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Simple and Conditional Discrimination and Specific Reinforcement in Teaching Reading: An Intervention Package

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Abstract This study evaluated an intervention package combining simple and conditional discrimination training and specific reinforcement for each stimulus class in teaching reading of simple words to individuals with intellectual disabilities. In conditional discrimination training, participants matched printed words and pictures to the recorded sounds made by the pictured objects and animals. Fourteen children and adolescents with intellectual disabilities were assigned to an experimental and a control group. The two groups' performance did not differ in the pretest. The experimental group demonstrated equivalence class formation and read the words that participated in the equivalence classes, whereas the control group did not.

Keywords Simple discrimination · Conditional discrimination · Specific reinforcement · Reading · Intellectual disabilities

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Educational technology, based on stimulus equivalence, also known as Equivalence-Based Instruction (EBI) has recently emerged. Its applications range from teaching basic academic skills such as reading (e.g., de Rose et al. 1996; Melchiori et al. 2000, Rehfeldt 2011) to teaching sophisticated academic concepts to college students (e.g. Fields et al. 2009; Fienup et al. 2010; Fienup and Critchfield 2010). In educational settings, researchers have employed EBI concepts and laboratory techniques to meet the learning demands of various populations, especially those with intellectual disabilities who have difficulty learning reading and spelling. This repertoire is socially relevant, because failure in learning to read may delay the academic progress of the child and result in frustration when learning academic skills. As a consequence, it may confer an aversive status to the academic context. On the other hand, identifying conditions under which students successfully acquire reading and other academic skills may help provide reinforcing experiences in formal educational contexts, increasing the motivation to learn. Also, reading skills are required in several daily activities, such as recognizing their own names, public transportation lines, addresses, etc. Therefore, teaching individuals to read even simple words is an important step towards the development of more complex reading repertoires that increase individuals' autonomy when performing daily activities.

Reading might be considered a special type of operant behavior, which is emitted under the control of discriminative stimuli (text) and strengthened or maintained by reinforcement (de Souza et al. 2009). In this sense, the act of reading can be broken down into smaller repertoires which are related by equivalence classes. According to de Rose (1993), reading can be conceived as a network of directly taught and emergent relations among different stimuli that may become larger and more complex as new members are incorporated into it.

Most studies on stimulus equivalence, including those on teaching reading, use conditional discrimination procedures to teach arbitrary relations between stimuli that do not share physical similarity or function. Typically, teaching sessions comprise a certain number of discrete trials, in which some stimuli serve as samples and others as comparisons, and the correct response is conditional to the sample. For example, considering three different sets of stimuli, A, B, and C, an individual may be directly trained to conditionally choose B upon the sample A and C upon the sample B. After this training, the individual may also present emergent discriminations that were not directly taught, such as choosing A upon the sample B and C upon the sample A. In this case, the conditional discrimination generated matching to sample performance in which the stimuli are not just related by conditionality but also by equivalence (Sidman & Taily, 1982).

Reading instruction via conditional discrimination procedures has been successful with typically developing students, individuals with intellectual disabilities, and illiterate adults (e.g., de Rose, Souza & Hanna, 1996; Melchiori et al. 2000). Although the results of basic and applied equivalence studies are robust, some variability may be found (de Rose et al. in press). It is possible that part of this variability may be attributed to the use of a common stimulus as a reinforcer for correct responses for all classes. Sidman (1994, 2000) suggested that all positive elements of the four-term contingency of a conditional discrimination, including the reinforcing stimuli, are members of equivalence classes. Therefore, if a common reinforcer is used, participants may form a large equivalence class that includes all stimuli used in training, instead of two or more equivalence classes. Natural demands of the differential reinforcement contingency, however, may cause elements that are common to all classes to drop out, making the formation of smaller classes possible. For example, when A1 serves as sample, choosing B1 is reinforced with R1, whereas choosing B2 will not produce any differential consequences; and when A2 serves as sample, choosing B2 is reinforced with R1, and choosing B1 will not produce differential consequences. Even though the reinforcer was the same in both cases (R1), the individual might be able to form different classes based on the differential reinforcement contingency. If this does not happen, however, traditional tests fail to demonstrate equivalence class formation because in that case, any comparison is correct for any sample (Saunders and Green 1992). Thus, the use of class-specific reinforcers for different stimulus classes during training may make equivalence class formation more likely (Dube et al. 1987; Goyos 2000).

