Stuttering and Phonological Disorders in Children

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Stuttering and Phonological Disorders in Children: Examination of the Covert Repair Hypothesis

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The purpose of this study was to evaluate whether the Covert Repair Hypothesis (CRH; Postma & Kolk, 1993), a theory designed to account for the occurrence of speech disfluencies in adults who stutter, can also account for selected speech characteristics of children who stutter and demonstrate disordered phonology. Subjects were 9 boys who stutter and exhibit normal phonology (S + NP; mean age = 61.33 months; *SD* = 10.16 months) and 9 boys who stutter and exhibit disordered phonology (S + DP; mean age = 59.11 months; *SD* = 9.37 months). Selected aspects of each child's speech fluency and phonology were analyzed on the basis of an audio/videotaped picture-naming task and a 30-min conversational interaction with his mother. Results indicated that S + NP and S + DP children are generally comparable in terms of their basic speech disfluency, nonsystematic speech error, and self-repair behaviors. CRH predictions that utterances produced with faster articulatory speaking rates or shorter response time latencies are more likely to contain speech errors or speech disfluencies *were not* supported. CRH predictions regarding the co-occurrence of speech disfluencies and speech errors *were* supported for nonsystematic ("slip-of-the-tongue"), but not for systematic (phonological process/rule-based), speech errors. Furthermore, neither S + NP nor S + DP subjects repaired their systematic speech errors during conversational speech, suggesting that systematic deviations from adult forms may not represent true "errors," at least for some children exhibiting phonological processes. Findings suggest that speech disfluencies may not represent by-products of self-repairs of systematic speech errors produced during conversational speech, but that self-repairs of nonsystematic speech errors may be related to children's production of speech disfluencies.

KEY WORDS: stuttering, phonology, speech errors, self-repairs, phonological processes

Considerable evidence indicates that children who stutter are more likely than children who do not stutter to demonstrate concomitant phonological concerns (e.g., Bloodstein, 1995; St. Louis & Hinzman, 1988; Wolk, Conture, & Edwards, 1990). Although Nippold (1990) has raised valid concerns about the methodology of certain studies on the co-occurrence of stuttering and various speech and language disorders, Wolk et al. (1990) presented a detailed review of studies on the co-occurrence of stuttering and articulation or phonological disorders in children and demonstrated that, on average, approximately 30%–40% of children who stutter also exhibit disordered articulation or phonology—considerably more than the 2%–6% found in the general population (Beitchman, Nair, Clegg, & Patel, 1986).

More specifically, in a descriptive study comparing 30 children who stutter and 30 children who do not stutter, Louko, Edwards, and Conture (1990) found that children who stutter produced a greater number and variety of phonological processes (i.e., systematic or rule-governed sound changes affecting sequences or classes of

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sounds; after Edwards & Shriberg, 1983), as well as a greater number of "atypical" phonological processes such as vowel changes or glottal replacement. Also, Wolk, Edwards, and Conture (1993) found that although the speech disfluency behaviors (e.g., frequency and duration of within- and between-word speech disfluencies) of children exhibiting both stuttering and disordered phonology (S + DP) were generally similar to those of children exhibiting only stuttering (S + NP), S + DP children produced significantly more sound prolongations than S + NP children. This suggests a fundamental difference in the speech disfluencies of S + DP children, because the presence of frequent sound prolongations is viewed as an important indicator of stuttering severity or chronicity (e.g., Conture, 1990; Riley, 1981; Schwartz & Conture, 1988). Furthermore, such findings suggest that there may be an interaction between stuttering and phonological disorders, though the nature of that interaction is unclear.

Although there are presently few empirical studies on the interaction between stuttering and phonology, there is some clinical evidence that the co-occurrence of speech disfluencies and phonological speech errors in some children may not be purely coincidental. For example, practicing speech-language pathologists occasionally report that a small number of children receiving speech treatment for articulation/phonological problems may exhibit an increase in the frequency of their speech disfluencies during the course of treatment (e.g., Comas, 1974; Hall, 1977; Ratner, 1995). The *cause* and *nature* of this increased disfluency is not readily apparent, and controlled research on this change in speech fluency has not yet been conducted. Thus, it is difficult to precisely determine the relationship between articulation/phonological treatment and children's production of speech disfluencies. Nevertheless, it seems reasonable to assume that some aspect of the children's phonological disorder or the nature of treatment for the phonological disorder may be related to this apparent change in children's speech fluency. In addition, children demonstrating both stuttering and disordered phonology may benefit from different treatment paradigms than children demonstrating only one of the two disorders (e.g., Conture, Louko, & Edwards, 1993; Louko, Wolk, Edwards, & Conture, 1989). Thus, there are theoretical as well as therapeutic needs for further evaluation of the potential relationship and interaction between speech disfluencies and speech sound errors in children who stutter.

Covert Repair Hypothesis

Among available explanations of the potential relationships between stuttering and phonological disorders in children (see Louko et al., 1990), one recent theory, the Covert Repair Hypothesis (CRH; e.g., Kolk, Conture, Postma, & Louko, 1991; Postma, 1991; Postma & Kolk, 1993; Postma, Kolk, & Povel, 1990a, 1991) appears to be relatively thoroughly defined and empirically testable. The CRH is based, in part, on recent psycholinguistic speech production models, such as Levelt's (1989) "blueprint for the speaker" and Dell's (1986, 1988) spreading activation theory of phonological encoding, as well as on studies of adults' speech errors (e.g., Dell & Reich, 1981; Fromkin, 1971; Meyer, 1992; Shattuck-Hufnagel, 1979). In essence, the CRH makes the following assumptions: (a) Speakers typically *monitor* their speech before it is produced for accuracy and appropriateness of content, form, and intent (e.g., Blackmer & Mitton, 1991; Garnsey & Dell, 1984; Laver, 1973, 1980; Levelt, 1983), (b) During this monitoring process, speakers have the ability to *detect* errors that arise in their phonetic plan (i.e., the "internal representation of how the planned utterance should be articulated," Levelt, 1989, p. 12) before such errors are produced, and (c) Following detection of errors, speakers may elect to interrupt their ongoing speech in order to *repair* such errors (Bredart, 1991; Levelt, 1983; Nooteboom, 1980). (Note that it is assumed that different speakers may have differing abilities or propensities to detect and repair speech errors.) According to the CRH, speech disfluencies occur as a by-product of this detection and repair process when a speaker disrupts ongoing speech production in an attempt to *covertly* repair errors within their phonetic plan *before* such errors are overtly produced. In this way, the CRH seeks to account for the mechanisms underlying all types of speech disfluencies, including those produced by individuals who stutter.

Based on studies of speech planning (e.g., Postma, Kolk, & Povel, 1990b), as well as rate and timing abilities (see Caruso, 1991, and Starkweather, 1987) of individuals who stutter, Kolk (1991; Kolk et al., 1991) suggested that individuals who stutter may demonstrate an *impairment* in their phonological encoding mechanisms. This assumption leads to the prediction that the activation of target phonemes (e.g., Dell, 1986, 1988) is somewhat delayed for people who stutter (see Figure 1), resulting in a relatively long period of time when target phonemes are in competition with other phonemes. Kolk et al. (1991) further suggested that individuals who stutter may attempt to speak faster than their peers or tend to initiate speech too rapidly (i.e., demonstrate relatively short response time latencies). Accordingly, individuals who stutter may not allow enough time for their relatively slow-to-activate phonological encoding mechanisms to select appropriate phonological targets (e.g., Dell & Reich, 1980), thereby increasing the likelihood that phonological encoding errors will become part of their phonetic plan. Based on the CRH, if the phonological encoding error is detected by the speaker's internal self-monitoring processes, the speaker may attempt to covertly repair the error *before* it is overtly produced and, as a by-product of this process, produce a speech disfluency.

