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BRIEF REPORT

RECOMBINATIVE GENERALIZATION IN MINIMAL VERBAL UNIT-BASED READING INSTRUCTION FOR PRE-READING CHILDREN

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Reading is a foundational skill that is essential for effective interaction with one's environment. This skill, however, proves difficult to teach to many students. In the United States, 20%-40% of students have reading problems ranging from mild to severe (Mueller, Olmi & Saunders, 2000). These problems are at least as severe in Brazil, leading to substantial school failure and high dropout (INEP, 2006).

Recently, a major programmatic effort at several Brazilian universities has sought an effective methodology for teaching basic reading skills to children who are at risk for or who have already experienced school failure (de Rose, de Souza & Hanna, 1996; Matos & Hübner D'Oliveira, 1992). This program was inspired by Sidman's (1971) work on stimulus equivalence and by Skinner's (1957) analysis of "minimal units" of verbal behavior. In the context of reading, minimal units include the phonemic and syllabic units common to other analyses of reading processes (Snow, Burns, & Griffin, 1998). Phonemic and syllabic recombination is an essential behavioral process for "word attack" skills (e.g., Mueller, Olmi & Saunders, 2000). It has been shown, for example, that teaching pre-reading children to discriminate visually and to name a small number of two-syllable units may be followed by emergent ability to read new words orally composed of those syllables (e.g., Matos & Hübner D'Oliveira, 1992; de Rose, de Souza & Hanna, 1996).

One aspect of the reading research program in Brazil has focused on the "constructed-response" procedure that was first described by Mackay and Sidman (1984). In that matching-to-sample variant, children were presented with sample stimuli – both pictures and printed words – and a comparison stimulus "pool" composed of individual letters. By touching these letters in sequence, children could "construct" comparison stimuli that were valid matches to the sample – either as identity matches (e.g., constructing A-P-P-L-E as a match for the printed-word sample APPLE) or arbitrary matches (i.e., sequencing A-P-P-L-E in

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response to a sample picture of that fruit). In recent work, constructed-response matching has been supplemented by the requirement that children speak the names of samples and/or elements of the comparison pool to verify discriminations judged prerequisite to directly taught and emergent reading (e.g., Matos, Avanzi, & McIlvane, 2006; cf. Saunders & Spradlin, 1990).

Our study was conducted as part of the larger Brazilian effort to develop an evidence-based curriculum for teaching foundations of reading. Our hypothesis was that contingencies designed in line with the analysis of Skinner (1957) and the procedures of Mackay and Sidman (1984) could prove sufficient to establish generative reading (i.e., performances that emerge without direct training). Our procedures took advantage of a useful characteristic of Portuguese – many words are comprised of two consonant-vowel combinations (e.g., BO+CA=BOCA [mouth]) – minimal units that might be spontaneously recombined into other meaningful combinations (e.g., CA+BO=CABO [handle]). We sought to encourage such behavior by requiring the children to name these minimal units aloud during constructed-response matching, thereby supplementing the training provided in past studies that emphasized "receptive" processes (cf. de Rose, de Souza, Rossito, & de Rose, 1992). Our hypothesis was that minimal-unit naming combined with the constructed response methodology would prove highly effective in promoting unit recombination and thereby establish behavioral prerequisites for generative reading. As in past studies, the procedures were designed to encourage generative reading also via provision of multiple-exemplar training with a series of word sets.

METHOD

Participants, Setting, and Apparatus

Four preschool children served (Bob, Ben, Betty and Britteny), aged 6:1, 4:6, 5:7, and 5:4 (years:months), respectively. Sessions were conducted in a quiet room with a computer placed on a table, chairs for the child and experimenter, and a display of items used as reinforcers (toys, candies, etc.).

Procedures

The procedures of this study were implemented in a series of sessions that were typically comprised of 483 matching-to-sample and naming trials. Sessions lasted about 30 min and were conducted twice weekly.