Also, it is argued that conditional discriminations consist, in fact, of two different simple discriminations: simple successive discrimination between samples and simple simultaneous discrimination between comparison stimuli (Saunders and Spradlin 1989). For this reason, separate training of each of these simple discriminations may accelerate the acquisition of conditional discriminations. In the aforementioned study, participants with intellectual disabilities who had extensive histories of failure to acquire arbitrary matching did so after training of the simple discriminations required. In studies with non-humans, Kastak, Schusterman and Kastak (2001) used both simple discriminations and class-specific reinforcers in some phases of a training procedure with two sea lions and encountered evidence of functional class formation. Importantly, the sea lion performed more accurately in the class-specific reinforcement phases than in the phases in which a common reinforcer was utilized.

Earlier studies teaching reading based on equivalence classes taught students to match dictated to printed words and sometimes also the same dictated words to pictures, if this performance had not been established before the study. This instruction has usually been sufficient to promote formation of equivalence classes comprising spoken words, pictures, and printed words and usually resulted in students reading the printed words orally (de Rose et al. 1996; de Souza et al., 2009; Matos et al. 2006; Melchiori et al. 2000; Sidman

1971; Sidman and Cresson 1973). However, the task may sometimes get repetitive and predictable, and participants may lose interest in the activity, showing an increasing number of errors. One way of solving this problem may be to vary the learning activity, for example, by varying the sample stimuli. For example, in some trials, the sample could be a spoken word corresponding to a particular visual stimulus, and in other trials, the sample could be a sound characteristic of the same visual stimulus (e.g., the recorded sound of a cat meowing instead of the spoken word "cat"). Because in the present study, all participants were diagnosed with mild to severe intellectual disabilities, it was especially important to make the teaching procedure as interesting as possible for them. Therefore, in an attempt to increase students' engagement in the task, they learned to match printed words and pictures to the sounds made by the objects and animals pictured and designated by the printed words, assuming that the recorded sounds would make the activity more enjoyable for them. The emergence of reading of the printed words was expected on the basis of previously acquired relations between sounds and respective objects and animals. We reasoned that if this technique proved to be efficient, recorded sounds might be incorporated as samples in EBI interventions to teach reading to render learning tasks more interesting.

Taking into account some procedural variations that could enhance the likelihood of equivalence class formation, the main goal of this study was to propose an EBI training package combining simple and conditional discrimination and specific reinforcement to each different stimulus class in order to teach individuals with intellectual disabilities to read a set of simple words. As previously noted, we tried to enhance engagement with the task by using recorded sounds as auditory stimuli instead of dictated words. An additional goal of the study was to assess the extent to which oral naming and recombinative generalization might emerge without the inclusion of dictated names in training.

Method

Participants

Fourteen children and adolescents participated. They had mild to moderate intellectual disabilities (according to the Wechsler Intelligence Scale for Children—Third Edition; Wechsler and Figueiredo 2002) and attended a special education school in a medium-sized Brazilian city. Five were male and nine female, and their ages ranged from 9 to 15 years (M=11.8, SD=2.3). Portuguese was the native language of all participants, and all instructions and words included in the teaching program were in this language. The participants had a history of difficulty acquiring reading skills via conventional methods (direct grapheme-phoneme training; e.g. Adams 1994). Participants were randomly assigned to an experimental and a control group, with seven participants in each group. Participants in the experimental group received individual training, whereas participants in the control group did not receive any training, but performed pre- and posttest activities at the same time as participants in the experimental group.

Setting and Materials

Training and testing sessions were conducted individually in a room provided by the school during breaks of the participants' regular activities, five times a week. Sessions lasted 3 min on the average and were carried on by means of a software application named LECHGEIC[1] (Orlando 2009). Each training session comprised 24 training trials of simple or conditional discriminations. One or two sessions were conducted daily with each participant. Edibles[2] were used as reinforcers selected on the basis of a paired stimulus preference assessment (Fisher et al. 1992; Derby et al. 1995).

Stimuli were visual and auditory, consisting of dictated (A) and printed (C) words, pictures (B), and recorded sounds (A'). All C stimuli consisted of two-syllable Portuguese words in which each syllable consisted of a consonant followed by a vowel. Training words were as follows: pato (duck), lobo (wolf), sino (bell), gato (cat), vaca (cow), and sapo (frog). Generalization words, constructed by recombination of the syllables of the training words, were as follows: boca (mouth), bolo (cake), galo (rooster), nova (new), papo (chat), and sito (site). Printed words were presented on the computer screen in lowercase Arial font size 65. B stimuli consisted of colored pictures

[1] Gerenciador de Ensino Individualizado por Computador (Individualized Learning Management System).

[2] Edibles are strawberry-flavored wafer-type biscuit, onion-flavored chips, cheese-flavored chips, ham-flavored chips, chocolate candy, corn cereal, milk-flavored biscuit and cornstarch biscuit.

corresponding to the printed words that measured 4.5× 4 cm on the computer screen. The auditory A and A' stimuli consisted of dictated words and recordings of sounds made by the animals and objects that the B and C stimuli represented. A stimuli were used only during pre- and posttests, whereas A' stimuli were used in conditional discrimination training.

