Letters to the Editor

Unified Treatment Recommendations:
A Response to Rvachew and Nowak (2001)

A recent report by Rvachew and Nowak (2001) would seem to call into question some of the work of Gierut and colleagues (Gierut, Elbert, & Dinnsen, 1987; Gierut, Morrissette, Hughes, & Rowland, 1996), which has shown that treatment of more complex targets results in system-wide changes in phonological acquisition (see Gierut, 2001, for a review). Our purpose here is to show that Rvachew and Nowak’s findings do not challenge earlier findings, but in fact, they extend the generalizability of those results in positive ways. In order to fully appreciate the compatibility of these studies, a comparative summary of the studies by Gierut et al. and Rvachew and Nowak is presented below.

Briefly, Gierut et al. (1987) examined the role of a child’s productive phonological knowledge in generalization learning. Productive phonological knowledge refers to a child’s linguistic competence and performance as determined by their phonetic and phonemic inventory, the distribution of sounds, the use of phonological rules and/or phonotactic constraints, and the underlying lexical representation of morphemes. Taking these basic properties of sound systems into consideration, six types of phonological knowledge were then established to characterize children’s phonological systems (Gierut, 1985). These types formed a continuum from most-to-least phonological knowledge of the target phonology, with Type 1 knowledge describing sound productions consistently correct relative to the adult target (i.e., most knowledge) and Type 6 knowledge indicating consistently incorrect productions relative to the adult target (i.e., least knowledge). Gierut et al. conducted three related investigations to test the psychological reality of claims about phonological knowledge against learning by 6 preschool children with functional phonological delays. Studies 1 and 3 provided descriptive characterizations of each child’s phonological knowledge prior to treatment and following treatment, respectively. Study 2 was a multiple baseline (multiple probe) across-subjects experiment wherein each child was taught three sounds in sequence from either most-to-least knowledge or the reverse, least-to-most knowledge, as based on their unique knowledge continuum. The dependent variable was generalization learning to treated and untreated sounds along the knowledge continuum (i.e., most and least knowledge). Quantitative results, based on percentages of accurate sound production, indicated that children taught in either treatment sequence, most-to-least or least-to-most knowledge, evidenced generalization learning for sounds of which they had most knowledge pretreatment (cf. Dinnsen & Elbert, 1984). Qualitative results, based on change in knowledge type, indicated that children taught in either treatment sequence also evidenced positive changes in their knowledge...
continuum for the treated sounds. Thus, either treatment sequence, most-to-least or least-to-most, resulted in changes in most knowledge and in treated sounds. Importantly, however, children taught in the sequence from least-to-most knowledge evidenced the greatest system-wide change, as demonstrated by quantitative and qualitative improvements to other untreated sounds for which they had least knowledge of prior to treatment. Given this, Gierut et al. concluded that the least-to-most order of treatment proved most effective because it induced system-wide change.

Subsequently, Gierut et al. (1996) reported the results of two complementary single-subject experiments aimed at establishing the effects of treatment based on normative age-of-sound acquisition. A single-subject alternating treatments design was used in Study 1 for a within-subject comparison of the treatment effects for 3 children with functional phonological delays. A multiple baseline across-subjects design was used in Study 2 for a complementary across-subjects comparison of 6 children with functional phonological delays. Early versus late acquired sounds were manipulated as the treatment targets. Notably, only sounds excluded from a child's pretreatment inventory were selected for treatment. In terms of phonological knowledge, this translated to “least knowledge” on the continuum. Thus, phonological knowledge was held constant across children. The dependent variable was again generalization learning to treated and untreated sounds. Across these two studies, results indicated that all children learned the treated sound, albeit early or late acquired. Also, specific to the multiple baseline across-subjects design, all children evidenced within-class generalization learning of untreated sounds from the same manner class as the treated sound. Thus, an early acquired or late acquired target in treatment resulted in changes in the treated sound itself and promoted within-class generalization. Importantly, however, only those children taught late acquired sounds evidenced across-class generalization to untreated sounds from different manner classes than the treated sound. Given this, Gierut et al. concluded that treatment of late acquired sounds proved more effective because it produced system-wide change.

