Published in final edited form as:
Aphasiology. 2002 January 1; 16(4-6): 609–622. doi:10.1080/02687030244000266.

Treatment of sound errors in aphasia and apraxia of speech: Effects of phonological complexity

E. Maas, **J. Barlow**, **D. Robin**, and **L. Shapiro**
San Diego State University, CA, USA

Abstract

Background—Recent research suggests that the complexity of treatment stimuli influences the effectiveness of treatment. However, no studies have examined the role of complexity on sound production treatment in adult individuals with sound production impairments.

Aims—This study examines effects of syllable complexity on treatment outcome in two patients with acquired sound production problems. Complexity is defined in terms of syllable structure: clusters are more complex than singletons. Using a single-subject multiple-baseline design, we address the question: Is treatment of complex syllables more effective than treatment of simple syllables?

Methods & Procedures—Two patients with aphasia and apraxia of speech were trained to produce complex or simple syllables (using modelling). Improvement was measured by percent correct on a word and nonword repetition test.

Outcomes & Results—We found that both treatment on simple syllables and treatment on complex syllables led to improved production of simple syllables, while treatment of complex syllables also led to improvement on some complex syllables for one of the two patients.

Conclusions—These results suggests that training complex items is more effective than training simple items, at least for some patients. Possible reasons for lack of stronger effects are discussed, as well as directions for future research.

The purpose of the present study was to expand our understanding of the factors that enhance the effects of treatment for sound production errors in adults with aphasia and apraxia of speech. More specifically, we were interested in the effects of phonological complexity of treatment stimuli on acquisition and generalisation of treatment outcomes. For the purposes of this study, phonological complexity was defined in terms of syllable structure: branching syllable onsets (consonant clusters) are considered more complex than non-branching onsets (singletons). Thus, *strip* has a more complex representation than *trip*, which in turn is more complex than *tip* (see also Figure 1).[1] One way of viewing this complexity difference is to consider singleton representations as contained within the cluster representation, i.e., they form a subset of the cluster representations.

Address correspondence to: E. Maas, SDSU/UCSD Joint doctoral Program in Language and Communicative Disorders, Department of Communicative Disorders, San Diego State University, 5500 Campanile Drive, San Diego, CA 92182-1518, USA. maas@rohan.sdsu.edu.

[1]Phonologists disagree about the proper representation of /s/ in clusters. An alternative to the representation in Figure 1c attaches the /s/ directly to the syllable node instead of to the onset node (e.g., Clements, 1990). However, what is important for this study is that both views assume that three-element s-clusters are most complex and singletons are least complex. In both cases, singleton representations are smaller, and contained within the cluster representations.

There have been several reports in the literature that have considered complexity effects in treatment outcomes, spanning different domains including research with phonologically impaired children and brain-damaged adults with syntactic and lexical disorders. Research with phonologically impaired children has provided evidence for the importance of syllable structure complexity in treatment (e.g., Gierut, 1999; Gierut & Champion, 1999: see Gierut, 1998, 2001, for a review). For example, when phonologically impaired children were trained to produce consonant clusters in non-words such as /skwIni/, they showed improved production of singletons and two-element clusters, although production of /skw/ non-words did not improve (Gierut & Champion, 1999). On the other hand, targeting singletons did not generalise to clusters (Elbert, Dinnsen, & Powell, 1984; Powell and Elbert, 1984). Several treatment studies with adults with aphasia also provide support for the relevance of complexity in promoting treatment generalisation in other domains of language. For example, Thompson, Ballard, and Shapiro (1998) trained agrammatic Broca's aphasics to produce either object-cleft sentences or wh-questions. Wh-questions can be described structurally as a subset of object-clefts (for a tutorial, see Shapiro, 1997). Thus, object-clefts are considered to be more complex. Indeed, training of object-clefts resulted in improved production of wh-questions (and object-clefts) but training of wh-questions did not improve production of object-clefts (see also Ballard & Thompson, 1999; Thompson, Shapiro, Ballard, & Jacobs, 1997). These findings support the idea that complex stimuli produce greater generalisation than simpler yet theoretically related stimuli in adults with language disorders (for a similar complexity finding involving naming and typicality structure, see Kiran & Thompson, 2001).

Although dimensions of phonological complexity have been applied to the treatment of phonological disorders in children, this approach has not been applied to treatment of apraxia of speech and aphasia. Acquired apraxia of speech is characterised by phonemic substitutions and distortions (with consonants more affected than vowels), articulatory groping, and problems with coarticulation (e.g., Ballard, Granier, & Robin, 2000; Code, 1998; Wambaugh & Martinez, 2000). Although often described phonetically and/or motorically, it is unclear whether apraxia of speech can best be characterised as a deficit in phonetic-motoric processing, or in phonological processing, or as a buffer capacity limitation (e.g., Ballard, Barlow & Robin, 2001; Code, 1998; Rogers & Storkel, 1999; Seddoh et al., 1996; Varley & Whiteside, 2001). Consequently, from a clinical perspective, it is unclear what is the most effective approach to intervention, and which factors contribute to optimal treatment outcomes.

Several studies have focused on the treatment of adults with apraxia of speech and aphasia (e.g., Knock, Ballard, Robin, & Schmidt, 2000; Wambaugh, Kalinyak-Fliszar, West, & Doyle, 1998a; Wambaugh, West, & Doyle, 1998b; Wambaugh, Martinez, McNeil, & Rogers, 1999; Wambaugh & Martinez, 2000). These studies investigated the nature and extent of generalisation of sound production treatment to other sounds and contexts.

For example, Wambaugh et al. (1998b) trained a patient with aphasia and apraxia of speech on different sound groups (stops, fricatives, and liquids/glides) as opposed to targeting individual speech sounds. Treatment consisted of modelling (repetition of short sentences containing phonemes from the different sound groups), integral stimulation, orthographic cueing, and response-contingent feedback. Wambaugh et al. (1998b) found rapid acquisition of targeted sound groups (trained and untrained items), but no generalisation to other sound groups. Maintenance of acquisition was observed for all three sound groups at 6 weeks post treatment.

