

Reading: A Matching to Sample Procedure in Teaching Generalized Reading Skills

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The purpose of the present research was to teach generalized reading skills to 6 years old boy diagnosed with PDD-NOS, who had already acquired a letter-sound correspondence. First, a matching to sample procedure was used to teach him to discriminate and read syllables (e.g. “ma”, “la”). Thereafter, a probe was conducted with words that consisted of recombinations of the previously taught syllables (e.g. “mala” or “lama”). The student was successful in reading these words. Additionally, reading of totally new words and syllables emerged. These data are discussed further for their importance in the development of effective and economical reading packages for children.

Key words: reading, matching to sample, recombination, generalization, stimulus equivalence

Several studies have shown that children who learned to read a set of words were also able to read new words formed by recombining textual units of the training words (de Rose, de Souza, & Hanna, 1996; Mueller, Olmi, & Saunders, 2000). Recombinative generalization is defined as the demonstration of novel recombinations of previously established linguistic units (Goldstein, 1993). The recombinative generalization literature has shown that persons taught to respond to several different complex stimuli that contain overlapping units come to respond appropriately to different combinations of the same units (Goldstein, 1993; Goldstein & Moussetis, 1989; Goldstein, 1984; Romski & Ruder, 1984; Strietfel, Wetherby, & Karlan, 1976, 1978). In these studies, the recombined units are discrete, whole words. For example, a child might be taught to name

several objects: a red square, a red cross, and a green square. Then, without training, the child could name a green cross. This procedure ensures exposure to all units involved in recombinative generalization.

Reading new words requires the recombination of units that are smaller than individual words. In reading, there are two levels of within-word units: syllables and phonemes. In 1992, de Rose, de Souza, Rossito, and de Rose used exclusion procedures to increase the children’s repertoires of conditional relations between printed-word comparisons and the corresponding dictated words. On exclusion trials, an undefined sample (not yet related to a participant comparison) is presented with an undefined comparison and other comparisons already defined. The participant may then “exclude” the defined comparisons, selecting the undefined one and often learning the relations between this stimulus and the sample. During this study, probes inserted periodically during training assessed whether the children named (read)

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the printed words to which they had previously responded in the exclusion procedure. In their study, generalization probes tested naming of novel words, formed by a recombination of the training words syllables (such as the word *boca* formed by the first syllable of the word *bolo* and the second syllable of the word *vaca*). In this study, subjects learned to read the printed words used during training. Further, as the repertoire of trained and emergent relations increased, most subjects began to read novel words, suggesting an acquisition of generalized reading performances. De Rose, de Souza, and Hanna (1996), showed that some Brazilian children, beginners in reading, were able to read novel two-syllable Portuguese words given that previous learned words contained the same component syllables. In this study, an exclusion based procedure and constructed response spelling was used to increase children's repertoires of conditional relations between printed-words comparisons and the corresponding dictated words. In their 1996 study, they also evaluated the extent to which the constructed-response task may have contributed to reading and spelling generalization.

In our study, the first major goal was to determine whether a child with autism could acquire generalized reading by learning to read syllables and afterwards words formed by those syllables. A second goal was to determine equivalence relations between printed words, dictated words and pictures. Equivalence relations provide behavioral criteria for the definition and assessment of meaning and comprehension (Sidman, 1986, 1994; Sidman & Tailby, 1982). The stimulus equivalence paradigm provides economical and effective methods to teach complex repertoires. For instance, Sidman (1971) taught a child with severe mental retardation who had learned to match pictures to dictated words, to match 20 printed-word comparisons to dictated samples. Afterwards, the participant would match picture comparisons to printed-word samples and printed-word comparisons to picture samples without

direct training. The participant could also name (read) the printed words. The emergent matching performances demonstrated in this study verified that the dictated words, printed words, and pictures were related by equivalence (Sidman, 1994). Related studies have shown stimulus equivalence that integrated reading and spelling. For example, MacKay and Sidman, (1984) and MacKay (1985) found that equivalence classes involving printed words could be established by teaching subjects to construct printed words with movable letters. For instance in one of their studies, Mackay and Sidman (1984) taught students who were mentally retarded to name color patches and construct the color names using movable letters (constructed-response spelling). Students subsequently matched printed-word comparisons to color patches and color comparisons to printed-word samples, and also named printed words. Teaching students to construct printed color names, therefore, established equivalence classes that consisted of dictated color names, printed color names and color names and colors. These findings suggest that equivalence relations may integrate reading and spelling performances. Another study from Stromer and Mackay (1992) supports this contention. The taught students with mental retardation to construct three different printed names in the presence of a picture and showed that the picture and the three printed words formed an equivalence class.

