and (b) received a total score of 11 or above (a severity equivalent of at least "mild") on the *Stuttering Severity Instrument-3* (SSI-3; Riley, 1994; CWS had a mean score of 18.40, *SD* = 8.77).

Children who do not stutter (CWNS)—A child was considered a CWNS if he or she (a) exhibited two or fewer SLD per 100 words of conversational speech based on a 300-word sample) and (b) received an overall score of 10 or less (a severity equivalent of less than "mild") on the *Stuttering Severity Instrument-3* (SSI-3; Riley, 1994; CWNS had a mean score of 5.00, *SD* = 3.30).

Standardized Speech-Language Tests and Hearing Screening—To participate in this study, all participants scored at the 16th percentile or higher on the (a) *Peabody Picture Vocabulary Test- Third Edition* (PPVT-IIIA or B; Dunn & Dunn, 1997), (b) *Expressive Vocabulary Test* (EVT; Williams, 1997), (c) *Test of Early Language Development-3* (TELD-3; Hresko, Reid, & Hamill, 1999) and (d) "Sounds in Words" subtest of the *Goldman-Fristoe Test of Articulation-2* (GFTA-2; Goldman & Fristoe, 2000), standardized tests used to assess receptive and expressive vocabulary, receptive and expressive language skills, and articulation abilities, respectively. These tests were administered to each child during a visit to the child's home approximately 1–2 weeks before experimental testing. Furthermore, each participant passed a bilateral pure tone hearing and tympanometric screening (ASHA, 1990) on the day they participated in the experimental tasks.

Race—The child's race was ascertained based on parental interview. There were ten Caucasian participants, two African-American participants, and one participant noted as "other" for the CWS group; there were thirteen Caucasian and no African-American participants for the CWNS group.

Socioeconomic Status (SES)—The child's SES was calculated and described for the parents of all participants. SES was determined through application of parent-report of occupation to the Two Factor Index of Social Position (Myers & Bean, 1968), which involves the assessment of each participant's "head of household" (father in case of dual-parent families) in terms of occupation and educational level. There was no statistically significant difference, $F(1,24) = 1.07$, $p = .311$, in SES between CWS ($M = 20.92$, $SD = 10.00$) and CWNS ($M = 25.69$, $SD = 13.26$).

Procedure

Participants for this study were tested on two separate occasions, once in the home and once in a clinical setting. During the home visit, all standardized testing of speech and language abilities was administered to the participant within 1.5 to 2.0 hours. Participants then visited the clinic 1–2 weeks later and participated in a parent-child conversational interaction for the analysis of speech disfluencies. Participants also were given a bilateral pure tone hearing and tympanometric screening and participated in the semantic processing priming tasks. Additional tasks were administered during the clinic visit, which were used for other studies within the

Vanderbilt University Developmental Stuttering Research Project. Participants were video-recorded during the clinic visit that lasted for 1.5 to 2.0 hours.

Lexical Priming Task

SRT was measured during four picture-naming conditions for the CWS and CWNS using a computer-assisted picture-naming program. Each participant was seated in a quiet room in front of a standard (Pentium 200 MHz) computer with a 20-inch Sony Trinitron monitor. The experimenter instructed each participant not to repeat the word ("prime") they hear ("don't say the funny word you hear"), but to name the pictures displayed on the screen ("as soon as you see it").

The onset of subsequent pictures was determined by the child's voice-activated microphone, which was attached to a co-processor, *E-prime* (Psychology Software Tools, 2002). E-prime was interfaced, synchronized, and run simultaneously with a Dell Dimension 8250 Pentium 4 central processing unit.

Each of four prime conditions consisted of 6 target pictures presented twice during each condition in a randomized fashion. All 6 target pictures were selected based on a set of 28 pictures previously included in a pilot investigation in which 3- to 5-year-old typically developing children ($N = 35$) demonstrated an overall mean percent correct naming score of 97% (Anderson, Pellowski, Conture, Melnick, & Ohde, 2001).

The four lexical priming conditions were (a) *neutral* prime condition, a pure tone consisting of a 100 ms, 1kHz, "beep" presented at 45 dB SPL; (b) *physical* prime condition, a physically-related word; (c) *categorical* prime condition, a categorically- related word; and (d) *functional* prime condition, a functionally-related word. Each condition was counterbalanced within and between groups. See Table 2 for a list of the stimuli. [1]

Time between prime offset and picture onset—The time between the offset of the auditory presentation of the prime and the onset of the target picture was set at 700 milliseconds (ms). This period of time was selected to ensure no temporal overlap between the offset of the auditory prime and the onset of the target picture. A brief 30-second break occurred between each of the four conditions to allow each participant to prepare for the following condition.

Definition/Description of Main Dependent Measures

There were two dependent measures employed with this study: (a) SRT and (b) errors, both of which are defined and described immediately below.

