Error consistency and the evaluation of treatment outcomes

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Abstract
The consistency/variability of error substitution patterns may hold important implications for subgrouping children with speech disorders, as well as for relationships between learning and generalization patterns. There is a need to quantify and examine the range of consistency/variability within the speech disordered population as it relates to system-wide change. This investigation compared two groups of preschool children (N=10 each) differing in the consistency/variability of errors on a variety of pre-treatment and treatment outcome measures. The Error Consistency Index (ECI), a measure of error variability across the entire phonological system, was used to identify groups at the extreme ends of the ECI distribution from a larger participant pool. Each participant was treated on three target singletons from among obstruents /s, z, f, j, tʃ, k, g/ and liquids /l, r/ and change on these targets, as well as their generalization to untrained positions was assessed. Although there were significant differences between the variable and consistent groups on all pre-treatment measures, there were no significant group differences in target and generalization learning or in percent consonants correct (PCC) change. These findings provide evidence to suggest that relationships observed between error variability for individual phonemes and learning of those targets may differ from those observed when consistency/variability is quantified for the entire system and change across a number of phonemes, and the system as a whole, is examined.

Keywords: Phonological disorders, consistency, variability, treatment, generalization

Introduction
The consistency or variability with which a child produces an intended phoneme in a variety of contexts has been the subject of investigation as it relates to generalization learning and to the nature of underlying deficit in phonological disorder. Variability may be a reflection of phonological factors, such as complex rule ordering, or of error instability as correct production is diffused through the lexicon. Rule ordering may render a target sound incorrect when it is intended, but produced correctly as an error for another target, or even further subject to a positional constraint. Variability may result from contextual factors such as word position, stress patterns, adjacent phonetic context, and allophonic variations (Kenney & Prather, 1986). From a developmental speech motor perspective, short-term, increased variability has been associated with the emergence of new behaviors that are
lexically diffused (Forrest, Weismer, Dinnsen, & Elbert, 1994; Tyler & Saxman, 1991; Tyler & Edwards, 1993), although over the longer term decreased variability reflects a maturing system (Kent & Forner, 1979; Sharkey & Folkins, 1985). Variability may also be associated with linguistic load, and in this case, or in instances of developmental advance, it may be viewed as advantageous. Dodd (1995) has suggested that when variability is extensive and does not appear to be related to the factors mentioned, it may be viewed as inconsistent phonological disorder, reflecting an underlying phonological planning deficit. Such variability is interpreted as a disadvantage with respect to learning the target contrast or pattern.

Variability or consistency can be evaluated from the perspective of whether or not there are some correct productions for a target phoneme, which is thought to be less problematic (Grunwell, 1987), as well as from consideration of the number of different substitutions for a target. Variability due to phonological or contextual factors may result in different error substitutions both across and/or within word position. For example, a child may omit final consonants, such as /k/, but this phoneme may also be affected by the pattern of fronting in another position. The status of a phoneme in the child’s inventory may also be an important factor in determining the consistency of error substitutions. Examples of variability are common in both typically developing children and those with phonological disorders. Yet, the extent of variability across a given child’s entire system, methods of quantifying such variability or error consistency, and the existence of subgroups defined by consistency/variability within the phonologically disordered population are relatively unexplored. Isermann (2001) addressed whether or not the consistency of error substitutions varies across different phonemes in 46 children with phonological disorder by examining the percentage of variable error substitutions and the relationship between this percentage and per cent consonants correct (PCC) for individual phonemes. Not unexpectedly, the later developing phonemes tended to have the highest percentage of variable error substitutions. Phonemes with the highest and lowest PCCs were least likely to have variable substitutions, because they were either consistently correct or consistently incorrect. Those phonemes in the mid-range, /s, z, v, f, g, k, t, j/, were most likely to have variable substitutions, suggesting that many children display a range of variability in error substitutions across phonemes.