Procedure

Pre- and Posttests

Pre- and posttests were identical; pretests were conducted prior to any training and posttests were conducted following completion of all training procedures. These tests aimed to assess the following repertoires: naming[3] pictures (BD[4]), words (CD), and syllables (CDs[5]); picture-printed word matching (BC); printed word-picture matching (CB); dictated-printed word matching (AC); dictated word-picture matching (AB); picture-picture matching (BB); printed word-printed word matching (CC); and copy using constructed response with syllables (CRCCs). In the naming tasks, one stimulus (picture, word, or syllable) was presented on the computer screen simultaneously with a verbal instruction presented by the computer ("What is this?" or "What is written?"), and participants were expected to emit an oral response such as naming the stimulus (which could be accurate or not) or state that they did not know the answer. The oral responses were videotaped and scored by a second observer to define whether they were correct or incorrect. Interobserver agreement was 100 % for all participants. Correct responses were defined as accurate vocalization of the picture name, word, or syllable presented on the screen. In the matching tasks, the sample stimulus was presented in the uppermost middle position of the computer screen, and three comparisons were simultaneously presented at the bottom (left, central, and right positions) of the screen. A correct response consisted of clicking the positive comparison with the computer mouse. In constructed response trials, a word served as the sample in the uppermost middle part of the computer screen. Participants were asked to copy the word presented (verbal instruction; "Copy the word") using as many as needed from 12 syllables that were available in the lower portion of the computer screen by clicking on the syllables they wanted to use.

If participants from either the experimental or the control group failed to name all pictures correctly, they were trained to match dictated words to their corresponding pictures (AB) given the verbal instruction "Point to the [name of the picture]." The procedure consisted of presenting six forced-choice AB trials for each picture that was incorrectly named during testing. In these forced-choice trials, only the correct picture was available for selection. The six AB trials for each picture were followed by one picture-naming trial. Then, the six pictures were presented in randomized order, and the participant was asked to name each one. This procedure was repeated until participants reached 100 % accuracy in the six AB trials of each picture, the six AB trials that presented all pictures together, and picture-naming trials (two for each picture). Proper training in the experimental group began only after this criterion was met.

Teaching Program

The teaching program consisted of at least 44 training sessions, starting with simple discrimination training, which was followed by conditional discrimination training. The total number of training sessions actually completed by participants varied according to their performance accuracy. In addition, there were six test sessions. Only participants in the experimental group were exposed to the teaching program.

Simple Discrimination Training The objective of this phase was to establish simple discriminations between three pairs of pictures and between three pairs of the corresponding printed words. The pairs were (a) pato (duck)/lobo (wolf), (b) sino (bell)/gato (cat), and (c) vaca (cow)/sapo (frog). In this list of pairs, the first member was always S+ and the second was always S−; simple discriminations were never reversed. Each training session contained 24 simple discrimination trials. There were six phases of training for pictures followed by six phases of training for printed words, and each phase required at least two sessions to complete. In the

[3] Naming in this manuscript refers to producing the oral name of the displayed picture or printed word, or, according to the taxonomy of verbal operants introduced by Skinner (1957), *tacting* the picture or emitting a *textual response* for a printed word or syllable. It does not imply the integration of speaker and listener repertoires implied in the concept of *naming* of Horne and Lowe (1996).

[4] Set "D" refers to the oral response given by participants.

[5] "s" stands for syllable.

first phase, we presented the first pair of pictures (duck as S+ and wolf as S−). Stimuli were presented in two of three possible locations: right, left, or center portion of the computer screen. Each stimulus appeared eight times in each possible position. Selection of the incorrect stimulus (S−) produced a correction message ("No"), and the exact same trial was presented again. Selection of the correct stimulus (S+) was followed by feedback such as "Yes!," "Very good," "Great!" and the immediate presentation of the specific reinforcer (a piece of Edible 1). The verbal correction and encouragement messages were automated, but the experimenter presented the edibles manually. In the second and third phases, we presented the second and third pairs of pictures, respectively, using Edibles 2 and 3, respectively, as consequences for correct responding. In the fourth phase, all three pairs were presented in blocks of eight consecutive trials with each pair. The fifth phase contained six blocks of four consecutive trials with each pair. In the sixth phase, the pairs were presented in randomized order. In these sessions, when all three pairs of stimuli were presented in the same session, each stimulus pair appeared eight times out of every 24 trials. Finally, the six subsequent teaching phases presented pairs of printed words using the same procedures.

Throughout training, selecting the picture of a duck or the printed word "pato" (duck) was always followed by a delivery of Edible 1, whereas Edibles 2 and 3 followed selections, respectively, of the printed word "sino" (bell) or picture thereof and the printed word "vaca" (cow) or picture thereof.