Speech reaction time—The primary dependent measure for this study was the SRT for the four experimental conditions (i.e., neutral, categorical prime condition, functional prime condition and physical prime condition). SRT or naming latency (associated with the participants' naming response) was measured (in milliseconds) from the onset of the

[1]It is a challenge to find physical primes that have *no* categorical similarity. Such was the case with three of the physical primes used for this study, that is, "apple," "banana," and "car" may not only be physically but categorically related. To assess whether any of this potential overlap impacted this study's findings, the experimenters removed those three targets ("apple," "banana," and "corn") from the physical condition and statistically re-analyzed the data., To accomplish this, a repeated-measures ANOVA with talker group (CWS and CWNS) as the between-groups variable and priming condition, using the revised physical condition (neutral, physical-*revised*, function, category), as the within-subjects variable to assess SRT data. Results of this analysis – with the three "overlapping" targets removed - indicated no difference in statistical significance. Specifically, these findings continued to indicate a significant main effect for condition with SRT varying significantly across conditions, $F(3,72) = 3.31$ $p = .03$, and a significant between-group effect, $F(1,24) = 7.45$, $p = .01$, for SRT with CWS presenting with SRT significantly slower than CWNS. Further, results revealed no significant Group x Condition interaction effect, $F(3, 72) = .190$, $p = .89$. Given that results of data analyses were the same, with or without inclusion of the three targets in question, our results report data analyses based on all 6 targets presented twice in each condition, which included the three "overlapping" targets.

presentation of the picture target to the onset of the participant's verbal or oral naming response of the target.

Errors—The frequency of picture-naming errors was also considered a dependent measure. Errors were considered responses that deviated in *any* way from the picture's "intended name," for example, if the picture-to-be-named was "dog" and the child's naming response was "horse," an error was tabulated.

Pre-Analysis Data Preparation: Definition of lost trials, outliers, and errors

Similar to Byrd et al. (2006) the following format was used for pre-analysis data preparation.

Lost trials—SRTs that were non-speech related were considered "lost trials" (see Brooks & MacWhinney, 2000) and were excluded from further data analysis. Lost trials typically consisted of responses that were preceded by, or associated with, any type of extraneous noise and/or sound (e.g., tongue click) that unintentionally triggered or failed to trigger the gating switch on the voice-activated microphone (e.g., when a participant responded too softly). All lost trials were excluded from the final data corpus.

Disfluent responses—All speech reaction times containing a stuttering-like disfluency (i.e., part-word repetition, sound-syllable repetition, audible prolongation, inaudible prolongation) or an interjection (e.g., "uhm…apple") were excluded from the final data corpus regardless of talker group.

Outliers—The experimenters excluded - from the final data corpus- any speech-related reaction times that were greater or less than two standard deviations above or below the mean of all participant responses for that particular condition. These outliers were excluded because they were most likely associated with inattention, and, thus are not reflective of the linguistic process being studied (see Ratcliff, 1993, for various analytical considerations and procedures regarding the handling of reaction time outliers).

Naming Response Errors—For the SRT analysis, to ensure that the remaining picture naming responses included in the final data corpus were the same target words associated with the pictures, the accuracy of participants' responses to the target pictures was assessed. Picture-naming responses were regarded as errors, and thus *not* included in the final data corpus for the measurement of SRT, if the participant produced a response that deviated in *any* way from the picture's intended name. Additionally, if more than 35% (greater than 17 errors) of a participant's naming responses contained errors in any of the four priming conditions, the participant was excluded from the study. The criterion of 35% is based on methodology used in similar priming research paradigms (Anderson & Conture, 2004; Byrd et al., 2006; Melnick et al., 2003; Pellowski & Conture, 2005); this criterion eliminated 3 CWNS and 2 CWS and permitted the investigators to assess the SRT of children in both talker groups who exhibited comparable numbers of fluent, accurate picture-naming responses.

Pre-Analysis Data Processing: Unusable data

Children who do not stutter (CWNS)—The 13 CWNS provided picture-naming responses for 624 trials (12 trials per condition × 4 priming conditions × 13 participants). Of the 624 available trials, 31% (n = 191) were considered lost trials and, thus, were excluded from the final data corpus (i.e., 624 minus 191 = 433) because they were preceded by, or associated with, an extraneous noise that unintentionally triggered or failed to trigger the voice-activated microphone.

Of the remaining 433 trials for the CWNS, 4% (n = 17) were considered disfluent responses containing a stuttering-like disfluency or an interjection and were removed from the data corpus. Twenty-one (5%) of the remaining 416 speech - related picture naming responses were excluded because the speech reaction times were +/− two standard deviations from the mean for all CWNS (i.e., outliers). This five percent of outliers/total corpus is substantially below the criterion of 15% suggested by Ratcliff (1993) for the presence of outliers per total corpus. Based on the criteria for error identification, 48 (12%) of the remaining 395 trials were excluded because they deviated from the picture's intended name. The *final corpus* for the measurement of SRT for the 13 CWNS consisted of 347 (56% of the 624 available targets) fluent, accurately named, usable picture-naming responses (see Table 3).

Children who stutter (CWS)—The 13 CWS provided picture-naming responses for 624 trials (12 trials per condition × 4 priming conditions × 13 participants). Within the 624 available trials, 37% (n = 228) were considered lost trials (i.e., 624 minus 228 = 396) according to the previously stated criteria for lost trials and were removed from the data corpus.