The CRH and children who stutter. Kolk et al. (1991) indicated that the basic assumptions of the CRH can be applied to children. Specifically, they suggested that children who stutter may demonstrate an impairment in their phonological encoding mechanism that, combined with a tendency to use rapid articulatory speaking rates or short response time latencies, might not permit sufficient time for their phonological encoding mechanisms to make appropriate selections of target phonemes. Although there is preliminary support for the suggestion that children who stutter speak more quickly than their peers who do not stutter (e.g., Meyers & Freeman, 1985) and that their articulatory speaking rates may exceed their motoric abilities (Conture, Ya-

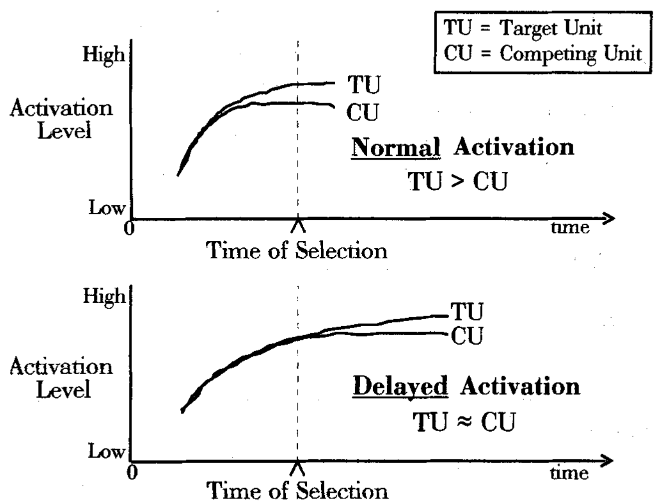

FIGURE 1. Normal versus delayed activation of phonological units. With *normal* activation (top), the target unit (TU) achieves higher activation (expressed on the ordinate in arbitrary units of activation level) than the competing unit (CU) at the time of selection (TU > CU). With *delayed* activation (bottom), the target unit (TU) is in competition with competing units (CU) at the time of selection (TU = CU), increasing the likelihood that an inappropriate target will be selected. The rate of activation is considered an *automatic* process (i.e., an event that a person cannot regulate), whereas the time of selection is considered a *controlled* process (i.e., an event that a person can regulate). Adapted from Kolk et al. (1991). Note that this figure does not indicate *decay* of activation (the construct typically used in such models to account for the system's ability to keep from repeating the same act continuously).

russ, & Edwards, 1995; Costello, 1983), there is also evidence that the articulatory (and overall) speaking rates of children who stutter do not differ appreciably from those of children who do not stutter (e.g., Kelly & Conture, 1992; Ryan, 1984; Yaruss & Conture, 1995). In addition, the only published study on the response time latencies of children who stutter in spontaneous conversational speech found no significant differences between children who stutter and their nonstuttering peers (Kelly & Conture, 1992), although there was a significant correlation between the duration of mother/child conversational overlaps ("simultalk") and the severity of the child's stuttering. Thus, further research on the relationship between articulatory speaking rates, response time latencies, and the production of speech disfluencies appears warranted.

Because the CRH incorporates phonological constructs in its attempts to account for both the occurrence and nature of speech disfluencies, the CRH appears to provide a salient and promising framework for examining the co-occurrence of children's stuttering and phonological disorders. However, one concern with the application of the CRH to the speech errors of children is that many children—particularly those children exhibiting phonological disorders—frequently produce both systematic and nonsystematic speech errors (see Table 1). It is not clear whether children's *systematic* speech errors, which are often described in terms of phonological processes (e.g., Edwards, 1992; Edwards & Shriberg, 1983),[1] are similar to the *nonsystematic* or "slip-of-the-tongue" speech errors (e.g., Jaeger, 1992; LaSalle & Conture, 1995; Stemberger, 1989) on which the CRH was originally modeled. Certainly, if children *are* able to detect systematic errors in the same manner as nonsystematic errors, they might attempt to repair the detected systematic errors, thereby producing speech disfluencies. However, present uncertainties about the relationship between children's systematic and nonsystematic speech errors and

TABLE 1. Definition, description, and hypothesized causes of nonsystematic and systematic speech errors.

Nonsystematic ("slip-of-the-tongue") speech errors

Definition: Nonhabitual speech errors that occur relatively infrequently in not necessarily predictable locations during conversation.

Description: Error is not rule-based; that is, it does not typically follow the same pattern and is affected by the other words in the utterance (e.g., the segment in error is influenced by, or tends to "slip" with, other sounds in the same word or utterance, e.g., when /l/ is affected by a nonsystematic error, it may be replaced by another segment from the same utterance). This error is commonly described as a "slip-of-the-tongue" error.

Intentionality: Error clearly represents deviation from the speaker's intention.

Hypothesized Cause: Cause of error is phonological or lexical encoding error.

Error Detection: Can be detected and repaired either (a) before production, resulting in covert-repair, or (b) after production, resulting in overt-repair.

Relationship to CRH: Represent errors described by the CRH as currently defined for adults.

Systematic ("phonological process") speech errors

Definition: Habitual speech errors that occur relatively frequently and predictably during conversation, but not necessarily with 100% consistency (i.e., error may occur at some times but not at others during conversation).

Description: Error is rule based; that is, it typically follows the same pattern (i.e., the segment in error is consistently replaced by a different sound in a given phonological setting, regardless of the specific words in the utterance, e.g., when /l/ is affected by the process of gliding of liquids, it is consistently replaced by /w/). This error is commonly described as a "phonological process" error.

Intentionality: Unclear whether "error" represents deviation from speaker's intention.

Hypothesized Cause: Precise cause in children's speech is not clear.

Error Detection: Potential for being detected and repaired has not been carefully examined.

Relationship to CRH: Unclear whether these are errors described by the CRH as it is currently defined for adults.

[1]Throughout this manuscript, a distinction will be made between *systematic* and *nonsystematic* speech errors. Systematic speech errors produced by children are often described in terms of phonological processes (e.g., Edwards, 1992; Edwards & Shriberg, 1983). Phonological processes traditionally refer to a set of mental operations thought to be used by children to simplify their speech output (e.g., Stampe, 1973); however, in the present investigation the term will simply refer to a descriptive system used to categorize classes of rule-based sound errors.

speech disfluencies, suggest the need for empirical investigations of the CRH. Furthermore, the CRH has been tested primarily with adults (e.g., Postma & Kolk, 1990, 1992a, 1992b; Postma et al., 1990a, 1991; cf. LaSalle & Conture, 1995) and several hypotheses resulting from the CRH have not yet been examined. Thus, further research on how the CRH might explain the relationship between childhood stuttering and disordered phonology, and the factors that affect each disorder, seems warranted.

The purpose of the present study was to assess whether the CRH accounts for selected aspects of the speech of children who demonstrate stuttering and disordered phonology. Given the basic CRH assumption that speech disfluencies arise as a by-product of the self-repair process, a number of predictions about potential relationships between stuttering and phonological disorders can be derived. In this study, one set of such predictions was selected for evaluation, specifically: (a) Children's production of speech disfluencies should be related to their production of (non)systematic speech errors because the production of speech errors provides an opportunity for the detection of errors and self-repair, (b) Children who stutter and exhibit disordered phonology should produce more speech disfluencies than children who only stutter because children with phonological disorders produce more (systematic) speech errors and therefore may have more opportunities for error detection and self-repair, and (c) The rate of production of children's utterances should affect the occurrence of speech errors and speech disfluencies because faster utterances should be associated with an increased likelihood of errors occurring in the phonetic plan.

Method

Subjects

Subjects were 18 boys who stutter (age 3 to 6), divided into two groups based on their phonological development (normal vs. disordered). As shown in Table 2, the normal phonology group (S + NP) consisted of 9 boys with a mean age of 61.33 months (*SD* = 10.16 months, *range* = 49 to 82 months) and the disordered phonology group (S + DP) consisted of 9 boys with a mean age of 59.11 months (*SD* = 9.37 months, *range* = 45 to 74 months). There were no significant between-group differences in chronological age (Mann-Whitney U = 36.0; p = .69) or reported time since onset of stuttering (U = 37.5; p = .79). In order to minimize the potential effects of speech-language treatment on children's speech fluency, phonology, and self-repair behaviors,

TABLE 2. Chronological ages, reported time since onset of stuttering, and Stuttering Severity Instrument (SSI, Riley, 1981) scores for children exhibiting Stuttering and Disordered Phonology (S + DP) and children exhibiting Stuttering and Normal Phonology (S + NP).