Several methods of quantifying variability have been suggested and reflect different notions of the source of variability. Dodd (1995) measures variability over three trials of production of multisyllabic words, assigning a criterion of 40% or greater inconsistently incorrect productions for diagnosis as inconsistent phonological disorder. Tyler and colleagues (Tyler, 2002; Tyler, Lewis, & Welch, 2003) developed a measure of error consistency across the entire phonological system, termed the error consistency index (ECI). ECI is the sum total of the number of different sound substitutions/omissions used across all word positions for all 23 phonemes from a single word citation task designed to sample each phoneme three times in initial and final positions. Low error consistency scores indicate fewer different errors across a small number of phonemes, while higher scores suggest that there are multiple errors across many phonemes. In a sample of 40 children with speech and language impairment ECI ranged from 12 to 70 (Tyler, Lewis, & Welch, 2003). Similarly, Isermann (2001) found that a measure of per cent of inconsistent substitutions for phonemes in error ranged from 3.85 to 55.81 in a sample of 46 children with phonological disorders. Error consistency may also be examined qualitatively on a phoneme-by-phoneme basis by describing whether or not errors are variable across word positions only or both within and across word position.
Variability/consistency of error substitutions may also hold important implications for subgrouping children with phonological disorders. It has been suggested that children with variable substitution patterns represent a unique group that may benefit from a specific type of intervention (Dodd, 1995; Dodd & Bradford, 2000; Forrest & Elbert, 2001). Forrest, Elbert, and Dinnsen (2000) discuss differences between consistent and variable substitution groups with regard to speech articulation measures prior to treatment. For example, the consistent substitution group scored higher on the Goldman Fristoe Test of Articulation (GFTA; Goldman & Fristoe, 1986), with a mean percentile rank of 29, as compared to the variable substitution group whose mean percentile rank was 12. For all matched pairs, the consistent group member had a higher GFTA percentile score than the matched variable substitution group member. The consistent substitution group also demonstrated higher Percent Correct Underlying Representation (PCUR; Dinnsen & Chin, 1995) scores than the variable substitution group. Similar pretreatment group differences are apparent in a study by Forrest Dinnsen, and Elbert (1997). The mean PCC for the consistent substitution group was 60% and for the variable group was 44%.

The differences between groups differentiated by consistency/variability of error patterns raise the question as to whether it is the substitution patterns that truly differentiate the groups or other characteristics of their phonological systems. Isermann (2001) found that the percent of inconsistent substitutions for phonemes in error increased continuously across a group of 46 children with phonological disorders, so no distinct group that made inconsistent substitutions was discernable. A comparison of the 15 children with the highest percentage of inconsistent substitutions for errors to those 15 with the lowest percentage, however, showed that the group with more inconsistent substitutions was significantly younger and had significantly lower GFTA scores. These findings and those from Forrest and colleagues suggest, at the least, that children with greater variability in substitution patterns are more severe.

The variability of pre-treatment substitution patterns may also hold predictive value for learning and generalization patterns. Elbert and McReynolds (1978) suggested the more consistent an error pattern prior to treatment, the more success the child had in producing the target as opposed to inconsistent errors, which were associated with less successful productions of the target following treatment. In a series of studies, Forrest and colleagues (Forrest et al., 1997; Forrest et al., 2000) investigated the relationship between pretreatment consistency of substitution patterns and generalization learning for phonemes absent from children’s inventories.

Post-hoc analysis of treatment data showed that all preschoolers with a consistent substitute across word positions for a target absent from the inventory learned the sound in the treated positions and generalized correct production to other word positions. Children who had variable productions across word positions learned the target in the treated position, but failed to generalize to untreated word positions. Four of five children who had variable productions both within and across word positions did not achieve correct production of the target phoneme in either treated or untreated positions. In a subsequent investigation, children with consistent substitution patterns for one error terminated treatment after 9–16 sessions because the 50% generalization criterion had been met (Forrest et al., 2000). Children with variable substitutions did not reach this criterion and treatment was terminated following 20 sessions with no participant achieving the 50% criterion on the administered probe. Based on these findings, Forrest et al. (2000) suggest that children with consistent substitution patterns learn the treated target and generalize its use, while children with variable substitution patterns have greater difficulty doing so.
In contrast to findings that suggest differences in generalization are related to pre-treatment error consistency patterns, other investigators have found no clear trends in generalization across word position (Huff, King, & Williams, 2002; Olswang & Bain, 1985). Huff et al. found that although both children with consistent and variable substitution patterns improved on their target, there was limited generalization. Instead, there were differences in phonological restructuring that appeared to be related to the child’s knowledge of the target, in addition to error pattern consistency. One of the two children with a variable substitution pattern showed a decrease in phoneme collapses similar to that observed for children with a consistent pattern, but this child had the knowledge of the target. Huff et al. suggest that examination of variability across the entire sound system, such as phoneme collapses, may inform differences in outcomes.