Extending the results of Gierut et al. (1987, 1996), Rvachew and Nowak (2001) conducted a group treatment study of the combinatorial effects of phonological knowledge and normative age-of-sound acquisition with 48 children with functional phonological delays. Children were randomly assigned to one of two groups: treatment of an early acquired sound of which they had most knowledge (most knowledge/early acquired sound) or treatment of a late acquired sound of which they had least knowledge (least knowledge/late acquired sound). Dependent variables measured generalization learning, as in Gierut et al., but also included treatment progress and child–parent satisfaction. Generalization learning was reported as children's overall production accuracy to all target English sounds and sounds for which they had Type 6 (or least) knowledge. Treatment progress was reflected by the number of incremental steps of the treatment program that were completed, ranging from imitated syllables to spontaneous sentences, whereas child and parent satisfaction were measured through subjective rating scales. Results indicated no statistically significant differences between the groups in terms of generalization learning; however, children in the most knowledge/early acquired sound group completed significantly more steps of the treatment program. There were also no statistically significant differences between groups in terms of outcome measures of satisfaction, with one exception: Parents of children in the most knowledge/early acquired sound group were subjectively more satisfied with their child's treatment progress. Given this, Rvachew and Nowak advocated treatment of most knowledge/early acquired sounds. This would seem to contradict conclusions drawn by Gierut et al. that least knowledge and late acquired sounds are most effective in treatment. We aim now to reconcile these apparent differences by focusing on the independent and dependent variables of these studies.

### Independent Variables

In each of their studies, Gierut et al. (1987, 1996) examined the variables of phonological knowledge or normative age-of-sound acquisition independently in treatment. This is illustrated in Gierut et al. (1987), wherein children taught in a given treatment sequence (i.e., most-to-least or least-to-most knowledge) were taught both early and late acquired sounds. That is, in certain cases, children evidenced most knowledge of relatively late acquired sounds and least knowledge of relatively early acquired sounds. Similarly, Gierut et al. (1996) varied age-of-sound acquisition while holding knowledge type constant. Thus, children were taught early or late acquired sounds for which they had least knowledge. By comparison, Rvachew and Nowak (2001) manipulated these same variables in tandem, but only partially, by treating most knowledge/early acquired sounds versus least knowledge/late acquired sounds. Rvachew and Nowak did not fully cross the variables to also include the logically remaining conditions: most knowledge/late acquired sound and least knowledge/early acquired sound. Without these conditions, it is not possible to determine the extent to which each variable (e.g., knowledge or normative age-of-sound acquisition) is responsible for the treatment effects. Thus, these cells are crucial to evaluating the combinatorial effects of knowledge and normative age-of-sound acquisition and...
to understanding the role that phonological knowledge and developmental normative sequence have in clinical treatment. There is a further complication of baseline accuracy associated with this gap in the design. By Rvachew and Nowak’s definition, children in the most knowledge/early acquired sound group were already producing the treated sounds accurately in some contexts and words prior to intervention. The reported average pretreatment level of accuracy was 30% for this group (range = 0%–93%; see www.medserv.mcgill.ca/srvachew for complete data). In contrast, children in the least knowledge/late acquired sound group maintained an average of less than 5% accuracy of the treatment sounds at pretreatment (range = 0%–67%). The fact that the children’s pretreatment performance across groups was noncomparable may have extraneously contributed to group differences in the number of completed steps in the program and parent satisfaction with the number of steps completed. However, even with these differences in pretreatment baselines, it is striking that there were no significant differences among groups in terms of generalization learning. That is to say, children with some production accuracy prior to treatment (most knowledge/early acquired sound) did not have an edge over those with minimal to no accuracy (least knowledge/late acquired sound) in terms of generalization learning or vice versa. This bears a strong resemblance to Gierut et al.’s findings that orders of treatment (most-to-least/least-to-most) were comparable on some dimensions of generalization (i.e., change in treated and most knowledge sounds), as were normative ages-of-sound acquisition (i.e., change in treated sounds and within-class generalization). Importantly, however, where these variables critically differ is in terms of across-class or system-wide change in the phonological system. Gierut et al. were able to discern these differences because of sensitivities in their dependent measures to untreated sound change, as is specifically afforded by the multiple baseline across-subjects design (Hersen & Barlow, 1976, p. 228).

