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A Longitudinal Study of Derived Relational Responding in an Infant with a Significant Language Delay

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A LONGITUDINAL STUDY OF DERIVED RELATIONAL RESPONDING IN AN INFANT WITH A SIGNIFICANT LANGUAGE DELAY

by
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ABSTRACT

Henry, a child (23 months old at the beginning of the study) with an expressive language delay was trained to derive relations over a three month period. He was taught to match visual, vocal, and signed stimuli for several objects. The researchers were searching for a pattern in the development of matching relations, relations of mutual entailment, and relations of combinatorial entailment over the duration of the study. For each relation the researchers examined the number of trials needed for independent correct responding. The results showed the child's performance on derived relational responding improved over time. Henry began to independently derive relations with fewer trials, and often on the first trial. The results also illustrate that mutual entailment does not always come before combinatorial entailment. These findings suggest that training may improve a child's performance on derived relational responding tasks, and also increase language use.

TABLE OF CONTENTS

LIST OF FIGURES

A Longitudinal Study of Derived Relational Responding in an Infant with a Significant Language Delay

Over thousands of years humans have acquired an extraordinarily complex system of communication. The ability to communicate at such a sophisticated level is uniquely characteristic of human beings. Of equal complexity is the development of this behavior from birth throughout life. For many years the emergence of language has been of great interest to psychologists. However, the psychology community has struggled to produce an empirical means to study this phenomenon (Hayes, Barnes-Holmes & Roche, 2001a, p. xi). With an empirical account of language, psychologists could effectively study verbal behavior. A new avenue into preventing and treating the growing number of language problems would be opened.

There have been many attempts to explain the phenomena of language development. History shows that even since the times of Aristotle this topic was debated (Modrak, 2009). Modern explanations have come from various fields such as behaviorism and cognitive psychology. The problem is that most of these theoretical accounts have not produced a lot of applied research. As stated by Noam Chomsky, "linguistics has nothing to offer to the teaching of language" (as cited by Abushibab, 2008).

Historical Overview

Among the most well-known perspectives on the development of language are the products of Noam Chomsky (1965), B.F. Skinner (1957) and Jean Piaget (1952). Chomsky's generative grammar theory states that humans have acquired an innate knowledge of rules which give structure to sentences (Chomsky, 1965, p. 8). He

describes language acquisition as, "a cognitive growth which grows in accordance with general principles that are a part of your nature" (Chomsky in Jack, 2006). Although his research received a lot of attention in the world of psychology, it was an openly theoretical approach and has led to little applied research (Abushibab, 2008).

Of equal magnitude was Jean Piaget's theory of cognitive constructivism (Piattelli-Palmarini, 1980). His theory states that children construct knowledge throughout their lives in several stages (Piattelli-Palmarini, 1980). Various tools such as the ability to speak are acquired after periods of development in their thought processes. This perspective suggests that children are not taught language, but they develop this ability on their own once they are mentally competent (Piattelli-Palmarini, 1980).

As this thesis focuses on behaviorism and language, emphasis will be given to B.F. Skinner's work. In Skinner's book *Verbal Behavior* he describes language as behavior subject to reinforcement from the environment, specifically reinforcement provided by a listener, as with any other operant behavior (Hayes, Blackledge & Barnes-Holmes, 2001, p. 9). *Verbal Behavior* gave valuable information to the field of linguistics, but several problems exist in Skinner's depiction of language. The problem lies within Skinner's definition of verbal behavior. Hayes et al. (2001) noted that Skinner's definition of verbal behavior is too broad. The definition describes a few simple forms of verbal behaviors, but does a poor job explaining complex language (Hayes et al., 2001, p. 14, 15). Due to this inadequate definition of verbal behavior very little research has been generated by Skinner's account. In a recent study by Dymond, O'Hora, and O'Donovan (2006) only 67 of 1093 articles citing Skinner's *Verbal Behavior* were empirical.

A Modern Behavior Analytic Treatment

Modern day behavior analysis provides an empirical avenue into examining human language. Through the works of Steven C. Hayes, Dermot Barnes-Holmes and many other researchers, Relational Frame Theory (Hayes et al., 2001) has grown from Skinner's behavioral account of language. This theory offers an explanation as to how humans acquire complex language.

Stimulus equivalence.

A key empirical antecedent of Relational Frame Theory is stimulus equivalence and the ability to derive relationships among stimuli. As stated by Hayes and colleagues the processes of stimulus equivalence had been recognized long before Sidman's 1971 paper. However, Sidman is a primary figure in the development of a contemporary empirical and theoretical behavioral account. In Sidman's study he trained a learning disabled child to match spoken to printed words. After multiple exemplars were trained, the child was then capable of matching printed words to pictures and naming printed words aloud without direct reinforcement (Sidman, 1971). This ability to form equivalence relations is important to behavioral scientists. There is a strong relation between equivalence performances and the kind of bi-directionality that seems to characterize word-referent relations (Hayes et al., 2001, p. 19). For behavioral researchers these equivalence relations are the missing link to a behavioral account of language (Hayes et al., 2001, p. 19).

Relational responding.

As stated by Hayes et al. (2001) most organisms are capable of responding to relations among the physical properties of two or more stimuli if given the appropriate

training. For example, Harmon, Strong, and Pasnak showed monkeys could learn to pick the tallest object in an array even when a novel, taller stimulus was presented along with a previously correct stimulus (Harmon, Strong, & Pasnak, 1982). Given enough examples an organism will respond to the relation between the stimuli rather than their absolute characteristics (Hayes, Fox, Gifford, & Wilson, 2001, p.25). This ability to respond relationally is acquired through multiple exemplar training (Hayes, Barnes-Holmes & Roche, 2001b, p.141, 148).

Multiple exemplar training.

As previously stated, it is through multiple exemplar training that relational responding can be taught to most organisms, including humans. Multiple exemplar training involves giving multiple opportunities to make a response within a given context and allowing the subject to experience the consequences (Fox, 2002). For example, a child may be reinforced to say the word "ball" when shown a ball, and touch a ball when the word "ball" is spoken. This symmetry relation may be trained with several other objects also. As stated by Hayes et al. (2001), with enough instances of this directly trained symmetrical responding, symmetrical responding may emerge with respect to novel stimuli. If one were to teach this child to say "book" when shown the novel stimuli book, the symmetrical relation of touching book when the word "book" is spoken should be derived. Multiple exemplar training of this type is abundant in language training history (Hayes et al., 2001, p. 26).

Classes of responding.

Relational Frame theory includes three classes of responding. These are mutual entailment, combinatorial entailment, and transformation of stimulus function. Mutual

entailment is responding to one event in terms of the other and vice versa. For example, if A is related to B, then B is related to A (Hayes et al., 2001, p. 29). Combinatorial entailment involves more than one stimulus relation. For example, if A is related to B, and B is related to C, then as a result of A and C are mutually related in that context (Hayes et al., 2001, p. 30). With transformation of stimulus function, if a given stimulus in a relational network has certain psychological functions, the functions of other events in that network may be modified in accordance with the underlying derived relation (Hayes et al., 2001, p. 31). For example, the word "ball" may be in the same relational class as the object ball. The object ball has the function of bouncing. Transformation of stimulus function allows one to think about bouncing, a function of the object ball, in the presence of the word "ball". The word "ball" has acquired a function of the object ball. This type of indirect responding is common in daily life. The derivation of these stimulus relations has not been robustly demonstrated in any species except language able humans (Devany, Hayes, & Nelson, 1986).

Relational framing.

Relational frames are generalized operant response classes formed by a history of multiple exemplar training (Gomez et al., 2001). Equivalence relations are the most researched frames. Relational frames are comprised of the three classes of responding previously mentioned. The stimulus members which an organism is relationally responding to are grouped into what can be called a relational frame. There are many types of relational frames. One kind is a frame of comparison. For example, A is larger than B and B is larger than C. Along with this many other comparisons between A, B and C can be derived. A, B and C are the stimulus members which are being responded to.

Grouped together these make up a relation frame.

Language and Relational Frame Theory.

Language is a tool that children acquire at a very young age. Often times this ability is hindered by problems such as a language delay. As shown by Lipkens, S. C. Hayes, & Hayes (1993) the ability to form relations does not require sophisticated language use. It may be the case that directly training relations among verbal and visual stimuli for a given object with multiple exemplar training will facilitate the development of language (Lipkens, et al., 2001). This type of training may be an effective means of aiding children with language delays.

