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A Longitudinal Investigation of Stuttering and Phonological Performance in Preschoolers who Stutter

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Abstract

Stuttering onset takes place during a critical period of rapid syntactic, lexical, and phonological development, when children are acquiring the ability to produce increasingly complex utterances. Because of shared influences among various domains in the development of speech and language during this period, we hypothesized that either interferences with normal development, or rapid progress in one aspect, can have multiple effects. A previous study [1] presented data that focused on the relationship between phonological performance and stuttering at a time close to onset. This report examines the relation between phonological progress and changes in stuttering over the course of one year post onset of stuttering in preschool children who exhibit different levels of phonological skills. Twenty-nine preschool children near stuttering onset, ranging in age from 29 to 49 months (M= 39.17 months), were divided based on the initial level of phonological ability: minimal phonological deviations and moderate phonological deviations. Phonological deviancy scores (PCC) and stuttering-like disfluencies (SLD) measures were obtained for 3 visits over the one-year period, and participants' profiles for these metrics were generated, allowing a determination of the amount of increase or decrease in each metric. Longitudinal development in the two domains was examined at three set levels of change criteria. The greatest significance of this project is that it studied the relationship between stuttering and phonological skill from a temporal perspective. The results indicated that although the majority of children demonstrated improvements in both domains simultaneously, a substantial minority exhibited several other patterns.

INTRODUCTION

Since the middle of the 20th century, attention has been drawn to the possibility of links between stuttering and other disorders, most commonly incorrect speech sound production. Initially, such links entailed the mere frequency of co-occurrence of two clinical classifications: stuttering and articulation disorders. Since the 1980s, the term *phonological disorders* have been used most often, reflecting the processes of acquiring intelligible speech.

Schindler [2] found that 49% of 126 school age children who stuttered (CWS) had concomitant speech problems, chiefly of articulation, as compared to only 15% among 252 of normally fluent children (NFC). This trend continued in subsequent studies [3,4], with some including samples that, unfortunately, included wide age-ranges from preschool to advance grade school or even higher, such as Darley [5], Johnson [6], and Riley and Riley [7], the first one being based on parent reports. Van Riper [8] also suggested co-occurrence based on his clinical impressions of his developmental Track II (characterized by speech delay), and two relatively large surveys of school aged children using speech/language clinicians' caseload data [9,10] reinforced the conclusion of high co-occurrence. Nippold [11-14] however, questioned that conclusion, arguing that findings of past studies reflected several methodological weaknesses.

Relatedly, Yairi [15] opined that overlooking important epidemiological information may have contributed to high co-occurrence findings. Accordingly, even if the reported data for the school-age children were valid, a critical fact to keep in mind is that these children represent but a small minority (20% or fewer) of the original preschool-age stuttering population near the onset of stuttering. This minority did not experience natural recovery, probably due to greater morbidity, making its members more likely to exhibit multiple deficits. Therefore, generalization to all children who have ever stuttered is not warranted. That group differences in articulation/phonology deviations may be larger in school children who stutter is supported by Morley's study in the United Kingdom [3]. Yairi [16] also pointed out that a large majority of school age CWS are boys, a sub-population known to exhibit more articulation/phonological disorders than girls.

To ascertain high co-occurrence in a representative population, a survey of preschool-age children near the onset of stuttering examined at different points would be necessary. To date, however, no such survey has been reported. Nearly all studies including preschool CWS were limited in size with participants' ages often extending into the school years; even the younger among them were examined long post-stuttering onset. For example, Louko, Edwards, and Conture [17] had only 30 CWS, ages 2.4 to 7.4 years, and Wolk, Edwards, and Conture

[18] employed 3 small groups, each of only 7 participants ages 4.2 to 5.11, ranges that could have included children 2-3 years post onset. Yaruss, LaSalle, and Conture [19] had 85 boys and 15 girls tested on the average 18.5 months post-onset, some, of course, after a longer post onset interval. Nierman-Throneburg, Yairi, & Paden [20] investigating 24 preschool age CWS stuttered, reported no relationship between the likelihood of a word to be stuttered and level of its phonological difficulty. Ryan [21], compared 20 preschool CWS with 20 NFC control peers and reported no differences in scores on the *Arizona Test of Articulation*.

While the frequency of co-occurrence has remained an open issue, researchers' attention has shifted to another dimension of possible stuttering-phonology links: certain observable features (e.g., severity) of disordered phonology in relation to features of stuttered speech.