In another study, Wambaugh and colleagues (1999) trained one patient with apraxia of speech and aphasia on individual sounds (/p/, /k/, and "sh"). Again, rapid acquisition of targeted sounds (trained and untrained) was found, but no generalisation across sounds was observed. In addition, performance was highly variable.

Using a slightly different approach, Knock and colleagues (2000) investigated the application of a principle of motor learning (e.g., Schmidt & Lee, 1999), namely random practice vs blocked practice, to the treatment of apraxia of speech in two patients, focusing on production of plosives and fricatives. Random practice is claimed to be more beneficial in terms of generalisation and maintenance than blocked practice (e.g., Schmidt & Lee, 1999). Although trained sounds improved, there was no generalisation to novel responses in either the random or the blocked condition. However, retention was better following random practice than following blocked practice. In addition, performance was less variable in random practice conditions than in blocked practice conditions. In the discussion of our results, we will consider this and other principles of motor learning.

One possible reason for the lack of more pronounced generalisation effects might be that most sound treatment studies in aphasia have focused almost exclusively on singleton targets rather than clusters, disallowing a test of whether training more complex items initially would improve generalisation. The focus of this study, then, is on the nature of the stimuli. Based on the literature, we hypothesise that complexity has an effect on the efficacy of treatment; generalisation will be greater when training complex structures than when training simple structures. More specifically, we predict that training of three-element s-clusters results in improved production of singletons and clusters, but that training of singletons will only result in improved production of singletons, not clusters.

We used a phonological measure of complexity instead of a motoric complexity measure, for several reasons. First, it is often difficult to determine whether apraxic sound production errors are motoric or linguistic in nature (e.g., Ballard et al., 2000; Code, 1998; Den Ouden & Bastiaanse, 1998; Wambaugh et al., 1998b). Second, there may be a relation between phonological and motoric complexity. For example, in terms of coarticulation one may assume that a consonant cluster requires or leads to more coarticulation than a singleton does. As coarticulation depends on very subtle timing parameters between articulators, clusters may be more complex than singletons in this respect. Third, while there are several parameters that determine complexity at the level of motor planning, it is unclear how these parameters are to be weighted relative to each other to determine difficulty of production. In short, syllable structure is used here because it provides a relevant and relatively clear-cut complexity metric.

To test our hypothesis, we conducted a treatment study with two adults with acquired sound production problems, manipulating the complexity of the onsets in monosyllabic non-words used for treatment.

METHODS

Participants

Two patients with apraxia of speech and aphasia participated in this study. Patient 1, JS, is a 50-year-old right-handed woman 5 years post onset at the beginning of treatment. She presents with a non-fluent aphasia secondary to one left-hemisphere stroke. Speech output is limited to single words and some short (mainly fixed) phrases. Auditory comprehension is relatively intact, as well as auditory input processing as indicated by intact minimal pair discrimination (see Table 1 for details). In addition, JS also has a moderate-to-severe apraxia of speech, with variable production of sounds, including substitutions and distortions and articulatory groping. Diagnosis of apraxia of speech was made by an ASHA-certified speech-language pathologist (DR, third author) according to procedures outlined in Kent and McNeil (1987).

Patient 2, NP, is a 69-year-old right-handed woman, 4 years and 9 months post onset at the beginning of the study. After one left-hemisphere stroke, she presented with a mixed aphasia characterised by word-finding difficulties, reduced utterance length, and occasional fluent runs of speech, some of which are stereotypical (relatively fixed phrases). Auditory comprehension is mildly impaired, and auditory input processing is intact as indicated by perfect minimal pair discrimination (see Table 1 for details). She also has a moderate-to-severe apraxia of speech, with variable production of sounds, substitutions and distortions, and articulatory groping. As with JS, diagnosis of apraxia of speech was made by an ASHA-certified speech-language pathologist (DR, third author) according to procedures outlined in Kent and McNeil (1987). Both patients gave their informed consent to participate according to institutional guidelines.

Design

We used a variant of a withdrawal design (e.g., ABCBC) combined with a multiple-baseline design across behaviours (e.g., Kearns, 1986). There were two treatment conditions, complex (B) stimuli and simple (C) stimuli and both patients received both treatment conditions, in different orders. After a baseline phase (A), patients were randomly assigned to a treatment condition order: NP was assigned to the ACBCB order and JS was assigned to the ABCBC order. Due to circumstances however, no treatment could be administered immediately following phase 1; therefore, an additional "A" phase was added for each patient (e.g., ABACBC).

Prior to treatment, a word repetition test was administered, which was also administered upon completion of treatment. This test contained a total of 265 words—132 singletons and 133 clusters. Treatment effects, in the form of generalisation, were assessed throughout the study using repetition probes.

The dependent measure in this study was the percentage correct productions of the words and nonwords on the generalisation probe lists. We set both a performance-based and a time-based criterion for treatment phase changes: treatment in a condition was continued until 90% of all generalisation probe items of the trained structure were produced correctly on three consecutive sessions, or until 10 sessions were completed, whichever came first. Both patients were seen approximately twice a week for 1-hour sessions. Each session started with repetition of the probe lists, during which no feedback was given.

Materials

Treatment materials—Each treatment condition consisted of 20 monosyllabic nonwords, either with a three-element s-cluster onset or with a singleton onset. We decided to use nonwords to control for frequency, familiarity, and imageability, as well as to avoid any interference from other linguistic levels of processing. By using nonwords, patients must focus on the sound patterns and cannot rely on semantics to activate a word form. Nonwords have been used successfully in the treatment of children (e.g., Gierut, 1999) and adults (e.g., Knock et al., 2000).