Purpose of Present Study

Behavior analysts have recently become interested in derived relational responding as the defining property of verbal behavior (Hayes, Barnes-Holmes, & Roche, 2001). The current study will examine the emergence of two aspects of derived relational responding (mutual entailment, and combinatorial entailment) in the repertoire of a 23-month old infant with a significant language delay. The present study will inspect if there is a pattern in the emergence of these responses.

Methods

Participant

"Henry," a male child with an expressive language delay, was the participant. Henry was 23 months old at the beginning of the study. Prior to the study, Henry had a series of middle ear infections resulting in hearing problems. This was treated with a tympanostomy tube. The expressive language delay made his language abilities

equivalent to that of a 14 month old child at the time the study began. This was measured with the Receptive-Expressive Emergence of Language Scales, REEL-3.

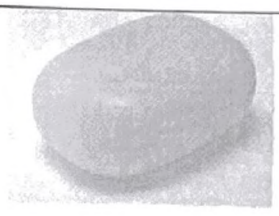
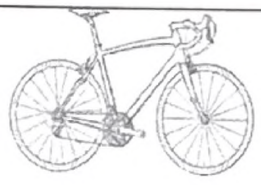
Experimental Setting

The first two days of the experiment took place in the child's bedroom with a small table and chair for the child to sit at during work time. The child's toys were located across the room and only available during play time. As the study progressed the child was given access to any location in and out of the house.

Materials

Twelve everyday objects were chosen at random for use in this study. For each object there was one vocal and two visual stimuli. The vocal stimuli used were spoken words such as "ball" or "book." The experiment also used two types of visual stimuli, signs and pictures. The two visual forms of each object were a picture and a hand sign. The sign for each object was taken from an American Sign Language dictionary. The pictures used were colored drawings of familiar objects on (4in. x 5in.) laminated cards (see Figure 1).

Spoken	Picture	Sign
"Ball"		
"Book"		

"Car"		
"Bed"		
"Soap"		
"Juice"		
"Bike"		
"Shirt"		
"Fork"		

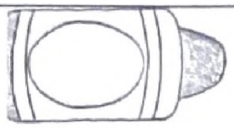
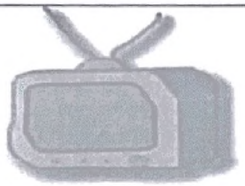
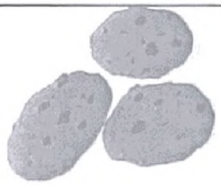
"Color"		
"T.V."		
"Cookie"		

Figure 1. Stimuli

Procedure

Testing.

Prior to any training sessions, baseline testing was given on his ability to form relations between the stimuli for each object. He was tested on his ability to form the following relations for each object: signed to spoken; spoken to signed; signed to picture; picture to sign; spoken to picture; picture to spoken. For example, Henry was shown a picture of a bike and told, "sign this." Henry was given three seconds to respond appropriately. If he did not respond correctly, no assistance or answer was given. During testing preferred stimuli were not delivered for correct responses. The response was simply marked as made or not, and the next relation was tested.

Training.

Training began following the conclusion of baseline testing. Starting with ball, the researchers trained the relations between the various stimuli of each object. The order of

relations trained was chosen at random. For each object the researchers began by choosing one matching relation to train first. For example, for the object ball the first matching relation was between the sign of ball and the spoken word "ball." The researcher would make the sign for ball with his hand, and then ask "what's this?" In this example the correct response was "ball." Next, the researcher would choose another relation to train. In our example with ball, the researchers chose to train a new matching relation between a picture of a ball and the sign of ball. The researcher would show the picture of the ball to Henry and say "sign this." In this example the correct response was for Henry to make the sign of ball with his hands. If the researchers wanted to directly train a relation of mutual entailment they would ask the inverse of a previously trained matching relation. For example, with ball the researchers trained the inverse of picture to sign with a relation of mutual entailment between the sign of ball and the picture of a ball. The researcher would arrange five pictures, make the sign for ball, and say "touch this." The correct response was to touch the picture of ball from the array of pictures. If the researchers chose to train a relation of combinatorial entailment they would train a relation between two stimuli which had not been matched yet. For example, if the researchers trained matching relations between the picture of ball and the sign of ball, and also the sign of ball to the spoken word "ball" they could then train a relation of combinatorial entailment between the picture of a ball and the spoken word "ball." This is because these two stimuli were not previously matched in a matching relation. For all trials during training the child was given three seconds to respond without prompting. This allowed the researchers to determine if the child was forming the relations independently on the first trial with each relation, or if reinforcement was need. The

researchers used errorless learning during the training. That is, if an inappropriate response or no response was given then the child would be prompted, from least to most, until he gave the appropriate response (see Figure 2). If the child responded correct on his own his behavior was followed with the delivery of a preferred stimulus. Correct responding, even with a prompt, was followed by delivery of a preferred stimulus.

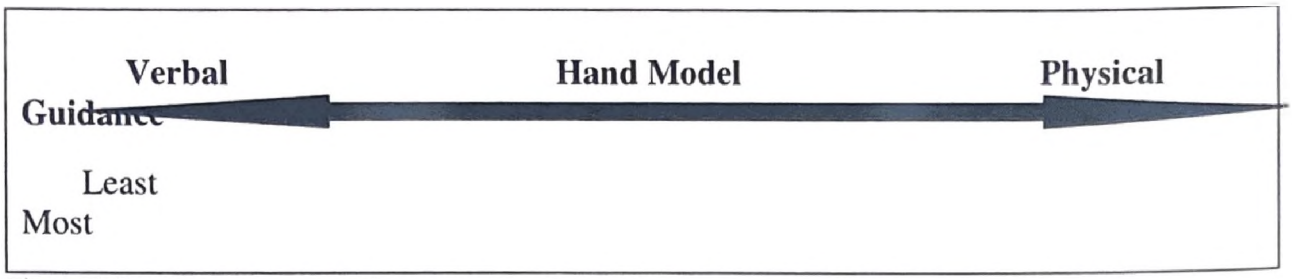


Figure 2. Least to most prompting

The researchers went through all relations for each object noting if it was a matching relation, a relation of mutual entailment, or a relation of combinatorial entailment. By allowing Henry to respond independently to the first trial of each new relation the researchers could examine which relations were formed without any direct reinforcement.

During the first two training sessions the child was asked to go to his seat when a timer signaled the end of play time. Access to toys was removed during testing. Several preferred stimuli such as small cars were chosen and used as reinforcers for sitting at the table and for correct responses. Training was not efficient in the first two sessions delivered in this manner. Only 3-4 trials could be asked during each work period before the child lost attention and became disruptive. The training shifted into child led sessions on the third day of training. The child was allowed to go freely around the house and do

any activity he pleased. While delivering questions, access to preferred areas and activities was withheld. For example, if the child wanted to play basketball a question was asked before he was allowed to hold the ball. Once the child responded correctly access to the basketball was given. Training of this type was very effective, and used for the remainder of the study.

During each session the child was trained one or two different relations. In each session, anywhere from 20-50 trials were asked depending on the child's behavior that day. For example, if the child wanted to play baseball for an hour, 40 questions might be asked in that time period. If the child was tired and wanted to read a book, only 20 questions might be asked before falling asleep. This procedure reduced the stress placed on the child during training.

Dependent variables.

There were several dependent variables in the current study. For the matching relations being directly taught the study was looking at the number of trials needed for independent correct responding. It is expected that with more exposure to these matching relations the child will make independent correct responses with fewer trials. The study also looked at the child's ability to form relations of mutual and combinatorial entailment. This was described as giving correct responses on the first trial for a given relation.

Results

Baseline testing

Consistent with an expressive language delay, Henry accurately matched spoken label to picture for all 12 objects; He responded inaccurately for relations involving

generation of signs and speech for most stimuli (see Figures 3). For example, when Henry was given the sign for each object and asked to say the spoken name for each (SI/SP) he did not match any correctly.