Thus, Louko, Edwards, and Conture [17] reported that the phonological deviations of CWS were more severe than those of NFC. Wolk, Edwards, and Conture [18], however, found that the phonology features of CWS who exhibited phonological disorders did not significantly differ from those of NFC with disordered phonology. Additionally they reported no differences in the severity of stuttering between CWS with or without phonological disorders. Ryan [21] compared 20 preschool CWS with 20 control peers and reported no differences in scores on the *Arizona Test*, although 5 of the stuttering children (all boys) later required articulation therapy. He was supported by the Yaruss and Conture [22] study who found no group differences in frequency, duration, or severity of stuttered speech events, as well as by Bernstein-Ratner and Silverman [23] who had a better sample of 15 CWS under the age of 36 months, all seen very close to the onset, and closely matched with NFC controls. No statistically significant group differences were found in scores on the *Goldman Fristoe Test of Articulation* (GFTA). Also Gregg and Yairi [1,24] did not demonstrate relationships between the level of stuttering severity and that of phonological skills in children close to onset. Lastly, Clark, Conture, Walden, and Lambert [25] administered the Sounds in Words subtest of the GFTA-2 to 128 CWS ages 3;0 to 5;11 and to 149 controls, with all 277 participants'GFTA-2 scores allowed to freely vary. No statistically significant group difference in test scores was found.

Paden, Ambrose, and Yairi [26], pursued another angle of this general direction by looking into differences in phonological skills among subgroups of children who stutter, combining it with another factor: the effect of time on the stuttering-phonology relationships. Participants were CWS first examined close to onset, then in several follow-ups. Children whose stuttering would eventually persist initially lagged in phonology skills as compared to the subgroup who would later exhibit natural recovery. After two years, the persistent group caught up with the one who would recover. The study, however, did not include the parameter of severity of either disorder or changes occurring over shorter time segments. More recently, Spencer and Weber-Fox [27] reported that preschool CWS who later persisted were less proficient than NFC and CWS who later recovered in measures of consonant production on the *Bankson–Bernthal Test of Phonology-Consonant Inventory* (BBTOP-CI) subtest, as well as in repetition of novel phonological sequences.

As with the issue of the incidence of co-occurrence, the question of whether or not the level of stuttering is linked to the level of phonological skills during early stage of stuttering, and how the two disorders interact over time, has remained open. In two aforementioned investigations, Gregg and Yairi [1,24] examined the phonological skills of preschool children near stuttering onset. Four groups participated: Two exhibited different levels of stuttering severity and two other groups had different levels of phonological skills. Little correlation was found between the two measures. Knowing, however, that both phonological skills and stuttering of young children change as a function of time, the next step would be to study the relations between these domains over consecutive time period beginning soon after onset.

Statement of the problem

A follow-up to the Gregg and Yairi investigation [1], the present study was designed to investigate possible interaction of phonological skills with the level of disfluency during the early stages of stuttering. We ask whether differences in the level of the two parameters occur simultaneously and in the same or the opposite direction during the critical time-window from close to stuttering onset and over the next year, prior to the time when many CWS exhibit natural recovery. Findings may shed light on the notion of a trade-off hypothesis, whereby a rapidly developing phonological system of a child who stutters is adversely impacting the stuttering [28], possible subtypes of stuttering [29], or the more recent multifactorial dynamic pathways theory [30]. To this end, CWS who exhibit two levels of phonological deviations were employed. The question posed was simple: If phonology remains stable or improves, are there corresponding changes in stuttering? This longitudinal interaction has not been addressed in previous investigations. Inasmuch as current knowledge allow us to expect that, on the average, phonological skills of young children increase with time, and the stuttering level of the majority of CWS decreases with time, and considering the small size of the sample, our main interest was the individual children's diversity in the pattern of progress of the two domains. Such an exploration would provide preliminary descriptive information pertaining to the developmental pathways and possible therapeutic considerations for those children who exhibit these disorders concomitantly.

METHOD

Participants

A rather rare group (by virtue of proximity to time of stuttering onset) of 29 participants was selected from a larger pool of children who stuttered who took part in the Stuttering Research Program at the University of Illinois. At the initial visit, they ranged in age from 29 to 49 months (M= 39.17). The low age was deemed necessary to recruit children more likely to exhibit phonological problems. The same cohort was employed in a previous study [1] that examined a different question (see literature review). To be included, somewhat stricter criteria than the already stringent criteria employed in the larger investigation of the Illinois Stuttering Research Program [31,32] were imposed:

1. Parental diagnosis. One parent, or both parents when

available, regarded the child as exhibiting stuttering.

2. Clinician's diagnosis. Two senior investigators (certified speech-language clinicians), independently diagnosed the child as exhibiting stuttering.

3. Clinicians' severity rating. The stuttering severity must have been rated at least 3 on an 8-point perceptual scale with 0 = normal speech; 1 = borderline; 2 = mild; 3-4 = moderate; 7 = very severe stuttering.

4. Number of disfluencies. The child must have produced a minimum of 3 Stuttering-Like Disfluencies (SLD): part-word repetition, single-syllable word repetition, and disrhythmic phonation (sound prolongation and blocks) per 100 syllables identified in a conversational speech sample of approximately 1,000 syllables.

5. Post-onset interval. The parents must have reported the onset of stuttering to occur no more than 6 months prior to the initial evaluation.

