RESEARCH IN PROGRESS

STIMULUS CONTROL RESEARCH AND MINIMAL UNITS FOR READING

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The work reported here is part of a broader research program with the goals of analyzing the basic behavioral processes involved in academic repertoires and developing programs to teach those repertoires (de Rose, de Souza, & Hanna, 1996). In particular, we have investigated the efficacy of stimulus control methods to teach basic repertoires of reading and writing, which can be regarded as networks of stimulus-stimulus and stimulus-response relations. Although such relations may function independently (Lee & Pegler, 1982), they seem well integrated and interrelated in the repertoire of a competent reader. One of the mechanisms by which these different relations may become interrelated is the formation of equivalence classes (Sidman, 1994). The demonstration of equivalence classes comprised of printed words, dictated words, and environmental events or their corresponding pictures, permit us to infer that the printed words are symbols for the events, and that the students read the words with comprehension.

An important issue in reading and writing instruction is how the student's skills generalize to new words. Skinner (1957) pointed out that teaching reading at the level of whole words may gradually produce control by smaller units, allowing for recombination and reading of new words, as the repertoire of textual behavior controlled by whole words increases. Current literature on the acquisition of reading (Adams, 1994) stresses the need to train students on the correspondence between graphic and phonic units, but usually some students fail to learn, even after being exposed to explicit teaching of graphic-phonic correspondences. To establish such correspondences requires establishing stimulus control by the minimal units in the auditory (spoken words) as well as in the visual (textual) stimuli. In a series of studies (de Rose et al., 1996) we addressed two questions about basic processes involved in the acquisition of reading and writing skills. The first question asked whether stimulus control methods could be effective in generating emergent academic behaviors, such as textual behavior and dictation taking. The second question sought experimental evidence of Skinner's (1957) assertion regarding the development of control by smaller units and recombinative generalization. The studies were conducted with approximately 40 typically developing children that had an extensive history of school failure, but whose speaking repertoires were well developed.

In the first phase of the program we taught the students to match pictures to dictated words (AB) and printed words to dictated words (AC; Upper panel on Figure 1), and expanded this matching repertoire through the exclusion procedure. Exclusion is an efficient way to teach new

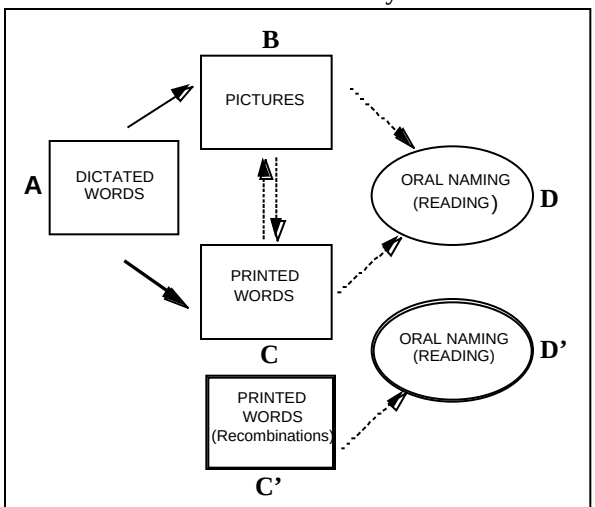

Figure 1

This research was supported by MCT/FINEP/PRONEX and by Grants #522290/95-7 and 520732/95-2 from CNPq. We thank Bill Dube and Richard Serna for very helpful comments and editing. Correspondence to D. G. de Souza or J. C. de Rose, Departamento de Psicologia, CECH/UFSCar, Caixa Postal 676, 13.565-905, Sao Carlos, SP, BRAZIl (E-mail: ddgs@power.ufscar.br; djcc@power.ufscar.br).

matching performances with virtually no errors by presenting new stimuli in a context of previously learned stimuli (Dixon, 1977; Ferrari, de Rose, & McIlvane, 1993; Wilkinson, Dube, & McIlvane, 1996). Exclusion trials, on which students selected novel printed words (displayed with words already learned) conditionally upon novel dictated words, alternated with trials on which students "constructed" the new printed words with movable letters (Dube, MacDonald, McIlvane, & Mackay, 1991). Tests conducted periodically throughout the program assessed the formation of equivalence classes (matching pictures to printed words and printed words to pictures), textual behavior (oral reading of words trained in matching printed words to dictated words) and generalization of textual behavior (oral reading of new words). Generalization words were novel recombinations of the syllables of training words (e.g., training: *bolo*, *vaca*, *tatu*, *mala*; generalization: *boca*, *lata*).

The results of this first phase of the program showed that, with relatively simple words, students matched the printed to the dictated words and constructed the words with virtually 100% accuracy. Tests demonstrated an equivalence relation among printed words, dictated words, and pictures. The data replicated and extended Sidman's (1971) findings: Teaching conditional discriminations between dictated words and their corresponding pictures, and between dictated and printed words, resulted in the emergence of textual behavior. Specifically, in our previous studies, the median (N=36) of training words read correctly was 95% (range 67-100%). The median for generalization words was approximately 45% with considerable variability across students (range 0% to 100%), and nearly one fourth did not read any generalization words. These results--the high percentage of reading training words and the varied scores in reading new words--from typically developing children with a history of school failure were also replicated with pre-school children, students with mental retardation, and nonreading adults (Melchiori, de Souza, & de Rose, in press).