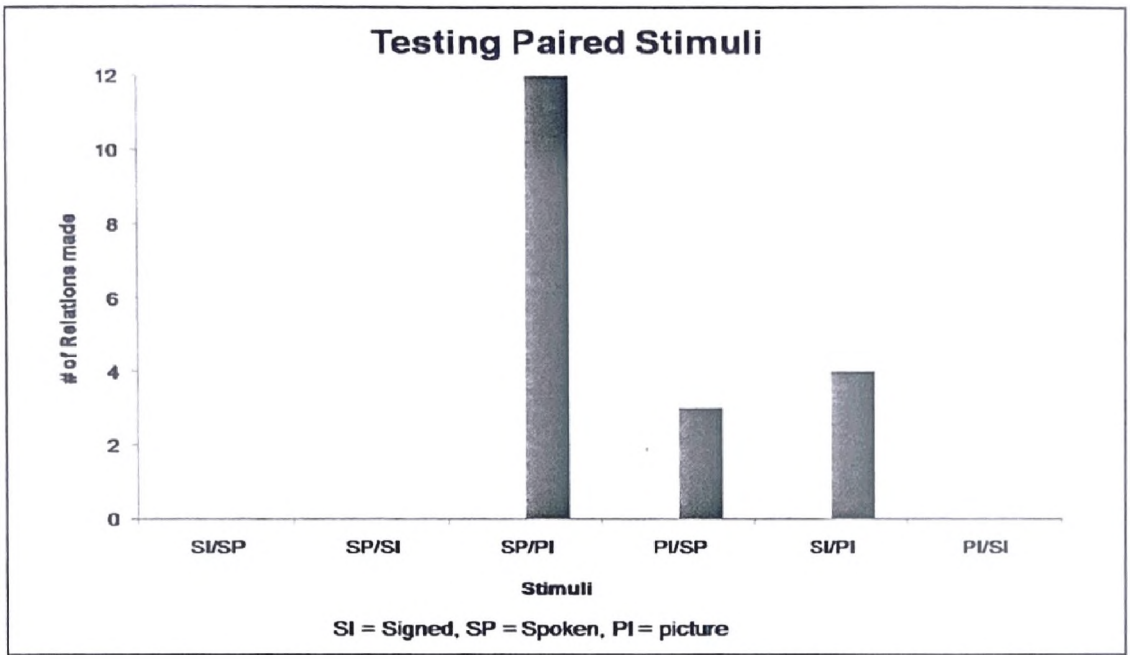


Figure 3. Testing Paired Stimuli

Training Results

Fourteen training sessions were carried out over a three month period. Early training showed slow acquisition of matching responses. For clarity the following relations are presented in object groupings. The groupings are arranged in the order in which Henry first encountered the various objects.

Training for ball.

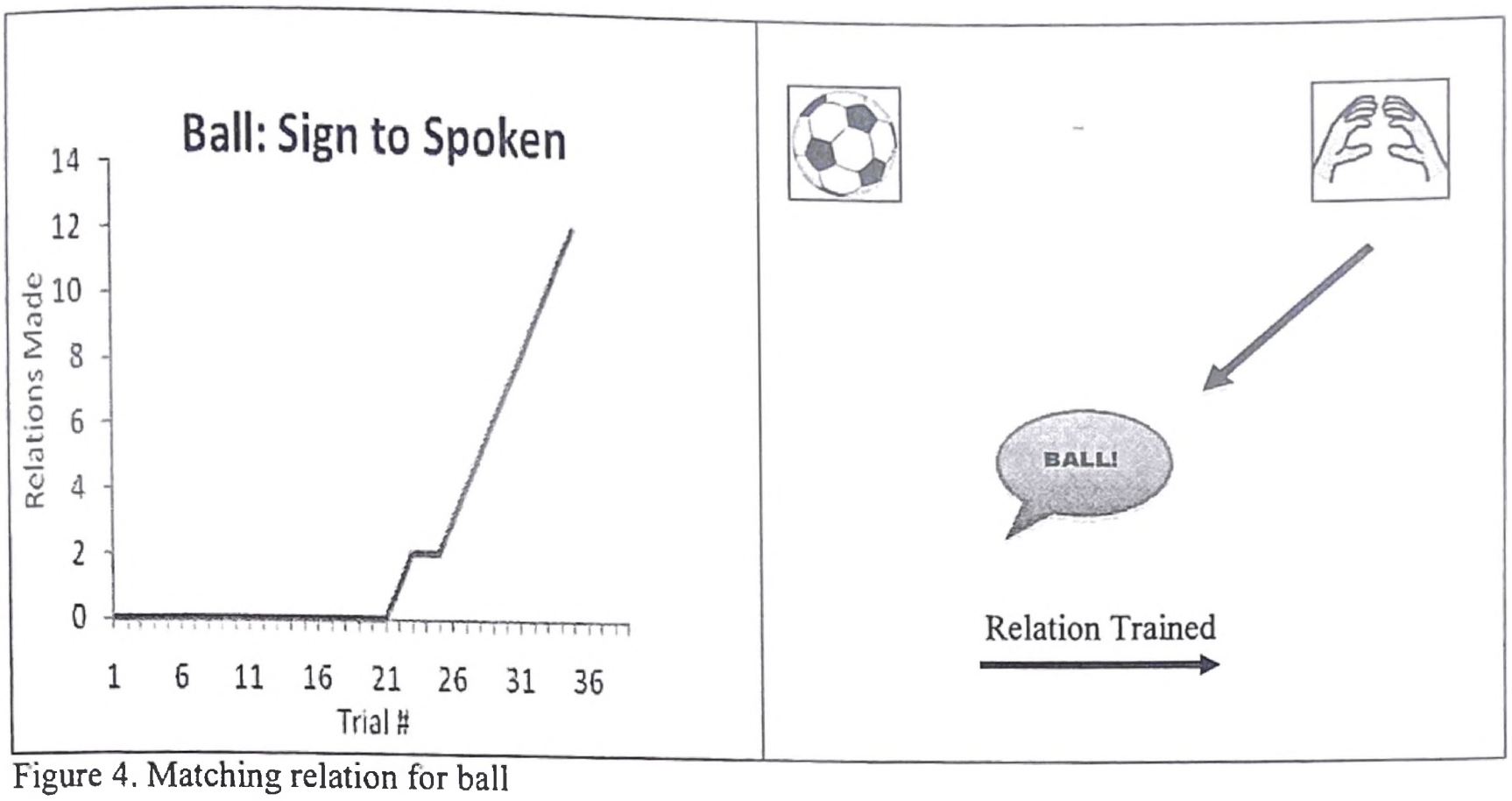


Figure 4. Matching relation for ball

In Henry's ball training, he was asked to produce the spoken word "ball" when given the signed form of ball (see Figure 4). Henry took 23 trials to produce a correct response without prompting. He formed the correct response on trials 23 and 24 without prompting. In the next two trials he made two errors. Correction and prompts were provided for these two trials. He demonstrated the correct relation on trials 27-36 without prompting.

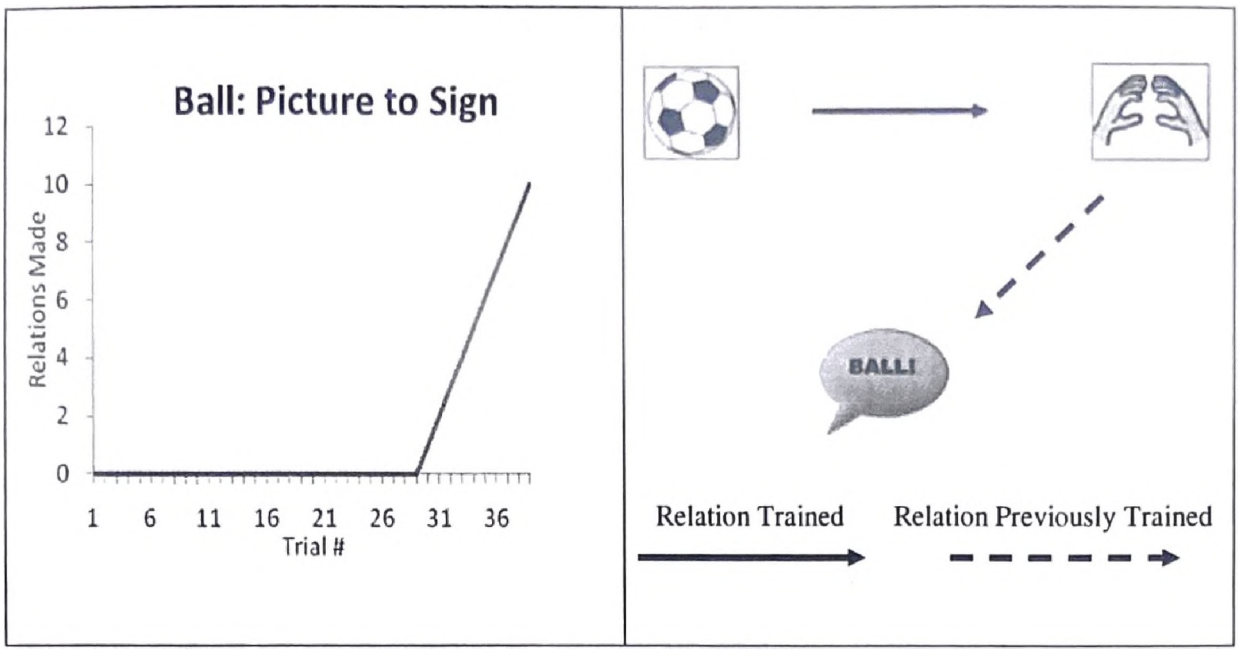


Figure 5. Matching relation for ball

In Henry's ball training, he was taught to match the picture of a ball to the sign of ball (see Figure 5). Henry took 31 trials before he produced a correct response without prompting. In trials 31-40 Henry made no errors.