			SSI			
Subject number	Age at time of videotaping	Time since onset of stuttering	Frequency task score	Duration score	Physical concomitant score	Total overall score
S + DP						
D1	45	18	10	2	1	13
D2	50	20	10	2	2	14
D3	53	21	10	3	4	17
D4	56	26	12	2	2	16
D5	58	2	6	2	0	8
D6	62	20	14	2	1	17
D7	64	35	12	1	2	15
D8	70	36	8	2	1	11
D9	74	20	6	3	5	14
M	59.11	22.00	9.78	2.11	2.00	13.89
SD	9.37	10.06	2.73	0.60	1.58	2.93
S + NP						
N1	49	15	6	3	7	16
N2	49	17	8	2	0	10
N3	54	22	16	2	3	21
N4	61	23	6	2	1	9
N5	63	14	12	2	0	14
N6	63	36	12	2	3	17
N7	65	23	10	2	1	13
N8	66	30	10	3	3	16
N9	82	34	6	2	0	8
M	61.33	23.78	9.56	2.22	2.00	13.78
SD	10.16	8.03	3.43	0.44	2.29	4.24
M – W U^a	36.0	37.5	43.5	37.0	44.5	42.0
p	.69	.79	.79	.70	.72	.90

[a]Mann-Whitney U test statistic.

all subjects participated in the present study *before* receiving treatment for stuttering, disordered phonology, or any other concerns. Subjects were paid volunteers from Standard-American-English-speaking families and were unfamiliar with the specific purposes of this study.

Subjects were referred to a university speech-language-hearing clinic because of concerns about the child's phonological development and/or speech fluency. Formal and informal testing of each child's speech and language development, conducted by ASHA-certified speech-language pathologists at the child's home before the present study, indicated that no child in either subject group demonstrated any speech, language, or hearing concerns other than stuttering or disordered phonology, and there were no known or suspected neurological, academic, emotional, or social problems in any of the 18 subjects.

Criteria for Subject Inclusion and Classification

Stuttering (S). Each of the 18 children in the present study were classified as children who stutter on the basis of the following two subject-inclusion criteria: (a) The child produced at least 3 within-word speech disfluencies (i.e., sound/syllable repetitions, monosyllabic whole-word repetitions, audible or inaudible sound prolongations, or within-word pauses; Conture, 1990) per 100 words of speech during a transcribed 300-word conversational speech sample taken while the child was conversing with his mother. and (b) An adult listener familiar with the child had expressed concern that the child was stuttering or at risk for stuttering (e.g., Kelly & Conture, 1992; LaSalle & Conture, 1991; Zebrowski & Conture, 1989). Table 2 summarizes children's scores on the Stuttering Severity Instrument (SSI; Riley, 1980).

Disordered Phonology (DP). The 18 children who stutter were divided into two groups (n = 9) according to the number and nature of their systematic speech errors or phonological processes (i.e., systematic sound changes affecting sequences or classes of sounds; Edwards, 1992; Edwards & Shriberg, 1983) following guidelines of Edwards and Shriberg (1983), Grunwell (1982), McReynolds and Elbert (1981), and Stoel-Gammon and Dunn (1985). A subject was classified as demonstrating *normal phonology* if he exhibited no phonological processes or if all of his phonological processes were judged to be typical of normal phonological development and appropriate for his age (e.g., Edwards & Shriberg, 1983; Grunwell, 1982; Stoel-Gammon & Dunn, 1985). A subject was classified as demonstrating *disordered phonology* if he exhibited either (a) two or more phonological processes not considered appropriate for his age (e.g., *weak syllable deletion* or *stopping of the fricative* /s/ demonstrated by a 4-year-old) or (b) one or more phonological processes that do not typically occur in children's normal phonological development (e.g., *velarization, glottal replacement*). (A more complete discussion of these processes is available in Edwards & Shriberg, 1983, and Stoel-Gammon & Dunn, 1985.) Furthermore, each subject's classification in the disordered phonology group was confirmed on the basis of their performance on the Goldman-Fristoe Test of Articulation (Goldman & Fristoe, 1982).

Data Collection

Testing conditions. All subjects were audio/videotaped with their mothers during data collection sessions lasting approximately 1½ hours. Recording sessions were divided into 3 sections administered in a random order to each child: (a) a parent-child (P-C) conversational interaction, (b) a picture-naming task (PNT), and (c) a diadochokinetic task (which was not analyzed in the present study and will not be detailed further). Brief rests were provided between each section to minimize children's fatigue.

Parent-Child (P-C) interaction. In order to obtain a conversational speech sample in as natural a setting as possible, children and their mothers were seated opposite each other at a small table containing age-appropriate toys (e.g., a space station and figurines). Mothers were asked to play with their children "as they would at home" and not to try specifically to get their children to talk or to speak fluently. Conversational topics often related to the toys; however, older subjects and their mothers often talked about other topics (e.g., activities at school, birthdays, etc.). The P-C interaction typically lasted approximately 30 to 35 min; however, if a child was especially nontalkative during this portion of the recording session, the recording time was extended until a representative 300-word conversational sample was obtained.

Picture Naming Task (PNT). In order to obtain a tightly controlled sample of words for a thorough analysis of the child's phonological development, each child was administered a 120-word or 162-word[2] Picture Naming Task (PNT; e.g., Wolk et al., 1993) by a certified speech-language pathologist. The PNT was designed to provide an opportunity to produce all of the sounds of English in all positions (initial, medial, final) in at least two familiar, age-appropriate, and readily picturable words. The length and difficulty of the words, as well as the vowel contexts that consonants were sampled with, was varied throughout the corpus. Two separate randomized orders of the elicitation pictures were used and selected at random for each child.

Because imitated responses may overestimate a child's true phonological ability (Elbert & Gierut, 1986; Ingram, 1976; Stoel-Gammon & Dunn, 1985), examiners attempted to elicit target PNT words in isolation (i.e., without modifiers or determiners) and without providing a direct model by presenting open-ended "elicitation phrases" (Examiner: "This boy just received a present. He ought to say . . . "; Child: "thank you"). On occasion, elicitation phrases and other cues were not sufficient to prompt the child's response, so the examiners provided a model, then elicited the child's response through delayed imitation (e.g., "He ought to say *thank you*. Can you tell me that? He ought to say . . . "). Finally, if a child produced a speech disfluency during his production of the target word, examiners attempted to elicit the word a second time without drawing attention to the child's disfluent production of the target word.

[2]Six children (5 S + NP and 1 S + DP) were administered the expanded 162-word PNT, which was a superset of the 120-word PNT. Only the 120 words common to both PNT tests were analyzed in the present study.

Instrumentation

Specific procedures and instrumentation use for audio/videotape-recording of the testing procedures have been detailed elsewhere (e.g., Wolk et al., 1993). In brief, high-quality audio/videotape recordings of both the P-C interaction and the PNT were obtained to facilitate later analysis of the data. During the P-C interaction, both the children and their mothers were audio/video recorded simultaneously using a split-screen image (mother's image on the left half of the screen; child's image on the right) because previous research has shown that knowledge of a mother's behavior during parent-child interactions often provides a valuable perspective on the child's behaviors (e.g., Conture & Kelly, 1991; Schwartz & Conture, 1988).

Data Transcription and Analysis

Picture Naming Task. During administration of the PNT a trained expert in phonetics and phonological analysis prepared a preliminary "live" transcription of the child's productions in accord with *Principles of the International Phonetics Association* (IPA, 1949). Next, transcriptions were refined on the basis of repeated viewing of the audio/videotapes by investigators trained in narrow phonetic transcription of children's speech. Instances of disagreement were resolved on the basis of the input of a third trained investigator.

Each child's PNT speech sample was then analyzed for the presence of systematic (phonological process) speech errors commonly demonstrated by children (see process definitions in Edwards & Shriberg, 1983; Grunwell, 1982; Hodson & Paden, 1991; Ingram, 1976; Stoel-Gammon & Dunn, 1985). In order for an error pattern to be considered a phonological process (i.e., a *systematic* error) the error had to occur in *at least* 25% of all possible locations, given at least four opportunities to occur (McReynolds & Elbert, 1981). Speech sound errors that follow common phonological process patterns, but which occurred *less than* 25% of the time or which did not have at least four opportunities to apply, were not included in that child's list of phonological processes. These seemingly systematic but inconsistent speech sound errors (which may indicate very sporadic phonological processes or processes that are "dropping out") were called "phonological process-like" errors to distinguish them from nonsystematic speech errors that do not resemble phonological processes.