Of the remaining 396 trials, five percent (n = 18) were considered disfluent responses according to the previously stated criteria for disfluent responses and were removed from the data corpus. Fifteen (4%) of the remaining 378 speech-related picture naming responses were excluded because the SRTs were +/− two standard deviations from the mean for all CWS (i.e., outliers), a percentage substantially below the 15% criterion established by Ratcliff (1993). Based on the criteria for error identification, 53 (9%) of the remaining 363 trials were excluded because they deviated from the picture's intended name. The *final corpus* for the measurement of SRT for the 13 CWS consisted of 310 (50% of the 624 available targets) fluent, accurately named, usable picture-naming responses. See Table 3 for number and percentage of error types and outliers per talker group for all four conditions.

Data Analysis

Dependent measures—Differences between groups were assessed using a repeated measures analysis of variance (ANOVA) with SRT data for each priming condition (neutral, physical, function, category) as the within-subjects variable and talker group (CWS and CWNS) as the between-groups variable. A repeated measures ANOVA was also used to assess differences between mean reaction time for each experimental condition (i.e., physical prime condition, categorical prime condition and functional prime condition) and the neutral prime condition for both talker groups. Such differences in SRT - between the neutral and experimental condition - will hereafter be referred to as a "priming effect." Speech reaction time served as the dependent variable, with talker group (i.e., CWNS and CWS) and priming condition (i.e., neutral, categorical prime, functional prime, and physical prime) as the independent variables. Similar analyses were conducted for fluently produced errors (i.e., "error deviating from correct response"). Histographic assessment of the dependent variables (speech reaction times and errors) indicated that dependent variables were approximately normally distributed.

Intrajudge and Interjudge measurement reliability

Identification of stuttering-like and nonstuttering - like speech disfluencies— Intra- and interjudge measurement reliability was obtained for total disfluencies (stuttering-like plus other) and stuttering-like disfluencies. Five participants were randomly selected from the CWS talker group. The 300-word conversational sample elicited from each participant was used for intra- and interjudge reliability resulting in a total of 1,500 words (an equivalent to approximately 38% of the total data corpus for the CWS talker group). Intrajudge reliability was assessed by having the first author judge each speech sample for the presence of all disfluencies and stuttering-like disfluencies on two separate occasions. Interjudge reliability was assessed by having the first author and a doctoral student, both certified speech-language pathologists with experience in assessing stuttering, judge each speech sample for the presence of all disfluencies and stuttering-like disfluencies.

Intra- and interjudge reliability percentages for the two speech disfluency measures were assessed across participants using the following measurement reliability index (Arnold, Conture, & Ohde, 2005; Byrd et al., 2006): (A+B/[A+B] + [C+D]) × 100, where A = number of words judged stuttered on both occasions, B = number of words judged nonstuttered on both occasions, C = number of words judged stuttered on one occasion, and D = number of words judged nonstuttered on one occasion. Intrajudge reliability for the mean frequency of total speech disfluencies and stuttering-like disfluencies for CWS was 99% and 98%, respectively, whereas interjudge reliability for the overall mean frequency of total and stuttering-like disfluencies was 97% and 99%, respectively.

Naming Response errors—Intrajudge and interjudge measurement reliability was also assessed for naming response errors by randomly selecting five different participants from both talker groups (CWS and CWNS; $n = 10$). Eight naming responses per participant (two responses from the neutral-priming condition, two responses from the physical-priming condition, two responses from the categorical-priming condition and two responses from the functional-priming condition) were randomly selected, resulting in approximately 6% of the total data corpus (8 responses × 10 participants = 80 responses) being used for intrajudge and interjudge reliability for response errors. For intrajudge reliability, the first author judged each response for accuracy on two separate occasions. For interjudge reliability, the first author and a certified speech-language pathologist judged each response for response errors. As with speech disfluency measures, intra- and interjudge reliability were assessed across participants using the following measurement reliability index: (A+B/[A+B] + [C+D]) × 100, where A = number of error responses judged on both occasions, B = number of accurate responses on both occasions, C = number of responses judged as errors on one occasion, and D = number of responses judged accurate on one occasion. Intrajudge and interjudge reliability for response accuracy measures was 100% and 99%, respectively.

Results

Descriptive Information

Stuttering/Speech Disfluencies—As expected, based on participant selection criteria, there was a statistically significant difference, t [18] = 3.99, $p < .01$), in average *total* disfluencies between CWS ($M = 10.57$, $SD = 5.19$) and CWNS ($M = 3.43$, $SD = 2.25$). Likewise, there was a significant difference, t[18] = 3.85, $p < .01$, in *stuttering-like* disfluencies between CWS ($M = 8.10$, $SD = 5.57$) and CWNS ($M = 1.13$, $SD = 1.34$).

Speech and Language Abilities—Based on participant selection criteria described above, all 26 participants in this study had to exhibit scores at or above the 16th percentile (less than 1 SD below the mean) on a series of standardized speech-language tests (PPVT-III, EVT, TELD-3, and GFTA-2). A multivariate analysis of variance (MANOVA) revealed no significant between-group differences on any of these four measures of speech and language: PPVT, $F(1,24)= .013$, $p<.911$; EVT, $F(1,24)= .010$, $p<.923$; TELD- Receptive Language, $F(1,24)= 1.06$, $p<.313$; TELD- Expressive Language, $F(1,24)= .150$, $p<.702$; and GFTA, $F(1,24)= .855$, $p<.364$. See Table 4 for means and standard deviations for each standardized test per talker group.