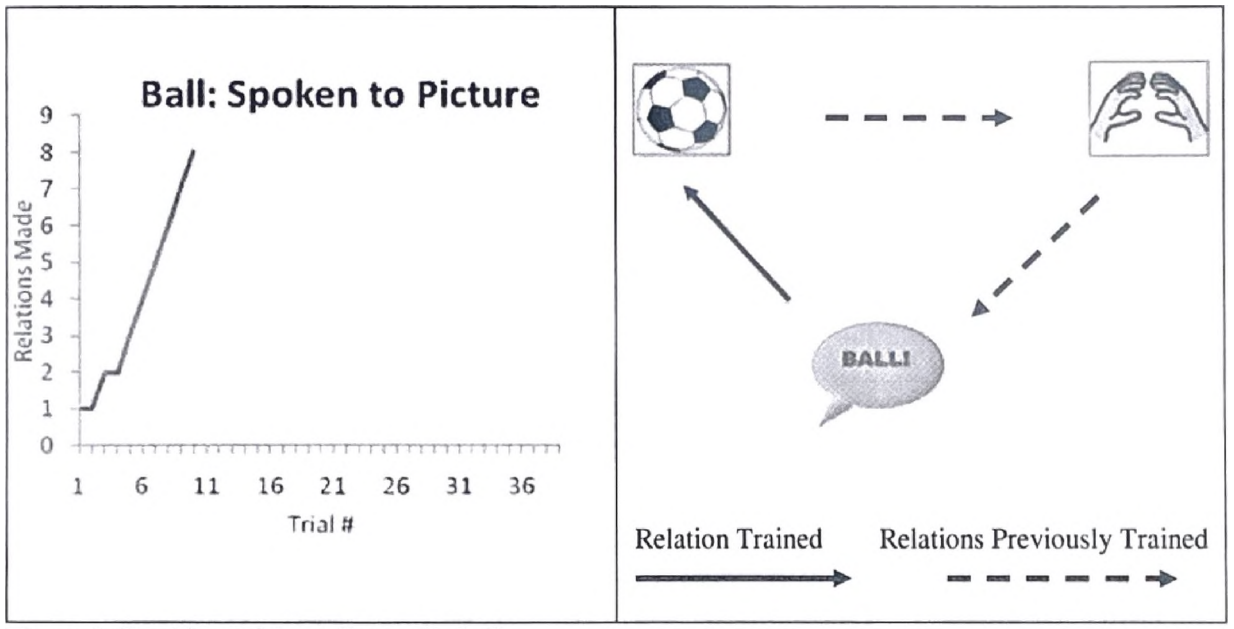


Figure 6. Combinatorial entailment for ball

In Henry's ball training, he was taught a relation of combinatorial entailment between the spoken word "ball" and the picture of ball (see Figure 6). Henry correctly responded on the first trial without prompting. He made errors on trials two and four and was provided correction and prompting. He demonstrated the correct response on trials 5-10 without prompting.

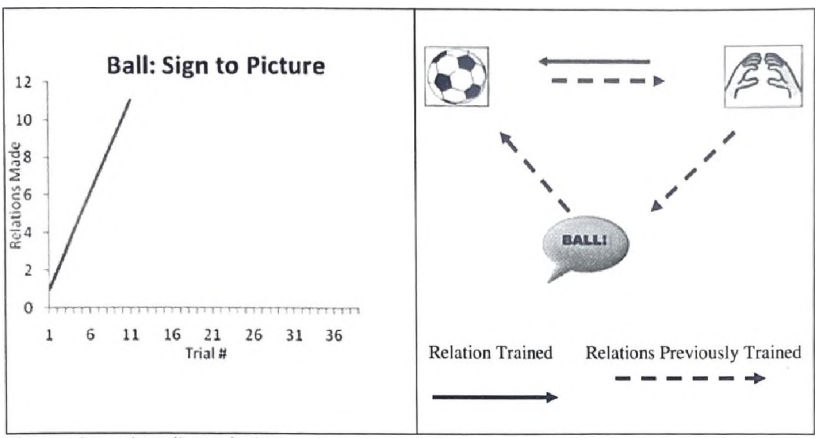


Figure 7. Mutual entailment for ball

In Henry's ball training he was trained for a relation of mutual entailment between the sign of ball and the picture of ball (see Figure 7). He correctly responded to all 11 trials without prompting.

Training for book.

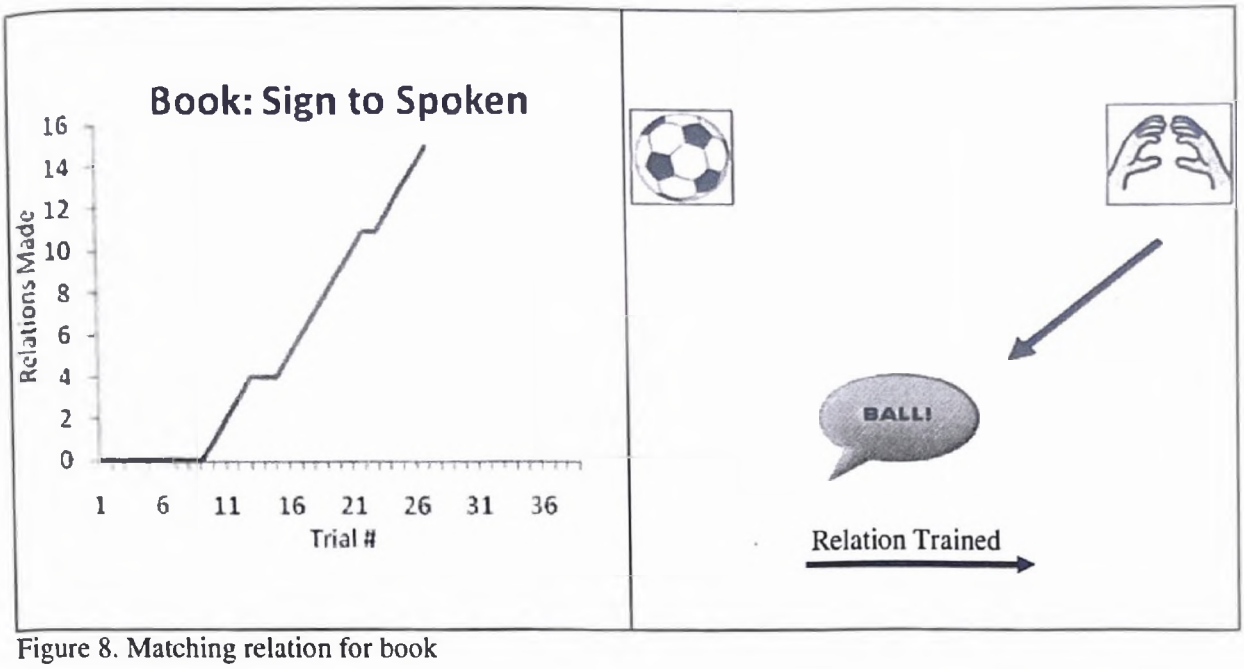


Figure 8. Matching relation for book

In Henry's training for book he was taught to produce the spoken word "book" when given the signed form of book (see Figure 8). Henry responded correctly on trials 10-13 without prompting after making nine errors. He made more errors on trials 14 and 15 and was prompted for the correct response. On trials 16-22 he made the correct response without prompting, followed by one error on trial 23 after which he received no prompting. He produced the correct responses on trials 24-27 without prompting.