For the singletons, 10 of the onsets were voiceless stops and 10 were liquids and glides (the phoneme /s/ was not included in the singleton condition because pretesting revealed that /s/ was not a problem for either patient). For the clusters, a variety of phonemes was used. Treatment materials were printed on separate cards in large font. All treatment materials are provided in Appendix A.

Generalisation materials—Two different probe lists were created, one containing 20 nonwords and another containing 40 real words. Both real words and nonwords were included to examine whether treatment using nonwords improves the production of both new and existing words to the same extent. Half of each list consisted of singleton onsets, the other half consisted of complex onsets. Complex onsets were evenly divided into three-element s-clusters and two-element clusters. The three different word type groups (singletons, two-element clusters, and three-element s-clusters) were matched for frequency (Francis & Kucčera 1982). See Appendix B for generalisation materials.

Treatment procedure

Treatment involved modelling, articulatory placement cues, and reading. The clinician presented targets in random order within a treatment condition. The clinician read the target nonwords aloud and asked the patient to repeat them. After each production, feedback (knowledge of performance and knowledge of results) was provided. When patients produced the target correctly, they were encouraged to repeat it several times to provide them with more opportunity to monitor their production. The number of repetitions varied, with a maximum of five repetitions per item. When the item was incorrect, feedback was provided and the clinician repeated the item, followed by a second attempt by the patient. When needed, articulatory placement cues were used by showing black-and-white diagrams of the vocal tract. In addition, sometimes the card with the nonword was shown to aid in production.

After five sessions into each treatment phase, we introduced a variation on this procedure of multiple repetitions with clinician feedback: now patients were asked to produce the targets only once, and were required to indicate whether they produced the target correctly or not. This approach was taken to reduce the patients' dependence on clinician feedback, and was alternated with multiple-repetitions-with-clinician-feedback within each session, such that the entire set of 20 treatment items was first presented with clinician feedback, after which the entire set was presented with self-generated feedback.

Transcription and reliability

The word repetition test and all generalisation probes were transcribed on-line by the clinician, and for approximately half of all sessions, a second judge transcribed the responses on-line as well to assess inter-judge reliability. Broad phonetic transcription was used. Distortions were treated as correct if both judges transcribed the intended phoneme. All sessions were audiotaped to resolve disagreements and to perform intrajudge reliability assessments for remaining sessions.

For JS, 77% of all probes were assessed for reliability (50% interjudge, 27% intrajudge reliability). For the word probes, mean interjudge point-to-point agreement was 86%(range: 72%–94%); for nonwords the mean interjudge point-to-point agreement was 83%(range: 71%–94%). Intrajudge point-to-point agreement was 91% for words as well as for nonwords (range 86% to 95% for words; 86%–98% for nonwords). For NP, 96% of all probes were assessed for reliability (48% inter-, 48% intrajudge reliability). For the word probes, mean interjudge point-to-point agreement was 89% (range: 83%–95%), for nonwords reliability was also 89% (range: 78%–98%). Mean intrajudge point-to-point agreement was 91% (range 85%–95%) for words and 92% (86%–97%) for nonwords.

RESULTS

Starting with the pre- vs post treatment word repetition comparison, we see that both patients improved (see Figure 2). Pre vs post treatment accuracy scores were compared using the nonparametric McNemar test (all tests are two-tailed). For JS, singletons improved from 34.1% to 58.3% ($p < .001$); clusters improved from 18.8% to 34.6% ($p < .001$). Singletons and clusters combined improved from 26.4% to 46.4% ($p < .001$). For NP, results showed a significant improvement for singletons from 12.1% to 32.6%($p < .001$); clusters improved significantly as well, from 2.3% to 9.0% ($p < .01$). Singletons and clusters combined improved from 7.2% to 20.8% ($p < .001$).

The generalisation probe data for JS are provided in Figure 3.[2] In the first treatment phase (complex), three-element s-clusters did not improve, for either the words or the nonwords. However, both singletons and two-element clusters were produced with slightly greater accuracy. After a 2-month summer break, three additional baseline probes were administered, which showed that correct production of singletons and two-element clusters decreased. In the second treatment phase (simple), singleton production improved for both word and nonword probes. No clear improvement for clusters was observed; however, performance on two-element cluster words seemed more variable from session to session than in the first (complex) treatment phase. The third (complex) phase again showed that three-element s-clusters, despite being trained, did not improve consistently. However, both singletons and two-element clusters showed fairly steady improvement both for words and for nonwords. In the fourth (simple) phase, performance for all structures remained at similar levels, although for nonwords especially, performance became more variable from session to session than in the third (complex) phase.[3] Errors produced included phoneme substitutions and distortions (e.g., /rid/ for "lead", and unaspirated stops in words such as "care"), as well as cluster simplifications (epenthesis of schwa between consonants, e.g., /peleIn/ for "plane", and deletion of consonants, e.g., /win/ for "queen"). Occasionally vowel substitutions also occurred (e.g., /kwEk/ for "quick").

Results for NP are presented in Figure 4. In the first treatment phase (simple), singleton treatment led to improved production of singletons, but not to improvements for either two-element clusters or three-element s-clusters. After the summer break, treatment focused on complex items, which resulted in continued slight improvement for singletons (with increased variability for nonwords); however, clusters did not improve. The third phase (simple) showed no clear gains for singletons or clusters; the fourth treatment phase (complex) also showed no clear improvement for either singletons or clusters. Errors produced included phoneme substitutions and distortions (e.g., /t^k/ for "luck", labialised /r/); cluster simplification also occurred (e.g., /wId/ for "squid", /serim/ for "scream").

DISCUSSION

To summarise, the results from these two patients with aphasia and apraxia of speech showed that strong, positive effects were only observed for singletons, and not for three-element s-clusters. Negligible generalisation was seen from trained singletons to untrained clusters, while there was limited generalisation from three-element s-cluster treatment to singletons and to two-element clusters for one patient (JS), but not for the other (NP). In addition, performance seemed more stable from session to session in the complex treatment condition than in the simple condition for JS.