Table 1

UNIT 1 (**lh**)			Generalization Test 1	UNIT 2 (**ch**)			Generalization Test 2
Sub-units	Training Words	Generalization Words		Sub-units	Training Words	Generalization Words	
	pa**lh**a	te**lh**a	1.reta**lh**o		**ch**apeu	**ch**ute	1. fagu**lh**a
1	fo**lh**a	fo**lh**eto	2. **ch**ale	1	**ch**uva	me**ch**a	2. to**ch**a
	mo**lh**o		3. pa**st**a		ta**ch**o		3. **es**cola
	co**lh**eita		4. ga**rf**o		du**ch**a		4. po**rt**a
			5. fo**nt**e				6. pa**nc**ada
	pio**lh**o	mi**lh**o	6. ca**ld**o		ma**ch**ado	**ch**apada	7. pa**lc**o
2	ta**lh**a	deta**lh**e	7. **gr**upo	2	**ch**inelo	co**chi**lo	7.li**vr**o
	rama**lh**ete		8. **cl**ube		**ch**ave		8. **gl**obo
	ore**lh**a		9.ca**rr**o		**ch**ocolate		9. te**rr**a
			10. ma**ss**a				10. pa**ss**eio
	te**lh**ado	ata**lh**o	11. moçã		bu**ch**a	**ch**u**ch**u	11. la**ça**da
3	novi**lh**a	agu**lh**a	12. va**s**o	3	ca**ch**o	coe**lh**o	12. ro**s**a
	ro**lh**a		13. **g**ema		**ch**icote		13. **g**irafa
	toa**lh**a		14. **c**ebola		**ch**upeta		14. **c**inema
			15. **qu**eijo				15. **qu**ilo
	ove**lh**a	mi**lh**a	16. gue		bi**ch**o	ni**ch**o	16.**gu**inada
4	novi**lh**o	ga**lh**o	17. pav**ã**o	4	**ch**iado	bu**ch**a	17.bal**ãoo**
	p**ilh**a		18. co**z**ido		ta**ch**ada		18. a**z**edo
	pa**lh**eta		19. ta**x**i		**ch**uleta		19. gala**x**ia
			20. e**x**ecutivo				20. e**x**ame
			21. li**x**o				21. **x**icara
			22. me**rgulh**o				22. o**rvalh**o
			23. e**stri**bo				23. g**runh**ido
			24. **gu**e**rr**i**lh**a				24. **tr**a**mbiqu**e
			25. **esquerd**a				25. fo**rquilh**a

The present study was conducted as a second phase of the program, in which we sought to analyze more closely the development of stimulus control by minimal textual units and to improve generalization to novel words. The training words had complex textual word fragments (minimal textual units; Skinner, 1957), such as consonant clusters. Table 1 shows a sample of training and testing words used in a series of instructional units. Each unit focused on one complex word fragment. The students matched printed words to dictated words through training with the exclusion procedure. Each training block (or sub-unit; see Table 1) contained a set of four words; each word was dictated four times. Training trials, on which undefined words containing the target fragment were presented as samples, alternated with control trials on which the sample was a defined dictated word learned in the first phase of the program. In the control trials, we added a probe for reading: After the student selected the printed word, he/she was asked to read the other word. Thus, reading the words containing the target word fragment was monitored after each matching trial. The criterion to progress to the next sub-unit was 100% correct reading of training words on a test conducted at the end of each sub-unit; this test also included generalization words that contained the same target textual fragments as the training words ("Generalization Words," Table 1). Each unit taught four sets of words. At the end of the whole unit a generalization test (gray columns) was conducted, which included 25 new words, each word containing one different complex word fragment. For example, in Generalization Test 1, Word 1 (retalho) contains the word fragment (lh) targeted in Unit 1, and Words 2-25 contain the fragments for subsequent units. In Generalization Test 2 (sixth column), Words 1 and 2 contain the word fragments targeted in Units 1 and 2, respectively, and so forth. Solid lines in Figure 2 show accuracy scores on the generalization tests given immediately after completing each sub-unit for all students (some of the students who participated in the first phase of the program, reported by de Rose et al., 1996). The dashed lines show estimated accuracy scores that would be obtained if a child read correctly only those new words that contained previously trained complex word fragments. Thus, obtained accuracy scores (solid lines) above the dashed lines indicate generalization to untrained word fragments. As shown in Figure 2, for four students generalization was obtained immediately, and for four others, generalization developed as training progressed. These levels of generalization were related to the generalization scores obtained on the first phase of the program (indicated in the figure, next to the student's identification). These data demonstrated, more directly than in the first phase of the program, the development of control by smaller textual units, not explicitly reinforced, showing that control by smaller textual units may be abstracted from the teaching of a set of larger units (whole words) containing the target smaller units. This may be yet another way, relatively unexplored so far, to develop the control by minimal textual units necessary for reading generalization, in the context of meaningful units (i.e., teaching sound-text correspondences for parts of a word, instead of teaching isolated graphemes or syllables). The inter-subject variability in the scores of reading generalization, however, suggests that the "whole-word" approach may leave this development subjected to uncontrolled variables (Sidman, 1994). Reading generalization could possibly occur more promptly and more systematically if the correspondence between textual units and sounds were explicitly taught. Other experimental work in progress in our lab is incorporating stimulus control procedures to teach explicitly graphic-phonic correspondences, as suggested by the literature on reading acquisition (Adams, 1994; Grossen, in press). In such procedures, matching trials with dictated whole words as samples alternate with trials on which the samples are syllable components of those words (and the comparison stimuli are printed syllables). Additionally, the students are required to construct both the words and the syllables, which they learned to select on the exclusion trials.