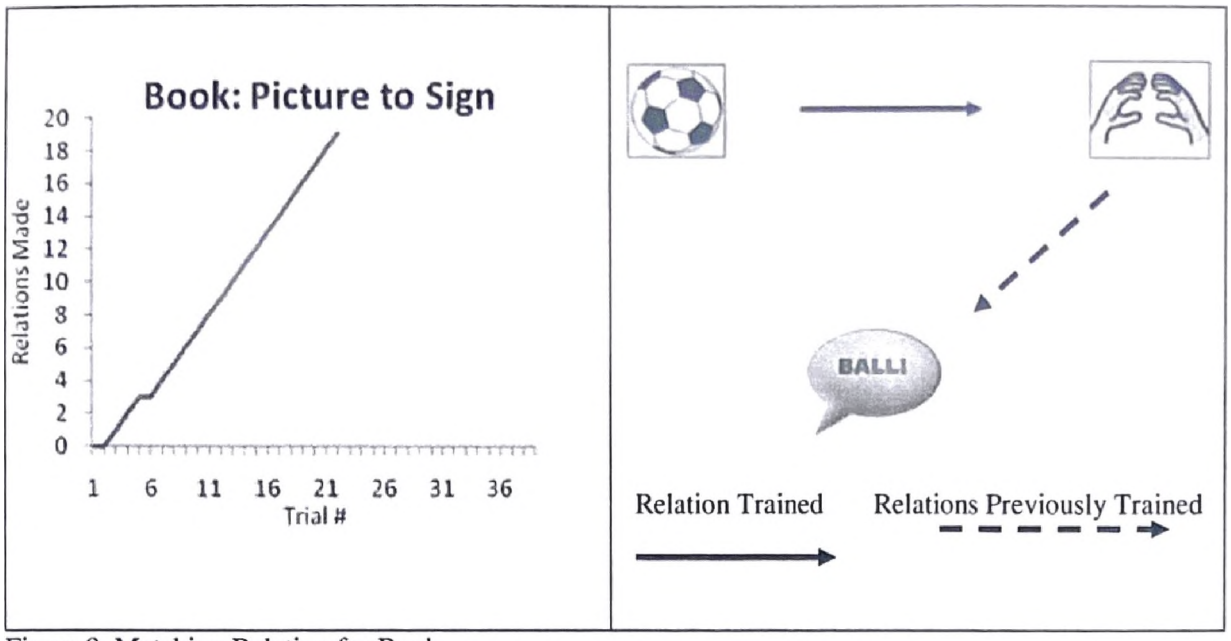


Figure 9. Matching Relation for Book

In Henry's training for book he was taught a matching relation between the picture of book and the sign of book (see Figure 9). He correctly demonstrated this relation on the third trial without prompting. He made an error on trial six and received prompting. He formed the correct relations on trials 7-22 without prompting.

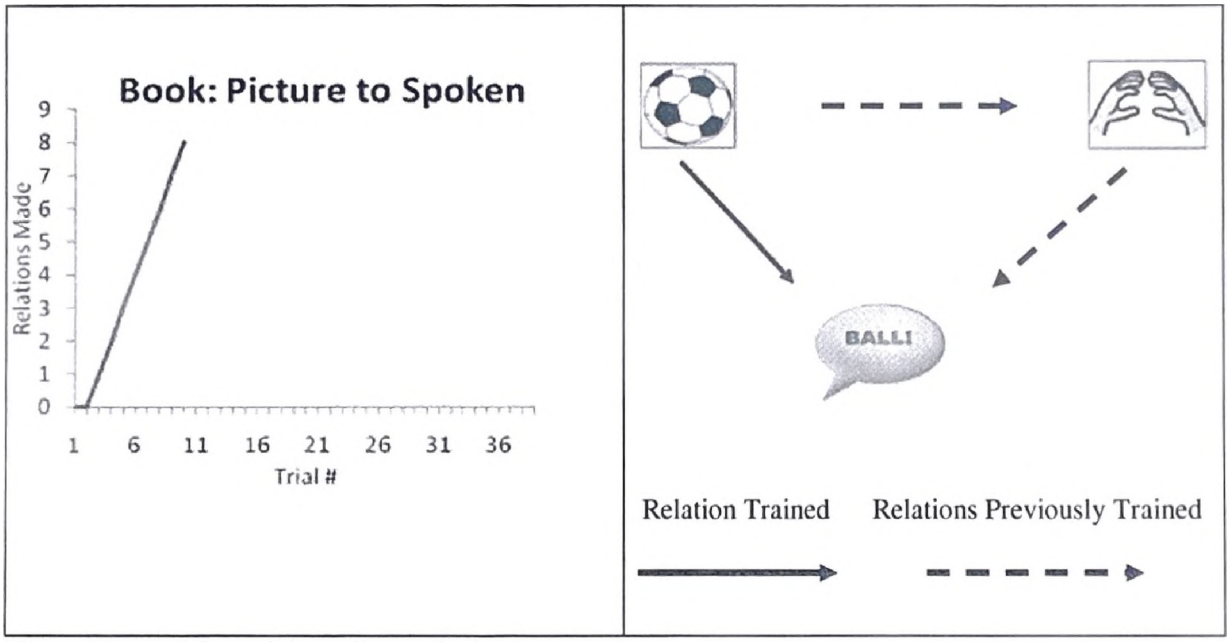


Figure 10. Combinatorial entailment for book

In Henry's training for book he was trained a relation of combinatorial entailment (see Figure 10). He made errors on trials one and two and received prompting. He correctly demonstrated the relation on trials 3-10 without prompting.

Training for car.

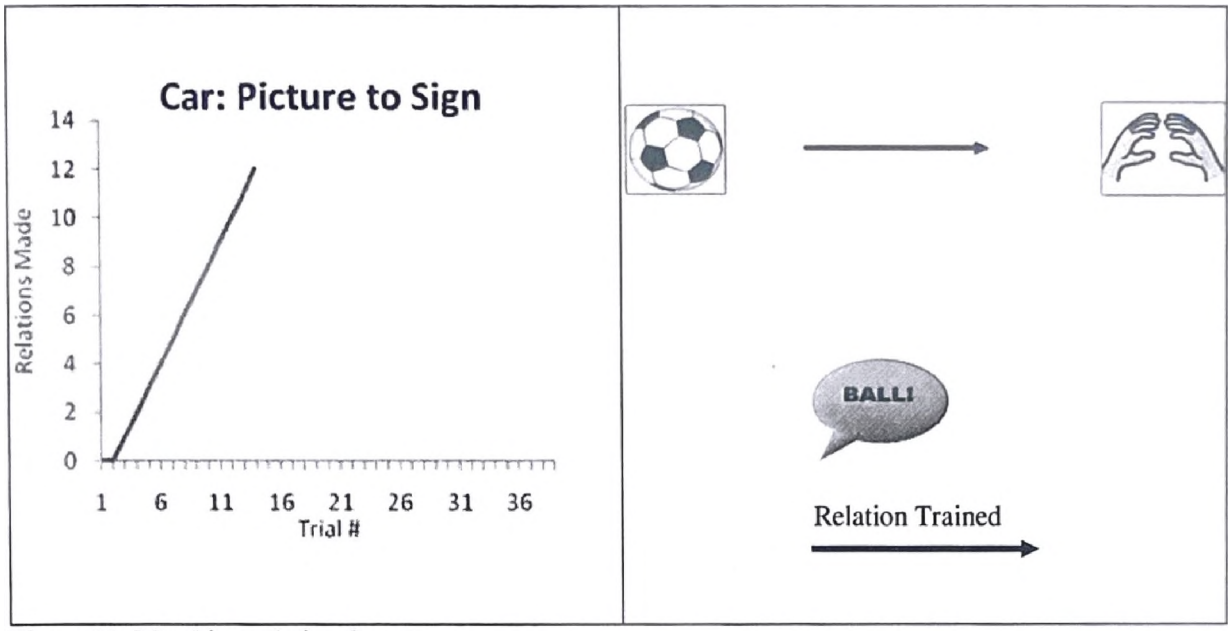


Figure 11. Matching relation for car

In Henry's training for car he was taught a matching relation between a picture of a car and the sign of car (see Figure 11). Henry made errors on the first two trials and received prompting. On trials 3-14 he correctly responded without prompting.

Training for bed.