[2]Unfortunately, there is only one baseline point for JS, due to the fact that some changes to the original baseline lists were made when JS was scheduled to come in for the first treatment session; it was considered better for the motivation of the patient not to delay treatment any further than we already had with the pretesting.

[3]Follow-up testing has been completed for JS only, and showed that at 1 month post treatment and 2 months post treatment performance on all structures remained at similar levels, with the exception of a slight decrease for the nonword singletons at 1 month follow-up.

Overall, then, the results do not fully support our hypothesis that training complex items leads to greater generalisation effects than training of simple items does. Although it was the case that JS showed improvement on singletons and, crucially, on two-element clusters in the complex conditions, several factors undermine the findings.

First, as singletons improved in all conditions, it could be claimed that the improvements were not due to any of our manipulations but rather to other, unknown or uncontrolled factors. However, the selective improvement of two-element clusters in the complex condition for JS suggests that our treatment manipulations did in fact effect the changes. Moreover, as singletons also improved during cluster treatment, but only slight changes in clusters were observed during singleton training, this finding still supports the notion of using complex stimuli in treatment.

Although it is possible that the percent accuracy of production of singletons would have been greater if only singletons had been trained, the design of the present study does not allow us to evaluate this issue. Specifically, even though JS achieved a higher level of accuracy on singletons in the first treatment phase (complex) than NP (simple), this may be related to the pre-treatment differences in word repetition between the patients. Suffice it to note that there is improvement for singletons even in the complex conditions for JS. It could be that singleton production would have improved even more if only singletons had been trained; although, as is clear from the third treatment (complex) phase for JS, some of the highest levels of accuracy for singletons were achieved when complex items were being trained. However, as has been said, the present study cannot settle this issue.

Second, due the fact that there was only one baseline point for JS, we cannot determine with confidence the level of performance before treatment started. In other words, it could be the case that the 30% correct achieved on two-element clusters in words at the end of the first complex treatment phase did not differ from baseline. However, the third phase showed stable improvements for both singletons and two-element clusters, whereas there was no stable improvement on two-element clusters in the previous (simple) phase.

Third, we also did not observe acquisition of three-element s-clusters, nor did we find the anticipated generalisation effects to two-element clusters for participant NP. Although this finding is contrary to our prediction, similar findings have been observed elsewhere (e.g., Ballard & Thompson 1999; Gierut & Champion, 1999; Powell, Elbert, & Dinnsen, 1991; Thompson et al., 1998, 1997; Thompson, Shapiro, Jacobs, & Schneider, 1996) in that training complex structures often does not increase the production of these targeted structures, but may still improve the production of less complex structures. This may simply be because simpler structures form a proper subset of more complex structures, whereas more complex structures are not formed as a subset of themselves.

Fourth, the observed generalisation effects only occurred for one of our two patients. It is possible that this finding is related to differences in severity between the participants. Indeed, JS performed slightly better on word repetition before treatment than NP. Alternatively, the underlying nature of the sound production problems may be different in these two patients. For example, it could be that JS exhibits an impairment of a more phonological nature, whereas NP might have a more motorically involved impairment. This would account for the fact that the phonological measure of complexity did have an effect for JS but not for NP. Unfortunately, at present this explanation must remain purely speculative, as tests and information on our patients are insufficient to independently establish such subtle differences.

Several other aspects of the present study might have prevented more substantial gains, and these aspects need to be considered in future studies. For example, our approach used

NIH-PA Author Manuscript

NIH-PA Author Manuscript

nonwords as training items (based on the work of Gierut, 1999; Gierut & Champion, 1999; Knock et al., 2000), and it appears that this may have limited the outcomes. Using real words in treatment may be more effective for adult populations, as presumably there is additional activation from lexical and semantic levels of processing to phonological output forms (moreover, using real words allows for other elicitation methods such as picture naming and sentence completion).

Relatedly, we used repetition as our elicitation method. As Ballard (2001) has pointed out, repetition may not be the most effective elicitation method for patients suspected to have apraxia of speech, although previous studies have used this method as well (e.g., Wambaugh et al., 1999). Future studies should explore differential effects of different elicitation methods on treatment outcome (controlling of course for factors such as frequency, imageability, and so on).

Finally, although it was not our intention to manipulate or test any principles of motor learning in this particular experiment (e.g., Knock et al., 2000; Schmidt & Lee, 1999), they may hold some explanatory value, as there is likely a motor component to this, and other, phonological treatment studies. For example, one principle suggests that optimal generalisation and maintenance occur with delayed feedback with a frequency between 30 and 60%; our experiment used 100% feedback. Another is that random practice is more beneficial to learning than blocked practice (see Knock et al., 2000, for some support for this principle in treatment for apraxia of speech). Future work connecting motor learning to phonological treatment (and treatment for other disorders as well) might prove beneficial.

In conclusion, the present study provides partial support for using more complex items in treatment for sound production problems in people with apraxia of speech and aphasia: More generalisation and stable performance were observed in the complex phases than in the simple phases, but only for one of two patients. Future research should focus on the application of different theoretical measures of complexity (e.g., phonological, motoric) to treatment for sound production impairments, as well as on the effects of principles of motor learning on treatment outcomes.

REFERENCES

Ballard KJ. Response generalisation in apraxia of speech treatments: Taking another look. Journal of Communication Disorders. 2001; 34:3–20. [PubMed: 11322568]

Ballard KJ, Barlow JA, Robin D. The underlying nature of apraxia of speech: A critical evaluation of Varley and Whiteside’s dual route speech encoding hypothesis. Aphasiology. 2001; 15:50–58.

Ballard KJ, Granier JP, Robin DA. Understanding the nature of apraxia of speech: Theory, analysis, and treatment. Aphasiology. 2000; 14(10):969–995.