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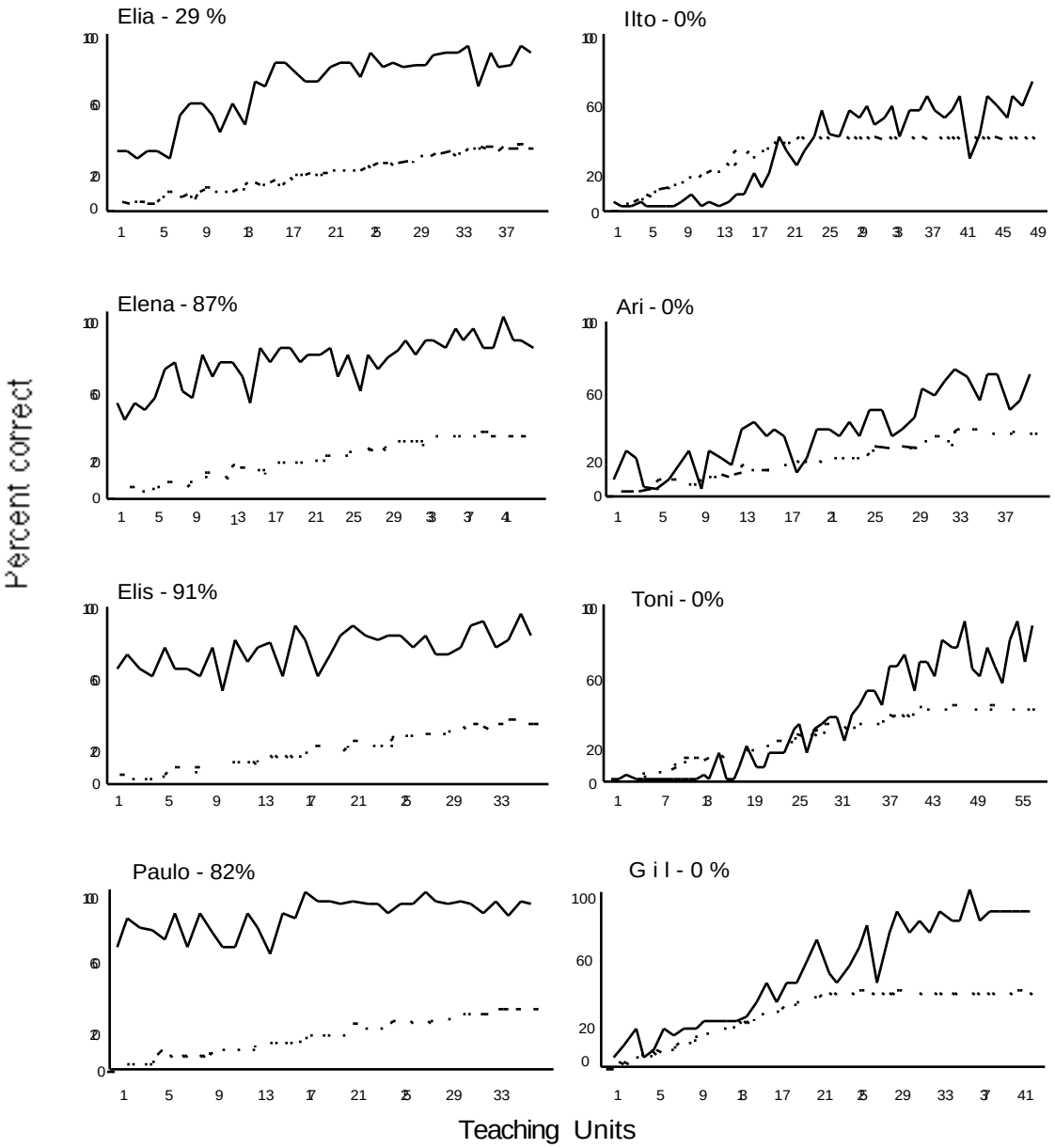

Figure 2