The criterion to move on to the next phase was no more than one error in each of two consecutive sessions, meaning that in each training phase, participants had to perform at least two training sessions. If this criterion was not met, the training session was repeated up to four times. If criterion was not yet attained, a performance correction session was implemented, consisting of 12 forced-choice trials, in which only the S+ was displayed followed by 12 simple simultaneous discrimination trials displaying both S+ and S−. In this case, the learning criterion was no more than one error in the session. When this criterion was reached, the participant returned to the regular training.

Conditional Discrimination Training Conditional discrimination training began after completion of simple discrimination training. The performance required was to match recorded sounds of animals and objects to pictures (A'B) and recorded sounds to printed words (A'C). Each session began with the following instruction: "Now you will hear the sounds of animals and objects. Choose the picture of what makes the sound you hear." Comparison stimuli were presented in pairs that were the same ones used in simple discrimination training. Samples were the sounds corresponding to each of the six training stimuli. Therefore, in 50 % of the trials in a training session, samples were the sounds of previous S+s in simple discrimination trials: duck, bell, and cow. In the remaining 50 % of the trials, samples were the sounds of previous S− in simple discrimination trials: wolf, cat, and frog. Thus, new edibles were introduced to serve as specific reinforcers for the selection of the pictures and printed words of wolf, cat, and frog.

There were 10 conditional discrimination training phases, the first five were dedicated to A'B (sound-picture) matching and the last five to A'C (sound-printed word) matching. Each training session consisted of 24 trials. The first three phases, as in the simple discrimination condition, introduced stimulus pairs 1, 2, and 3, respectively, as the comparison stimuli. The sample was a recorded sound corresponding to one of the members of the pair. The sound corresponding to the S+ in the simple discrimination condition was presented as sample in the first 12 trials, and the sound corresponding to the S− was presented as sample in the last 12 trials of each session.

The fourth phase presented trials with all pairs of stimuli, in blocks of four consecutive trials with each sample. In the fifth phase, samples were presented in a randomized sequence, and reinforcement probability was reduced to 50 %, with no more than three consecutive trials unreinforced. The purpose of this reduction was to prepare for probes, in which only 25 % of the trials would be reinforced (baseline trials). The modification in the reinforcement contingency was signaled by the following instruction: "Now, the computer will not always tell whether you are right or wrong. Continue playing with attention." Learning criterion and performance correction sessions were the same as in the simple discrimination condition. As in simple discrimination training, the learning criterion was no more than one error in each of two consecutive sessions.

Equivalence Test

This phase consisted of one session with 36 trials: 12 baseline trials interspersed within 24 test trials. Twelve test trials involved picture-printed word matching and the other 12 printed word-picture matching. Equivalence test trials did not necessarily present the same pairs of comparison stimuli used in the conditional discrimination trials. Correct responses were reinforced in baseline trials but not in test trials. If participants' performance on the equivalence test ranged from 50 to 75 % correct, training and testing were repeated once.

Printed Word-Naming Test

In this phase, each printed word (training and generalization) was presented individually on the center of the computer screen with the following dictated instruction: "Which word is this?"

Results

The minimum number of sessions required for participants in the experimental group to complete training was 44. The actual number of sessions ranged from 47 to 76, with an average number of 60 sessions (mean number of trials; 1,426). Table 1 presents the minimum and actual number of sessions for each participant during each phase of simple and conditional discrimination training. Errors appeared related to three different aspects of the procedure, (a) the type of discrimination required (simple vs. conditional), (b) the type of visual stimulus (pictures vs. printed words), and (c) the schedule of reinforcement (continuous vs. intermittent). When trials involved pictures as stimuli, participants rarely needed more than the minimum number of sessions required and never needed performance correction sessions in either simple or conditional discrimination conditions. All participants made more errors, however, when trials involved discrimination between printed words, especially in the conditional discrimination condition. In this condition, participants required a total of 17 performance correction sessions (resulting from errors in regular training sessions), whereas in the simple discrimination condition, only one such session was required. Also, participants made more errors in conditional discrimination trials with printed words after reinforcement became intermittent.

Participants in both the experimental and the control groups had a high percentage of correct responses on the pretest for relations between dictated words and pictures (AB), picture-picture (BB), and picture naming (BD), ranging from 83.3 to 100.0 % correct. The only exceptions were two participants from the experimental group, E4 and E7, who initially correctly named pictures in 33.3 and 66.7 % of trials. Because correct picture naming was a prerequisite to start the training, these two participants received one AB training session each (six AB trials followed by one picture-naming trial) and afterwards performed picture naming with 100.0 % accuracy. Some variability was observed in both groups for identity matching with printed words (CC) and copying using constructed responses with syllables (CRCCs), with correct responses ranging from 25.0 to 100.0 % (M=41 %) and 0.0 to 100.0 % (M=67 %), respectively. The control group had a mean score of 60.7 and 23.8 % of correct responses on CC and CRCC trials, respectively; and the experimental group had a mean score of 70.2 and 53.6 % of correct responses on CC and CRCC trials, respectively.