6. Health history. Negative history of neurological involvement.

Given that one of our aims was to examine the dynamics of the children's stuttering, the stuttering severity level (moderate) was selected to increase the chances that a significant number of disfluencies would be observed during the conversational speech samples.

MEASURES AND PARTICIPANT SELECTION

Phonology

The children's initial level of phonological ability was evaluated through the *Assessment of Phonological Processes-Revised* (*APP-R*) [33] that requires production of 50 single syllable and multisyllable words, yielding phonological deviancy scores (PDS). It features phonemes in prevocalic and postvocalic positions where they usually occur in American English, focusing on 10 phonological patterns typically acquired during the age span of the participants and most essential for communication. Garrett and Moran [34] reported that PDS were highly correlated with Percent Consonants Correct (PCC) from conversational speech as well as with listener severity ratings of phonology.

Accurate transcription of word productions was considered essential. In addition to the administrator of the *APP-R*, who transcribed the children's responses live, two team members, including the first author, skilled in phonetic transcription, independently transcribed the children's responses from audiotape. The three transcriptions for each child were compared and, where differences occurred, agreement of two transcribers was accepted. Next, the number of times a phonological targeted pattern was not produced was divided by the total opportunities for its occurrence, yielding a child's *percentage of error* for each of the 10 phonological patterns assessed. The mean of all pattern percentages yielded the child's *mean percentage of phonological error* score -- the higher number, the poorer is the performance. Inasmuch as equal scores at different ages do not indicate equal phonological achievement [33,35] because fewer errors are expected with age advancement, the *APP-R* specifies adding 5 points to the score of children over 3 years of age per each additional year. Given that phonological development typically is very rapid during the age range of our participants, a finer age weighting was employed by adding .417 points for each month of a child's past age 3, or subtracted if younger than age 3 [35]. This was designated as the child's *Age-Weighted Error Score*.

According to the *APP-R*, severity interval categories are derived from the phonological deviancy scores as follows: 0-19% = Mild; 20-39% = Moderate; 40-60% = Severe. Here, a child was regarded as having moderate phonological deviations if he/she received a mean phonological error score of 39% or higher; he/she was regarded as exhibiting minimal phonological deviations if the mean error score was lower than 20%. The gap between the two marking point screated clearly two distinguished groups.

Stuttering

Stuttering severity rating was based on four components: number of SLD, duration or length of disfluency, tension, and accessory characteristics [36]. Severity was judged by the two aforementioned investigators/ clinicians independently. Ratings that differ by up to half a point were set at the higher of the two estimates. In rare cases of greater differences, the videotaped sample was reviewed to obtain a mutually agreed-upon rating. As indicated above, severity was rated on an 8-point scale from 0 to 7.

Participant groups

The 29 participants were divided into two groups, one of 15 and one of 14 children. An attempt was made to have the children age- and gender-matched, maintaining a 2:1 male-to- female ratio representative the stuttering population of the particular age. Each group was defined by the age-weighted mean percentage of phonological error scores. Again, every child must also have been rated at least a 3 (the fourth interval) on the 8-point stuttering severity rating scale.

Group I: Moderate Phonological Deviations + Stuttering

The 14 children, 10 boys and 4 girls, ranged in age from 29 to 49 months (M = 39.2) at the initial visit. They exhibited moderate phonological deviations as defined. Table 1 features individual information.

Group II: Minimal Phonological Deviations + Stuttering

The 15 children, 10 boys and 5 girls, ranged in age from 31 to 48 months (M = 39.1) at the initial visit. They exhibited minimal phonological deviations as defined. Table 2 features individual information.

PROCEDURES

Speech samples

A conversational speech sample of approximately 1,000 syllables was audio- and video-recorded in a sound-treated room during the initial evaluation within 6 months from onset (Visit I) and in two follow-up visits: 6 months later (Visit II), and 12 months later (Visit III). Each visit consisted of two recording sessions separated by about one week, thereby increasing the

Table 1: Individual Data, Means, and Standard Deviations for the Stuttering and Moderate Phonological Deviations Group, Including Age, Gender, Initial APP-R Scores, Initial SLD Count, and Stuttering Severity Ratings.

Subject	Age (mos.)	Gender	*APP-R*	SLD/100Stuttering Severity	Rating
P1	49	M	39.02	14.3	4.5
P2	48	F	39.49	4.65	3.83
P3	38	M	40.04	20.23	3.17
P4	33	F	40.18	11.19	4.92
P5	47	M	43.27	12.08	6.06
P6	37	F	43.61	10.34	5.16
P7	48	M	43.67	6.85	6.25
P8	29	F	43.89	12.89	4.37
P9	35	M	44.75	8.61	3.16
P10	47	M	44.86	4.21	3
P11	36	M	45.25	12.6	3.42
P12	36	M	45.29	24.47	3.67
P13	30	M	49.11	4.04	3
P14	36	M	61.47	6.9	3.5
Mean	**39.2**		**44.56**	**10.95**	**4.14**
SD	**7.09**		**5.59**	**5.95**	**1.09**

Table 2: Individual Data, Means, and Standard Deviations for the Stuttering and Minimal Phonological Deviations Group, Including Age, Gender, Initial APP-R Scores, Initial SLD Count, and Stuttering Severity Ratings.