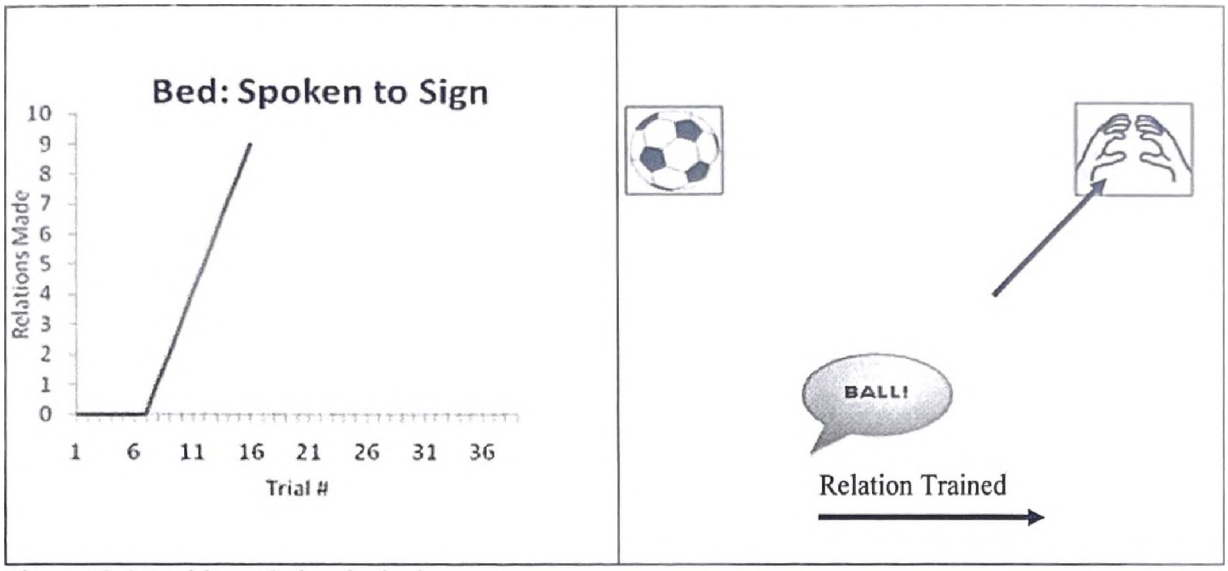


Figure 12. Matching relation for bed

In Henry's training for bed he was taught the matching relation between the spoken word "bed" and the sign of bed (see Figure 12). He made errors on the first seven trials and received prompting. He responded on the eighth trial without prompting. He did not make errors on trials 8-16.

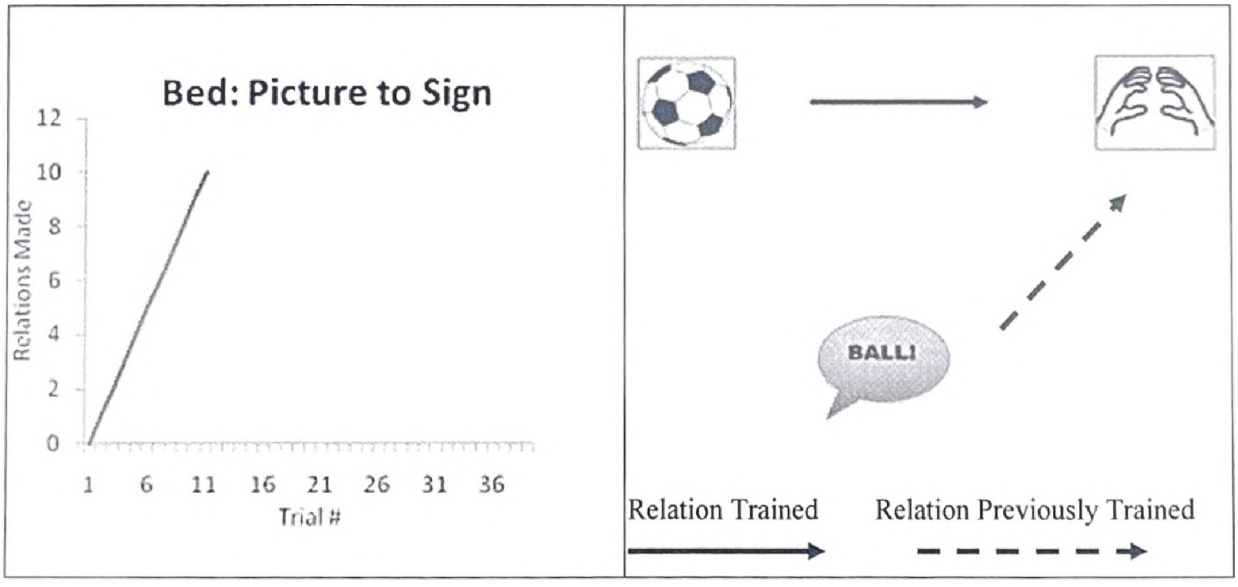


Figure 13. Matching relation for bed

In Henry's training for bed he was taught the matching relation between the picture of a bed and the sign of bed (see Figure 13). He made an error and was prompted on the first trial. He correctly demonstrated the relation on trials 2-11 without prompting.

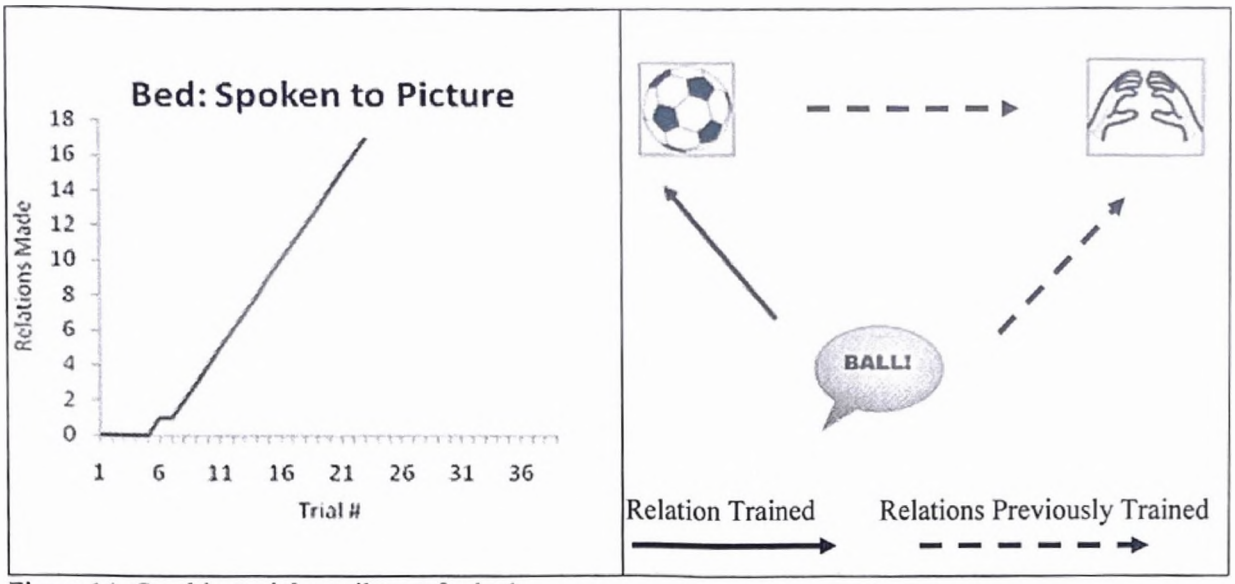


Figure 14. Combinatorial entailment for bed

In Henry's training for bed he was taught a relation of combinatorial entailment between the spoken word "bed" and the picture of a bed (see Figure 14). Henry made errors on trials 1-5 and was prompted. On the sixth trial he answered correctly without prompting. He made an error on trial seven and was prompted. He demonstrated the correct relation on trials 8-23 without prompting.

prompting. He made an error on trial seven and was prompted. He demonstrated the correct relation on trials 8-23 without prompting.