Ballard KJ, Thompson CK. Treatment and generalisation of complex sentence production in agrammatism. Journal of Speech, Language, and Hearing Research. 1999; 42:690–707.

Clements, GN. The role of the sonority cycle in core syllabification. In: Kingston, J.; Beckman, ME., editors. Papers in laboratory phonology I: Between the grammar and physics of speech. New York: Cambridge University Press; 1990. p. 283-333.

Code C. Models, theories and heuristics in apraxia of speech. Clinical Linguistics and Phonetics. 1998; 12(1):47–65.

Den Ouden, DB.; Bastiaanse, R. Singletons and clusters in onsets and codas: The performance of phonemically and phonetically impaired aphasics on a repetition task; Paper presented at the Academy of Aphasia; Santa Fe, NM. 1998 Nov.

Elbert M, Dinnsen DA, Powell TW. On the prediction of phonologic generalisation learning patterns. Journal of Speech and Hearing Disorders. 1984; 49:309–317. [PubMed: 6748626]

Francis, WN.; Kucčera, H. Frequency analysis of English usage. Boston: Houghton-Mifflin; 1982.

Gierut JA. Treatment efficacy: Functional phonological disorders in children. Journal of Speech, Language, and Hearing Research. 1998; 41:s85–s100.

Gierut JA. Syllable onsets: Clusters and adjuncts in acquisition. Journal of Speech, Language, and Hearing Research. 1999; 42:708–726.

Gierut JA. Complexity in phonological treatment: Clinical factors. Language, Speech, and Hearing Services in Schools. 2001; 32(4):229–241.

Gierut, JA.; Champion, AH. Learning and the representation of complex onsets. In: Greenhill, A.; Littlefield, H.; Tano, C., editors. BUCLD 23 Proceedings. Somerville, MA: Cascadilla Press; 1999. p. 196-203.

Goodglass, H.; Kaplan, E. The assessment of aphasia and related disorders. Philadelphia: LEA & Febiger; 1983.

Kearns KP. Flexibility of single-subject experimental designs. Part II: Design selection and arrangement of experimental phases. Journal of Speech and Hearing Disorders. 1986; 51(3):204–214. [PubMed: 3525987]

Kent, RD.; McNeil, MR. Relative timing of sentence repetition in apraxia of speech and conduction aphasia. In: Ryalls, JH., editor. Phonetic approaches to speech production in aphasia and related disorders. Vol. Ch. 10. San Diego: College-Hill Press; 1987.

Kiran, S.; Thompson, CK. Effect of exemplar typicality on naming deficits in fluent aphasia; Paper presented at the 31st Annual Clinical Aphasiology Conference; Santa Fe, NM. 2001 May-Jun.

Knock TR, Ballard KJ, Robin DA, Schmidt RA. Influence of order of stimulus presentation on speech motor learning: A principled approach to treatment for apraxia of speech. Aphasiology. 2000; 14(5/6):653–668.

Powell TW, Elbert M. Generalisation following the remediation of early- and later-developing consonant clusters. Journal of Speech and Hearing Disorders. 1984; 49:211–218. [PubMed: 6716992]

Powell TW, Elbert M, Dinnsen DA. Stimulability as a factor in the phonologic generalisation of misarticulating preschool children. Journal of Speech and Hearing Research. 1991; 34:1318–1328. [PubMed: 1787714]

Rogers MA, Storkel HL. Planning speech one syllable at a time: The reduced buffer capacity hypothesis in apraxia of speech. Aphasiology. 1999; 13(9–11):793–805.

Schuell H. A re-evaluation of the short examination for aphasia. Journal of Speech and Hearing Disorders. 1966; 31(2):137–147. [PubMed: 5935775]

Seddoh SA, Robin D, Sim HS, Hageman C, Moon JB, Folkins JW. Speech timing in apraxia of speech versus conduction aphasia. Journal of Speech, Language, and Hearing Research. 1996; 39:590–603.

Schmidt, RA.; Lee, TD. Motor control and learning: A behavioral emphasis. 3rd Edn.. Champaign, IL: Human Kinetics; 1999.

Shapiro LP. An introduction to syntax. Journal of Speech, Language, and Hearing Research. 1997; 40:254–272.

Thompson CK, Ballard KJ, Shapiro LP. The role of syntactic complexity in training wh-movement structures in agrammatic aphasia: Optimal order for promoting generalisation. Journal of the International Neuropsychological Society. 1998; 4:661–674. [PubMed: 10050370]

Thompson CK, Shapiro LP, Ballard KJ, Jacobs BJ. Training and generalized production of wh-and NP-movement structures in agrammatic aphasia. Journal of Speech, Language, and Hearing Research. 1997; 40:228–244.

Thompson CK, Shapiro LP, Jacobs BJ, Schneider SL. Training wh-question productions in agrammatic aphasia: Analysis of argument and adjunct movement. Brain and Language. 1996; 52:175–228. [PubMed: 8741981]

Varley R, Whiteside SP. What is the underlying impairment in acquired apraxia of speech? Aphasiology. 2001; 15(1):39–49.

Wambaugh JL, Kalinyak-Fliszar MM, West JE, Doyle PJ. Effects of treatment for sound errors in apraxia of speech and aphasia. Journal of Speech, Language, and Hearing Research. 1998a; 41:725–743.

Wambaugh JL, Martinez AL. Effects of rate and rhythm control treatment on consonant production accuracy in apraxia of speech. Aphasiology. 2000; 14(8):851–871.

Wambaugh JL, Martinez AL, McNeil MR, Rogers MA. Sound production treatment for apraxia of speech: Overgeneralization and maintenance effects. Aphasiology. 1999; 13(9–11):821–837.

Wambaugh JL, West JE, Doyle PJ. Treatment for apraxia of speech: effects of targeting sound groups. Aphasiology. 1998b; 12(7/8):731–743.