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Between-Group Differences in Speech Reaction Time (SRT)

Differences in SRT among all four priming conditions—To assess the hypothesis that SRT would differ across various lexical priming conditions, a repeated-measures ANOVA with talker group (CWS and CWNS) as the between-groups variable and priming condition (neutral, physical, function, category) as the within-subjects variable was used. Results, illustrated in Fig. 1, indicated a significant main effect for condition with SRT varying significantly across conditions, $F(3,72) = 6.24$, $p < .01$. There was also a significant between-group effect, $F(1,24) = 9.59$, $p = .01$, for SRT with CWS presenting with SRT significantly slower than CWNS. There was no significant Group × Condition interaction, $F(3, 72) = 1.00$, $p = .39$. Therefore, no follow-up between-group analyses were conducted for SRT.[1]

Within-groups Differences in Speech Reaction Time

Differences in SRT between priming conditions: CWS—To determine the nature of the SRT differences across conditions for each group, a repeated-measures ANOVA was conducted for each of the two talker groups. Results indicated a significant difference across priming conditions for CWS, $F(3,36) = 5.01$, $p = .01$, as well as differences in the priming effects (i.e., between each priming condition and the neutral condition), $F(2,24) = 3.62$, $p = .05$. A series of follow-up t-tests were conducted to assess whether, for CWS, there were significant differences among priming effects. For CWS, illustrated in Fig. 2, there was significant difference in priming effect between functionally-related (i.e., Functional – Neutral) and the physically-related (i.e., Physical – Neutral) priming conditions, t (12) = 2.40, p = .03. The functionally-related prime was significantly less interfering (i.e., more facilitating) than the physically-related prime. However, CWS exhibited no significant differences in priming effect between the functionally-related (i.e., Functional – Neutral) and the categorically-related (i.e., Categorical – Neutral) priming conditions, t (12) = −1.89, $p = .08$, or between the physically-related and the categorically-related priming conditions, t (12) = 1.19, $p = .26$.

Differences in SRT between priming conditions: CWNS—A repeated-measures ANOVA was also conducted to assess overall differences in SRT among the four priming conditions for CWNS only. Results revealed no significant differences in priming conditions for CWNS, $F(3, 36) = 1.53$, $p = .23$, and no significant differences in priming effects, $F(2, 24) = 1.05$, $p = .36$.

Namng Errors: Between-groups differences

Differences in errors among all four priming conditions—Naming error data were also analyzed using a repeated measures ANOVA, with group as a between-subjects variable, condition as a within-subjects variable, and number of errors as the dependent variable. Results, illustrated in Figure 3, revealed no significant main effect for error across conditions, F (3, 72) = 1.95, $p = .14$, or between groups, F (1, 24) = .096, $p = .76$, and no significant Group x Error interaction, F (3, 72) = 2.27, $p = .09$.

Discussion

The present study resulted in three main findings. The first main finding indicated that even when instances of stuttering were removed from preschool children's picture-naming responses, CWS were significantly slower initiating accurate, fluent picture naming than CWNS (a finding consistent with Bloodstein's 1995 review). The second main finding, contrary to prediction, was that CWS, but not CWNS, were significantly faster in response to functionally-related primes than in response to physically-related primes. The third main finding indicated that regardless of talker group, there were no significant differences in error production during picture naming responses. The general implications of each of these three findings will be discussed immediately below.

CWS exhibit slower initiation of picture naming

The first main finding indicated that, regardless of the fact that both CWS and CWNS exhibited receptive and expressive vocabulary test scores within normal limits, children who stutter (CWS), when compared to CWNS, are slower initiating even accurate, perceptibly fluent picture-naming responses. From a *linguistic or speech-language planning* perspective, this finding could be taken to suggest that CWS exhibit slower lexical retrieval than CWNS. Within this perspective, slower naming responses in CWS may indicate that the development of lexical access and retrieval in preschool CWS is subtly delayed or inefficient relative to their normally fluent peers. Such development in preschool CWS may be less advanced than CWNS in terms of maneuvering from one semantically related pathway to another when attempting to quickly and accurately name the target picture.

Of course, we do not know with certainty whether the above speculation regarding lexical retrieval adequately accounts for our results, either in whole or in part. What we do know, however, is that our findings are consistent with those of Pellowski and Conture (2005) who reported that CWS, when compared to CWNS, exhibit slower speech reaction times when accurately and fluently naming pictures presented after a semantically-related prime. Present findings are also in accord with Weber-Fox (2001), who reported linguistic processing differences between individuals (adults) who do and do not stutter. Current findings are also consistent with other previous studies of reaction time and stuttering (e.g., see Bloodstein, 1995, Table 15, for a review). Furthermore, present findings of a possible difference in one aspect of speech-language planning and producation – lexical retrieval - complement studies that indicate that syntactic (Anderson & Conture, 2004; Cuadrado & Weber-Fox, 2003) as well as phonological aspects (Byrd et al., 2006) of speech-language planning may differ between people who do and do not stutter. Hence, considerable consistency appears to be emerging within the literature regarding speech-language planning variables and stuttering. Besides linguistic perspectives, other perspectives should be considered when attempting to account for these observations.