### Dependent Variables

Across studies, Gierut et al. (1987, 1996) examined qualitative and quantitative changes across all properties of children’s phonological systems. This provided differential opportunities to evaluate change in linguistic characterizations of productive knowledge, accuracy of treated sound production, within-class generalization, and across-class generalization. By comparison, Rvachew and Nowak (2001) either collapsed quantitative change across all sounds of the system, including sounds that were correct and incorrect for which the children had most and least knowledge, or they focused exclusively on changes in only one property of the knowledge continuum (i.e., least knowledge or sounds with 0% baseline accuracy). Because there was no further differentiation in generalization to untreated sounds, it was not possible to establish potential differences associated with within- versus across-class changes in these children’s systems that may have been revealing of system-wide gains.

Also, across Gierut et al.’s studies (1987, 1996), delivery of treatment was held constant, with all children completing the same steps in treatment (i.e., imitation and spontaneous production of words) to preestablished time and performance criteria. Yet, even when children completed the same steps in treatment, across-class generalization differences emerged favoring treatment targets associated with least knowledge and late acquired sounds. Although progress in treatment was not among the dependent variables in their studies, Gierut et al. were able to examine the point at which generalization first occurred, at least in their normative report: Late acquired treatment targets promoted immediate generalization to treated and untreated sounds, within and across class, during the course of treatment, whereas early acquired targets delayed generalization to the completion of treatment. The fact that Rvachew and Nowak monitored number of treatment steps as a dependent factor would appear to be a much needed addition to conventional efficacy variables, which are typically associated with performance rather than time (cf. Tyler, Edwards, & Saxman, 1987). In future studies, however, evaluations of these variables will require that time (e.g., number of steps in treatment) and performance be independent. In the case of Rvachew and Nowak, the group of children who progressed through the most steps of the treatment program was also the same group of children who were already producing the treated sound accurately in certain contexts at the start of intervention.

Finally, Gierut et al.’s studies (1987, 1996) were limited in that they focused on treatment efficacy but not also treatment outcomes (cf. Frattali, 1998). Rvachew and Nowak’s (2001) inclusion of satisfaction surveys provides this complement, although no group differences were found in parent or child satisfaction except along the aforementioned dimension of number of treatment steps completed. Treatment outcomes for phonological delays is an avenue of study that may warrant future development (Goldstein & Gierut, 1998).

### Conclusion

Collectively then, these three research reports converged on parallel sets of findings. Across five single-subject evaluations (Gierut et al., 1987, 1996; N = 15)
and one group study (Rvachew & Nowak, 2001; N = 48), involving a total of 63 children with phonological delays, treatment targets selected on the basis of a child's productive knowledge and/or normative sequence do not seem to differentially impact how a child learns the treated sound or generalizes to untreated sounds of the same manner class. The real significance (and perhaps also a tension) lies in the evaluation of treatment efficacy versus outcomes. Efficacy measures of across-class generalization or system-wide changes, as in Gierut et al.'s work, reveal that performance differences do emerge, favoring treatment target selection based on least knowledge and late acquired sounds. Outcome measures of parent satisfaction, as in Rvachew and Nowak's work, also revealed differences, favoring treatment target selection based on most knowledge and early acquired sounds. Clearly, future research will be needed to help us better understand the trade-offs between a child's phonological gains that foster generalization and affect intelligibility and the steps achieved in treatment relative to parents' subjective satisfaction with progress.

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Clinical Outcomes as a Function of Target Selection Strategy: A Response to Morrisette and Gierut

In Rvachew and Nowak (2001), we reported that children made significantly greater progress toward mastery of their target phonemes when their treatment progressed from easier to more difficult targets than when their treatment progressed from the most difficult to easier targets. Progress toward the mastery of untreated phonemes was similar for both groups of children. We concluded that our findings supported the use of traditional target selection practices. Morrisette and Gierut (2003, this issue) have written to disagree, claiming that our data support the use of nondevelopmental target selection strategies. We refute this claim by showing that the traditional target selection strategy resulted in superior outcomes, in comparison with the nondevelopmental strategy, even after controlling for between-group differences in pretreatment productive phonological knowledge.