For relations between dictated and printed words (AC), participants in both groups performed with less than 50.0 % accuracy on the average (M=45.0 % for the experimental group and M=35.0 % for the control group). On posttests, the percentage of correct responses on AC trials did not change for the control group but increased to 74.0 % for the experimental group. On CC and CRCC trials, both groups had slightly higher scores compared to pretest results: the control group had a mean average of 65.5 % of correct responses, respectively, and the experimental group 88.1 % and 72.6 %, respectively. Individual results for the aforementioned relations are shown in Table 2. A non-parametric Wilcoxon test was conducted to assess differences in performances on pre- and posttests, revealing that percentage of correct responses for the experimental group was significantly higher in the posttest than in the pretest for the relations CC (Z=−2.032; p=0.042) and AC (Z=−2.207; p=0.027).

The most important results concern the relations between printed word and picture (CB), picture and printed word (BC), and word naming of training words (CD) that refer to emergent relations that may indicate equivalence class formation and rudimentary reading. Figure 1 presents the percentage of correct responses for the aforementioned relations on pre- and posttests for the experimental and control groups (top panel) and individual results for the experimental (middle panel) and control (bottom panel) groups. The top panel shows that pretest performance of both groups was similar, ranging from 33.0 to 45.0 % correct in BC/CB trials

Table 1 Minimum number of training sessions required and actual number performed by each participant in simple and conditional discrimination training

Training Conditions			Minimum number of sessions required	Number of sessions performed							
				E1	E2	E3	E4	E5	E6	E7	Group
Simple Discrimination	B	Pair 1	2	2	3	2	3	2	2	3	17
		Pair 2	2	2	4	2	2	2	3	2	17
		Pair 3	2	2	3	2	2	2	3	3	17
		All pairs—blocks of 8	2	2	2	2	2	2	2	2	14
		All pairs—blocks of 4	2	2	2	2	2	2	2	2	14
		All pairs—random	2	2	2	2	2	3	2	2	15
		Performance correction	0	0	0	0	0	0	0	0	0
	C	Pair 1	2	3	2	3	4	2	2	4	20
		Pair 2	2	2	3	2	2	2	2	3	16
		Pair 3	2	3	3	2	3	2	2	2	17
		All pairs—blocks of 8	2	2	4	2	3	2	3	3	19
		All pairs—blocks of 4	2	2	2	2	2	2	3	4	17
		All pairs—random	2	2	3	5	4	2	3	2	21
		Performance correction	0	0	0	1	0	0	0	0	1
Conditional Discrimination	A'B	Pair 1	2	2	2	2	3	2	2	2	15
		Pair 2	2	2	2	2	2	2	2	2	14
		Pair 3	2	2	2	2	2	2	2	2	14
		All pairs—blocks of 4	2	2	2	3	2	2	2	2	15
		All pairs—random[a]	2	2	2	3	2	2	2	2	15
		Performance correction	0	0	0	0	0	0	0	0	0
	A'C	Pair 1	2	2	2	2	2	3	2	2	15
		Pair 2	2	2	2	2	3	2	2	2	15
		Pair 3	2	2	2	2	2	3	2	2	15
		All pairs—blocks of 4	2	2	2	2	12	8	6	2	34
		All pairs—random[a]	2	3	5	2	8	11	13	4	46
		Performance correction	0	0	0	0	7	4	6	0	17

A' recordings of sounds made by actual animals and objects, *B* pictures, *C* printed words

Pair 1—pato$^+$/lobo$^-$, Pair 2—sino$^+$/gato$^-$, Pair 3—vaca$^+$/sapo

[a] Intermittent reinforcement schedule

and from 0.0 to 4.7 % correct in CD trials (i.e., word naming). Individual results (Fig. 1b and 1c) suggest that despite relatively high pretest scores on BC or CB relations for E2, E3, E5, and C7, the participants' responses were not under control of the conditional stimulus, as there was no consistency between correct responses in BC and CB trials. For example, the percentage of correct responses in BC trials for E3 was approximately 83.0 % but only 16.0 % in CB trials. Scores increased in the posttest for the experimental group and, moreover, there was a consistency of correct BC/CB matching for most classes, indicating that learned relations were transitive and symmetric. Examining individual performances, there was evidence of class formation for all the six stimuli trained for E3, five for E1 and E4, three for E5, two for E2 and E7, and one for E6.