In an attempt to further explore the relationship between error pattern variability and treatment progress, Tyler et al. (2003) sought to identify predictors of PCC change for a group of 20 participants and to replicate this procedure with a second group of 20. Participants were preschoolers who received phonological and morphological treatment as part of a larger goal attack strategy study. A multiple regression was performed on the following predictor measures to determine which variable or combination of variables had the strongest relationship with PCC change; inventory size, error consistency (ECI), finite morpheme composite (FMC; Bedore & Leonard, 1998), and chronological age. In the first group, Tyler et al. found that error consistency and FMC combined accounted for 52% of the variance in the criterion variable, PCC change. ECI accounted for 31.6% of the variance at the first step in the regression. In the replication sample, ECI was the only variable to show a moderate relationship to PCC change and it again accounted for 31% of the variance. Thus, Tyler et al. found that a highly inconsistent system was associated with greater PCC change.

In summary, there is a need to further explore the existence of subgroups defined by consistency/variability within the phonologically disordered population with different methods of quantifying error consistency. This will help to determine if children who differ in their substitution patterns with respect to consistency have phonological systems that differ in other primary ways. There is also a need to further examine learning and generalization for the group of sounds that are typically in error and/or more inconsistent in children differing in their pre-treatment error consistency. The purpose of this study was to further evaluate error consistency and target learning, using measures reflecting error consistency and learning across the larger system. The primary research question concerned whether there were differences in target sound learning, generalization of targets to untrained positions, and PCC change between groups with consistent and variable error patterns. It was hypothesized that, if differences existed, they would favor the consistent group. The present study also sought to determine if there were significant pre-treatment differences between consistent and variable substitution groups for other phonological measures, such as PCC, inventory size, and error consistency index for target sounds.

Method

Participants

Twenty preschool children, ages 3;0–5;11, with impairments in both phonology and morphosyntax were participants in this investigation. All participants were enrolled in early
childhood programs affiliated with the local school district (Washoe County, NV). All met the state requirements for enrollment in this early childhood program with eligibility under the domain of speech-language impairment. Children serving in this investigation were part of a larger study of forty monolingual English-speaking children conducted earlier to evaluate different goal attack strategies for sequencing multiple goals in phonology and morphosyntax (Tyler, Lewis, Haskill, & Tolbert, 2003). Children met the following inclusion criteria: (1) phonology scores at least one standard deviation below the mean on the *Bankson-Bernthal Test of Phonology* (BBTOP; Bankson & Bernthal, 1990); (2) documentation of expressive language scores at least one standard deviation below the mean on the *Preschool Language Scale-3* (PLS-3; Zimmerman, Steiner, & Pond, 1992) or a mean length of utterance (MLU) in morphemes greater than one and a half standard deviations below the mean based on Leadholm and Miller’s (1993) normative data; (3) nonverbal cognitive functioning within one and a half standard deviations of the mean on the Columbia Mental Maturity Scale (CMMS: Burgemeister, Blum, & Lorge, 1972); (4) normal hearing as indicated by pure tone screening; (5) normal oral motor functioning (Robbins & Klee, 1987); and (6) neurological, behavioral, and motor skills reported to be within normal limits in assessment results.

Participants selected for the present study were those with error consistency index scores at the extreme ends of the distribution of scores for the 40 participants in the larger study. ECI was calculated based on the total number of different substitutions made for each of 23 phonemes, across all word positions (Tyler, Lewis, & Welch, 2003). Using the upper and lower quartiles, subjects at the extreme ends of the distribution were placed in two groups. The variable substitution group consisted of children in the upper quartile with high ECI scores, >44.75. The consistent substitution group consisted of children in the lower quartile with low ECI scores, <22.25. Each group consisted of ten participants.