On the basis of a series of single-subject studies, Gierut, Morrisette, Hughes, and Rowland (1996) concluded that “treatment of seemingly more difficult aspects of the phonology may induce relatively greater sound change” (p. 227), and consequently they suggested that clinicians employ a nondevelopmental approach to the selection of treatment targets. Subsequently, we reported the results of a randomized-control study of 48 children that had the purpose of evaluating treatment outcomes when phonology treatment targets were selected according to traditional criteria, in comparison with the treatment outcomes observed when a nondevelopmental target selection strategy was employed (Rvachew & Nowak, 2001).

We designed the study to ensure rigorous experimental control over all aspects of the treatment program for all participants while simultaneously ensuring that the procedures employed were consistent with “real-world” clinical conditions and practices. In keeping with all standard teaching, as well as Gierut et al.’s (1996) recommendations with respect to target selection strategy, the decision rule used to select targets for each child took into account a combination of factors. Specifically, potential treatment targets for each child were placed on a continuum that reflected both the expected age of mastery of the potential target sound and the child’s level of productive phonological knowledge. Half of the children received a treatment program that targeted four phonemes selected from the “most knowledge” and “earliest developing” end of the continuum (ME group), and the remaining children received treatment targeting four phonemes selected from the “latest developing” and “least knowledge” end of the continuum (LL group). The children received two blocks of treatment with new targets selected at the beginning of each block. In this way, we were able to assess the impact of the opposing target selection strategies as they were implemented over time.

We included a number of different kinds of outcome measures, some that assessed the children’s progress with respect to the treatment targets specifically and others that assessed overall change in the children’s phonological abilities. Children in the ME group made greater gains toward the mastery of their treatment targets when the treatment program progressed from relatively easy to more difficult targets. Children in this group also showed significantly greater improvements on a generalization probe that assessed the children’s ability to produce their target sounds in both treated and untreated words and word positions at the request of an assessor who was blind to the child’s treatment group. Finally, we examined overall change in the children’s phonological system by measuring (a) change scores on a posttreatment probe that included all English consonants, (b) percentage of consonants correct in conversation, and (c) number of new phonemes added to the children’s phonemic inventory. Both groups made gains on these measures of overall change in their phonological system, but there were no significant differences between the groups in the amount of observed progress. We concluded that our findings supported the use of traditional target selection practices.

Morrisette and Gierut have criticized our choice of independent variable, pointing out that we “did not fully cross the variables to also include the logically remaining conditions: most knowledge/late-acquired sound and least knowledge/early-acquired sound” (p. 383). We did not include these conditions because it was our intention to contrast typical clinical practice with the new target selection procedure recommended by Gierut et al. (1996). Typically, clinicians are advised to select targets that are both early developing and stimulable (e.g., Creaghead, Newman, & Secord, 1989). In contrast, Gierut et al. (1996) recommended that clinicians consider various factors, including nonstimulable sounds, least phonological knowledge, and later-acquired sounds. We agree with Morrisette and Gierut that further studies that vary developmental order and phonological knowledge in an orthogonal fashion would be valuable.