Subject	Age (mos.)	Gender	*APP-R*	SLD/100StutteringSeverity	Rating
G1	38	M	4.77	12.9	4.29
G2	45	M	5.38	22.91	4.83
G3	48	F	7.55	26.83	5.5
G4	32	M	7.7	4.79	5.79
G5	36	M	8.06	7.78	3.75
G6	42	M	9.43	12.22	5.08
G7	42	M	11.43	8	4.5
G8	31	F	12.82	10.59	5.58
G9	39	M	12.92	9.66	3
G10	48	F	13.43	8.06	6.16
G11	41	M	14.11	9.03	3.58
G12	41	M	14.79	14.97	5.5
G13	31	F	17.78	12.27	4.83
G14	34	F	18.99	20.22	4.5
G15	39	M	19.39	9.72	4.33
Mean	**39.1**		**11.9**	**12.66**	**4.75**
SD	**5.57**		**4.7**	**6.17**	**0.88**

Table 3: Individual Data, Group Means, and Standard Deviations for PCC and SLD (per 100 Syllables) Across Three Visits for the Moderate Phonological Deviations Group (*change between visits noted as up: + +; down: --; no change: NC).

	PCC						SLD				
Visit	**I**	**+/-**	**II**	**+/-**	**III**		**I**		**II**	**+/-**	**III**
P1	**74.55**	+ +	**86.04**	NC	**87.11**		**14.3**	- -	**3.29**	NC	**3.69**
P2	**55.81**	NC	**56.29**	+ +	**74.29**		**4.65**	- -	**1.96**	- -	**0.61**
P3	**60**	+ +	**69.21**	+ +	**93.69**		**20.23**	+ +	**23.1**	- -	**2.41**
P4	**57.98**	+ +	**70**	+ +	**76.22**		**11.19**	- -	**3.41**	- -	**2.36**
P5	**61.03**	+ +	**69.74**	+ +	**78.41**		**12.08**	- -	**11.1**	- -	**4.42**
P6	**62.75**	+ +	**68.29**	+ +	**73.12**		**10.34**	- -	**7.43**	+ +	**19.6**
P7	**43.16**	NC	**44.9**	+ +	**59**		**6.85**	NC	**6.96**	- -	**4.48**
P8	**68.18**	+ +	**82.76**	+ +	**90.64**		**12.89**	- -	**5.66**	+ +	**7.2**
P9	**71**	+ +	**84.1**	NC	**84.42**		**8.61**	- -	**1.02**	- -	**0.68**

P10	65.48	+ +	69.07	NC	70.57		4.21	+ +	14.4	- -	7.24
P11	65.99	+ +	71.39	+ +	79.62		12.6	- -	2.03	- -	0.91
P12	58.58	+ +	72.73	+ +	77.24		24.47	- -	10.8	- -	6.66
P13	71.46	+ +	77.34	+ +	82.88		4.04	+ +	4.58	+ +	5.47
P14	75.59	- -	73.66	+ +	79.31		6.9	- -	4.36	- -	1.69

Table 4: Changes in Direction of Phonology and Stuttering (up: + +; down: --; no change: NC) Between Visit I and Visit II and Between Visit II and Visit III for the Moderate Phonological Deviations Group.

Visit I to Visit II		
No. of Children	**Phonology**	**Stuttering**
8 (#1, 4, 5, 6, 8, 9, 11, 12)	++	--
1 (#7)	NC	NC
2 (#2, 14)	NC	--
Visit I to Visit II		
No. of Children	**Phonology**	**Stuttering**
8 (#2, 3, 4, 5, 7,11, 12, 14)	++	--
1 (#1)	NC	NC
2 (# 9, 10)	NC	--
3 (#6, 8,13)	++	++

Table 5: Individual Data, Group Means, and Standard Deviations for PCC and SLD (per 100 Syllables) Across Three Visits for the Minimal Phonological Deviations Group (change between visits noted as up: + +; down: --; no change: NC).