Spontaneous speech sample. A 75-utterance conversational speech sample, obtained from the middle 10 min (e.g., Kelly & Conture, 1992; Zebrowski & Conture, 1989) of each child's P-C interaction, was orthographically and phonetically transcribed into a customized computer database. An utterance was defined as a string of words, which (a) communicated an idea, (b) was set apart by pauses, and (c) was bound by a single intonational contour (e.g., Kelly & Conture, 1992; Logan & Conture, 1995; Meyers & Freeman, 1985; Yaruss & Conture, 1995). Utterances of less than 3 words in length were excluded because previous research (Yaruss & Conture, 1995) has shown that utterances of 1 to 2 words in length can be either unusually fast (e.g., more than 400 words per minute [wpm]) or unusually slow (e.g., less than 60 wpm), depending upon the pragmatic intent of the speaker. Repeated short formulaic utterances or lexicalized phrases (e.g., "I don't know") were also excluded because such utterances may be produced at a faster-than-normal rate. The entire 75-utterance sample was used for the analyses of the co-occurrence of speech errors and self-repairs within utterances; the first 300 words of the 75-utterance sample (divided into 3 equal samples of 100 words each) were used for measures of the frequency of speech disfluencies, speech errors, and utterance timing.

Speech Disfluencies, Speech Errors, and Self-Repairs

Onset and offset times of each utterance (within 1 videoframe, or 33.33 ms) were recorded in the database, along with the onset and offset times and types of all instances of within- and between-word speech disfluencies, (non)systematic speech errors, and overt and covert self-repairs summarized below.

Within-word speech disfluencies. Within-word speech disfluencies were defined as (a) sound/syllable repetitions (SSR), (b) monosyllabic whole-word repetitions (MWR), and (c) audible (ASP) and inaudible (ISP) sound prolongations consisting of (tense) pauses or stoppages occurring within or at the beginning or end of words (e.g., Conture, 1990; Conture & Kelly, 1991; Schwartz & Conture, 1988; Schwartz, Zebrowski, & Conture, 1990).[3]

Between-word speech disfluencies. Between-word speech disfluencies were defined as (a) interjections (INT; e.g., an editing term such as "um"), (b) polysyllabic whole-word repetitions (PWR), or (c) phrase repetitions (PR) consisting entirely of whole words or containing a cutoff word (e.g., Berg, 1986, Blackmer & Mitton, 1991; Bredart, 1991; Evans, 1985; LaSalle & Conture, 1995; Levelt, 1983).

Systematic speech errors. Systematic speech errors characteristic of the child's phonological processes (e.g., cluster reduction, gliding of liquids, vocalization) were identified on the basis of the analysis of the child's PNT speech sample described above. All opportunities for each child's systematic sound errors to occur were also tallied so the consistency of errors could be determined. As noted above, errors that followed common phonological process patterns, but which occurred with less than 25% consistency, were also tallied and analyzed separately (phonological process-like errors).

Nonsystematic speech errors. Nonsystematic speech errors were defined as a word or string of words that apparently deviated from the speaker's intention, but that were not characteristic of the child's systematic (phonological pro-

[3]The relatively definable and replicable measure of within-word speech disfluencies was selected for analysis in this study rather than instances of "stuttering" because of well-known problems in reliably defining and measuring instances of stuttering. (Note, however, seminal work by Ingham, Cordes, and colleagues [e.g., Cordes, 1994; Cordes & Ingham, 1994, Ingham, Cordes, & Gow, 1993], who have attempted to improve such measures by evaluating the reliability of stuttering measurements and by offering alternative means for identifying the occurrence of stuttering.)

cess) speech errors (see Table 1 and LaSalle & Conture, 1995, Table 1). Such deviations were typically indicated by the interruption or repair of the utterance before its completion (e.g., "I'll go—I'll get him"; "This—the bad guy got out"); however, subjects occasionally produced nonsystematic speech errors that were not repaired (e.g., "he's the bad buy" for "he's the bad guy"). In these cases, nonsystematic overt speech errors were defined as a word or string of words that did not match the speaker's apparent intention ("slip-of-the-tongue error"; e.g., Cutler, 1982; Fromkin, 1971, 1973; Hockett, 1967).

Overt and covert self-repairs. An *overt* self-repair was defined as a between-word disfluency in which a word or string of words restated or reformulated a speaker's prior (non)systematic speech error (e.g., "you can play—you can have these"). A *covert* self-repair was defined as a within-word or between-word speech disfluency (see above) in which such reformulation was not apparent (i.e., no overt error was repaired; e.g., "she's gonna um play" or "look at the—the monster").

Articulatory Speaking Rate and Response Time Latency

Finally, the following temporal aspects of the children's utterances were calculated (within 1 videoframe, or 33.33 ms) from frame-by-frame analysis of the audio/videotapes.

Articulatory speaking rate (ASR). Articulatory speaking rate was defined as the child's rate of speech (in syl/s) *excluding* all instances of between- and within-word speech disfluencies, hesitations, and pauses of greater than 250 ms (e.g., Kelly & Conture, 1992; Walker, Archibald, Cherniak, & Fish, 1992; Yaruss & Conture, 1995).

Response time latency (RTL). Response time latency, or the length of time (in ms) of the silent pause between the end of the mother's utterance and the beginning of the child's utterance (e.g., Kelly & Conture, 1992; Newman & Smit, 1989; Yaruss & Conture, 1995), was calculated from the offset time of the mother's preceding utterance and the onset time of the child's utterance for those occasions where a child's utterance followed a mother's utterance.

Inter- and Intrajudge Measurement Reliability

Ten utterances were selected at random for each of the 18 subjects (total = 180 utterances [13.33% of all utterances] encompassing 1,148 words [13.97% of all words]). Each utterance was (re)analyzed by the first author and by an ASHA-certified speech-language pathology doctoral candidate trained in the analysis of videotapes of children's spontaneous speech samples. First, the occurrence of within- and between-word speech disfluencies and (non)systematic speech errors in each utterance was identified. Next, to provide an additional indication of reliability for the pool of utterances containing within-word speech disfluencies, judges identified the *types* of disfluencies produced. Finally, measures of articulatory speaking rate and response time latency were verified for all of the 180 utterances.

In order to provide a reliability index for categorical measures that takes chance agreement into account, inter- and intrajudge reliability measures for measures of speech disfluencies, speech errors, and self-repairs were based on the Kappa statistic (Cohen, 1960; see Hollenbeck, 1978). Because it is a relatively conservative test, however, Kappas reported below that range from .60 to .75 are considered "good," and those that range from .76 to 1.00 are considered "excellent" (after Fleiss, 1981):

	Intrajudge	/	*Interjudge*
	(Kappa Statistic)		
Within-word speech disfluencies	.77	/	.76
Types of within-word disfluencies	.82	/	.81
Between-word speech disfluencies	.88	/	.77
Nonsystematic speech errors	.75	/	.85
Systematic speech errors	.76	/	.71
Overt self-repairs	.79	/	.91

Because articulatory speaking rate and response time latency represent continuous measures, rather than categorical measures, measurement reliability was calculated in terms of mean differences (and standard deviations), rather than percent agreement:

	Intrajudge	/	*Interjudge*
Articulatory speaking rate (syl/s)	−0.03	/	−0.25
	(0.45)	/	(0.48)
Response time latency (s)	12.70	/	−78.83
	(118.90)	/	(114.59)

Although the mean *inter*judge reliability difference for RTL was greater than that for *intra*judge reliability, the mean difference is still equivalent to approximately 2 videoframes. Further, strong positive Pearson product-moment correlations were found for response time latency ($r = .98$; $p < .001$ for both inter- and intrajudge reliability) and articulatory speaking rate ($r = .89$; $p < .01$ for both inter- and intrajudge reliability).

Results

Between-Group Differences

Because of the relatively small number of children in the two subject groups in this study and the difficulty of determining that such a small sample is normally distributed (Conover, 1980), the nonparametric Mann-Whitney U statistic was used to compare between-group differences in the production of within- and between-word speech disfluencies, as well as (non)systematic speech errors between subject groups. Bonferroni corrections for multiple comparisons were applied where appropriate.