Individual analysis of CD performance reveals that naming performance was null on the pretest for almost all participants, with the exception of one participant in the experimental group (E3) who correctly named one word and another participant in the control group (C7) who correctly named two words. On the posttest, C7 maintained correct naming of only one word, and no other participant from the control group read any word

Table 2 Individual performance of participants in experimental (E) and control (C) groups in pre- and posttest for trials AB, BB, CC, CRCCs, BD, CDs, and CD of generalization words

Participants	Test	AB	BB	CC	CRCCs	BD	CDs	CD generalization
E1	Pretest	100	83.33	58.33	0	100	0	0
	Posttest	100	83.33	58.33	16.67	100	0	0
E2	Pretest	91.67	100	83.33	100	100	0	0
	Posttest	100	100	100	100	100	0	0
E3	Pretest	100	100	91.67	100	100	0	0
	Posttest	100	100	91.67	100	100	0	0
E4	Pretest	91.67	100	50	25	100*	0	0
	Posttest	100	100	83.33	33.33	100	0	0
E5	Pretest	100	100	58.33	8.33	100	0	0
	Posttest	100	100	91.67	91.67	100	0	0
E6	Pretest	100	100	75	91.67	100	0	0
	Posttest	100	100	100	91.67	100	0	0
E7	Pretest	91.67	100	75	50	100*	0	0
	Posttest	91.67	100	91.67	75	100	0	0
C1	Pretest	100	83.33	50	25	83.33	0	0
	Posttest	100	83.33	33.33	0	83.33	0	0
C2	Pretest	100	83.33	83.33	25	100	0	0
	Posttest	100	100	91.67	16.67	100	0	0
C3	Pretest	100	100	100	50	50	0	0
	Posttest	100	100	58.33	33.33	66.67	0	0
C4	Pretest	100	83.33	25	0	100	0	0
	Posttest	100	83.33	75	33.33	100	0	0
C5	Pretest	83.33	100	75	25	50	0	0
	Posttest	83.33	100	91.67	50	50	0	0
C6	Pretest	75	66.67	16.67	0	50	0	0
	Posttest	83.33	100	25	8.33	33.33	0	0
C7	Pretest	100	100	75	41.67	100	0	0

The asterisks denote participants that received AB training before the experimental procedure because their picture-naming performance was lower than 100 % in the pretest

E participants in the experimental group, *C* participants in the control group

correctly. On the other hand, all participants from the experimental group correctly named at least one word in the posttest, and half of them correctly named 50 % or more of the training words. Neither group showed naming of syllables and generalization words.

The Mann-Whitney *U* non-parametric test was conducted to investigate differences in performance between groups on test trials, and it revealed no statistically significant differences in performance for any of the relations assessed in the pretest. Thus, it can be concluded that the participants' initial repertoire was similar for both groups. When each group's pre- and posttest performances were compared (Wilcoxon test), percentage of correct responses was significantly higher in the posttest for the experimental group for relations BC ($Z=-2.197$; $p=0.028$), CB ($Z=-2.366$; $p=0.018$), and CD ($Z=-2.371$; $p=0.018$). Differences between tests were not statistically significant for the control group. No participants in the experimental or the control group named syllables or generalization words correctly in either the pre- or the posttest.

A comparison between groups (Mann-Whitney *U* Test) revealed statistically significant differences in accuracy in the posttest for relations AC ($U=1$; $p=0.001$), BC ($U=2$; $p=0.002$), CB ($U=6$; $p=0.017$), CC ($U=10$; $p=0.043$), CRCCs ($U=8$; $p=0.038$), and CD of training