Phase 1 (Pretests). Pretests evaluated whether children would speak the names of a series of pictures (B) of common items and printed words (C) corresponding to those items. Visual stimuli presented on these tests are shown in Figure 1. Children were also tested for ability to name letters that made up the printed words. If the children did not name the pictures with names corresponding to printed words shown in Figure 1 (a necessary entry skill), then supplemental teaching was provided.

Phase 2 (Pretraining). Pretraining was conducted to familiarize children with the setting, instructions, materials, reinforcers and other operations. During this phase, auditory-visual and visual-visual identity matching-to-sample baselines were taught using color patches (yellow, blue, red and green). Initially, matching-to-sample tasks presented only two comparisons; that number was increased throughout pretraining until all trials presented four comparisons.

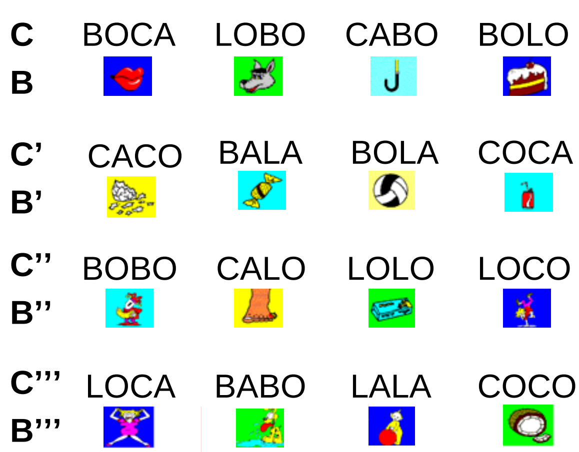

Figure 1

During pretraining and subsequent training phases, correct responses were followed by computer-delivered auditory feedback, verbal praise, and tokens. The latter could be exchanged post-session for toys or candies. When learning criteria were met at the end of each phase, the computer delivered a musical phrase from the "Happy Birthday" song.

Phase 3 (Training). Training was initiated with Set 1 words and replicated as necessary across three further word sets (designated by one, two, or three "prime" marks in Figure 1 and in the subsequent text). AB matching involved selecting pictures (B) in response to dictated samples (A). AC matching entailed selecting syllables to construct printed words (e.g., Set C: BOCA - CABO - BOLO - LOBO) in response to such samples. Children were required to name the syllables as they selected them. In addition, after each constructed-response selection was concluded, the child was required to name the syllables selected in correct sequence. That requirement was in place with the first three Set C stimulus sets (C, C′, and C′′).

A quasi-programmed teaching procedure was used initially to establish AC matching while minimizing potentially negative effects of frequent errors on learning (cf. Stoddard & Sidman, 1967). A multi-step program faded in incorrect comparisons over trials and gradually increased the number of comparisons on each trial. In the final baseline, four comparison stimuli were presented on each trial, and the sample and the position of the correct comparison varied unsystematically across trials. When the constructed response procedures were used in AC training, 12 training trials were typically programmed.

Phase 4 (Testing). Testing presented two types of tests, which were replicated across Sets 1-3 and repeated until 100% scores were achieved. The first were BC/CB equivalence tests (Sidman, 1971). Having been taught AB and AC auditory-visual relations, would all-visual BC and CB relations emerge without further training? The more critical test type was for recombinative matching. These were BC/CB tests with new printed words that were recombinations of syllables that had appeared in different orders on past AC training trials. Such tests (involving the C′, C′′, & C′′′ word sets, see Figure 1) could allow emergent demonstrations of new BC and CB relations without explicit AC training – via spontaneous recombination of minimal phonemic/syllabic units. Test sessions were typically comprised of 649 test trials.

To illustrate further, AC relations were taught initially for Set 1 (BOCA, CABO, BOLO, LOBO), setting the stage for potential emergence of BC/CB equivalence relations on tests with those words specifically. We also conducted B′C′/C′B′ tests, however, using the words of Set 2 (CACO, BALA, BOLA and COCA). If a child's accuracy on such a recombinative matching test was less than 75%, then the corresponding A′C′ relations were taught via the constructed response procedure, and the B′C′/C′B′ tests were repeated. This same approach was used with Set 3 (i.e., A″C″ relations taught, B″C″/C″B″ tested). With Set 4, only the recombinative matching tests were presented.