Within-word speech disfluencies. No significant between-group difference ($U = 42.50$; $p = .86$) was found in the mean *frequency* of within-word disfluencies produced by S + NP ($M = 6.2$; $SD = 3.72$) and S + DP ($M = 6.1$; $SD = 3.15$) subjects. Likewise, no significant between-group difference ($U = 39.00$; $p = .90$) was found in mean *duration* of within-word disfluencies produced by S + NP ($M = 525.80$ ms; $SD = 166.49$ ms) and S + DP ($M = 513.13$ ms; $SD = 148.60$ ms) subjects during the 300-word conversational speech samples. Also, as shown in Figure 2, no significant (Bonferroni-corrected) between-group differences (Mann-

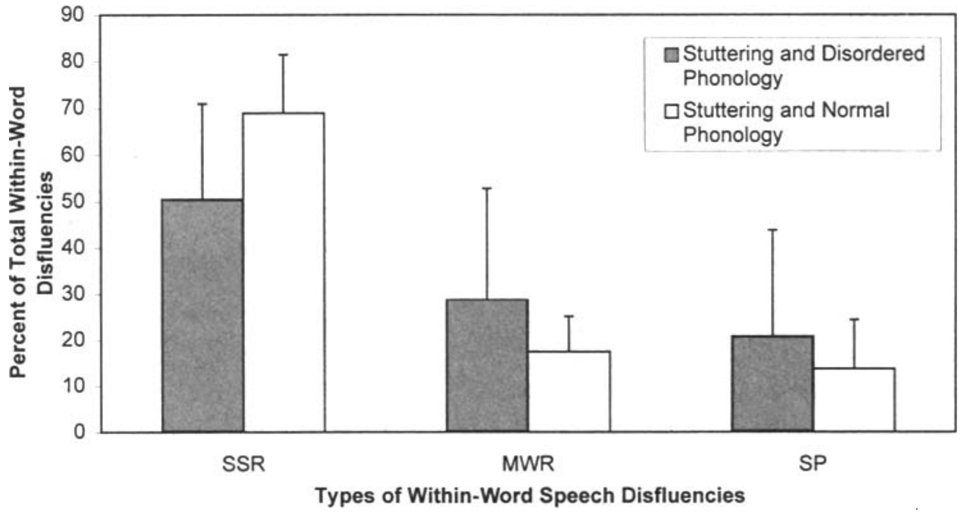

FIGURE 2. No significant (Mann-Whitney *U*, $p > .05$) differences were found between children exhibiting stuttering and disordered phonology (S + DP) and children exhibiting stuttering and normal phonology (S + NP) in the percent occurrence of within-word disfluency types. SSR = Sound/syllable repetition; MWR = Monosyllabic whole-word repetition; SP = Sound prolongation. Vertical bars indicate 1 standard deviation.

Whitney *U*; overall $\alpha > .05$; individual $\alpha = .017$) were found in the relative percent occurrence of 3 different *types* of within-word speech disfluencies (sound/syllable repetitions [SSRs], monosyllabic within-word repetitions [MWRs], and (in)audible sound prolongations [ASPs and ISPs]).

Between-word speech disfluencies. No significant ($U = 23.5$; $p = .13$) differences were found in the number of utterances containing between-word speech disfluencies during the 300-word conversational speech samples of S + NP ($M = 13.00$; $SD = 6.27$) and S + DP ($M = 8.89$; $SD = 4.99$) subjects.

Systematic (phonological process) speech errors. As expected, in both the PNT and P-C Interaction speech samples, S + DP subjects exhibited significantly (PNT: $U = 76$; P-C: $U = 75$; $p = .002$) more phonological processes (PNT: $M = 5.8$; $SD = 2.6$; P-C: $M = 3.11$; $SD = 1.62$) than S + NP subjects (PNT: $M = 1.7$; $SD = 1.5$; P-C: $M = 0.56$; $SD = 1.01$).[4] As shown in Figures 3 and 4, the three most

[4]Differences in the phonological processes identified in the speech samples can be attributed to differences in the number of opportunities for each process to occur in conversational speech versus the highly structured elicitation task, as well as to previously demonstrated variations in phonological productions based upon the speaking task (Morrison & Shriberg, 1992).

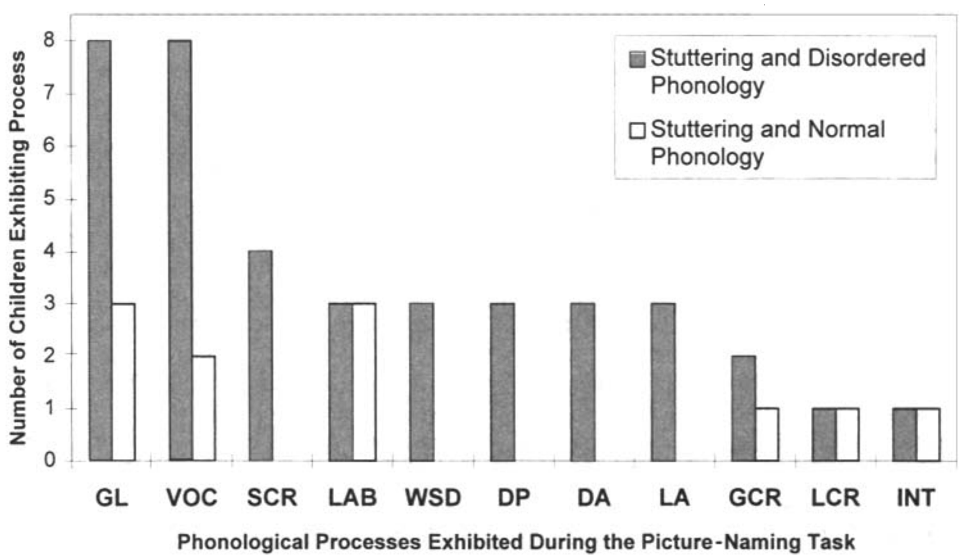

FIGURE 3. Phonological processes exhibited by at least 2 subjects on the Picture-Naming Task (PNT). GL = Gliding of liquids; VOC = Vocalization; LAB = Labialization; SCR = /s/-Cluster Reduction; WSD = Weak Syllable Deletion; DP = Depalatalization; GCR = Glide Cluster Reduction; DA = Deaffrication; LCR = Liquid Cluster Reduction; LA = Labialization; INT = Interdentalization.

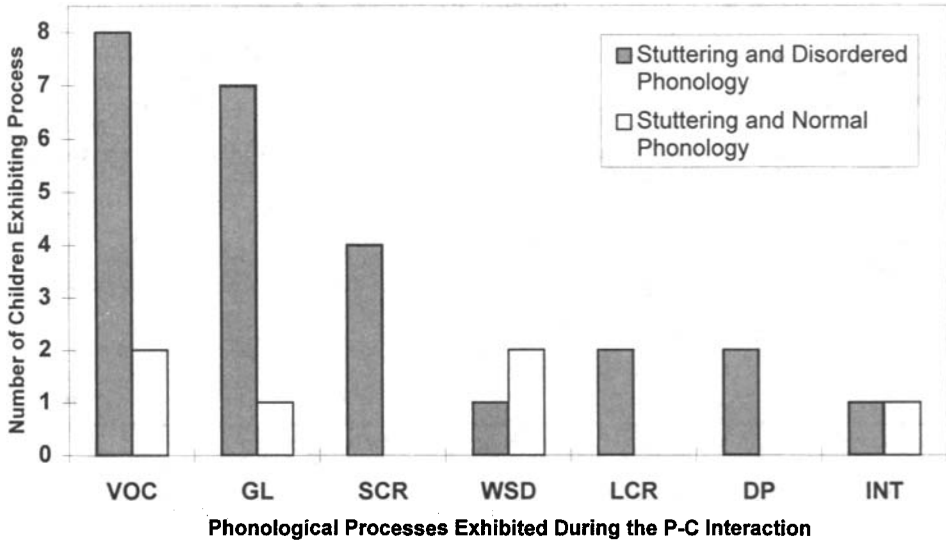

FIGURE 4. Phonological Processes exhibited by at least 2 subjects during the Parent-Child (P-C) Interaction. VOC = Vocalization; GL = Gliding of Liquids; SCR = /s/-Cluster Reduction; WSD = Weak Syllable Deletion; LCR = Liquid Cluster Reduction; INT = Interdentalization.

common phonological processes during both the PNT and the P-C Interaction were Gliding of Liquids, Vocalization, /s/-Cluster Reduction for S + DP subjects and Gliding of Liquids, Vocalization, and Labialization for S + NP subjects. It is interesting to note, however, that some phonological processes exhibited by at least 2 S + DP subjects were not exhibited by any of the S + NP subjects—such processes as /s/-Cluster Reduction, Weak Syllable Deletion, Depalatalization, Deaffrication, and Labial Assimilation. Furthermore, only 3 of the 9 S + NP subjects exhibited systematic speech errors during conversational speech that reached the 25% cut-off for consideration as a phonological process in this study.