**Procedures**

For the purposes of the present investigation, speech samples collected pre- and post-intervention (24 weeks) through administration of the BBTOP supplemented by 15 additional words (primarily nouns) were analyzed. Inclusion of the 15 supplemental words insured that each of 23 consonants occurred a minimum of three times each in initial and final word positions. The samples were collected by speech-language pathology graduate assistants or certified SLPs in small, quiet rooms in the children’s early childhood settings or a university clinic. Each sample was audio-taped using a Marantz PMD 430 with two external lapel microphones. Broad transcriptions were made from the audiotapes using the International Phonetic Alphabet (IPA) by graduate research assistants. Transcriptions were entered in to the *Interactive System for Phonological Analysis* (ISPA; Masterson & Pagan, 1994), a computer analysis program that was used to generate quantitative data including frequency of phones in the phonetic inventory and percent consonants correct (PCC; Shriberg & Kwiatkowski, 1982).

**Reliability**

Transcriptions made by graduate research assistants were checked and modified from audiotape replay by two trained transcribers, a senior research assistant and the first author. To determine inter-judge reliability for the two trained transcribers, 20% of the BBTOP samples were re-transcribed by the transcriber who had not performed the original
transcription. Point to point agreement was calculated based on each judge’s transcription of each consonant. Segmental transcriptions that were identical in place, manner, and voicing, were coded as agreements. The overall mean for transcription agreement was 90% (ranging from 73% to 97%). A research assistant and the primary investigator in the larger study calculated inventory size and ECI with inter-judge agreement of 100% and 99%, respectively, for 20% of the samples.

**Goal selection and intervention procedures**

As noted, intervention was part of a large-scale study designed to evaluate goal attack strategies in which the present children participated. Goal selection procedures and intervention strategies are described in detail elsewhere (Tyler et al., 2003) so only major characteristics will be summarized here. Participants were randomly assigned to four different goal attack strategies all involving cycling of both phonology and morphosyntax goals, but in different configurations across a 24-week intervention period. With respect to the possible effects of the different intervention sequences in the larger study on the dependent variables, it is important to note that there were no significant differences in phonological change between the different strategies, \( F (3, 35) = .12, p = .95 \). Participants were seen twice weekly in one 30-minute individual session and one 45-minute group session. Group sessions comprised no more than three children. Intervention was provided by graduate student interns supervised by early childhood program SLPs. The programs were located at four elementary school sites.

Four phonology goals and four morphosyntax goals were selected for each child, based on results from analysis of pre-intervention BBTOP and language samples. The four goals in each domain were scheduled in cycle-configurations so that each goal was the focus for one week after which a different goal was targeted. Goals were recycled differently in the four goal attack strategies, but each goal received a focus for a total of 3 weeks, or six sessions. Language goals addressed finite grammatical morphemes (e.g., past tense –ed, third person singular regular, copula and auxiliary be) and phonology goals addressed initial and final segments and clusters. Goal selection was based on the needs of the majority of children in a group so that children grouped together shared the same goals. Phonology targets were selected by taking into account overall phonetic inventory, phonological processes used >35–40%, sound classes affected, word/syllable structure, and positional constraints. Each child typically had three initial and/or final phoneme targets and several cluster targets. For the purposes of the present investigation, cluster targets were omitted. It should be noted that the targets in the present investigation were not always sounds omitted from the children’s inventories, unlike those in other investigations of the relationship between error consistency patterns and generalization learning. All participants worked on three targets from among the obstruents /s, z, f, j, tʃ, k, g/, and liquids /l, r/. The only difference in targets was that one child in the consistent group had /dʒ/ and /θ/ as targets and these were not represented in the variable group, where one child had /p/ as a target.

Phonological intervention procedures were both clinician-directed and child-centered and involved auditory awareness activities, conceptual activities, and production practice activities. The majority of each session focused on production practice activities, after 5–10 minutes of initial awareness and conceptual activities. Awareness activities involved listening to books containing numerous models of the target sound to heighten awareness. Production practice in drill play and naturalistic activities was designed to establish production of sounds in new contexts and to facilitate practice in spontaneous
communicative situations. In naturalistic activities, incorrect productions were immediately recast by the clinician, whereas in drill play activities, clinicians responded to incorrect responses by providing a model and requesting an imitation. All clinicians were provided with the same books, stimulus pictures, and naturalistic scripts, accompanied by written directions for their use, to ensure reliable implementation across settings.

**Group comparison measures**

PCC was selected as a measure of overall phonological severity and was compared for the variable and consistent groups to determine if there were group differences in pre-intervention severity.