Mean	63.68	+ +	71.11	+ +	79.03		10.95	- -	7.15	- -	4.82
SD	8.62		10.74		8.77		5.95		6.02		4.86

Visit	I	+/-	II	+/-	III		I	+/-	II	+/-	III
G1	91.84	NC	91.90	NC	92.90		12.9	- -	4.37	- -	1.43
G2	82.80	NC	82.96	+ +	89.11		22.91	- -	4.42	- -	1.09
G3	94.92	+ +	98.19	NC	98.94		26.83	- -	4.88	- -	1.69
G4	83.04	+ +	88.10	+ +	93.72		4.79	- -	1.49	+ +	2.80
G5	95.05	NC	97.54	NC	97.56		7.78	- -	2.05	+ +	2.30
G6	93.93	NC	95.12	+ +	99.64		12.22	- -	6.13	+ +	12.44
G7	88.30	NC	89.63	+ +	95.07		8.00	- -	5.02	+ +	6.09
G8	82.67	+ +	88.82	+ +	93.59		10.59	- -	3.48	- -	1.29
G9	85.38	+ +	90.28	+ +	98.78		9.66	- -	2.39	- -	2.00
G10	90.37	+ +	96.71	NC	96.90		8.06	- -	2.55	+ +	4.94
G11	87.96	+ +	91.67	+ +	96.44		9.03	+ +	10.82	- -	2.95
G12	89.13	NC	92.92	NC	94.76		14.97	- -	10.07	+ +	17.02
G13	97.03	NC	98.20	NC	99.16		12.27	- -	2.91	+ +	5.20
G14	88.18	+ +	96.41	NC	97.26		20.22	- -	9.09	- -	6.63
G15	96.14	NC	97.70	NC	99.70		9.72	- -	3.61	- -	1.34
Mean	89.78	+ +	93.74	+ +	96.24		12.66	- -	4.89	NC	4.61
SD	4.94		3.60		3.02		6.17		2.93		4.57

representativeness of the child's speech. Samples were recorded during interaction with one parent and also with one investigator. They were orthographically transcribed, the number of syllables counted, and disfluencies counted. The three listeners have had extensive experience with the task. The speech sample recordings were replayed multiple times until the listener determined classification of each disfluent event. The *Systematic Analysis of Language Transcripts* [37] program was used for transcript and disfluency entry.

Disfluency analysis

All disfluencies were marked on the transcripts, including more than one type in the same syllable (e.g., repetition followed by prolongation). They were classified as: (a) part-word repetition; (b) single-syllable word repetition; (c) disrhythmic phonation (blocks and sound prolongation); (d) multisyllabic word or phrase repetition; (e) interjection; (f) revision/incomplete phrase. Only the first three categories are considered

SLD and were used for the purpose of this investigation [38].

Each of the three SLD types and the total SLD was tallied for each participant using *SALT*. Due to some differences in sample length, totals were converted to frequency per 100 syllables. A syllable-based analysis more accurately reflects the quantity of speech affected by disfluency, compared to word-based analysis. Note, however, that frequency per 100 syllables is different from percent of syllables disfluent because there can be more than one disfluency per syllable.

Phonological analysis

Although the *APP-R* was employed as a general measure to identify participants based on their initial phonological ability, the PCC measure was used for analyzing phonological performance because it provides more information about a child's phonological development. Moreover, longitudinal data collected by Shriberg, Kwiatkowski, and Hoffman [39] showed the PCC metric to be sensitive to changes in a child's speech sounds over time. PCC requires narrow transcription and yields six types of consonant sound changes as incorrect: (a) deletions of targets, (b) substitutions with another sound for targets, (c) partial voicing of initial target, (d) distortions of targets, no matter how subtle, (e) addition of a sound to a correct or incorrect targets, and (f) initial /h/ deletion and final n/n substitutions when occur in stressed syllables.

The *Programs to Examine Phonetic and Phonologic Evaluation Records* (PEPPER) protocol [40] was used to calculate the PCC for the speech samples recorded in the three visits. Accordingly, only the 90 non-questionable, first-occurring words were used for scoring. This guideline ensures that the sample is neither too short nor too long for PEPPER analyses. The PCC was calculated using the following formula [40]:

Number of Correct Consonants

PCC= X 100

Number of Correct + Incorrect Consonants

A PCC value of 85% is considered the cut-off point for normal phonology, a score in the range of 65% to 85% is considered as mild to moderate phonological deviation, and a score in the range of 50% to 65% is considered as moderate- severe. A score below 50% reflects severe involvement [40]. Significantly, phonological deviancy scores obtained on the *APP-R* had high correlation with PCC obtained from conversational speech samples [39].

Reliability:

Disfluency: Reliability indexes for disfluency analyses were obtained by dividing the number of agreements for type and location of SLD by the number of agreements plus disagreements [41]. Interjudge reliability between the first author and another experienced listener was established based on 40% of the samples. The average point-by-point interjudge agreement was 0.87. Values for point-by-point reliability above .80 are considered good, whereas reliability of .90 is considered high for disfluency data [42].

Percent consonants correct: Reliability of phonetic transcription was assessed as the percentage of point-by-point agreement/disagreement. Interjudge reliability was based on 15% of the total samples and compared against transcripts completed by a clinician trained in PEPPER transcription. Interjudge reliability was 79.2%. Intrajudge reliability for the first author was 91.6%.