In learning to read Spanish words, the skill of recombining syllabic units is very important, as words are all broken into syllables and are pronounced in the same way independently of the position of the syllables (beginning, middle or end of the word). That means that, if a child learns to read all syllables, he can then combine them and read any word in Spanish. The studies previously mentioned assessed recombination after the student learned to read whole words. Our procedure differed because the student learned to match syllables and then demonstrated recombinative generalization of those

syllables. For example, set 1 consisted of the following syllables: ma, me, la, and le. We assessed generalized reading performances by presenting words formed by those syllables. Also, the study determined whether reading words promote comprehension by matching those words to pictures. Another novelty of this study is that it was conducted with a child diagnosed with PDD-NOS.

Method

Participant and Setting

A 6-year old boy diagnosed with PDD-NOS participated in this study. He attended an ABA home-based program intervention for 5 hours a day and had been enrolled in the program for 1 year and 5 months. His verbal skills included advanced receptive language (e.g., being able to follow multiple component instructions), intermediate mand repertoire (e.g., asking for help or manding for different things using sentences), intermediate tact repertoire (e.g., being able to label the function, feature and class of several objects), intermediate intraverbal repertoire (e.g., answering who, what and where questions) and advanced writing skills (e.g., being able to write any dictated letter or number without a model). Before the beginning of the study, the child had already acquired a letter-sound correspondence being able to discriminate among letters depending on the sound heard and also being able to read different letters by vocalizing the corresponding sound (e.g., saying "a" when asked to read the letter a). There had been a previous attempt to teach to the student global reading using whole words (without having previously taught him the syllables). This attempt failed, as the student was not able to discriminate among words that began or ended with the same letter but included different letters afterwards (e.g., lobo, loro or moto, pato). Words used during that teaching attempt were different from those probed during our study.

Sessions were conducted once a day,

three times a week, and usually every other day. Each session lasted about 15 minutes and was conducted in a small room at the participant's house. The child was seated next to the experimenter. Trials were presented only when the child was sitting quietly, displaying good eye contact, and not engaging in any off-task behavior (i.e., self-stimulation).

Materials

The visual stimuli were syllables, words and pictures. The auditory stimuli were dictated syllables.

The visual stimuli were categorized as: training syllable, recombined words, probe syllables, probe words and generalization stimuli. The training syllables were formed by a beginning consonant and a vowel (e.g., ma, me, la, and le). The recombined words were two syllable words formed by combining the training syllables (e.g. mala, mele). The probe syllables were syllables formed by a beginning consonant and a vowel (e.g. to, di). The probe words were one or more syllable words and were formed by combining probe syllables (e.g. todo, dito), by combining inverse syllables (vowel-consonant combinations such as "baul") or by including syllables containing different letter combinations (e.g., consonant-consonant-vowel combinations such as "pra"). The probe syllables and words were not taught. All the stimuli described were typed in Verdana 36. The generalization stimuli were the training stimuli and the recombined words typed in three different fonts: Capital letters in Times Roman font, size 36, Comic Sans MS, size 36 and Impact, size 36 (Table 1).

In all lessons, we used a combination of non-sense (e.g., mele, lama, leme) with existing Spanish syllables (e.g., mala). From lesson 1 to lesson 6, there were two-syllable unit words and from lesson 7 to lesson 15 there were one or more syllables in each word.