Morrisette and Gierut also disagree with our conclusions. Specifically, they state that our data show that “treatment targets selected on the basis of a child’s productive knowledge and/or normative sequence do not seem to differentially impact how a child learns the treated sound” (p. 385). They appear to have reached
this conclusion by focusing on one of our several outcome measures: highest step achieved in treatment. Morrisette and Gierut argue that changes in this dependent variable are difficult to interpret because some children began the treatment program with the ability to produce the target in at least some contexts, whereas the other children were unstimulable for their target sound. We point out, however, that all target sounds were treated in only one word position (usually but not always word-initial position). We endeavored to treat the target sounds in the word position for which the child demonstrated consistently incorrect production during the pretreatment production probe, a task in which the child attempted to imitate each target sound in 15 words (5 words for each of the word positions: initial, medial, and final). All 24 children in the LL group received a score of 0% correct on this probe in the targeted word position for both Block 1 target sounds. Fifteen children in the ME group also achieved a score of zero on the pretreatment probes for both of their Block 1 target sounds in the treated word position. The remaining children achieved 10–20% correct imitations during the pretreatment production probe, with the exception of 1 child who received a score of 80% correct. This child consistently misarticulated his target sounds during spontaneous productions; therefore, these sounds were targeted despite his good pretreatment probe performance. Overall (including the outlier described in the previous sentence), pretreatment probe performance for Block 1 targets in the treated word position averaged 9% correct for the ME group and 0% correct for the LL group. All children began treatment with the same step of the treatment program (imitated syllables). On average, children whose treatment program commenced with the easier targets achieved spontaneous production of patterned sentences, whereas the children who commenced treatment with the more difficult targets failed to progress beyond single words. In fact, the children in the latter group failed to achieve stimulability for more than one third of their target sounds.

In their letter, Morrisette and Gierut state that there were no differences in generalization learning in our study. Although this is true when speaking of generalization to untreated sounds, it is not at all accurate when speaking of generalization of target phonemes from the treatment context to the posttreatment generalization probe. In our study, the primary outcome measure was the pretreatment-to-posttreatment gain on an imitative production probe that was administered by a research assistant who was blind to the child’s group assignment and treatment targets. Figure 1 of the study (Rvachew & Nowak, 2001) shows that gain scores on these probes were significantly greater, on average, for children in the ME group than for children in the LL group when the analysis considers treated consonants specifically.

The data shown in this figure can also be expressed as residualized gain scores averaged across all targets and children (a residualized gain score is the difference between the child’s actual posttreatment probe score and the score that would be predicted from the child’s pretreatment probe score, as determined by a regression equation derived from the pre- and posttreatment probe scores for all 48 children). This analysis reveals a mean standardized and residualized gain score of 0.31 (standard error = 0.11) for the ME group compared with –0.31 (standard error = 0.08) for the LL group. These scores indicate that the ME children’s pretreatment-to-posttreatment gain scores were higher than the average for all 48 children, after controlling for individual differences in pretreatment probe performance. In contrast, gain scores for the LL group children were lower than the average for the full sample. Even after controlling for pretreatment probe score in this fashion, the advantage to the ME group is clear.

Furthermore, Figure 1 (of this letter) shows that ME group progress was superior to that observed for the LL group regardless of whether the children were stimulable for their target phoneme before treatment. For example, a child who received a pretreatment probe score of zero in all word positions for a given target sound was clearly unstimulable for that phoneme. ME group children achieved a mean posttreatment probe score of 4.47 for unstimulable targets, whereas LE group children achieved a mean posttreatment probe score of 1.66 for unstimulable targets. A pretreatment probe score between 1 and 4 indicates that the child was stimulable for the target sound but had not mastered the sound in any word position. Pretreatment-to-posttreatment gains in probe score for this type of target sound averaged 7.14 for the ME group in comparison with a mean gain of 1.67 for the LL group. Clearly, the superior treatment progress observed for the ME group reflects the effectiveness of the traditional target selection procedure.
rather than an extraneous effect of between-group differences in pretreatment production accuracy.

The sample size is large enough that one can even examine between-group differences in mastery of specific sounds in order to control for both productive phonological knowledge and normative sequence. For example, the phoneme /ʃ/ was a frequent Block 2 target for both groups, and many of our 4-year-old participants misarticulated this phoneme consistently during the pretreatment assessment. If the analysis of outcomes for Block 2 target /ʃ/ is restricted to those children who never articulated this sound correctly before treatment, children in the ME group clearly achieved higher post-treatment probe performance \((n = 5, M = 55\% \text{ correct})\) than did children in the LL group \((n = 7, M = 6\% \text{ correct})\). The same analysis for Block 2 target /l/ also reveals much higher posttreatment probe performance for the ME group \((n = 6, M = 48\% \text{ correct})\) than for the LL group \((n = 9, M = 14\% \text{ correct})\). These data suggest that the children in the ME group benefited from their experience with easier targets in the previous treatment block. On the other hand, the practice of beginning treatment with the most difficult sounds did not appear to facilitate the LL children’s acquisition of the /l/ and /ʃ/ phonemes.