Data analysis

Individual subject scores for thePPC and SLD for each of the 3 visits were tabulated and were first used to obtain group data. As per our specific objective, the scores were then used to identify individual progress in terms of change in scores (up, down, or no change) from visit to visit. Change was defined as at least 5% increase or decrease in the respective score. The individual subject analysis also minimized the effect of some initial age differences on comparisons of phonological progress over the year (e.g., phonological development of a 29 month-old child at the initial visit should not be merged with that of a 40 month-old child across the same time).

RESULTS

Moderate Phonological Deviations: Group and Individual Data

Table 3 presents individual data, as well as group means and standard deviations, for PCC and SLD across the three visits for themoderate phonological deviations group. Also noted are descriptors of the direction of change (++: up; --: down; and NC: no change).

For this group as a whole, improvement in both stuttering and phonology occurred across the three visits: the mean SLD decreased from 10.95 at Visit I to 4.82 at Visit III, while the mean PCC increased from 63.68 to 79.03. Individually, the children exhibited several different trends, such as simultaneously improving fluency and phonology, improvement in only one domain, or a "neutral" trend, where minimal or no improvement in either domain. This variability is noteworthy inasmuch as the very composition of this group (stuttering + moderate phonological deviations) created a situation for potential mutual interference. The upper part of Table 4 displays the number of children who followed a particular pattern of change in the two measures from Visit I to Visit II (with "change" at least 5% increase or decrease). Five patterns were identified: (a) increase in phonology and decrease in stuttering, (b) neutral: no change in both measures, (c) no change in phonology and decrease in stuttering (d) increase in both measures, (e) increase in phonology and decrease in stuttering. As can be seen, 8 children (upper line) exhibited simultaneous improvement of the two measures, and one child revealed a neutral pattern (second line). Hence, 9 children appear to indicate no mutual interference of the two domains. The remaining 5 children were distributed among the other 3 patterns which may interpret as indicating some trade-off.

There was substantial variability, especially in the SLD scores, reflected in very large standard deviations, ranging from more than 50% of the mean to larger than the mean. Three children even increased SLD output over time. A two-way, repeated measures ANOVA with a Greenhouse-Geisser test for sphericity was conducted to examine SLD and PCC across time. Results for

SLD/time revealed a significant effect ($F_{2, 25}$ = 5.54, p<.05). Results for PCC/time also revealed a significant effect ($F_{2, 22}$ = 38.43, p< .05). Post hoc *t*-testsfor SLD revealed significant difference between Visits I and II (t= 2.25; p< .05) but not between Visits II and III (t = 1.24; p = .233). Post hoc t-tests for the PCC revealed significant differences between Visits I and II (t = 5.21; p = < .05) as well as between Visit II and III (t = 4.38; p = < .05).

The lower portion of the table presents the change pattern data between Visit II and Visit III. Here, 8 children demonstrated simultaneous improvement in both phonology and stuttering, with an additional child exhibiting no change in either domain. Hence, again we observe a situation where 9 of the 14 participants did not evidence apparent domain trade-off. Interestingly, only four children appear in the same (first) pattern in the upper and lower part of the table. The remaining 5 children in the group demonstrated two patterns that could be interpreted as indicative of trade-off.

Minimal Phonological Deviations: Group and Individual Data

Table 5 presents individual data, as well as group means and standard deviations, for PCC and SLD across the three visits for the minimal phonological deviations group. Also, as with the above group, the descriptors of change are indicated.

As expected, because all children in this group exhibited good phonological skills at the initial visit, they had limited room for changes in this domain. Table 5 shows that although all children improved their phonological scores over the full year period, 7 of the 14 did not reach the minimum 5% change criterion between Visit I and II and 8 failed to do so between Visit II and III. Note also that this group initially presented an unexpected level of moderate to severe stuttering, as well as considerable variability in this domain as evident in the large standard deviations for the SLD data that are similar in size to those of the first group. A two-way, repeated measures ANOVA with a Greenhouse-Geisser test for sphericity was conducted to examine SLD and PCC across time. Results for SLD/time revealed a significant effect ($F_{1, 18}$ = 17.50, p<.05). Results for PCC/time also revealed a significant effect ($F_{2, 23}$ = 36.55, p< .05).

($F_{2, 25}$ = 5.54, p<.05). Results for PCC/time also revealed a significant effect ($F_{2, 22}$ = 38.43, p< .05). Post hoc *t*-tests for SLD revealed significant difference between Visits I and II (t = 5.10; p< .05) but not between Visits II and III (t = .272; p = .789). Post hoc t-tests for the PCC revealed significant differences between Visits I and II (t = 5.18; p = < .05) as well as between Visit II and III (t = 4.62; p = < .05).