Reading Pre and post-test (recombined words, training and probe syllables and generalization stimuli). The stimuli during

Table 1. *Stimuli presented in each lesson.*

	Training Syllables	Probe syllables	Re-combinated words	Probe words	Generalization and Comprehension probes
Lesson 1	ma, me, la, le	to, ti, do, di	mala, male, mela, mele, lama, lame, lema, leme	todo, todí, tido, tidi, doto, doti, dito, dito	
Lesson 2				misa, misi, musa, musi, sami, samu, simi, simu	
Lesson 3				tilo, tili, tulo, tuli, lito, liti, lotu, loti	
Lesson 4				dafi, dafo, dufi, dufo, fida, fidu, foda, fodu	Same stimuli written in Impact instead of Verdana
Lesson 5				badi, baji, fadi, faji, diba, difa, jiba, jifa	Same stimuli written in Impact instead of Verdana
Lesson 6				piva, pive, pova, pove, vapi, vapo, vepi, vepo	Same stimuli written in capital letters
Lesson 7				pelota, sosuto, vonlú, bejoyu, bideja, bojeki, budofe, jukamo	Same stimuli written in Comic Sans MS instead of Verdana
Lesson 8				kenuse, kovivu, comida, patata, panaro, nerate, pureno, yariru	Same stimuli written in capital letters
Lesson 9				yexuku, moyoxi, yoxaxi, maxesa, yiseno, lavabo, dinero, sábado	Same stimuli written in capital letters
Lesson 10				pelota, comida, lavabo, patata, camisa, moneda, Katerina, maleta	Same stimuli and visual stimuli (pictures)
Lesson 11				abejas, atunes, olivos, ubadas, ebejes, iteres, utopes, inirux	
Lesson 12				bla, pru, fi, kte, sto, nta, mni, kme	
Lesson 13				ae, ua, io, ou, ci, ai, oa, uo, iu	
Lesson 14				mando, cuatro, baúl, tres, seis, siete, Silvio, papel	
Lesson 15				naranja, Nicolás, cuarenta, bañera, montaña, pendientes, gimnasio, camión	Same stimuli and visual stimuli (pictures)

these conditions were typed in the middle of a sheet of paper and presented in a list. The distance between the stimuli was 1 cm.

Matching- to- sample discrimination training (training syllables). During this condition a matching-to-sample format was used with training syllables. On the left hand edge of the sheet there was a sample (e.g. ma) and there were two comparisons to the right of it (e.g. ma, me). One of the choices matched the sample.

A vinyl display mask with a window in it was used during pre and post-test and during matching-to-sample. The purpose of using a mask was to reduce the distracters and each lesson was presented on a sheet of paper with the mask on it moving down from one line to the next one, with each line containing the sample and three comparisons during matching trials and one comparison during reading trials.

Comprehension test. The pictures that were used for comprehension were approximately 5cm by 5cm coloured photos and were printed on a separate sheet of paper.

Overview

The study was comprised of several lessons (See Table 1). Each lesson targeted reading a set of 8 words and 4 syllables that

were taught using a matching-to-sample procedure. Lesson 10 and 15 also included comprehension tests. First, we conducted a syllable and words reading pre-test. Then, a matching-to-sample procedure was used to teach reading syllables. This procedure consisted of 5 phases that were repeated until criterion was achieved. Reading post-test assessed whether the participant could read words formed by the syllables learned through the matching-to-sample procedure. A reading post-test was also conducted with probe syllables, probe words and generalization stimuli. The conditions and the type of stimuli used to teach each lesson can be seen in Table 2.

Correct responses for reading, matching and comprehension test consisted on reading or pointing to the stimulus respectively that occurred after 3 seconds of the instruction and with no prompts. During pre and post-test, correct responses were not reinforced and incorrect responses were not followed by feedback or correction. During matching-to-sample training and comprehension test, correct responses were always followed by social reinforcement (confirmation and praise) and by tokens that could be exchanged, after the participant gained 10 tokens, for items available on a shelf. If the child made an

incorrect response, the experimenter used manual guidance to help him point to the correct comparison. The trial was repeated until the child made a correct response. Correct responses following this prompt were not reinforced.

Procedure

Only lesson 1 required all 5 conditions. The remaining lesson only required Condition 5.

Condition 1. Words reading-Pretest (Recombined, Probe and Generalization stimuli). During this condition, we conducted a pretest for three different types of stimuli. First a pretest was conducted with recombined words, then with probe words and finally with generalization words. During the pretest for each of the different type of stimuli, the experimenter presented a list of 8 words and conducted 16 trials for each set of stimuli. For example, during the pretest of recombined words, we presented 16 trials consecutively. Each stimuli appeared twice on the list in a randomize order. In each trial, the experimenter gave the instruction “read”, waited for 3 seconds and then presented the next trial. If the participant did not achieve criterion (15 out of 16 consecutive trials), we moved on to the next condition.