Inventory size was selected as a measure of the total number of different sounds a child could produce, regardless of their accuracy with respect to the target sound. The total number of different phones produced a minimum of two times across positions was calculated from ISPA printouts. Thus, the inventory size specified the number of phones for which a child had knowledge, regardless of word position or accuracy.

The two groups were also compared for differences in overall ECI score to confirm that the upper and lower quartile ranges in fact distinguished the two groups according to error consistency. In addition, a substitution index score extrapolated from the ECI score developed by Tyler et al. (2003) was used to compare the groups’ error consistency on just the specific targets selected for intervention. This target composite index (TCI) was calculated by summing the total number of different sound substitutions/omissions each participant made across word positions for each target. This comparison was made to confirm that the groups’ error consistency differed specifically for those targets that subsequently received treatment. See Table I for examples of the two group participant’s PCC and TCI scores, as well as their targets and different substitutes for those targets across word positions.

**Outcome measures**

The three dependent outcome measures used in this study were target composite change, generalization composite change, and PCC change. These were derived from the supplemented BBTOP citation samples designed to sample each phoneme production at least three times in the initial and final positions. Words in the citation sample were never used as training words during intervention.

Table I. Pre-treatment scores, targets, and substitutes for sample consistent (C) and variable (V) group participants.

<table>
<thead>
<tr>
<th>Participant</th>
<th>PCC</th>
<th>TCI</th>
<th>Treatment targets</th>
<th>Substitutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>V15</td>
<td>49</td>
<td>11</td>
<td>l/ʃ#<em>, s/ʃ#</em>, tʃʃ_/#</td>
<td>l→j, w, d, b; j→p, θ, ts, s; tʃ→ts, t, tw</td>
</tr>
<tr>
<td>V25</td>
<td>45</td>
<td>10</td>
<td>g/ʃ#<em>, ʃ/ʃ#</em>, tʃʃ_/#</td>
<td>g→h, d, θ; l→m, w, d; tʃ→h, s, t, tf</td>
</tr>
<tr>
<td>V19</td>
<td>33</td>
<td>10</td>
<td>f/ʃ#<em>, kʃ</em>/#, sʃ_/#</td>
<td>f→b, p, Ø; r; k→g, ts, tʃ; s→d, Ø, r</td>
</tr>
<tr>
<td>C29</td>
<td>84</td>
<td>2</td>
<td>fʃ#/<em>, tʃʃ#/</em>, zʃ#/</td>
<td>r→w; z→s</td>
</tr>
<tr>
<td>C16</td>
<td>71</td>
<td>4</td>
<td>lʃ#/<em>, sʃ#/</em>, tʃʃ#/</td>
<td>l→w, j; j→s; tʃ→t</td>
</tr>
<tr>
<td>C40</td>
<td>81</td>
<td>4</td>
<td>fʃ#/<em>, zʃ#/</em>, tʃʃ#/</td>
<td>z→Ø, Ø, k; tʃ→ʃ</td>
</tr>
</tbody>
</table>

*Note: PCC=per cent consonants correct; TCI=target consistency index; #._=word-initial position; _#=word-final position; Ø=zero consonant (i.e., deletion).
The target composite percentage reflects the number of correct productions of each child’s three target sounds in the position treated out of the number of opportunities for these in the citation sample. For example, if a child had initial /k/, final /f/, and final /tS/ as targets, the number of correct productions of these sounds was divided by the total number of opportunities for them in the supplemented BBTOP sample. The target composite change was calculated by subtracting each child’s pre-intervention composite percentage from the post-intervention composite percentage.

Similarly, the generalization composite percentage reflects the combined number of correct productions of each child’s target sounds in the untreated position from the number of opportunities in the citation sample. The generalization composite change was calculated by subtracting each child’s pre-intervention composite percentage from the post-intervention composite percentage.

PCC change was chosen as a global measure of phonological change and was calculated by subtracting each child’s pre-intervention PCC from the post-intervention PCC.