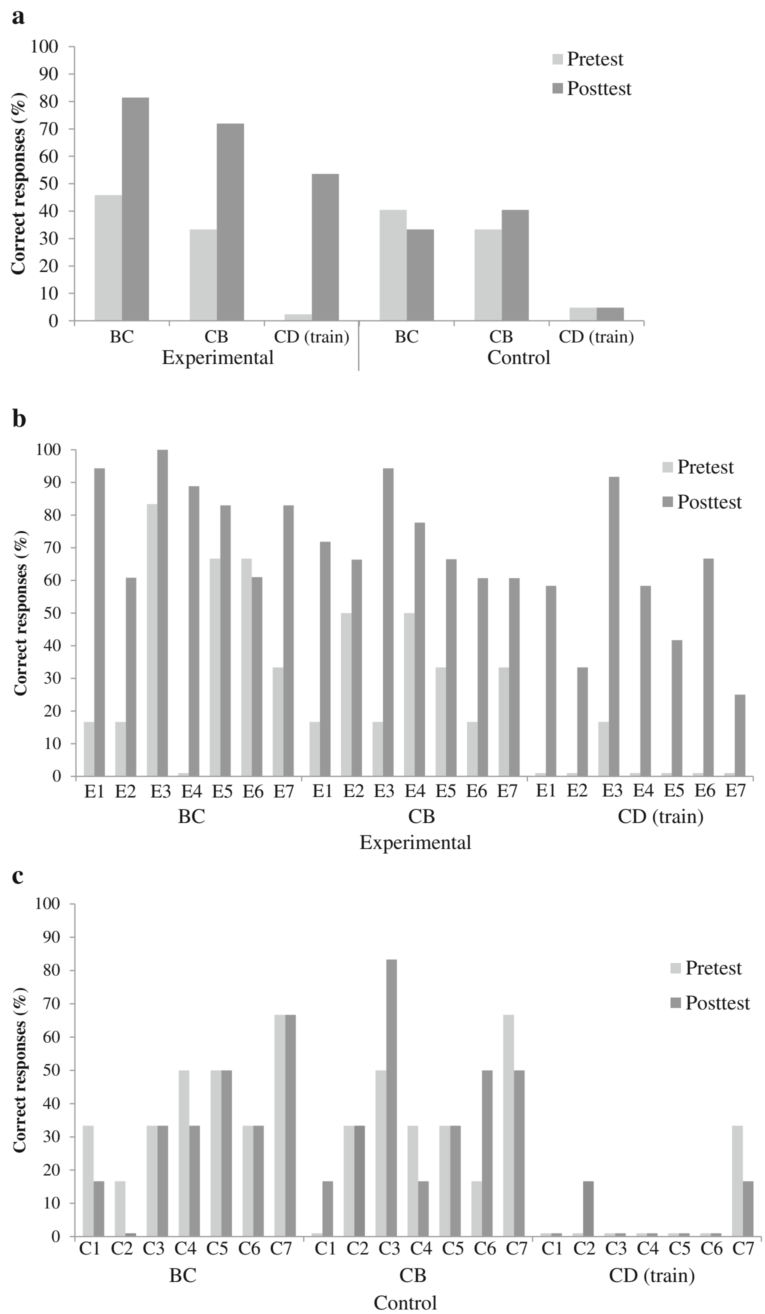

Fig. 1 Percentage of correct responses on BC, CB, and CD relations on pre and posttests for participants sorted by experimental and control groups (**a**) and individual participants' performances of experimental (**b**) and control (**c**) groups

words (U=0.5; p=0.001). Accuracy for the experimental group was, on the average, twice as high as for the control group. For printed word naming, differences in performance between groups after training were even larger, since accuracy of the experimental group was more than 10 times higher than that of the control group.

Discussion

The present study aimed to propose an EBI package to teach reading to individuals with intellectual disabilities, combining simple and conditional discrimination training and specific reinforcement. Symmetry and transitivity tests indicated that training relations A'B and A'C (recorded sounds related, respectively, to pictures and printed words) resulted in the formation of equivalence classes, each comprising the corresponding pictures, printed word, and recorded sound. When asked to name the printed words in the posttests, however, participants produced the spoken word rather than the recorded sound, being able to read the printed words in more than 50 % of the trials, in average. This was possible because training with recorded sounds as samples established printed words and pictures as members of the same class (together with their respective recorded sounds). Instructions for the naming posttest specified that words were required rather than recorded sounds. Although no formal tests verified this, it is very likely that an equivalence relation between recorded sounds and pictures and names of corresponding objects existed before the study began. Therefore, after training established printed words and pictures as equivalent (together with respective recorded sounds), participants extended to printed words the names of pictures equivalent to them.

The use of recorded sounds instead of dictated words as auditory stimuli was intended to make training more interesting and motivating for participants. This did not impair stimulus class formation, indicating that recordings of sounds made by objects and animals could be included in teaching programs that use conditional discrimination procedures, in order to make activities more playful. It is possible, however, that absence of dictated words as samples during training might have resulted in an inferior posttest performance on word naming than could be obtained with the dictated words as samples. Studies with deaf children with cochlear implants have shown that the probability of equivalence class formation increases with exposure to the dictated words (Almeida-Verdu, dos Santos, de Souza & Bevilacqua, 2008; Battaglini 2010). Further research should compare posttest results after training with recorded sounds or with the words themselves. If training with the actual words results in superior performance, teaching programs might present the words in some trials and recorded sounds in other trials in an attempt to maximize advantages of both types of sample stimuli. This would guarantee that students are sufficiently exposed to the actual dictated words and would also render learning sessions less repetitively. In addition, posttest naming scores may have been reduced because naming was never required during training. Naming of printed words was, therefore, a completely new repertoire required only on test situations. Considering this, the inclusion of echoic trials, requiring the student to repeat the dictated word, could facilitate naming (Almeida-Verdu et. al., 2008; Matos et al. 1997; Souza 2010), because it would include in training a task similar to the one required in the posttest.