Specifically, from a *motoric* perspective, an overall slowness in SRT for CWS, when compared to CWNS, cannot be solely ascribed to linguistic or planning processes. Rather, it is also possible that speech motor control/productive processes could contribute to these between-group differences, although not as the only factor accounting for the differences. Van Lieshout, Hulstijn, and Peters (1996), for example, suggested that atypical motor control in individuals who stutter is neither the sole cause nor sole factor to consider when studying the development of stuttering. Indeed, it is recognized that SRT is the end-product of several processes (e.g., cognitive + linguistic +motoric); however, in the present study we attempted to minimize between-condition differences in motoric demands while allowing linguistic differences to vary in known or prescribed ways. That is, any concomitant speech motor control difficulties exhibited by CWS or CWNS in the present study should affect both the control and experimental conditions alike given the fact that the motor response required in all four of our conditions was identical.

Thus, although one cannot definitively state that the between-group differences in SRT are solely due to inefficient lexical retrieval, one might safely say that such differences, at the least, represent one possible contributor to the present findings. If such differences are also present during conversational speech, difficulties with lexical retrieval may be one of several causal contributors (i.e., "mediators") to the onset and development of childhood stuttering. Furthermore, in addition to linguistic and motoric perspectives regarding present findings, there is an "in-between" perspective, one involving the transfer of instructions and/or information between the linguistic plan and motor program.

Specifically, from a *transfer* perspective, the interface or transfer between the linguistic plan and motor program may be subtly difficult and/or different for CWS. Thus, it is possible that difficulties or differences in this “hand-off” or transfer contribute to the relative slowness of CWS’s SRT during picture naming. In essence, the slow SRTs of CWS may relate to neither the linguistic nor the motor systems per se. Rather the problem may relate to a transfer of information, code, or the like between the linguistic plan and the motor program. This possibility – that both the linguistic plan and the motor program are reasonably operational with only their interface or transfer being problematic – has not, to these authors’ knowledge, been addressed with preschool CWS. It seems, therefore, that this possibility might be interesting to explore in future empirical studies.

CWS are faster in response to a functional prime than a physical prime

The second main finding was that CWS exhibited faster naming latencies when primed with the functionally-related than physically-related properties of targert pictures. This finding suggests that some conceptually-related aspects (i.e., functional components) of words – at least as defined in this study - appear to be better developed in preschool children who stutter than conceptual as well as perceptual aspects of words (cf. Nelson, 1977). At this point in development, CWS appear to be organizing lexical information functionally more so than physically. As a consequence, the functional priming effect resulted in significantly shorter SRT than the physical effect. These findings lend support to Nelson’s (1973, 1974b) *functional core hypothesis*, that is, semantic development is primarily based on functional characteristics of vocabulary. In at least the present study, CWS appear to be most “sensitive” to these aspects of lexical priming, when compared to their normally fluent peers. Anecdotally, this appears to make some sense, given the authors’ experience with preschoolers naming pictures on standardized tests (e.g., the *Peabody Picture Vocabulary Test*). These authors have noted that when preschool children make errors in naming, the error is more likely to be functionally than physically related (e.g., given a picture of “knife”, they are apt to say “cut-cut” - functional relation- rather than “stick” - physical relation).

Perhaps, what is more important than finding that young CWS seem better able to make use of functional relations during lexical retrieval, is the possibility that their lexical retrieval skill may remain, for a relatively long period of time, at an earlier (i.e., functional) level of development. Of course, present findings do not address the length of time CWS most readily use functional relations during lexical retrieval; rather, the findings suggest only that CWS seem to favor this aspect of processing. Whether their relatively greater reliance, sensitivity, or usage of functional relations during lexical retrieval reflects a subtle delay, disorder, or inefficiency and whether such challenges impact their speech (dis)fluency remains an open but intriguing empirical question. It is especially intriguing to contemplate the possibility that CWS rely more on functional relations during lexical retrieval for an inappropriately long period of time, a possibility that again must await further empirical study.

No significant differences in error production for all participants

The third main finding was that there were no significant differences between CWS and CWNS in error production during picture naming responses. In essence, no between-group differences in error production, together with slower picture naming abilities for CWS, suggest that CWS – at least during picture naming - are not more *erroneous* but *slower* in terms of lexical or word retrieval when compared to CWNS. If this low error/slow retrieval relation is applied to conversational performance, in which the child needs to rapidly retrieve multiple lexical items, it seems reasonable to suggest that problems in maintaining relatively smooth, fluid speech-language production may ensue. That is, perhaps the confluence of an increased “need to speed,” created by conversational requirements and the preschool CWS’s relatively slower lexical retrieval, may challenge the CWS’s ability to efficiently map lexical information onto word forms. This challenge may, in turn, (in)directly contribute to disruptions in the forward flow of CWS's speech-language planning and production.

Ancillary considerations

In passing, alternative accounts of present findings might suggest that other characteristics or related speech-language abilities of the participants account for present findings. Specifically, some might argue that present findings could be explained by the possibility that (1) CWS exhibit clinically significant speech-language problems and/or (2) CWS lack of sufficient knowledge of the pictures-to-be-named and/or the descriptive primes for the pictures. Neither consideration, in our opinion, provides a particularly compelling account of present findings. First, given the fact that this study's inclusion criteria required all participants – both CWS and CWNS – to exhibit speech and language within normal limits, it seems difficult to suggest that between-group differences in lexical priming effects were due to the fact that CWS in this sample exhibited more clinically significant speech-language than their CWNS controls. Second, it seems equally difficult to account for present findings by suggesting that CWS neither knew the pictures nor comprehended the primes provided given empirical findings that typically developing preschool-aged children (*N* = 35) exhibit an overall mean percent correct score of 97% when naming these pictures (Anderson et al., 2001). Certainly, such variables should be controlled for – as they were in this study – but because they were reasonably controlled for, they would not seem to provide an adequate account of present findings.