Table 6 presents the distribution of the children according to the diverse developmental patterns from visit to visit. Only 6 children improved in both phonology and stuttering between Visit I and II (first line of the table), whereas 8 improved (decreased) their stuttering when phonology remained stable (last line in top part of the table), and one child's stuttering increased when phonology improved.

Overall, comparison of the changes in SLD for the two phonology-based groups reveals a much sharper decline between the first two visits for the minimal phonological deviations group (61%) than for the moderate phonological deviations group (35%). From Visit II to Visit III, however, as the minimal phonological deviations group remains unchanged, the moderate phonological deviations group continues to show a decrease in SLD (33%) to reach the level of the minimal phonological deviations group at Visit III.

But what effect might the predetermined level of percent change have on the presence of trends here when only looking across one year? In other words, if we were to establish "change" at 8% or 10%, instead of the predetermined 5%, how might this impact what we observe in terms of overall trends from the initial to the final visit? Table 7 presents such changes in phonology and stuttering for both groups, from Visit I to Visit III. For the moderate phonological deviations group, the majority of the children (10/14) exhibited improving phonology concurrent with decreasing stuttering from Visit I to Visit III, regardless of the set level of change. The minimal phonological deviations group presents a slightly more complex picture, with two trends appearing. Eight children evidenced improving phonology paired with a decrease in stuttering with change defined at 5%; this number decreases to 5 children at 8 and 10% change. There also was a cohort of children who exhibited no change phonologically while improving in fluency, beginning with 5 children when change was identified at 5%, and increasing to 8 children at 8 and 10% change. It is important to keep in mind, however, that this group already was performing at a relatively high level of phonological skill.

Table 6:

Visit I to Visit II		
No. of Children	**Phonology**	**Stuttering**
6 (#3, 4, 8, 9, 10, 14)	++	--
0	NC	NC
0	--	--
1 (#11)	++	++
0	++	NC
Visit I to Visit II		
No. of Children	**Phonology**	**Stuttering**
4 (#2, 8, 9, 11)	++	--
0	NC	NC
0	--	--
3 (#4, 6, 7)	++	++
0	++	NC
2 (#1, 3)	NC	--
1 (#10)	NC	**++**

DISCUSSION

The main significance, and greatest strength, of this research is that it examined the relationship between stuttering and phonological skill from a temporal perspective during the early stage of childhood stuttering with particular reference to individual developmental trends. To study developmental interaction between features of stuttered speech and those of phonological deviations, we employed rarely available epidemiologically-desired groups of children who were: (a) within 6 months of stuttering onset, (b) within a narrow age-

Table 7: Number of Children Exhibiting Change (up: + +; down: - -; no change: NC) Between Visit I and Visit III, with Change Defined at 5, 8, and 10%.

Moderate Phonology		5% Change	8% Change	10% change
Phonology	Stuttering			
++	- -	10	10	10
NC	NC	0	0	0
NC	- -	1	1	1
++	++	3	2	2
++	NC	0	0	0
NC	++	0	1	1
Moderate Phonology		5% Change	8% Change	10% change
Phonology	Stuttering			
++	- -	8	5	5
NC	NC	0	1	1
NC	++	0	1	1
++	++	1	0	0
++	NC	1	0	0
NC	- -	5	8	8

range, (c) representing an appropriate gender distribution for the stuttering population for the age under study, and (d) carefully defined to represent at least a moderate level of stuttering severity and clearly distinguished two levels of phonological ability. Indeed, the longitudinal data for the levels of stuttering and phonological skills derived during the critical one-year window beginning soon after stuttering onset, when many children still exhibit substantial amounts of stuttering as well as many phonological errors that allow observations of variations, have yielded interesting results. Inasmuch as it has been well documented that, on the average, stuttering decreases with time and phonological skills increase, individual child variations were the focus of this study.

Moderate Phonological Deviations Group

A main observation was that8children (57%) followed the average groups' trend of simultaneously increasing phonological scores while decreasing the frequency of stuttering between Visit I and II. That is, the two domains improved in synchrony. Adding one child (#7) who showed no change in either domain, 9 of the 14 participants (63%) did not show apparent trade-off effect of one domain upon the other. The remaining five children, a substantial minority of 36%, followed different patterns that could be interpreted as some domain interference. For example, while phonology improved, stuttering remained unchanged (child #13).

A similar picture was seen in the progress from Visit II to Visit III. Here, 8 children (57%) improved in both phonology and stuttering scores indicating no trade-off, whereas 6 (43%) either changed, or did not change course, in ways that could be interpreted as trade-off. The extensive individual variability also is seen in that only 4 children who exhibited improvement in both domains between Visit I and Visit II, repeated this pattern between Visits II and III. We note that, in general, increasing the level of defined "change," has not altered this scene.

Overall, considering that the composition of this group (stuttering + moderate phonological deviations) created a potential for mutual domain interference, it is apparent that the majority of the children were able to progress quite well in both domains simultaneously. Nevertheless, some showed progress in only one domain during at least one of the two 6-month periods of the first year post onset. Still, interpretations in terms of domain interference remain to be substantiated by hard evidence.