Only one participant named all training words and showed evidence of class formation for all of them. The other participants learned a variable number of words. This is a common result in EBI applications to reading. Most errors in CB/BC matching occurred when comparison stimuli had many letters in common (for example, “pato” and “gato” have the last three letters in common; “sapo” and “sino” have the first and last letters in common). Such similarities may have impaired discrimination between those stimuli and, consequently, the correct matching between them. In the present study, training never required participants to discriminate between comparison stimuli with many letters in common. In subsequent studies, therefore, it would be interesting to require subtler discriminations between words with several common letters.

Naming of syllables and generalization words were not observed in this study. Most typically, developing individuals, when exposed to conditional discrimination procedures, show recombination of syllables to form new words and generalized reading, which may indicate control by minimal textual units (letters and syllables), though performance on generalized reading is likely to be inferior to reading of training words. These procedures might generate control by smaller textual units, though equivalence relations might not be sufficient to produce control by all units (Matos et al. 1997). A study by Melchiori et al. (2000) that aimed to teach reading to adults and children with and without intellectual disabilities found that participants with intellectual disabilities needed more performance correction procedures and presented poorer results on generalized reading. This might suggest that although generalized reading might be a result of conditional discrimination training, it is possible that individuals with intellectual disabilities may need direct training of letters and syllable discrimination and naming to enhance control by these units and produce better results on generalized recombinative reading. In addition, substituting dictated words for recorded sounds as sample stimuli might impair performance on syllable naming and recombinative reading. When dictated words are not presented as sample stimuli, the correspondence between the sound pattern of the spoken word and the visual pattern of the printed word is removed and, as a result, recombinative generalization and syllable naming might be hindered. Also, at no point during training the spoken words that the participants must produce in the naming test were presented. This way, the names were not explicitly included in the equivalence class intended by training. And as a result, the emergence of oral naming of printed words might be hindered.

It should be noted, however, that picture naming was pretested, and training only began after participants showed 100 % accuracy in pretest AB trials. Thus, before training, there were preexisting relations in the participants' repertoire between dictated names and sounds and objects. In this case, oral naming might emerge due to the participation of the name in the existing equivalence class, and recombinative generalization might be expected if the participants correctly name the sounds in AB and AC training trials, permitting relations to emerge between parts of oral names and parts of printed words. The results showed that naming of training words was a frequent outcome even though dictated names were not included in training, but there was no evidence of recombinative generalization.

Regarding the role of simple discriminations and specific reinforces, both were used in an attempt to make the procedure easier for participants and to increase the probability of equivalence class formation and reading. There is considerable indication that this can facilitate learning for populations with restricted repertoires or intellectual deficiencies (Debert et al. 2006; de Rose et al. 1988; Lionello-DeNolf et al. 2008). Although results show that the intervention package used in this study was effective, it is not possible to isolate the respective contributions of simple discrimination and specific reinforcers. Thus, it is possible that simple discrimination with class-specific reinforcers might be sufficient to produce similar outcomes, or that these results could have been produced with conditional discrimination training alone (with or without class-specific reinforcers), without simple discrimination training. Future research should try to separately analyze these variables in order to determine to what extent these contribute to the positive outcomes found in the present study. For example, maintaining the training structure here proposed, additional test sessions could be administered immediately following simple discrimination training, but before conditional discrimination training. If all positive elements of the contingency, including the reinforcing stimuli, are members of equivalence classes as suggested by Sidman (1994, 2000), then specific reinforcers may be sufficient for equivalence class formation by themselves due to each one being contingent on selection of particular stimuli; in our study, a picture and also the corresponding word.

In addition, Saunders and Spradlin (1989) argue that simple discriminations are prerequisite for conditional ones. The present study began with simple discrimination training in an attempt to proceed from simple to more complex requirements, thus minimizing the occurrence of errors. Simple discrimination training occurred, however, only between some pairs of comparison stimuli. In subsequent studies, it would be interesting also to train simple discrimination between stimuli that would be samples in subsequent conditional discrimination training.

The present study shows that it is feasible to mix simple discrimination training and specific reinforcers in an instructional package to teach reading to students with intellectual deficiencies. Training comprising an average of 60 sessions of 3 min each (i.e., a total of three hours) was successful to promote reading, in variable degrees, for all students in the experimental group. Similar training could be applied to teach these individuals other symbolic relations of practical value in their lives, such as recognition and reading of their own names, public transport lines, phone numbers, addresses, etc., promoting independence and ability to handle a larger number of situations as their behavioral repertoire increases.

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