Caveats and Conclusions

Sample size—The participant sample size is relatively small for both talker groups (CWS: n = 13 and CWNS: n = 13). However, comparable priming studies yielding similar findings were based on sample sizes that ranged from 13 to 23 participants per talker group (e.g., Anderson & Conture, 2004; Byrd et al., 2006; Pellowski & Conture, 2005). Thus, although present results are most conservatively interpreted to represent only the performance of the participants in this study, the sample size for each talker group appears to be adequate for assessing the constructs under consideration.

Time between prime offset and picture onset—The present study attempted to minimize any temporal overlap between offset of the auditory prime and onset of the following picture stimuli. To do this, the time period - 700 ms - from the offset of the picture stimuli to the onset of the auditory prime was kept constant for all prime-picture pairs. Other published studies by the second author (e.g., Melnick et al., 2003; Pellowski & Conture, 2005) using the priming paradigm have maintained a constant time interval between the *onset* of the picture stimuli to the *onset* of the auditory prime (the so-call "stimulus onset-asynchrony"). This latter procedure permits control of prime offset but makes control of prime onset - given inherent differences in lengths of primes - problematic. It is an empirical question, in need of future research, whether the former or latter procedure provides the most appropriate means for assessing temporal aspects of semantic processing in preschool children.

Conclusions—The present findings, taken together with those of other similar empirical studies (e.g., Anderson & Conture, 2004; Byrd et al., 2006; Melnick et al., 2003; Pellowski & Conture, 2005), appear to suggest that preschool CWS, when compared to CWNS, exhibit subtle differences in various aspects of speech-language planning. One could reasonably speculate that the source of these differences could be (1) the *linguistic* plan, (2) the *motor* program, and/or (3) the *transfer* of information between linguistic plan and motor program.

Whatever the case, these apparent differences in SRT during picture naming suggest a degree of difference between preschool CWS and CWNS in terms of the nature and speed in lexical retrieval. This possible association between stuttering and lexical retrieval in preschool CWS supports the continued need to consider assessing these and related processes of CWS. Particularly, as recent findings by Anderson, Pellowski and Conture (2005) suggest, lexical retrieval should be empirically considered relative to other aspects of speech-language planning and production, namely, syntactic and phonological processing.

In essence, present findings appear to provide further insights into the speech-language planning and production abilities of CWS. Our results, and those of others (e.g., Pellowski & Conture, 2005), would appear to extend this line of research beyond descriptive tabulation of differences between CWS and CWNS on standardized tests of expressive and receptive vocabulary to more experimental manipulation of lexical retrieval in young children. Continued experimental investigation of these abilities should help improve our understanding of how linguistic aspects of speech-language planning and production may contribute to and/or exacerbate developmental stuttering in young children.

1. Previous research examining lexical retrieval skills in young children indicates that:
    - **a.** Perceptual properties develop earlier than functional properties of objects.
    - **b.** Perceptual properties develop earlier than categorical properties of objects.
    - **c.** Functional properties develop earlier than perceptual properties of objects.
    - **d.** Categorical properties develop earlier than perceptual properties of objects.
    - **e.** a & b

    CORRECT ANSWER: **e. a & b**
2. Perceptual processing is considered to involve:
    - **a.** Grammatical words that are related to one another due to shared vowels.
    - **b.** Lexical concepts that are related to one another due to shared initial phonemes.
    - **c.** Lexical concepts that are semantically related to one another due to shared perceptual or physical attributes.
    - **d.** Lexical words that are semantically related to one another due to shared categorical attributes.
    - **e.** None of the above.

    CORRECT ANSWER: **c. Lexical concepts that are semantically related to one another due to shared perceptual or physical attributes.**
3. Conceptual processing is considered to involve:
    - **a.** Nonphysical attributes of objects or pictures
    - **b.** Lexical words that are related to one another based on shared categorical aspects of these objects.
    - **c.** Lexical words that are related to one another based on shared functional aspects of these objects.
    - **d.** Semantic processing of more abstract features
    - **e.** All of the above.

    CORRECT ANSWER: **e. All of the above.**
4. Lexical priming methods:

- **a.** Provide experimental control over salient variables of speech-language planning and production.
- **b.** Allow the experimenter to pair auditory lexical representation with visual lexical representation of target picture.
- **c.** Allow experimental manipulation of the time course or speed of covert linguistic planning processes that lead to participants' overt speech language production.
- **d.** Generate a standard score and percentile ranking to suggest receptive vocabulary abilities in young children.
- **e.** a, b, c, & not d.