Condition 2. Syllables reading-Pretest (Training, Probe and Generalization stimuli). During this condition, we also conducted the pretest for three different types of stimuli. First, a pretest was conducted with training stimuli, then with probe stimuli and finally with generalization stimuli. During the pretest for each type of stimuli, the experimenter presented a list of 4 syllables, and conducted 8 trials. For example, during the pretest of training syllable, we presented 8 trials consecutively. Each stimuli appeared twice on the list in a randomize order. In each trial, the experimenter gave the instruction read, waited for 3 seconds and then presented the next trial. If the participant did not achieve criterion (7 put of 8 consecutive trials), we moved on to the next condition.

Condition 3. Matching to Sample Discrimination Training (Training syllables).

This condition was divided in 5 phases

Phase 1. Discrimination between syllables *ma* and *la*. We first targeted two syllables that differ on the first letter. The training consisted of 20 trials (15 auditory-visual to visual matching and 5 auditory-visual discriminations). For each pair of syllables, a block of 4 auditory-visual to visual matching trials was conducted with one syllable as a sample in each trial and two syllables as comparisons. The experimenter presented the instruction (e.g. “Match *ma*”) and waited for 3 seconds. Following, a block of 4 auditory-visual to visual matching trials, a trial in which the sample was only auditory (spoken syllable) was presented. Two syllables were presented as comparisons and pointing to the comparison corresponding to the dictated syllable was reinforced. The mastery criterion to move on to a new phase was 19 correct responses out of 20 trials.

Phase 2. Discrimination between syllables *me* and *le*. During this phase we also targeted two syllables that differ on the first letter. During this phase, training was conducted in the same manner as in phase 1. Mastery criterion was also the same.

Phase 3. Discrimination between syllables *ma*, *me*. During this phase we targeted two syllables that differ on the second letter during this phase, training was conducted in the same manner as in phase 1. Mastery criterion was also the same.

Phase 4. Discrimination between syllables *la* and *le*. During this phase we also targeted two syllables that differ on the second letter. During this phase, training was conducted in the same manner as in phase 1. Mastery criterion was also the same.

Phase 5. Discrimination between syllables *ma*, *la*, *me* and *le*. During this phase there were a total of 8 auditory-visual trials. The experimenter only presented auditory samples (spoken syllables) and four visual comparisons (written syllables). As in the other phases, the participant was required

Table 2. *Type of stimuli presented in every experimental condition and phase.*

	Training Syllables	Probe syllables	Re-combinated words	Probe words	Generalization and Comprehension probes
Lesson 1	ma, me, la, le	to, ti, do, di	mala, male, mela, mele, lama, lame, lema, leme	todo, todi, tido, tidi, doto, doti, dito, ditto	
Lesson 2				misa, misi, musa, musi, sami, samu, simi, simu	
Lesson 3				tilo, tili, tulo, tuli, lito, loti, lotu, loti	
Lesson 4				dafi, dafo, dufi, dufo, fida, fidu, foda, fodu	Same stimuli written in Impact instead of Verdana
Lesson 5				badi, baji, fadi, faji, diba, difa, jiba, jifa	Same stimuli written in Impact instead of Verdana
Lesson 6				piva, pive, pova, pove, vapi, vapo, vepi, vepo	Same stimuli written in capital letters
Lesson 7				pelota, sosuto, vonilu, bejoyu, bideja, bojeki, budofe, jukamo	Same stimuli written in Comic Sans MS instead of Verdana
Lesson 8				kenuse, kovivu, comida, patata, panaro, nerate, pureno, yariru	Same stimuli written in capital letters
Lesson 9				yexuku, moyoxi, yoxaxi, maxesa, yiseno, lavabo, dinero, sábado	Same stimuli written in capital letters
Lesson 10				pelota, comida, lavabo, patata, camisa, moneda, Katerina, maleta	Same stimuli and visual stimuli (pictures)
Lesson 11				abejas, atunes, olivos, ubadas, ebejes, iteres, utopes, iñirux	
Lesson 12				bla, pru, ftí, kte, sto, nta, mni, kme	
Lesson 13				ae, ua, io, ou, ei, ai, oa, uo, iu	
Lesson 14				mando, cuatro, baúl, tres, seis, siete, Silvio, papel	
Lesson 15				naranja, Nicolás, cuarenta, bañera, montaña, pendientes, gimnasio, camión	Same stimuli and visual stimuli (pictures)