Treatment effects are not restricted to specific target phonemes. Gierut and her colleagues have made a significant contribution to modern practice in the treatment of phonological disorders by emphasizing the goal of reorganizing the child’s phonological system as opposed to teaching individual speech sounds. Further, they have identified across-class generalization as one indicator of treatment effectiveness. For example, Gierut et al. (1996) concluded “treatment of later-acquired phonemes had the effect of promoting widespread changes in the sound system because across-class generalization was observed” (p. 225). Gierut, Elbert, and Dinnsen (1987) made a similar claim with respect to the targeting of phonemes for which the child has least productive phonological knowledge. In their response to Rvachew and Nowak (2001), Morrisette and Gierut (2003, this issue) claim that our findings and theirs “converge on parallel sets of findings.”

However, we do not agree that our results can be taken as support for the conclusion that a nondevelopmental target selection approach facilitates system-wide changes in the child’s phonological system. Our study was not designed to reveal between-group differences in across-class generalization. In fact, the decision to simultaneously treat multiple targets representing a range of place and manner contrasts specifically precluded the assessment of across-class generalization. In our study, we attempted to assess system-wide changes using a number of different measures, including Percentage Consonants Correct in conversation, imitative probe performance averaged across all English consonants, and the number of new phonemes added to the inventory. Both groups made similar gains in all of these measures.

Although our study did not address across-class generalization, we agree that it is important to understand the means by which across-class generalization might be facilitated. Any such studies must employ a randomized-group design and an untreated control group because of the difficulty of distinguishing generalization (as a treatment effect) from maturation effects that occur regardless of whether or not treatment is provided. As discussed in Rvachew and Nowak (2001), there is no other means of ensuring that performance improvements for untreated sounds are due to the treatment approach employed with the participants. Morrisette and Gierut tacitly acknowledge that single-subject designs are not appropriate for this research question when they describe their previous studies as employing a multiple baseline (multiple probe) across-subjects design, in which the relative effectiveness of different target selection strategies is compared across groups containing 3 participants each. We agree with Morrisette and Gierut that “the process of generalization is highly variable across misarticulating children. The rate, amount, and extent of generalization differ for particular children” (Gierut et al., 1987, p. 462). Given this fact, randomized control trials are necessary in order to control for the maturation and participant effects that lead to extreme across-subjects, within-group variability in generalization.

We (Rvachew & Nowak, 2001) observed considerable within-group variation in the acquisition of untreated sounds and complete overlap in variation between our two groups. For example, among other indices of overall sound change, we examined the number of new sounds added to the inventory during the 12-week treatment period. Within each group, the range was from 0 to 7 phonemes, with a mean of approximately 2.5 for each group. This finding is open to multiple interpretations: It is possible that the gains observed for untreated sounds is a generalization effect that may be attributed to the treatment that the children received; on the other hand, these children might have made similar gains even if they had not received treatment at all. We were able to establish that the children’s improved performance for treated sounds was in fact a treatment effect. However, in the absence of an untreated control group, we cannot conclude that our participants’ acquisition of untreated sounds represents any sort of generalization or treatment effect.

In conclusion, we (Rvachew & Nowak, 2001) found that children made significantly greater progress toward mastery of target phonemes when treatment progressed
from easier to more difficult targets than when treatment progressed from the most difficult to easier targets. Superior performance was achieved by the ME group for treated sounds both during treatment sessions and on the posttreatment generalization probe. The advantage to the ME group is maintained even after controlling for pretreatment differences in target phoneme probe score. Progress toward the mastery of untreated phonemes was similar for both groups of children. Further research is required in order to determine the best means of promoting generalization from treated to untreated phonemes, and this research must employ research designs that include adequate controls for participant and maturation effects.

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