Minimal Phonological Deviations Group

Inasmuch as all children exhibited good phonology at the initial visit, relatively little movement occurred in this domain occurred. Although all children improved their performance over the year, 7 of the 14 children did not reach the minimum 5% change criterion between Visit I and II and 8 failed to do so between Visit 2 and 3.

Additionally, the SLDs of this group clearly decreased across the three visits for 13 of the 15 children. Although one may suggest that the decline in stuttering was enhanced because fewer resources were directed toward developing phonological skills, findings from the previous group of participants would seem to restrain such interpretations.

CONCLUSION AND THEORETICAL CONSIDERATION

The overlapping age range, 2 to 4 years, when most stuttering onsets occur while rapid speech and language development takes [28,43,44], has led to speculations that the co-occurrence reflects either (a) common etiologies, such as genetics [35], and/or (b) that the occurrence of one facilitates the manifestation of the other [9,10,45, 46,47,48,30].Perhaps the most well-known has been the aforementioned trade-off hypothesis [28], whereby a rapidly developing phonological system of a child who stutters is adversely impacting the stuttering. Conversely, when a child's phonological system is relatively stable, stuttering is more likely to decrease.

We contend that if a link between stuttering and disordered phonology exists, there is certainly not a one-on-one relationship. That much can be inferred even from past findings showing that only some of the children who stutter also exhibit phonological difficulties. Examining simultaneous progression of the two disorders over time, the current study lends support to the above statement regarding the absence of clear relationship, as far as observed disorders are concerned, at least during the first year or so of stuttering. In terms of our study, this means that, for the most part, changes in one disorder do not seem to impact changes in the other regardless of direction. With regard to the trade-off hypothesis in the moderate phonological deviations group, if stuttering emerges during a period of skill expansion in another domain, then how can this hypothesis account for the co-occurrence of stuttering in association with poorer phonology at onset? In other words, if stuttering begins in a child who already has phonological difficulties, where is the trade-off? With regard to the minimal phonological deviations group, although it can be suggested that high phonological skills could trigger stuttering, this model does not appear to clearly tie the two domains, as it does not account for differences in the level of stuttering. Thus, the questions of the probability of co-occurrence of stuttering and phonological deficits, as well as whether or not the level of stuttering is linked to the level of phonological skills during the early stages of stuttering, and how the two disorders interact over time, remain open. In other words, the fact that the majority of children improved in both phonological and stuttering domains may not provide evidence for an absence of an interaction between both parameters. Consequently, neither does a behavior of both parameters that differs from this typical development indicate an interaction.

LIMITATIONS OF THE PRESENT INVESTIGATION AND FUTURE RESEARCH

Even though the scope of this investigation was quite unique, and, in many respects, addressed the methodological concerns of previous investigations by employing a more strict design, there are certain limitations that should be noted. The present findings, as those reported in several past studies, have yielded little evidence of a link between stuttered speech and phonological skills. This in spite of the fact that important methodological concerns voiced by Nippold [13] were addressed. Although it is tempting to conclude that this direction of research may be nearing a dead-end, we keep in mind the relevance of information reported on phonological skills in early childhood involving persistency and recovery in past studies [35,36] and the recent studies by Smith and Weber [30], and Spencer and Weber-Fox [27] would seem to leave the door open for research in this direction.

Finally, some of the results lend themselves to the multifactorial dynamic pathways theory where stuttering development can be examined over time as an "unfolding trajectory of a system's behavior and how it is affected by external and internal conditions" [30]. This may refer to the participants' ongoing interactions among speech motor and linguistic processes. As the theory implies, sudden dynamic changes in output may be driven by relatively small changes in underlying processes. Unstable speech motor networks place pressures on the collective system and push it outside the boundaries of fluent operation when there are increased linguistic demands.

A larger sample size will allow for more critical statistical examinations of the longitudinal curves using analyses such as hierarchical linear models. Additionally, some past investigations [49,35,26] employed the *APP-R* as the measure of phonological ability that bases performance on single-word utterances. Even though the present investigation examined phonological performance through conversational speech samples via PCC, specific measures of phonological ability, perhaps an investigation where initial phonological skills are determined by PCC would provide more specific information about the nature of the child's phonological abilities near stuttering onset.

Regardless, we cannot learn about complications in the connected speech of children who stutter until connected speech is examined. One way to examine the stuttering-phonology link is to pursue more refined research of sub-groups. Perhaps future research should examine the stuttering-phonology connection in conjunction with additional and larger number of factors, such as language, fine oral-motor skills, and genetics, moving beyond descriptive research and into experimental studies. Where PCC is more robust and less vulnerable to variability due to conversational partner and topic, future studies should consider looking at additional language measures in concert with PCC and NDW and the potential differences between them.

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