APPENDIX A

TREATMENT MATERIALS

Singletons		Complex	
keeve	kig	skweeve	skwig
kipe	koove	skripe	skroove
leem	lish	spleem	splish
paf	paim	splaf	spraim
parge	poot	splarge	sproot
rame	reeze	skrame	skreeze
rell	rew	strell	sprew
rit	ruse	strit	struse
teef	tize	streef	strize
waf	wurn	skwaf	skwurn

APPENDIX B

GENERALISATION MATERIALS

Words			
Complex		Simple	
three-elements	two-elements	liquids/glides	voiceless stops
stress	cruise	roof	kid
scream	queen	rain	pain
squid	plain	luck	purge
splurge	cream	rich	pies
spray	trip	wheel	keys
squash	quick	wash	tide
scratch	proud	lean	tease
split	treat	lash	cape
stroll	plate	roll	pin
sprain	pray	lead	care
Nonwords			
Complex		Simple	
three-elements	two-elements	liquids/glides	voiceless stops

squeer	croove	weer	kell
scrutch	queeve	rutch	kip
strill	plim	rill	pim
spreb	prute	leb	pife
splife	treef	lutt	tull

NIH-PA Author Manuscript
NIH-PA Author Manuscript

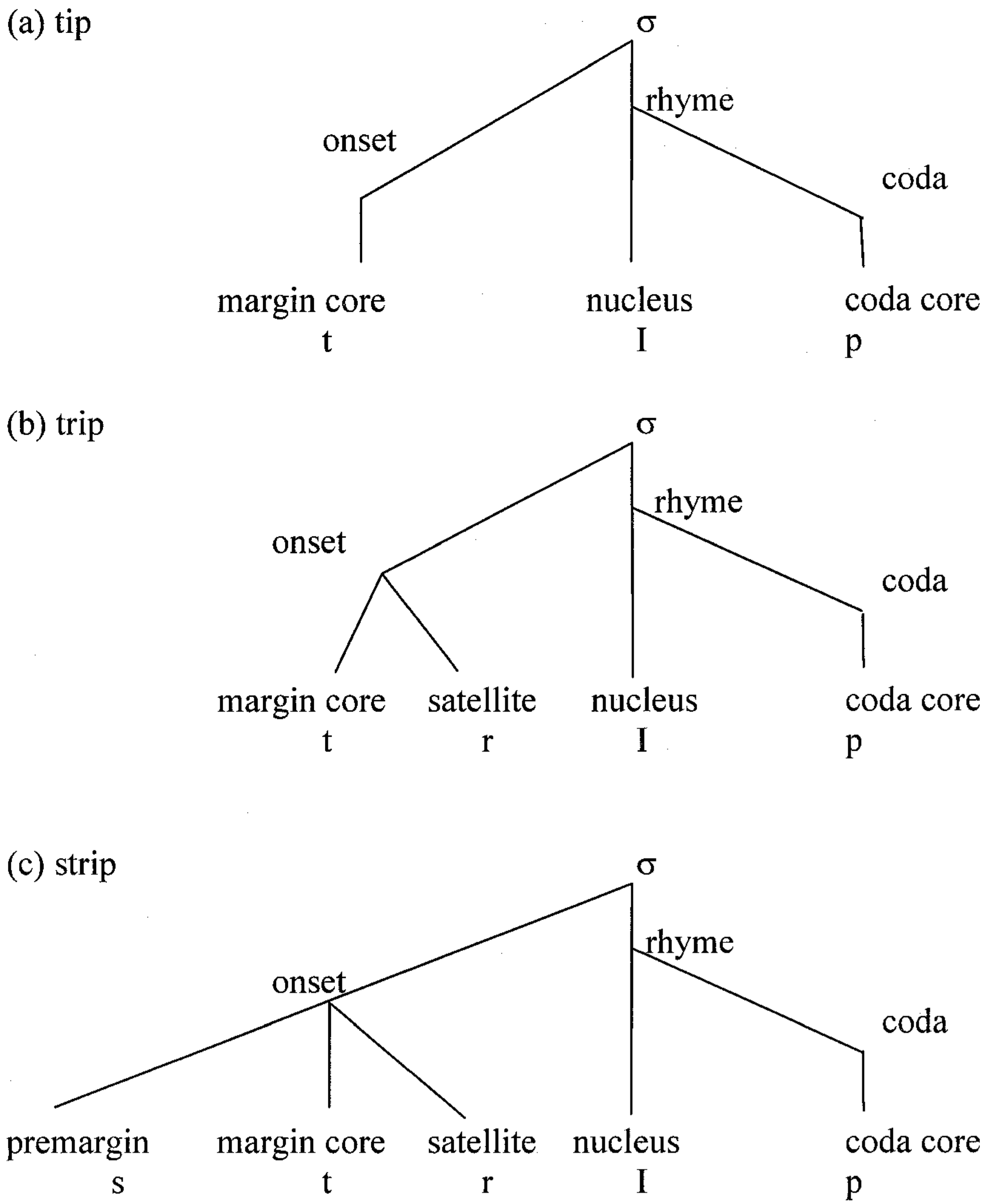

Figure 1.
Syllable templates for *tip*, *trip*, and *strip*.