Results

Pre-intervention measures

To examine whether groups with consistent and variable substitution patterns displayed pre-intervention differences, independent t-tests were used for ECI (group assignment criterion), inventory size, PCC, and target consistency index (TCI) (i.e., a substitution index score extrapolated from the ECI designed to evaluate error consistency on specific targets). Significant differences were found between the consistent and variable substitution groups for pre-treatment ECI, (t (18)=12.61, p<.00); PCC, (t (18)=9.93, p<.001); inventory size, (t (18)=4.63, p<.001); and TCI, (t (18)=7.83, p<.001). The variable substitution group showed significantly higher TCI, and ECI scores than the consistent substitution group (see Table II). This result was not unexpected, as the greater the score for both measures of TCI and ECI, the greater the amount of error substitution variability. The consistent error pattern group demonstrated significantly larger inventory size and PCC prior to intervention than the variable group.

Although the groups did demonstrate different pre-treatment phonological measures (i.e., PCC, ECI, inventory size, and TCI), no differences were found between the consistent and variable group for any of the three treatment outcome measures. Results that follow are displayed in Table III.

Outcome measures

Analyses of covariance were applied to assess group differences for two of the three outcome measures; generalization composite change, and PCC change. ANCOVA
procedures were not used to assess group differences for the third outcome measure, target composite change, because the assumption of equality of variances was not met (Levene’s Test: \( F = 6.32, p = .02 \)). Group differences with respect to target composite change scores were assessed using the non-parametric Mann-Whitney Test.

For generalization composite change and PCC change, scores for each of these variables obtained prior to initiation of treatment were used as the covariate in each respective ANCOVA. For generalization composite change, group means for the variable and consistent groups were 40.81 and 38.36, respectively. This difference was not significant (\( F (1,17) = .02, p = .897 \)). A partial eta squared of .001 was obtained as a measure of effect size. An effect size of this magnitude is considered trivial. Similarly, the results for the main effect of PCC change were nonsignificant, \( (F (1,17) = .48, p = .496) \). Group means for the variable and consistent groups were 17.87 and 10.52, respectively. Again, the obtained partial eta squared effect size of .028 is considered very small.

The Mann-Whitney analysis revealed group differences for target composite change were also not significant \( (U = 36.5, p = .31) \). Mean ranks of 11.85 and 9.15 were found for the variable and consistent groups, respectively.

### Discussion

One important finding from this investigation is that the variable and consistent error pattern groups demonstrated pre-intervention differences on several phonological measures, suggesting that they differ in a variety of ways. First, the groups were significantly different on the ECI, verifying that the upper and lower quartile scores differentiated group membership. The finding that the variable substitution group also had significantly higher TCI scores than the consistent group provided confirmation that the groups differed with respect to the number of different substitutions for their specific target sounds. In addition to differences on global measures of error consistency, the groups differed on inventory size and PCC, with the variable group performing lower on each of these variables. When PCC severity metrics are applied, the variable group averages in the severe-profound range \( (M = 38.6) \) and the consistent group averages mild-moderate \( (M = 75.3) \). These differences together suggest that children who have multiple substitutes both within and across word position for a number of consonants (i.e., a high ECI) also likely have small inventories and low PCCs, representing more compromised phonological capabilities than children with consistent substitution patterns across the system. Some of these potential differences in pre-treatment measures were noted by Forrest et al. (2000)
and are similar to those observed by Isermann (2001) showing that groups of children delineated by extent of inconsistent error substitutions differed on the GFTA.

Yet outcome measures reflecting change in target accuracy, generalization to an untreated word position, and PCC change were not significantly different for the two groups differentiated by their overall error consistency in this study. These results are similar to those of Huff, King, and Williams (2002) who also found children with consistent and variable error patterns performed similarly with respect to learning their target and demonstrating system-wide improvement, although generalization was limited.

There are a number of plausible explanations for the finding of no group difference in learning in the present study, despite the pre-treatment differences. The present investigation tested outcome measures that reflect a combination of three similar targets, all from the group of phonemes most likely to have inconsistent errors, /s, z, v, f, g, k, t, j/ (Isermann, 2001). These are also among the phonemes noted to be most difficult for children with phonological disorders, /s, z, v, k, g, l, r, f, s, t, j, d, s, 0/ (Rvachew, Nowak, & Cloutier, 2004). Thus, the finding that children in the variable group did not differ from those in the consistent group on outcome measures may be due to the measurement of change for several phonemes with similar status in the two different groups. The status of a phoneme and source of variability may be important factors in evaluating learning outcomes. For example, in the case of a phoneme that is in the inventory, variability may be a reflection of complex phonological error patterns. A phoneme may be affected by an optional error pattern in one position, thus rendering it sometimes correct, and a different obligatory error pattern in another position. Even though such a phoneme is subject to variable substitutions, the child may have a rudimentary representation and more knowledge of this phoneme, than of a phoneme that is absent from the inventory. Variability has been viewed both as an indication that the child’s phonological system is in a state of change (Dodd, 1985) and as an indication that the child is unable to establish stable categorical representations (Forrest et al., 2000). The source of variability as it relates to type and frequency of error patterns may play a role in determining whether the child’s system is at an amenable state for learning or at a learning disadvantage.