To promote recombinative matching, supplemental training was provided to encourage attending to the minimal syllabic units comprising the printed words of the set. The constituent syllables from previous AC trials were presented on wooden blocks. The child was required to sequence the blocks in the correct order in relation to whole-word samples from the prior AC training. During such training, the child was required to imitate the verbal model presented by the experimenter (e.g., "bo"…"lo," "ca"…"bo," etc.). Correct syllabic productions (via block arrangements and imitations) were followed by reinforcing consequences.

To conclude the procedures, oral naming posttests were conducted with all C-stimuli.

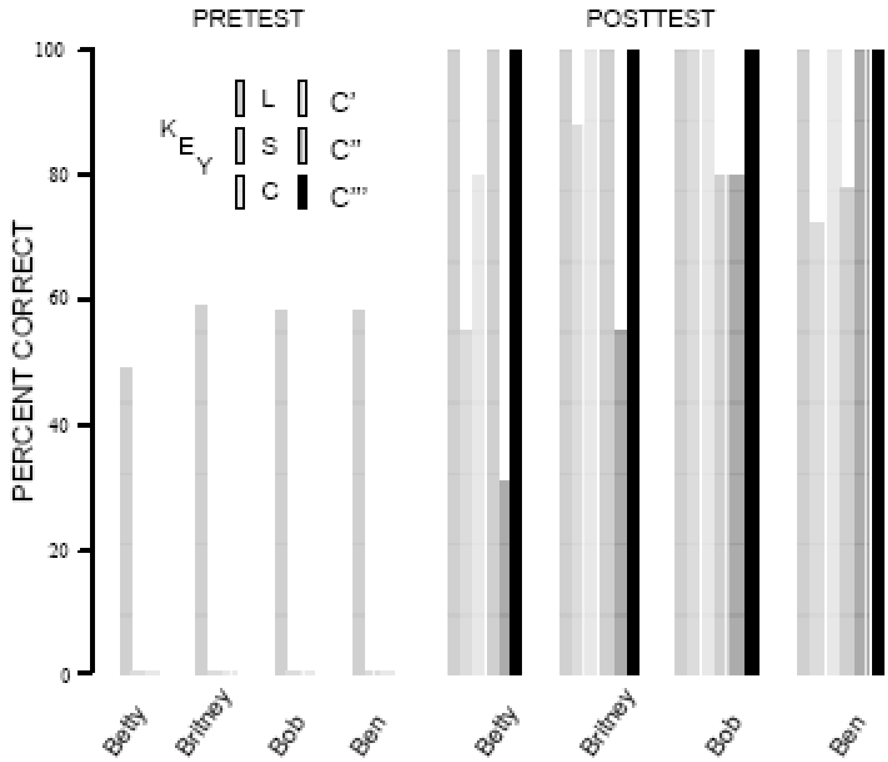

Figure 2

RESULTS AND DISCUSSION

The left portion of Figure 2 shows pretest results for each of the four participants on printed letters (L), syllables (S), and words (C, C′, C′′, C′′′). Children named letters unreliably (see intermediate scores in Figure 2). They were unable to read any syllables or words.

AC training proved highly successful whenever it was implemented. Errors during training were infrequent, and no child made more than six incorrect selections during training. Moreover, as training progressed across phases, both errors and trials to achieve mastery diminished. On the equivalence tests involving Set C (i.e., the BC and CB relations), the scores always substantially exceeded chance levels and typically were at or near perfection (mean: 89% correct; range: 63%-100%). Indeed, only Betty achieved a score in the intermediate range. No child required more than two repetitions of any BC/CB tests to achieve 100% scores.