"Phonological process-like" speech errors. Again, as expected, S + DP subjects exhibited significantly (U = 65.0; p = .015) more "phonological process-like" speech errors (i.e., systematic speech errors that occurred in less than 25% of possible opportunities) during the P-C interaction (n = 476; M = 52.89; SD = 20.18) than S + NP subjects (n = 223; M = 24.56; SD = 25.37). (Overall α = .05 [individual α = .017] used for the 3 preceding comparisons.)

Nonsystematic (slip-of-the-tongue) speech errors and self-repairs. No significant (U = 25.0; p = .17) differences were found in the mean number of utterances containing overt speech errors in the 75-utterance conversational speech samples of S + NP (M = 12.56; SD = 5.55) and S + DP (M = 9.56; SD = 3.05) subjects. Also, no significant (U = 30.5; p = .37) between-group differences were found in the mean number of utterances containing overt self repairs during the conversational speech samples of S + NP (M = 3.67; SD = 2.24) and S + DP (M = 2.67; SD = 2.06) subjects.

Repair-to-error ratio. The number of utterances containing overt self-repairs was divided by the number of utterances containing overt speech errors to derive the repair-to-error ratio. No significant (U = 31.5; p = .43) differences were found in the mean repair-to-error ratios of S + NP (M = 0.37; SD = 0.25) and S + DP (M = 0.28; SD = 0.21) subjects. It is most interesting to note, however, that no subject in either group evidenced *any* self-repairs of systematic (phonological process) speech errors in their conversational speech samples (i.e., none of the 871 instances of systematic speech errors in the total corpus of 8,213 words were self-repaired).

Mean articulatory speaking rate (ASR). No significant between-group difference (U = 29.00; p = .31) was found in the mean ASRs of S + NP (M = 3.82 syl/s; SD = 0.30 syl/s) and S + DP subjects (M = 3.65 syl/s; SD = 0.24 syl/s).

Mean response time latency (RTL). As noted above, subjects' mean response time latencies were calculated from those utterances in the 75-utterance conversational speech samples that followed a parent utterance. The number of utterances used for calculation of mean RTLs ranged from 17 to 47 utterances, but did not differ between subject groups (U = 56.00; p = .17). No significant difference (U = 26.00; p = .20) was found in the mean RTL of S + NP (M = 699.28 ms; SD = 204.67 ms) and S + DP (M = 849.33 ms; SD = 205.56 ms) subjects.

Relationships Between Speech Disfluencies and Speech Errors

Correlations. As shown in Table 3, Spearman *rho* correlations were used to examine relationships between measures of speech disfluencies and speech errors. The correlation between the number of nonsystematic overt errors and the mean frequency of within-word speech disfluencies for S + NP subjects (*rho* = 0.68; p = .05) reached statistical significance at individual α = .05; however, no other significant Bonferroni-corrected (overall α = .05) correlations were found between measures of speech disfluencies (mean frequency and duration, and overall severity) and measures of both systematic (number of types of phonological pro-

TABLE 3. Spearman rho correlations between measures of within-word speech disfluencies and (non)systematic speech errors.

Measures of within-word speech disfluencies	Spearman *rho* Correlation Coefficients			
	No. of phonological processes (PP)[a]	Total no. of phonological processes errors	No. of PP-like[b] errors	No. of nonsystematic errors
S + DP				
Frequency	.10	.15	−.12	.27
Duration	−.45	−.22	.23	−.10
Severity	−.21	−.03	−.13	−.33
S + NP				
Frequency	.25	.48	.25	.68[c]
Duration	.00	−.26	−.08	−.17
Severity	.02	.00	−.01	.13

Note. Severity of stuttering is based on the Stuttering Severity Instrument (SSI; Riley, 1980) Total Overall Score, based on an analysis of the subjects' within-word speech disfluencies.
[a]Phonological process, or systematic speech errors that occurred with *at least* 25% consistency.
[b]PP-Like = Systematic speech errors that occurred with *less than* 25% consistency.
[c]Individual $\alpha = .05$.

cesses, total number of phonological process errors, number of phonological-process-like errors) and nonsystematic (number of overt errors) speech errors for either S + DP or S + NP subjects.

Independence. The independence of within-word speech disfluencies and both systematic (phonological process) speech errors and nonsystematic (i.e., "slip-of-the-tongue") speech errors on *words* produced during subjects' 75-utterance conversational speech samples were tested using chi-square tests for independence calculated on 2 × 2 contingency tables (Conover, 1980). For systematic speech errors, separate contingency tables were calculated for those words that provided an opportunity for a child's systematic speech errors to occur (i.e., words that contained a sound affected by the child's systematic speech errors, regardless of whether the error occurred) and words for which a child's systematic speech error *did* actually occur.

Nonsystematic speech errors. There was no significant ($p > .05$) dependence between the occurrence of nonsystematic speech errors and *between-word* speech disfluencies. There was, however, a significant ($p < .001$) dependence between the occurrence of nonsystematic speech errors and *within-word* speech disfluencies for both S + DP ($T = 30.49$) and S + NP ($T = 29.26$) subjects. Specifically, as shown in Table 4, within-word speech disfluencies and nonsystematic overt speech errors co-occurred at a rate greater than that expected by chance.

Systematic speech errors. There was no significant dependence between the occurrence of systematic speech errors and the occurrence of either within- or between-word speech disfluencies on words that provided an opportunity for a child's systematic speech errors to occur (overall level of significance $\alpha = .05$) for any of the chi-square tests (T-values ranged from 0.05 to 4.60). Likewise, there was no significant dependence between the occurrence of systematic speech errors and the occurrence of either within- or between-word speech disfluencies on words for which a child's systematic speech errors did actually occur (overall level of significance $\alpha = .05$; T-values ranged from 0.01 to 2.91).

Articulatory Speaking Rate and Response Time Latency in Utterances That Contained Speech Errors and Speech Disfluencies

Wilcoxon signed-rank tests, calculated separately for each subject group, were used to compare differences in articulatory speaking rate and response time latency between utterances that *did* contain speech disfluencies or (non)systematic speech errors and utterances that *did not*. Table 5 summarizes means and standard deviations for

TABLE 4. Group contingency tables for co-occurrence of nonsystematic speech errors and within-word speech disfluencies on words produced by Stuttering plus Disordered Phonology (S + DP) and Stuttering plus Normal Phonology (S + NP) subjects. Within each cell observed values are followed by (expected values).

Subjects	Words in which nonsystematic speech errors	
	Did occur	Did not occur
S + DP		
Words in which within-word speech disfluencies *did* occur	26 (9.69)	218 (234.3)
Words in which within-word speech disfluencies *did not* occur	131 (147.3)	3580 (3564)
S + NP		
Words in which within-word speech disfluencies *did* occur	36 (15.81)	252 (272.2)
Words in which within-word speech disfluencies *did not* occur	198 (218.2)	3777 (3757)

Note. A significant dependence was found between the occurrence of within-word speech disfluencies and nonsystematic speech errors on words. Note that the co-occurrence of stuttering and speech errors on words is greater than that expected by chance. (Chi-square test of independence, $p < .001$; S + DP: $T = 30.49$; S + NP: $T = 29.26$).

TABLE 5. Mean articulatory speaking rates (and standard deviations) in syllables per second (syl/s) for Stuttering and Normal Phonology (S + NP) and Stuttering and Disordered Phonology (S + DP) subjects' utterances that *did* and utterances that *did not* contain (a) within-word speech disfluencies, (b) between-word speech disfluencies, (c) nonsystematic speech errors, and (d) systematic speech errors (phonological processes). Also included are results of Wilcoxon Signed Ranks tests (and *p* values) associated with differences between utterance groups.