to point to the correct stimulus that corresponded to the sample stimulus in less than 3 seconds. The mastery criterion was 7 correct responses out of 8 consecutive trials.

Condition 4. Syllables Reading-Posttest (Training, Probe and Generalization stimuli). A reading posttest was conducted with the syllables taught during training, as well as with the generalization and probe stimuli. This condition was conducted in the same manner as the condition 2.

Condition 5. Words Reading-Posttest (Recombined, Probe and Generalization stimuli). A reading posttest was conducted with the words presented during the pretest. This condition was conducted in the same manner as the condition 1. Following the completion of the posttest for the first set of recombined words and the set of probe words, more sets of words were introduced but without providing additional training with syllables. During this condition, no prompts were given with the exception of the 11th and 12th lessons, where echoic prompts were used in two sessions of each lesson when an incorrect response was given. In those lessons, inverse syllables (vowel-consonant instead of consonant-vowel) and syllables with two consonants and one vowel (e.g., “blu”, “pra”, etc.) were included respectively. Follow-up data were taken qualitatively ten

months after the completion of the study, included parent’s reports on the student’s reading skills and indicated that the student’s reading skills were maintained

Data Collection

The experimenter recorded manually correct and incorrect responses on a data sheet. A correct response was recorded when the participant emitted the correct vocalization or pointed to the correct comparison within 3 seconds of stimulus presentation, in both discrimination and reading trials. If an incorrect response was given or no response was given within 3 seconds, an incorrect response was recorded. If more than one response was emitted, an incorrect response was also recorded.

Interobserver Agreement

A second observer independently collected data on 9% of all sessions and across all the different conditions. An agreement was scored for each trial in which both observers recorded a correct or an incorrect response. Otherwise, a disagreement was scored. A total point-by-point Interobserver Agreement (IOA) was calculated by dividing the number of agreements by the sum of agreements and disagreements and converting this ratio to a percentage. The mean percentage of

Interobserver Agreement (IOA) was 99.7% (range: 94-100%).

Results

Condition 1. Words Reading Pretest (Recombined, Probe and Generalization stimuli). In the first condition, the accuracy was 0% in the three different probes (recombined, generalization and probe words). The student did not make any correct responses when asked to read three different sets of words, the target-recombined words in the teaching and generalization formats and the probe words (Figure 1).

Condition 2. Syllables Reading Pretest (Training, Probe and Generalization stimuli). In the second condition, the results were again 0% of correct responses for all the different syllables presented (target, generalization and probe syllables) (Figure 1).

Condition 3. Syllables Matching to Sample Discrimination Training (Training syllables). The results for the five phases of this condition can be observed in Figure 1. The student reached the mastery criterion in all the different phases and needed a total of 15 sessions to complete all the trials.

Condition 4. Syllable Reading Posttest (Training, Probe and Generalization stimuli). In this condition, the student

reached the mastery criterion by reading all target syllables, all the generalization syllables (syllables written in different format) and by additionally reading totally new syllables (Figure 1).

Condition 5. Words Reading Posttest (Recombined, Probe and Generalization stimuli). A reading posttest was conducted with the words presented during the pretest. The student read the words consisted of a recombination of the taught syllables and also read them in a different format (generalization stimuli) (Figure 1). Additionally, he read totally new words.

Following the completion of the experiment for the first two sets of words (the recombined words and the probe ones) and in the next 22 days, the student learned to read 117 totally new words, as more sets of words were introduced without providing additional training with syllables (Figures 1 and 2).