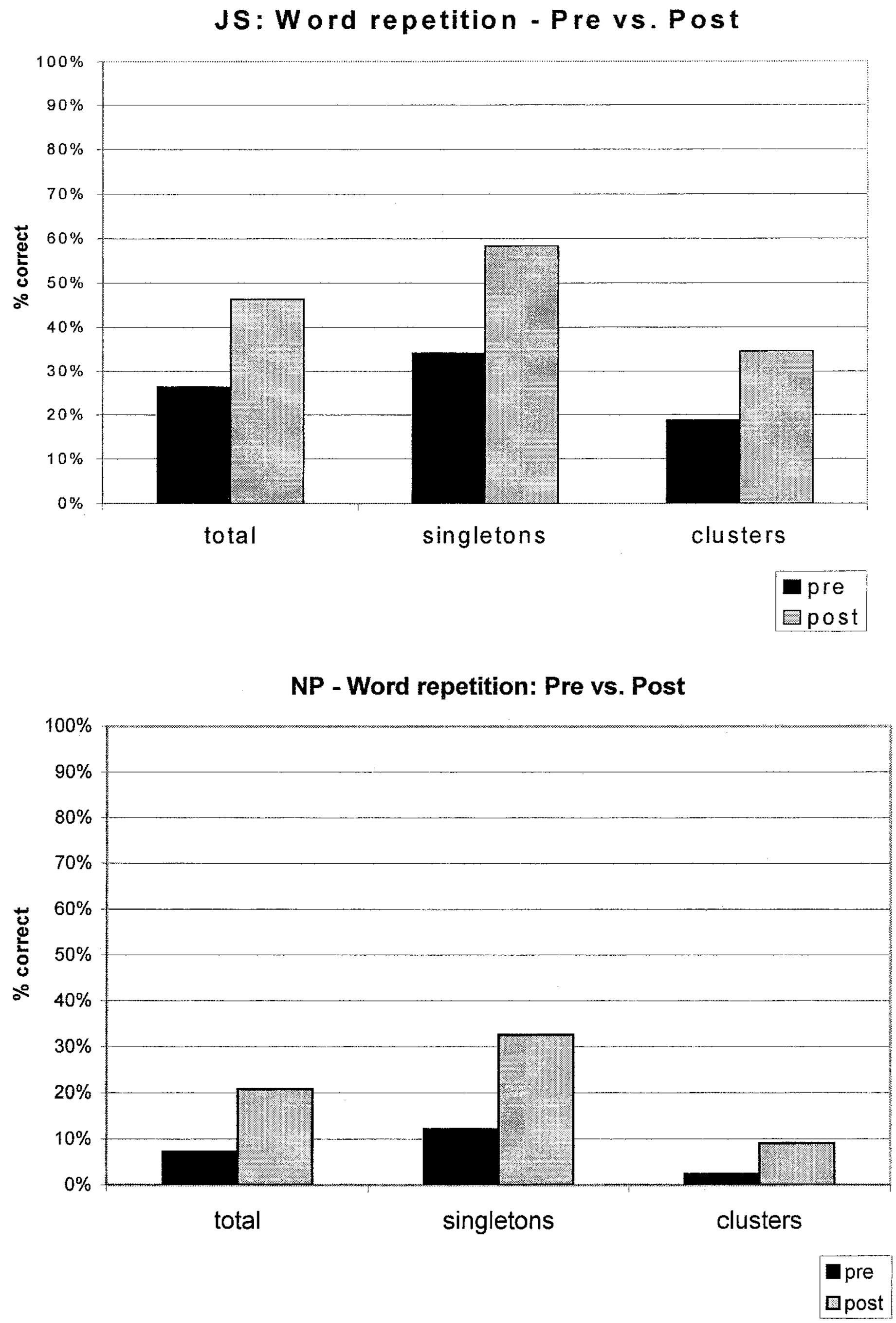

Figure 2.
Pre vs post scores on word repetition: Correct production of target words on the 265 item probe.