Figure 3 shows the results of the tests for recombinative matching of new minimal-unit pairs (i.e., involving stimulus sets C′, C′′, and C′′′) with their corresponding B stimuli. Note that units comprising Sets C and C′ could be recombined to yield all of the two-syllable words that constituted Set C′′. Note further that these units could also be recombined to yield Set C′′′, with the exception of the similar unit LA. The results of the tests largely confirmed our hope that the cumulative history could lead to accurate recombinative matching. Scores on the final tests were nearly perfect even though no AC training had preceded them. All children thus proved ultimately capable of recombinative BC/CB matching. Notably, a systematic replication of these procedures was conducted with children with similar ages and behavioral histories but without the requirement to emit post-construction sequenced syllable-naming responses during AC training. Those data (not shown) were similar to data obtained in the present study, and thus it appears that this

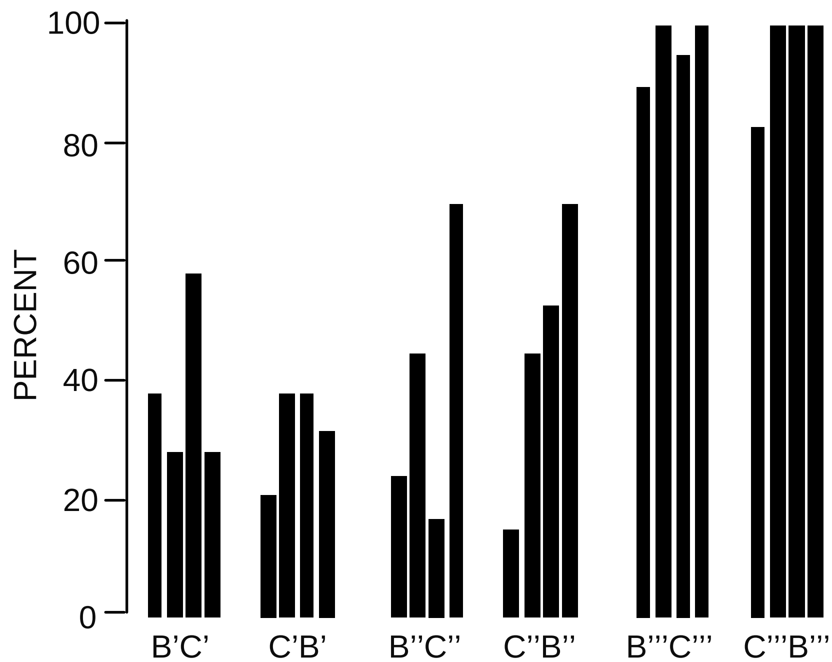

Figure 3

behavioral requirement may not have added value to the training procedures.

The right portion of Figure 2 shows the results of posttests of oral naming of individual letters, syllables, and printed words. As compared with the pretests, all children's scores improved markedly, although the performances proved short of perfection. Particularly interesting was the generally reliable oral naming of letters, which improved substantially although these performances were not explicitly targeted in training. Regarding the syllables and words, the few errors that were made appeared orderly in relation to the training. With respect to the printed words, posttest errors were typically a combination of one correct and one incorrect syllable, and the latter typically were off by a single letter. With respect to the syllables, only Betty made more than a single error (three), and these were always rhyming syllables.

The data from the present study may be compared informally also to a similar study recently reported by Matos, Avanzi, and McIlvane (2006), which had many of the same procedural features, but in a somewhat more direct and elaborated form (e.g., explicit training of all syllables in all positions). These investigators reported somewhat better results with the early training sets, suggesting that more comprehensive training with the minimal units may have some benefit, at least initially. That said, the children in the present study achieved about the same levels of rudimentary reading within three to four repetitions of the procedures. That finding suggests that the primary effective variable(s) were those involved in the provision of multiple exemplars of potentially recombinable syllables. Yet to be assessed are the (a) degree of value added by procedures designed to train separately the minimal units to be recombined and (b) training-time efficiency resulting from the presence or absence of specific features of such supplementary training. Also yet to be determined is the impact of participant variables (e.g., age, behavioral history, etc.), which may potentially interact with specific features of training to establish the generalized recombinative behavior that undergirds skilled reading.

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