  CORRECT ANSWER: **e. a, b, c, & not d.**

5. Findings from the present study indicate:

- **a.** Regardless of priming condition, children who stutter are significantly slower initiating accurate and fluent picture naming than their nonstuttering counterparts.
- **b.** Children who stutter are fastest in functionally-related processing rather than categorically- and physically- related processing.
- **c.** Children who stutter are significantly slower initiating accurate and fluent picture naming than children who do not stutter in categorically- related processing only.
- **d.** Regardless of talker group, there were no significant differences in error production during picture naming responses.
- **e.** a, b, d, & not c.

  CORRECT ANSWER: **e. a, b, d, & not c.**

Educational Objectives: The reader will learn about and be able to (1) communicate the relevance of examining lexical retrieval in relation to childhood stuttering and (2) describe the method of measuring speech reaction times of accurate and fluent responses during a picture-naming task as a means of assessing lexical retrieval skills.

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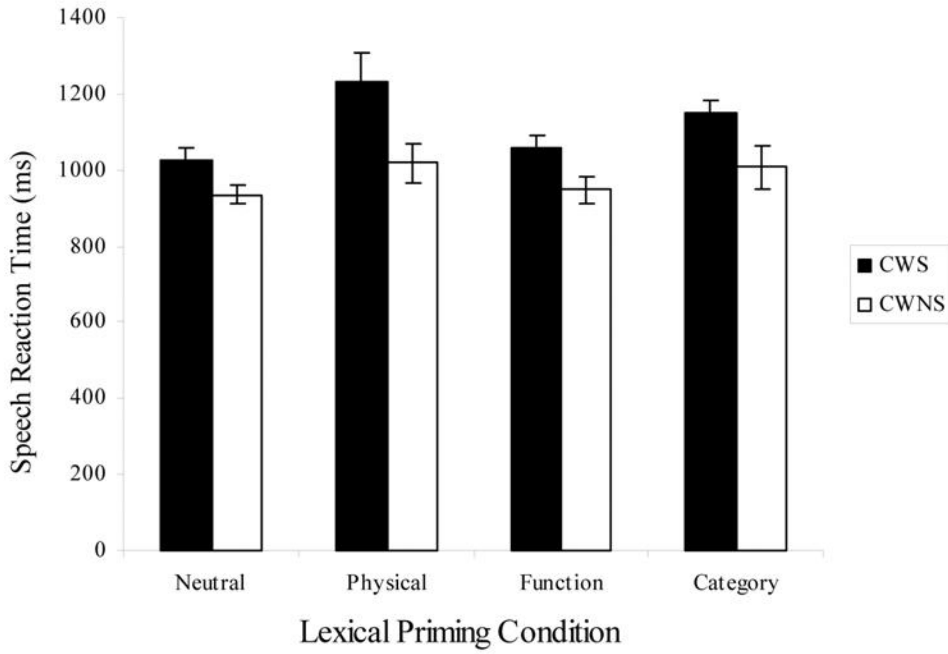

Figure 1.
Mean speech reaction time (SRT, in milliseconds, ms; ± standard error) in each lexical priming condition for two talker groups: preschool CWS (n = 13) and preschool CWNS (n =13).

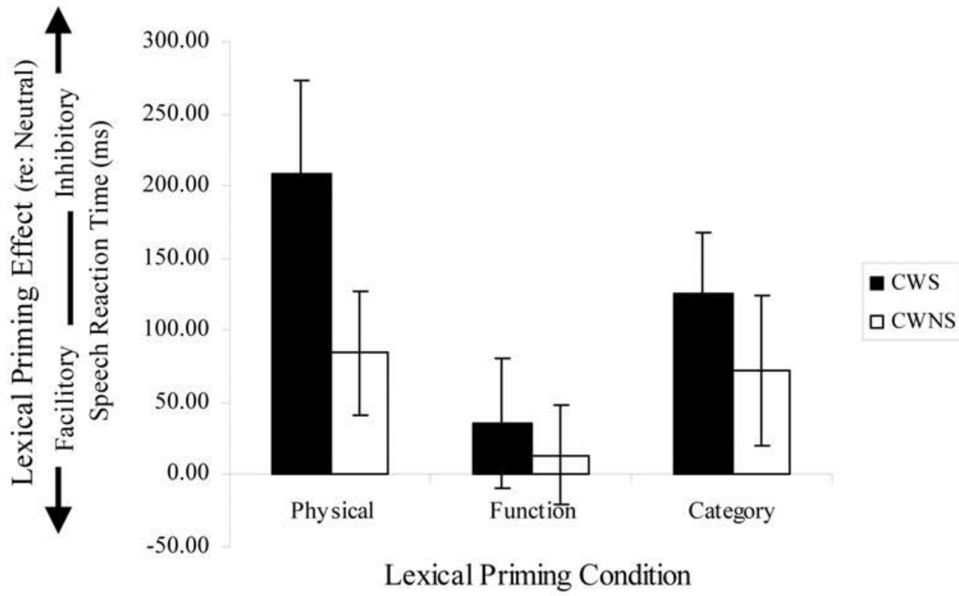

Figure 2.
Mean semantic processing priming effects (SRT, in milliseconds, ms; ± standard error) in each lexical priming condition for two talker groups: preschool CWS (n = 13) and preschool CWNS (n =13).