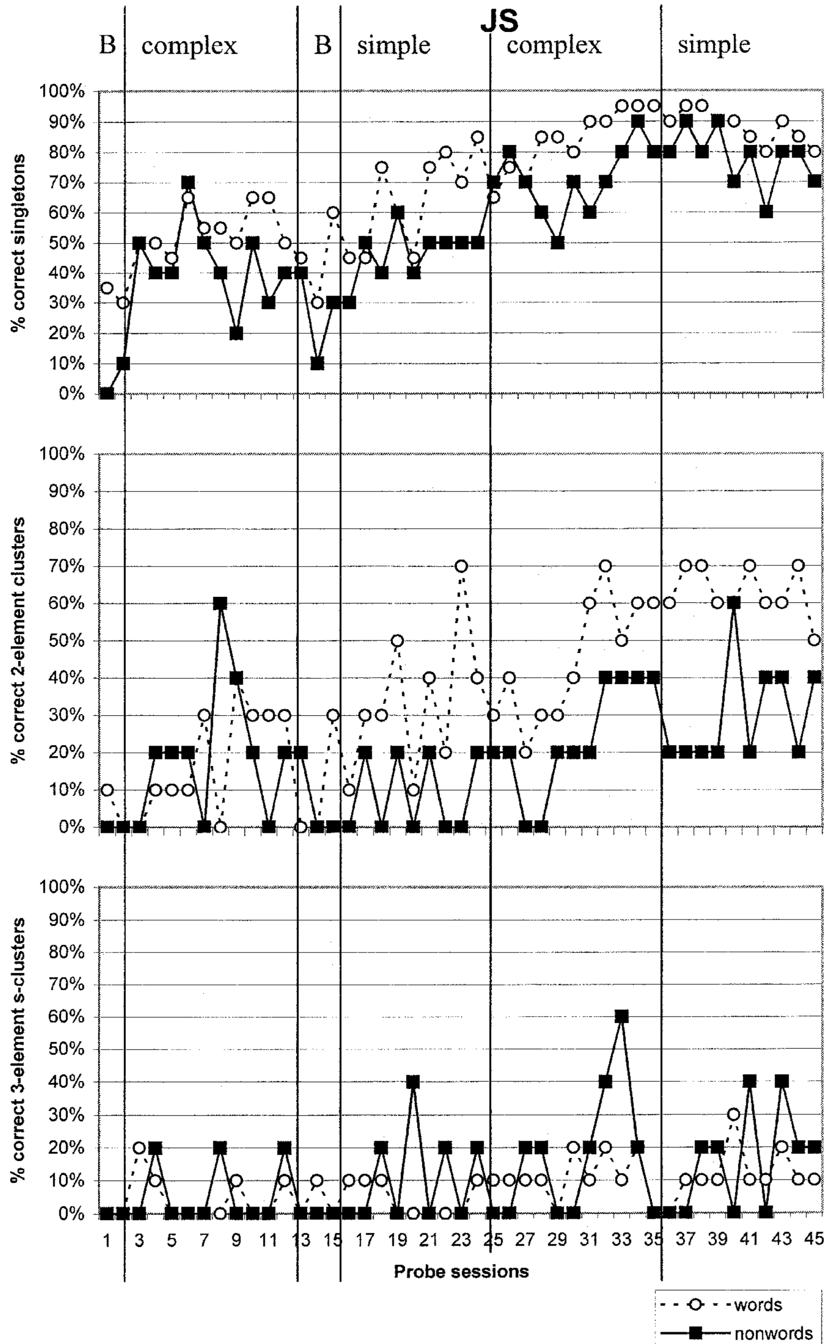

Figure 3.
Results for JS on the probe lists. The top figure represents singletons, the middle figure represents two-element clusters and the bottom figure represents three-element s-clusters. Filled squares indicate nonword probes; open circles indicate word probes. B = baseline sessions; complex = three-element s-cluster treatment; simple = singleton treatment. (Note: in the first, complex, treatment phase, an additional treatment session was inadvertently administered.)

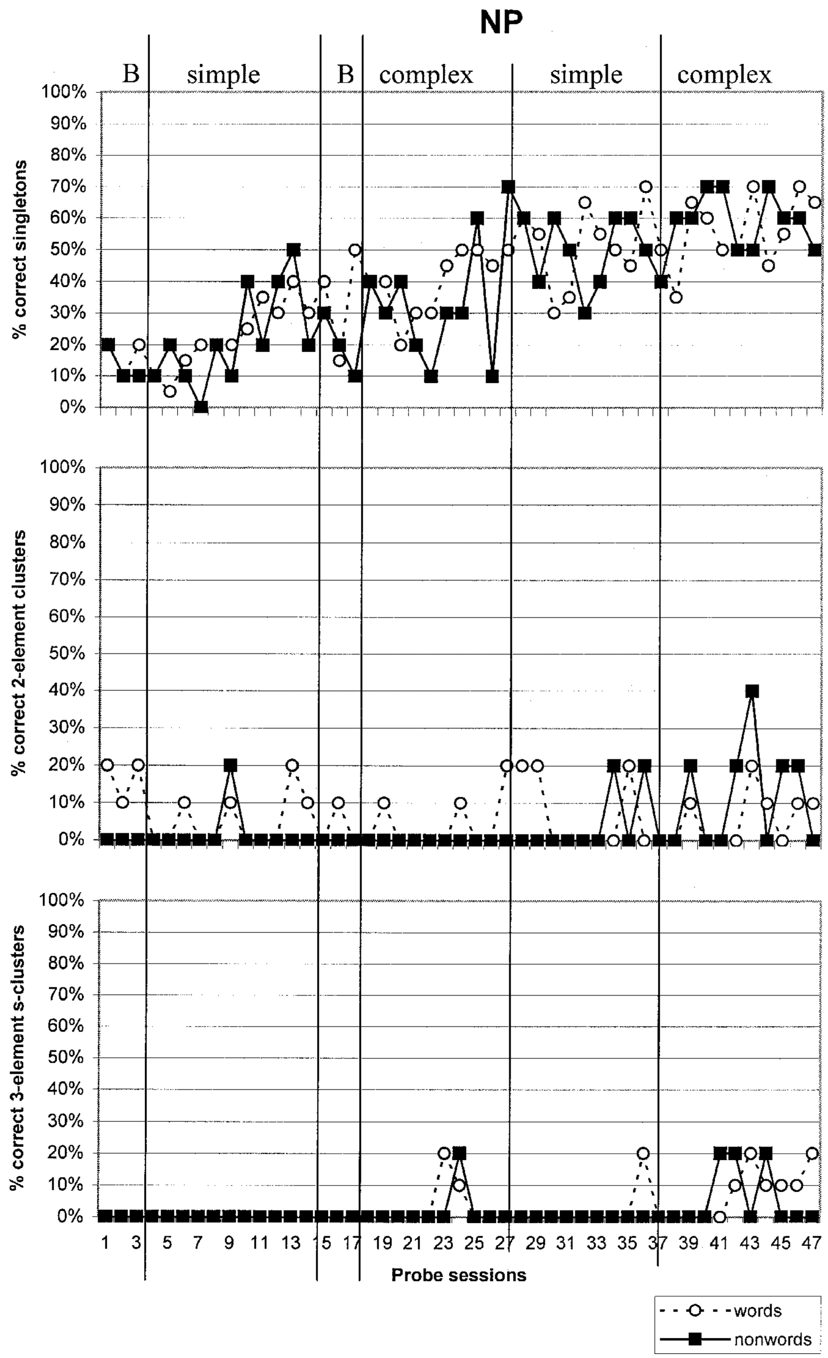

Figure 4.

Results for NP on the probe lists. The top figure represents singletons, the middle figure represents two-element clusters and the bottom figure represents three-element s-clusters. Filled squares indicate nonword probes; open circles indicate word probes. B = baseline sessions; complex = three-element s-cluster treatment; simple = singleton treatment. (Note: in the first, simple, treatment phase, an additional treatment session was inadvertently administered.)

TABLE 1

Pre-treatment assessment information

Test	Subtest	JS	NP
BDAE[a]	Auditory word comprehension	62/72	51.5/72
	Confrontation naming	48/114	25/96[c]
	Word repetition	8/10	7/10
	Phrase Repetition	0 (terminated)	0 (terminated)
	Verbal fluency (animals)	5/minute	2/minute
Minnesota[b]	Minimal pair discrimination	24/24	24/24

[a]Goodglass and Kaplan, 1983.

[b]Schuell, 1966.

[c]One item was accidentally not presented, and naming of body parts was not assessed.