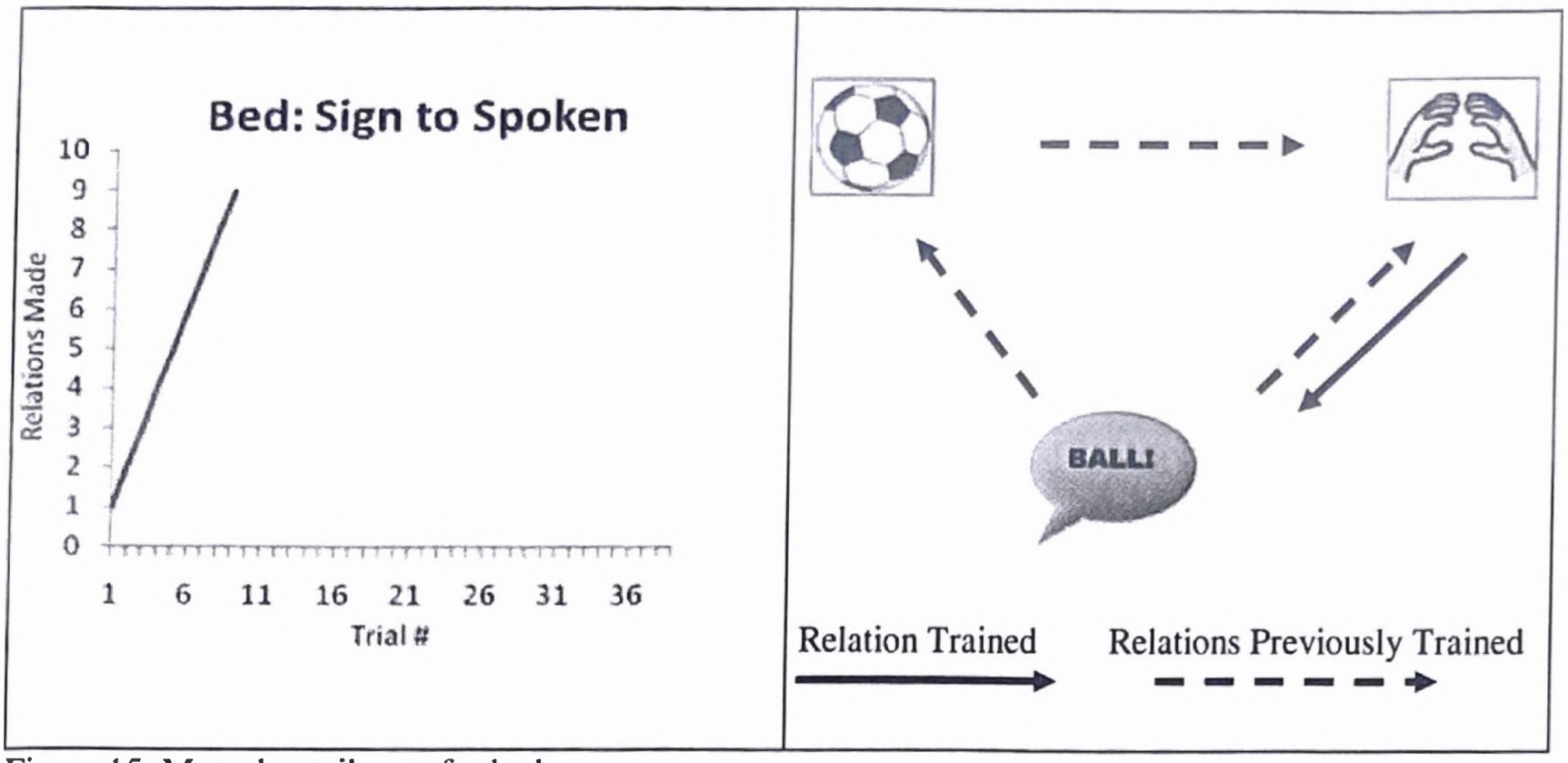


Figure 15. Mutual entailment for bed

In Henry's training for bed he was taught a relation of mutual entailment between the sign of bed and the spoken word "bed" (see Figure 15). Henry responded correctly without a prompt on the first trial. He made no errors on all nine trials and did not receive prompts.

Training for juice.

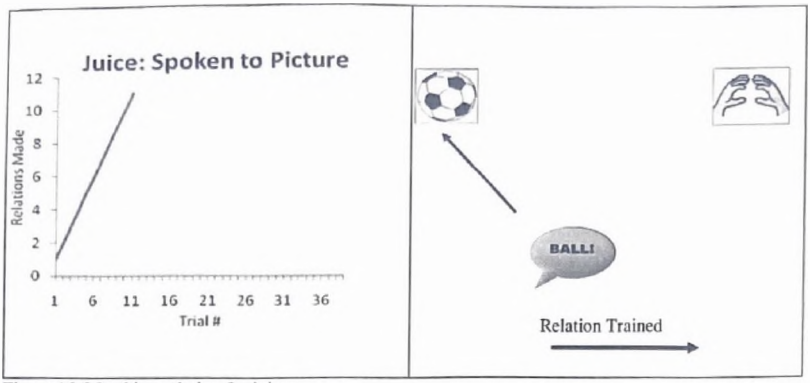


Figure 16. Matching relation for juice

In Henry's training for juice he was taught a matching relation for the spoken word "juice" and the picture of juice (see Figure 16). Henry responded correctly on the first trial without a prompt. He did not make errors on any of the 10 trials and did not receive prompting.

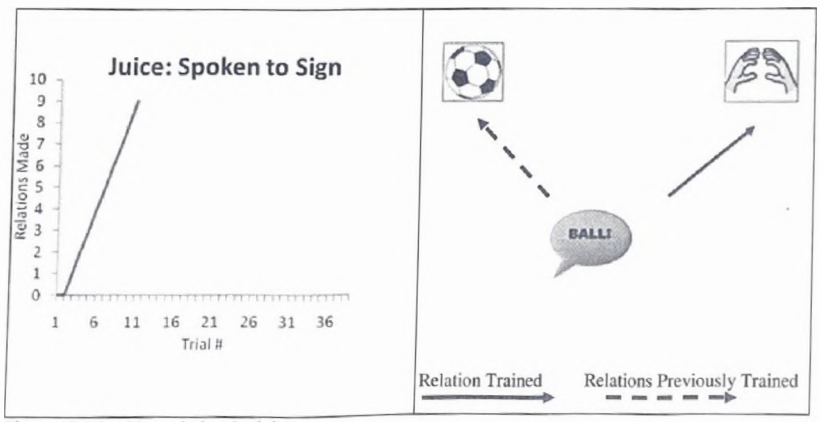


Figure 17. Matching relation for juice

In Henry's training for juice he was taught the matching relation between the spoken word "juice" and the sign of juice (see Figure 17). Henry responded correctly without prompting on the third trial. He made two errors on the following trials and received prompting. He correctly demonstrated the relation on trials 3-9 without prompting.

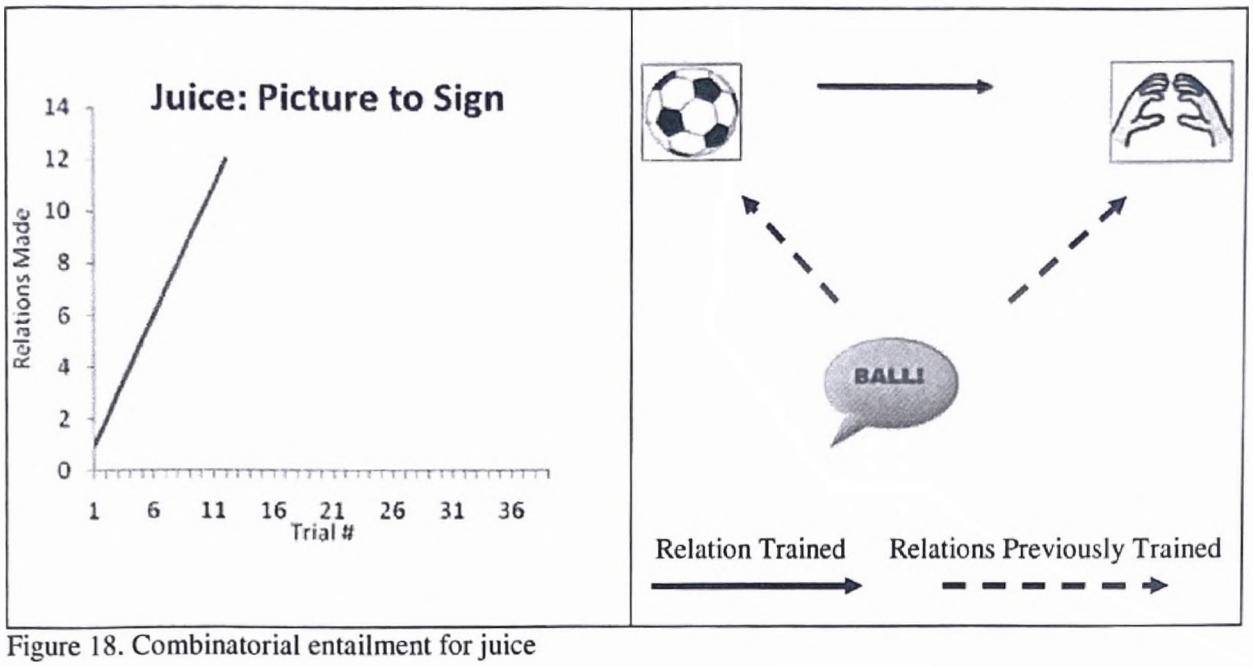


Figure 18. Combinatorial entailment for juice

In Henry's training for juice he was taught a relation of combinatorial entailment between the picture of juice and the sign of juice (see Figure 18). Henry responded correctly on the first trial without prompting and made no errors on the remaining 10 trials.