	Articulatory Speaking Rate (syl/s)					
	Stuttering and Normal Phonology			Stuttering and Disordered Phonology		
	Utterance *did* contain	Utterance *did not* contain	Wilcoxon Signed Ranks Test (*p*-value)	Utterance *did* contain	Utterance *did not* contain	Wilcoxon Signed Ranks Test (*p*-value)
Within-word speech disfluencies	3.70 (0.36)	3.88 (0.35)	1.84 (.066)	3.57 (0.23)	3.69 (0.27)	1.96 (.051)
Between-word speech disfluencies	4.00 (0.31)	3.80 (0.34)	−1.36 (.17)	3.31 (0.24)	3.69 (0.24)	2.67 (.008)
Nonsystematic speech errors (slips-of-the-tongue)	3.78 (0.50)	3.83 (0.31)	0.42 (.68)	3.50 (0.30)	3.67 (0.24)	2.31 (.02)
Systematic speech errors (phonological processes)	3.64 (0.40)	3.87 (0.28)	0.94 (.34)	6.64 (0.28)	3.62 (0.23)	−0.53 (.59)

articulatory speaking rate for the utterance groups, as well as results of Wilcoxon signed-ranks tests referred to below.

Articulatory Speaking Rate (ASR). *Within-word speech disfluencies.* The difference in subjects' mean ASR between utterances that did and utterances that did not contain within-word speech disfluencies approached statistical significance at individual $\alpha = .05$ for both S + NP ($Z = 1.84$; $p = .066$) and S + DP ($Z = 1.96$; $p = .051$) subject groups. For both S + DP and S + NP subjects, utterances that did contain within-word disfluencies appeared to be produced with a somewhat *slower* ASR than those that did not; however, neither of these comparisons reached significance at a Bonferroni-corrected individual significance level of $\alpha = .025$ (overall $\alpha = .05$).

Between-word speech disfluencies. The difference in subjects' mean ASR between utterances that did and utterances that did not contain between-word speech disfluencies was significant (overall $\alpha = .05$; individual $\alpha = .025$) for S + DP subjects ($Z = 2.67$; $p = .008$), but not for S + NP subjects ($Z = -1.36$; $p = .17$). For S + DP subjects, utterances that did contain between-word speech disfluencies were consistently produced with a slower ASR than utterances that did not.

Nonsystematic speech errors. The difference in mean ASR between utterances that did and utterances that did not contain nonsystematic overt speech errors was significant (overall $\alpha = .05$; individual $\alpha = .025$) for S + DP subjects ($Z = 2.31$; $p = .02$), but not for S + NP subjects ($Z = 0.42$; $p = .68$). For S + DP subjects, utterances that did contain nonsystematic speech errors were produced with a slower ASR than utterances that did not.

Systematic speech errors (phonological processes). No significant differences were found in mean ASR between utterances that did and utterances that did not contain phonological processes for either S + DP ($Z = -0.53$; $p = .59$) or S + NP ($Z = 0.94$; $p = .35$) subjects. Four S + NP subjects were excluded in this comparison because they did not demonstrate phonological processes during the PNT.

Response Time Latency (RTL). A set of 8 Wilcoxon Signed-Rank tests was conducted to examine differences in RTL comparing utterances that did contain (a) within-word speech disfluencies, (b) between-word speech disfluencies (covert repairs), (c) nonsystematic overt speech errors, and (d) systematic speech errors (phonological processes) to utterances that did not for both S + DP and S + NP subject groups. None of the 8 statistical comparisons yielded significant differences in response time latency (*p*-values ranged from .173 to 1.00).

Discussion

Given the results of the present findings, it is possible to evaluate some of the basic predictions derived from the CRH in this study regarding the speech of children who stutter.

Differences Between S + DP and S + NP Children

Frequency of speech disfluencies. Because S + DP children produce more (systematic) speech errors than S + NP children, the CRH would appear to predict that S + DP children should also produce more speech disfluencies. In the present investigation, however, few differences were found between S + DP and S + NP subjects in terms of measurable aspects of their within- and between-word speech disfluencies. For example, no significant differences were found in the frequency of within- and between-word produced by S + NP and S + DP children, a finding consistent with prior findings of Louko et al. (1990), St. Louis and Hinzman (1988), and Wolk et al. (1993). Furthermore, and again consistent with Louko et al. (1990), no significant between-group differences were found in the duration of within-word speech disfluencies. Within-word disfluency durations for the 4- to 7-year-old subjects in this study (approximately .5 s) were similar to those reported previously by Conture and Kelly (1992) and Zebrowski (1991, 1994), but somewhat shorter than those reported by Louko et al. (1990).

The present analysis did not reveal the significant between-group difference in the occurrence of sound prolongations reported by Wolk et al. (1993); however, Wolk's analysis appears to have measured the frequency of sound prolongations in relation to *all* disfluency types (i.e., both between- and within-word speech disfluencies), rather than just within-word types (SSR, MWR, and SP) as in the present study. Indeed, although the apparent difference did not reach significance, inspection of the data in Figure 2 suggests that SSRs may have occurred relatively more frequently in some S + NP subjects than S + DP subjects, a pattern somewhat contradictory to that observed by Wolk et al. (1993). Combined, these results suggest a continued need for research on the potential differences in the types of within-word disfluencies produced by S + DP and S + NP children.

Systematic (phonological process) speech errors. As expected, S + DP subjects exhibited more systematic speech errors than S + NP children, a finding consistent with those of Louko et al. (1990) and Wolk et al. (1993). Although these results are not surprising because of the group-inclusion criteria, the findings do confirm that S + DP subjects produced more speech errors (and, therefore, may have had more opportunities for self-repair and speech disfluencies) than S + NP children.

The common occurrence of Gliding of Liquids and Vocalization in both subject groups, which was not unexpected given the relatively young age of the subjects in this investigation, has been noted in prior studies of children who stutter (e.g., Louko et al., 1990; Wolk et al., 1993), as well as in studies of children who do not stutter (see Edwards & Shriberg, 1983). Also consistent with prior studies (e.g., Louko et al., 1990), cluster reduction processes (including Liquid Cluster Reduction, Glide Cluster Reduction, and especially /s/-Cluster Reduction) were more prevalent for S + DP subjects than for S + NP subjects. Furthermore, comparison of present results to those of Wolk (1990, Appendix B) reveals many similarities between the two studies in the phonological processes exhibited by S + DP subjects but not by S + NP subjects (e.g., Depalatalization, Deaffrication, /s/-Cluster Reduction, Liquid Cluster Reduction, Labial Assimilation, Weak Syllable Deletion). Although present findings cannot be considered conclusive because of the small number of subjects in this and other studies, similarities and differences in the patterns of systematic speech errors demonstrated by S + DP and S + NP subjects are consistent with those described elsewhere.

Nonsystematic speech errors. The present finding that children in both subject groups produced relatively few nonsystematic speech errors in their conversational speech samples is consistent with previous reports that children's (and adults') nonsystematic speech errors occur relatively infrequently (Jaeger, 1992; LaSalle & Conture, 1995; Stemberger, 1989; Warren, 1986). Because the specific frequency of children's nonsystematic errors during conversation has not been previously reported, however, it is difficult to determine whether present error levels are similar to those found by other researchers. It is interesting to note, however, that the two oldest S + NP subjects produced very few errors of any kind during the conversational speech task. Therefore, it may be necessary to consider children's chronological or developmental age in further investigations of the occurrence of nonsystematic speech errors.

Overt self-repairs. On the basis of the CRH, Kolk et al. (1991) suggested that the frequent production of systematic speech errors by children with disordered phonology may be due to the children's inability to either detect or successfully repair phonological encoding errors in their speech (i.e., their internal monitors are in some way deficient). In the present study, however, no significant between-group differences were found in children's ability to detect and repair nonsystematic speech errors as indicated by the frequency of overt self-repairs and by repair-to-error ratios. Thus, although the present negative findings cannot be considered conclusive, it does *not* appear likely that monitoring difficulties were the cause of systematic speech errors in the speech of these S + DP children. Also, as previously mentioned, it is interesting to note that subjects did not overtly repair their systematic speech errors, suggesting that children may not consider such systematic deviations from adult forms as true "errors," that is, as speech behaviors in need of repair.