The present results contrast with other findings that suggest children with variable error patterns are less likely to learn and generalize correct production of target sounds absent from their inventories than are children with consistent error patterns for such sounds (Forrest et al., 1997, 2000). There are a number of possible explanations for these seemingly conflicting findings. One explanation may lie in the different methods of measuring consistency. A composite score of error consistency or a quantitative approach to evaluating consistency was used in the present study, while Forrest and colleagues used a descriptive categorization or a qualitative approach involving evaluation of specific phoneme substitution patterns. Using ECI, a measure of variability across all phonemes in the system, two distinct groups could be differentiated. Further, Isermann’s (2001) findings suggest that, rather than showing exclusively one type of pattern, it is likely that many children with phonological disorders have variable patterns for some phonemes and consistent patterns for others.

Different measures of variability, both quantitative and qualitative, may reflect different aspects of the child’s system, and as such, hold different relationships to treatment outcomes. Another explanation for the different results in the present study and previous single subject studies may lie in the different measures of change. The PCC measure of change reflects overall accuracy of consonants attempted in a sample, whereas Forrest et al. (1997) referred to change specifically as it was associated with generalization of the treated phoneme in untreated word positions. In addition, the target consistency change score used in the present study quantifies variability across three phonemes in error which were
selected as targets. This can be contrasted with examining variability for an individual phoneme which may be related to the child’s knowledge of, and subsequent learning, for just that phoneme.

Not only did children with variable vs. consistent error patterns in the present study show no difference in learning of their target sounds after 24 weeks of intervention, they also showed no difference in generalization of their targets to the untrained word position. This lack of difference, however, should not be interpreted as evidence of no difference in learning patterns between the groups. First, it is possible that target sound learning and generalization differed at an earlier point in the intervention program, such as after 16 weeks, which was the length of treatment evaluated by Forrest et al. (2000). Further, it is important to note that target and generalization learning was evaluated in the present study for three sounds in error without consideration of their inventory status. In contrast, Forrest et al. (1997; 2000) examined consistency patterns and learning for only one sound absent from the phonetic inventory. Thus, it remains possible that differences in generalization learning exist between children with globally variable and consistent error patterns when specific sounds absent from the inventory are examined.

As a follow-up analysis, target sounds for the two groups of children in the present study were examined for their inventory status. Across the consistent group, there were four participants who each had one target that was absent from his/her inventory (/f, r, s, t/). In the variable group there were four participants with 2–3 sounds missing from their inventories (/s, f, t, z, r/) and one child missing one sound, /f/. Examination of the post-treatment accuracies for these absent sounds showed that two of the four targets in the consistent group were learned, whereas only three of the 11 total targets among the variable group were learned. The patterns of generalization for these absent sounds, however, were more similar for the two groups. For the consistent group, one of the four sounds generalized (25%) and for the variable group, three of those sounds generalized (28%). In addition, the groups had highly similar target sounds, although this was not a selection criterion.

In conclusion, the present results and those from previous studies suggest that there are numerous factors that may be considered in explaining different findings regarding the consistency/variability of pretreatment error patterns and subsequent treatment outcome measures. The present findings point to the need for additional research that considers the variability of error patterns for phonemes that are in the inventory, but subject to different error patterns by position. One factor that has not been examined in studies of variability and learning is the type of error pattern resulting in variable substitutions across word positions. Further, patterns of consistency and variability across all phonemes in the system should be examined for numerous children over time to determine how change occurs. Comparisons should also be made between system-wide variability and change measures and individual phoneme substitution patterns and outcomes. Clearly, the present results suggest that, even groups that differ in their pretreatment phonological skills along a number of measures, may not necessarily differ in their long-term treatment outcomes for similar targets.

References