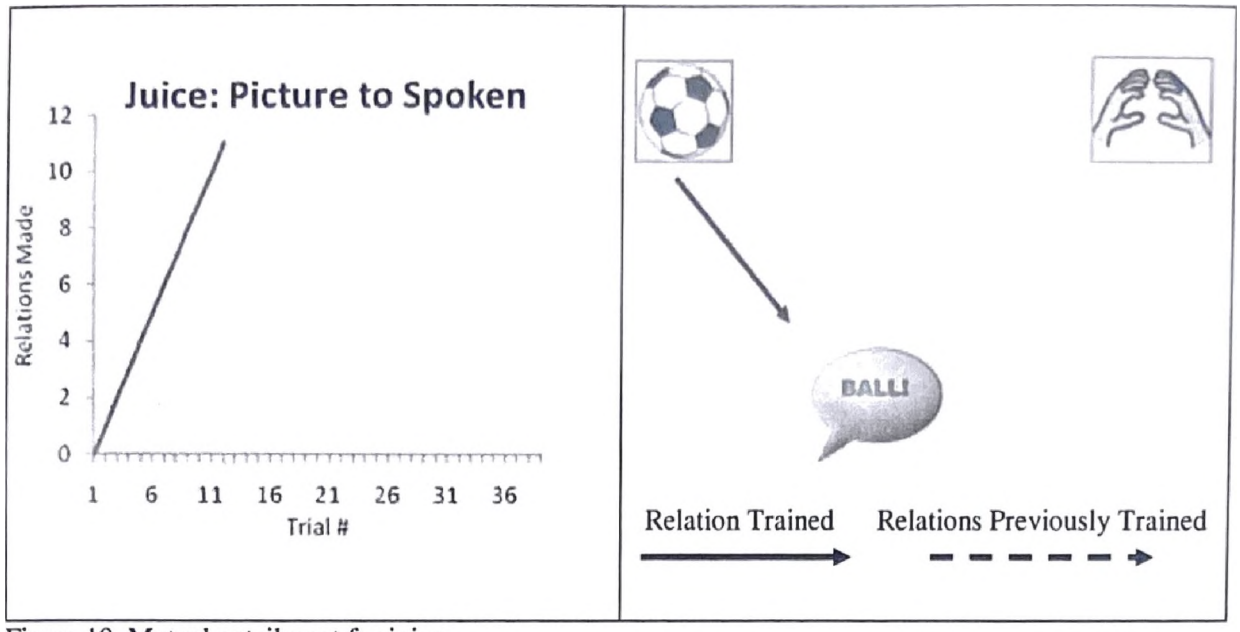


Figure 19. Mutual entailment for juice

In Henry's training for juice he was taught a relation of mutual entailment between the picture of juice and the spoken word "juice" (see Figure 19). Henry made an error on trial one and received prompting. He responded correctly on the second trial without prompting. He did not make errors on trials 2-11 and was not prompted.

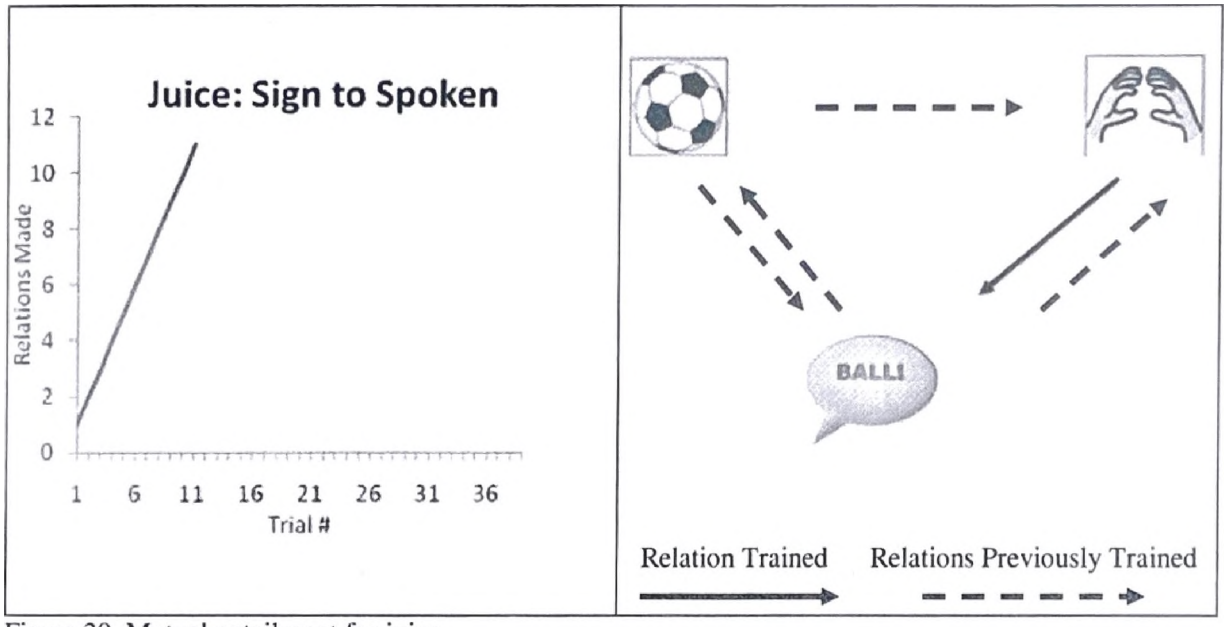


Figure 20. Mutual entailment for juice

In Henry's training for juice he was taught a relation of mutual entailment for the object juice (see Figure 20). Henry demonstrated the relation between the sign of juice and the spoken word "juice" on the first trial without prompting. He responded correctly on all 10 trials without prompting.

Discussion

The purpose of the present study was to examine if there is a pattern in the emergence of derived relational responding. The present study examined if this pattern was evident in a toddler with a significant language delay. Specifically, the researchers evaluated the child's ability to demonstrate matching relations, relations of mutual entailment, and relations of combinatorial entailment over time. The present study results show that, over time, fewer trials were needed for the Henry to demonstrate new matching relations. For example, for the object juice Henry demonstrated a matching relation on the first trial. Also, over time, fewer trials were needed to demonstrate relations of mutual and combinatorial entailment. Henry was eventually able to demonstrate many of these relations on the first trial, including relations of mutual and combinatorial entailment. The present study also showed that Henry's demonstration of mutual entailment did not always arise before combinatorial entailment. In many instances, such as for the object juice, a relation of combinatorial entailment was demonstrated before a relation of mutual entailment. Anecdotally, the parents, researchers, friends and colleagues noticed dramatic improvements in language use and communication skills over the duration of the study.

The results suggest that, over time, training may improve a child's performance on derived relational responding tasks. This training may also increase language use. This

type of direct training may be useful for training relational responding. It may also be useful in training language use to children with language delays and other developmental delays. Also, the use of child-led sessions may be an effective way to train these relations and work with children of this age.

Limitations

There are several limitations to the present study. Most notably is the use of one child. Apart from this the researchers encountered several other problems over the course of the study. The time frame of the study was cut short because the mother was unexpectedly, and abruptly moved to another city for a job. Due to this, the study only ran for three months, and only five of the objects were trained. Another problem is that because the child was in school, the majority of the sessions took place at the end of the school day. The child often became tired which ended several sessions prematurely. Also, the present study did not formally test language development over the course of the study.

Future Research

In future studies researchers should include more participants, perhaps employing a group or multiple baseline design. It would be helpful to see the results among a larger group. These studies should examine the development of derived relational responding over a longer time period. Future studies should examine a wider range of objects, and look into relational responding in regards to function. For example, an object such as book can be given a function such as "reading" in which the experimenters could test relations between function, and vocal and visual stimuli. Experimenters should use formal tests of language use throughout the course of the study. Also beneficial would be

a formal analysis of the number of relations trained before independent correct responding over time.

Summary

By means of Relational Frame Theory (Hayes et al., 2001), behavior analysis provides an empirical avenue into examining human language. This theory can be used in applied research and teaching. In the present study, directly training relations among stimuli with multiple exemplar training led to improved relational responding skills and language acquisition. This may prove to be an excellent tool for training language acquisition. This technique may be useful as part of an early intervention for children with language delays and developmental disabilities.

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