Relationships Between Speech Disfluencies and Speech Errors

The CRH also appears to predict that speech disfluencies are related to speech errors (e.g., Postma et al., 1990a). The present finding that utterances containing *nonsystematic* speech errors were significantly more likely to contain within-word speech disfluencies for both S + DP and S + NP subjects provides some support for this prediction. This finding is similar to that of LaSalle and Conture (1995), who found that within-word disfluencies are more likely to coincide with overt errors than with covert error words for children who stutter. It is interesting to note that this dependence was not found for nonsystematic speech errors and *between*-word speech disfluencies, suggesting that the CRH's predictions may be particularly relevant to the types of speech disfluencies frequently produced by children who stutter. Furthermore, in the present study, no dependence was found between within-word speech disfluencies and systematic speech errors, again suggesting that there may be a fundamental difference between children's *systematic* and *nonsystematic* speech errors in relation to self-repairs and the production of speech disfluencies.

Effects of Utterance Timing on Speech Disfluencies and Speech Errors

Effects of Articulatory Speaking Rate and Response Time Latency. The CRH assumes that individuals who stutter exhibit delayed phonological encoding and attempt to initiate speech too rapidly or use too-fast articulatory speaking rates. As described above, this set of assumptions leads to the prediction that utterances produced with a faster ASR are more likely to contain a speech disfluency or overt speech error. However, present findings do not appear to support this prediction. First, no significant differences were found between S + DP and S + NP subjects in terms of their articulatory speaking rate, a finding similar to that of Wolk et al. (1993). Furthermore, utterances containing within- and between-word speech disfluencies or nonsystematic speech errors were actually produced by some subjects with a *slower* ASR than utterances that did not. This finding does not support the assumption that children are more likely to produce speech disfluencies or speech errors when they use a faster articulatory (or overall) speaking rate (e.g., MacKay, 1971). However, Logan and Conture (1995) also noted that some of their subjects' ASRs were slower on utterances that did contain within-word disfluencies than on those that did not. Thus, it appears that increased ASR by itself does not increase the likelihood of within- or between-word speech disfluencies or (non)systematic speech errors.

There also appeared to be no difference in RTL between utterances that did contain speech disfluencies and speech errors and utterances that did not. The RTLs of S + DP and S + NP children have not been compared previously, so it is difficult to compare the present nonsignificant between-group differences to other studies; however, prior studies have indicated no significant differences in the RTLs of children who stutter and children who do not stutter (Kelly & Conture, 1992; Yaruss & Conture, 1995). Thus, present findings do not support the CRH predictions that faster articulatory speaking rates or shorter pausing times result in the production of speech disfluencies or speech errors.

Clinical Implications/Extending the CRH

Although the present study did not support the notion that systematic speech errors are associated with the production of speech disfluencies, results still appear to have clinical implications for treatment of children who exhibit disordered phonology. Specifically, the CRH mechanism can be extended to account for one of the clinical phenomena sometimes observed informally by speech-language pathologists treating children who stutter and demonstrate disordered phonology. As noted above, clinical evidence suggests that children may occasionally begin to produce frequent speech disfluencies while receiving treatment for phonological disorders (Comas, 1974; Hall, 1977; Ratner, 1995). One possible explanation for this increase in the production of speech disfluencies is that during the course of speech treatment for articulation or phonological disorders, children become increasingly aware of and sensitive to the differences between their own productions and the adult form of the target words. Thus, as children's internal monitors become more sensitive to systematic speech errors (i.e., as children are better able to detect such errors within their phonetic plans or recognize that their phonological productions are not correct), children may become more likely to try to repair these systematic speech errors, which they did not previously try to repair. According to the CRH, such changes in children's internal monitors may result in more frequent speech disfluencies because children are trying to repair more of their systematic speech errors. Of course, subjects in the present study had received *no* speech-language treatment before their participation in this study, so it is unlikely that these children were engaging in such error repair behaviors. Furthermore, empirical analyses of changes in children's speech fluency during articulation/phonological treatment has not yet been conducted. Such empirical investigation will certainly be required in order to test this possible extension of CRH.

Caveats and Additional Suggestions for Further Research

Statistical issues. As with many studies of conversational speech, the power of the statistical analyses in this investigation may have been affected by the varying number of speech disfluencies, speech errors, and self-repairs produced by each subject during their conversational speech samples. Conversational samples were specifically selected so that results would be generalizable to naturalistic conversational settings. Future studies of children's speech disfluencies and speech errors could improve statistical power by employing a paradigm that allows comparison of the same utterances within and between subjects (e.g., split-plot factorial design); however, such a controlled experimental design may limit the generalizability of findings to naturalistic conversational settings.

Nature of selected utterances. Again, because the present study used conversational speech samples, it was impossible to control for the length and grammatical and phonological complexity of the utterances analyzed. Because of the apparent relationship between utterance length and complexity and the timing of utterances (e.g., Amster & Starkweather, 1987; Logan & Conture, 1995; Meyers & Freeman, 1985; Walker et al., 1992), further studies of the co-occurrence of speech errors and speech disfluencies should consider such issues as *utterance length* (e.g., Gaines, Runyan, & Meyers, 1991; Logan & Conture, 1995; Peters & Hulstijn, 1987; Ratner & Sih, 1987; Weiss & Zebrowski, 1992), *grammatical complexity* (e.g., Logan & Conture, 1995; Gordon & Luper, 1989; Gordon, Luper, & Peterson, 1986; Ratner & Sih, 1987), and *phonologic complexity* (e.g., Bauer, 1988; Nelson & Bauer, 1991; Throneburg, Yairi, & Paden, 1994, Waterson, 1978).

Definition and identification of phonological processes. In order to describe systematic speech errors demonstrated by subjects, this study used phonological process analysis, a technique that has previously been shown to be a meaningful way of categorizing children's speech sound errors for clinical and research purposes (e.g., Edwards, 1992). However, informal phonological analyses such as those conducted in this study and others (e.g., Wolk et al., 1993) may not be specific enough to reveal subtle relationships between systematic speech errors and speech disfluencies in conversational speech. The phonological process definitions employed in the present study were designed to facilitate between-subject and between-group comparisons of children's phonological development; however, future studies may need to specify phonological processes more completely, involving such factors as phonetic context or the apparent nature of the children's underlying phonological representations (e.g., Dinnsen, 1984; Elbert & Gierut, 1986; Maxwell, 1984; Weismer, 1984). Finally, rather than considering error patterns (phonological processes), further investigation of the relationships between children's systematic speech errors and speech disfluencies could also take into account children's (in)accurate production of specific words or sounds (e.g., Caruso, Angello, & Sommers, 1993).

Inclusion of control groups. In the present study, S + NP children were compared to S + DP children in an attempt to examine the possible interactions between disordered phonology and stuttering. Questions relating to the CRH might further be evaluated using groups of children with normal fluency and normal phonology (NF + NP), as well as children with normal fluency and disordered phonology (NF + DP). Of course, in these populations, it is quite difficult to study interactions between, for example, systematic phonological errors and within-word speech disfluencies because these groups, by definition, will produce very few, if any, of these types of speech errors and speech disfluencies. For example, the 10 children who do not stutter examined by LaSalle & Conture (1991) produced only 22 within-word speech disfluencies during their conversational speech samples totalling 3,000 words. Because of the small number of such disfluencies produced by children who do not stutter, the applicability of inferential statistical analyses to examine the relationship between speech disfluencies and speech errors in these populations is severely limited. However, such work might be useful for examining potential interactions relating between-word speech disfluencies to nonsystematic speech errors and overt self-repairs, and such studies are currently being conducted by the present authors.

Summary and Conclusions

Present findings support some, but not all, of the basic predictions of the Covert Repair Hypothesis for children who stutter and exhibit disordered phonology (S + DP) and children who stutter and exhibit normal phonology (S + NP). Given these findings, as well as the apparent differences between children's systematic and nonsystematic speech errors, it seems reasonable to conclude that the CRH will need further research and elaboration (such as that offered above regarding the apparent increase in speech disfluencies which sometimes occurs during treatment for articulation or phonological disorders) if it is to provide a meaningful framework for evaluating the speech disfluencies of children who stutter, and particularly of children who stutter and exhibit disordered phonology.

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