During the 5th condition and for the following sets of words, no prompts were used, except for the 11th and 12th sets of words. The student's errors in the 11th set involved not reading the consonant, reading the consonant and the vowel in inverse order or other random textual responses (e.g., reading "o" instead of "os" in the word "olivos" or reading "ba" instead of "ab" in the word "abre", etc.) In the 12th set, errors included vocalizing a

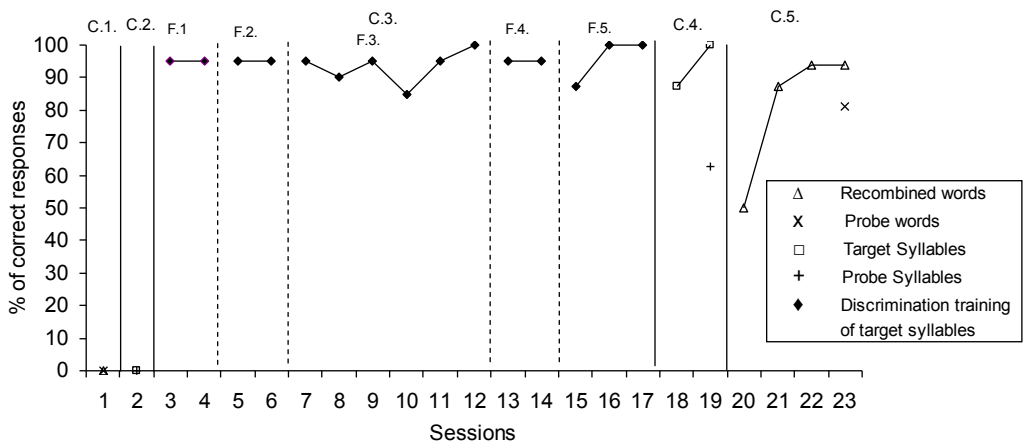


Figure 1. Vocal textual response emergence and recombination generalization after MTS and auditory-visual discrimination training.

vowel between the two consecutive consonants (e.g., reading “bala” instead of “bla” and/or “noco” instead of “nco” in the word “blanco”, etc.).

The total amount of time dedicated to this reading activity, including all conditions, was 4,5 hours and the student finished the program reaching mastery criterion on all different sets of words presented (Figures 2 and 3).

In Figure 2, reading, generalization and

comprehension tests can be observed. The student obtained 15 out of 16 correct responses on the first comprehension test and 16 out of 16 on the second, showing a very high and satisfactory comprehension level. Maintenance data are reported qualitatively, mentioning that the student is able to read phrases including any different kind of words without any prompt 10 months after the completion of the study.

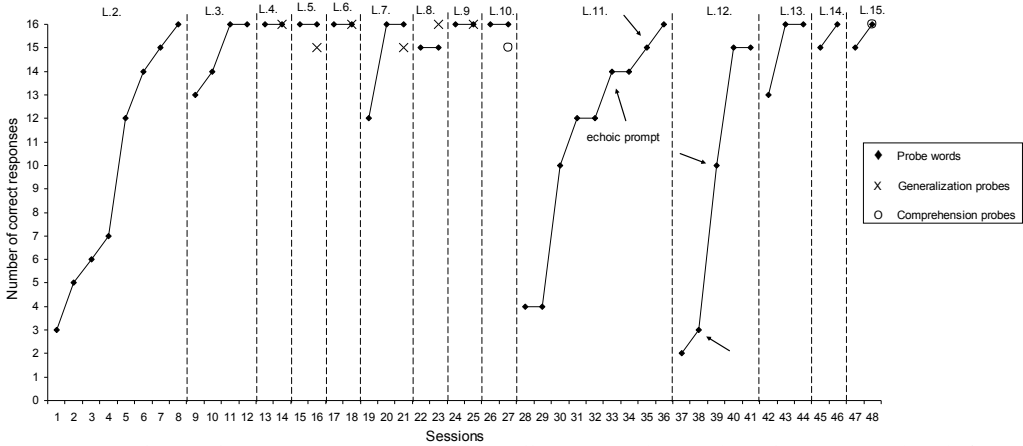


Figure 2. Vocal textual response emergence with totally new words (words probe) presented in different formats (generalization probes) and stimulus equivalence (comprehension probes).