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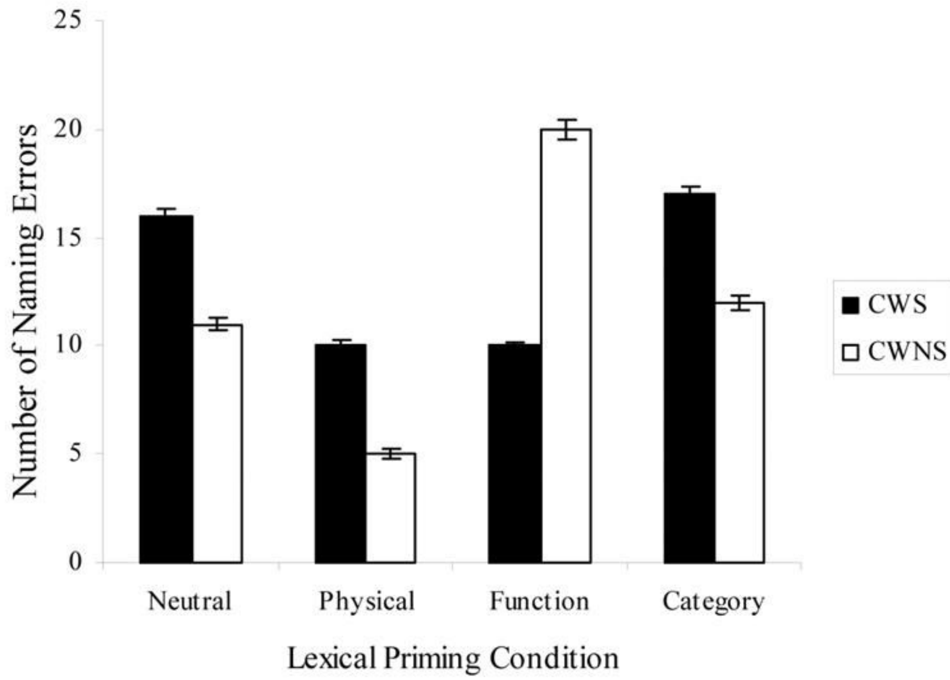

Figure 3.
Number of errors in each lexical priming condition (± standard error) for two talker groups: preschool CWS (n = 13) and preschool CWNS (n =13).

Table 1

Description of perceptual and conceptual properties of objects as well as examples of their instantiation as primes and target stimuli in the present study

Perceptual Properties	**Conceptual Properties**	
-Based on shared physical attributes	-Based on nonphysical attributes	
Physically-related primes	*Categorically-related primes*	*Functionally-related primes*
Description: Lexical concepts semantically related to one another through shared *physical* features	*Description:* Lexical concepts semantically related to one another through shared *categorical* features	*Description:* Lexical concepts semantically related to one another through shared *functional* features not readily physically observed
Example: Prime = “ball” Target = “sun”	*Example:* Prime = “star” Target = “sun”	*Example:* Prime = “shine” Target = “sun”

Table 2

Six picture targets and associated primes used in the function, category, and physical lexical priming conditions

Condition	Neutral	Primes Function	Category	Physical
Picture Naming Target				
Apple	Pure Tone	Bite	Lemon	Tomato
Banana	Pure Tone	Peel	Orange	Corn
Sun	Pure Tone	Shine	Star	Ball
Pencil	Pure Tone	Draw	Crayon	Straw
Car	Pure Tone	Drive	Truck	Wagon
Spoon	Pure Tone	Feed	Fork	Shovel

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Table 3

Number (no.) and percentage (%) of naming error types as well as outliers for the neutral and each of the three experimental lexical priming conditions for children who stutter (CWS) and children who do not stutter (CWNS)

	CWS								CWNS							
Condition	**Neutral**		**Physical**		**Function**		**Category**		**Neutral**		**Physical**		**Function**		**Category**	
Error Type	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Premature/ late key triggers	41	6.6	54	8.7	66	10.6	67	10.7	22	3.5	60	9.6	49	7.9	60	9.6
Outliers	7	1.1	1	0.2	4	0.6	3	0.5	7	1.1	4	0.6	5	0.8	5	0.8
Error incorrect responses	16	2.6	10	1.6	10	1.6	17	2.7	11	1.8	5	0.8	20	3.2	12	1.9
Disfluent responses	3	0.5	2	0.3	6	1.0	7	1.1	9	1.4	4	0.6	3	0.5	1	0.2
Total	67	10.7	67	10.7	86	13.8	94	15.1	49	7.9	73	11.7	77	8.2	62	9.9

Note. For each talker group (CWS and CWNS), there were 624 available trials or picture-naming responses - prior to application of exclusionary criteria (see text for description of exclusionary criteria).

Table 4

Standard Scores (means, M, and standard deviation, SD) for children who stutter (CWS) and children who do not stutter (CWNS) for all standardized speech-language tests

Speech-language test	CWS		CWNS	
	M	**SD**	**M**	**SD**
PPVT-III	110	14.38	113	14.71
EVT	113	10.86	116	8.05
TELD-3				
Expressive subtest	110	17.51	110	14.01
Receptive subtest	111	17.32	119	10.70
GFTA-2	110	7.90	112	11.29

Note: PPVT-III: Peabody Picture Vocabulary Test – III; EVT: Expressive Vocabulary Test; TELD-3: Test of Early Language Development -3; GFTA-2: Goldman-Fristoe Test of Articulation-2.