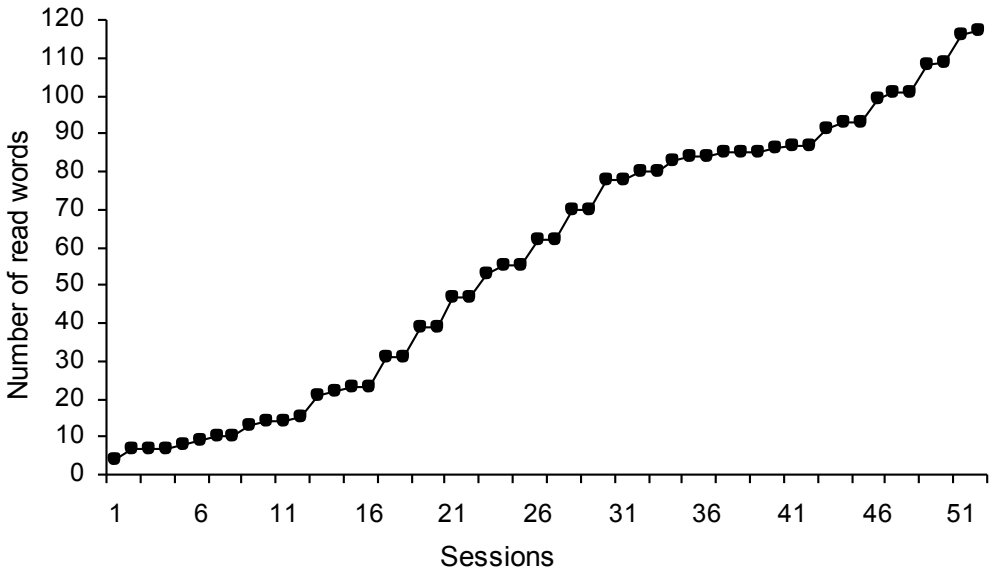


Figure 3. Number of read words (vocal textual response) in 52 sessions of 5 minutes each (22 days).

Discussion

The student's accuracy on the discrimination task was very high and after reaching the mastery criterion, he was able to read the taught syllables (textual response emergence) written in different formats (generalization). Also, he achieved criterion in reading totally new syllables, suggesting that units smaller than syllables (phonemes) controlled his responses. Additionally, the student was able to read words constructed by the previously taught syllables (recombination generalization), as well as totally new words (generalized reading), showing comprehension at the same time (stimulus equivalence).

In this study, training included an auditory-visual to visual matching. Assuming that the participant could complete correctly this task without regard to the spoken work presented in each trial (e.g., "Match ma"), it would be interesting for future research to determine whether the visual stimuli prompted correct auditory-visual response resulting in discrimination acquisition (naming) or learning was conducted during corrections provided in the auditory-visual discrimination trials. Our data suggest that few errors were made during auditory-visual discriminations, thus suggesting that acquisition occurred during visual-visual matching to sample training and stimulus control effectively transferred to auditory stimuli afterwards. Therefore, naming, the capability to learn speaker behavior from instruction as a listener and listener behavior from instruction as a speaker, may have been the basis for the obtained results (Fiorile & Greer, 2006; Greer & Ross, 2008).

Letter-sound correspondence could account for the emergence of reading of totally new syllables and words. Phonemes are the smallest units and in Spanish language the correspondence between letters and sounds is univocal (exceptions such as ca-ce-ci-co-cu were not included), thus facilitating generalized reading after only teaching to read single phonemes. Also, the fact that

the participant had already a letter-sound correspondence and the fact that he was taught to read phonemes combined in syllables may have accounted for the fact that after learning to read some syllables, he was able to read any other new syllables or words. In Figure 1, we observe that the student was able to read correctly 60% of the totally new syllables presented and after repeated testing through the presentation of words including the same new syllables, his accuracy increased significantly.

In sum, this method can be easily converted into an effective computerized instructional programme, offering the advantage of a relatively free of treatment integrity failures teaching procedure and assuring the efficient development of functional reading skills.

Future research is needed to be conducted with more subjects to support that similar results can be obtained with typically developing children or with children with learning difficulties of different developmental levels. Also, different teaching procedures could be compared to discrimination training (listener response), as for example copying, spelling or dictation repertoire training.

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