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THE ROLE OF MULTIPLE-EXEMPLAR TRAINING AND NAMING IN ESTABLISHING DERIVED EQUIVALENCE IN AN INFANT

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The conditions under which symmetry and equivalence relations develop are still controversial. This paper reports three experiments that attempt to analyze the impact of multiple-exemplar training (MET) in receptive symmetry on the emergence of visual–visual equivalence relations with a very young child, Gloria. At the age of 15 months 24 days (15m24d), Gloria was tested for receptive symmetry and naming and showed no evidence of either repertoire. In the first experiment, MET in immediate and delayed receptive symmetrical responding or listener behavior (from object–sound to immediate and delayed sound–object selection) proceeded for one month with 10 different objects. This was followed, at 16m25d, by a second test conducted with six new objects. Gloria showed generalized receptive symmetry with a 3-hr delay; however no evidence of naming with new objects was found. Experiment 2 began at 17m with the aim of establishing derived visual–visual equivalence relations using a matching-to-sample format with two comparisons. Visual–visual equivalence responding emerged at 19m, although Gloria still had not shown evidence of naming. Experiment 3 (22m to 23m25d) used a three-comparison matching-to-sample procedure to establish visual–visual equivalence. Equivalence responding emerged as in Experiment 2, and naming emerged by the end of Experiment 3. Results are discussed in terms of the history of training in bidirectional relations responsible for the emergence of visual–visual equivalence relations and of their implications for current theories of stimulus equivalence.

Key words: Receptive symmetry, listener behavior, equivalence relations, multiple-exemplar training, naming, verbal behavior, Relational Frame Theory, matching to sample, infant

Derived stimulus relations have become an important issue in the experimental analysis of human behavior. For most authors in the area, the ability to derive arbitrary relations among stimuli is the core issue, or at least a most relevant one for the analysis of human language and cognition (Hayes, Barnes-Holmes, & Roche, 2001; Sidman, 1994). The conditions under which the most basic and commonly studied form of derived relations (i.e., equivalence relations) emerges is a focus of controversy among different theoretical approaches.

Equivalence responding is readily observed in language-able humans using matching-to-sample (MTS) preparations. Suppose that reinforcement is provided for selecting comparison stimulus B1, and not B2, in the presence of a sample A1, and for selecting C1, and not C2, in the presence of sample B1. Most verbally-able humans learn these conditional discriminations (A–B and B–C relations) with ease. In addition, they readily demonstrate the emergence of a set of novel or derived relations among the stimuli. Without specific training, subjects will select A1 in the presence of B1, and B1 in the presence of C1. They will also select C1 in the presence of A1, and A1 in the presence of C1. According to Sidman and Tailby (1982), these novel, emergent relations are referred to respectively as symmetry (B–A), transitivity (A–C), and equivalence (C–A). In the terms of Relational Frame Theory (RFT), these novel relations are referred to as mutually entailed (involving a pair of stimuli) and combinatorially entailed (involving more than two stimuli) relations (Hayes et al., 2001).

Among the main theories that have been proposed to account for stimulus equivalence (Hayes et al., 2001; Horne & Lowe, 1996; Sidman, 1994), two have explicitly tried to specify the historical conditions that give rise to this sort of responding. RFT has focused on the history of reinforcement for bidirectional responding across multiple-exemplar training

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(MET) that results in a nontopographically defined, overarching relational operant class (Hayes et al., 2001). In contrast, Naming Theory (Horne & Lowe, 1996) has focused on the contingencies that generate naming as the coordination of listener and speaker repertoires that is said to be necessary for equivalence to emerge. In support of the Naming Theory, the explicit training of common names for sets of stimuli has been shown to facilitate derived equivalence responding (Eikeseth & Smith, 1992) and the formation of arbitrary stimulus classes (Lowe, Horne, Harris, & Randle, 2002; Lowe, Horne, & Hughes, 2005). However, a number of issues complicates the empirical evidence in this regard: (1) Much of the research on equivalence conducted with humans thus far has used participants with already existing competent naming and categorizing repertoires, which means that these abilities are already part of the experimental procedures (Cabello, 2005; Cabello & O'Hora, 2002; Wulfert, Greenway, & Dougher, 1991); (2) Name training is itself training in arbitrary stimulus relations, and, thus, positive outcomes for naming may be taken as confirmatory for either account; (3) Both naming and bidirectional responding to arbitrary stimulus relations codevelop at very early ages in the natural development of language, making it difficult to disentangle the relative impact of either variable. Nevertheless, there is a clear difference between the predictions derived from the Naming Theory and those from RFT.

Horne and Lowe (2000) have argued that the training of a listener repertoire without a speaker component should not be sufficient for the establishment of equivalence. Indeed, these authors have argued that such a finding would constitute disproof of the naming account (Horne & Lowe, 2000; Horne, Lowe, & Randle, 2004; Lowe et al., 2002). In contrast, according to RFT (Hayes & Hayes, 1989), MET in listener behavior should help establish relational operants such as equivalence without the necessity of naming training. This issue has not been broadly explored empirically, and available data cast lights and shadows in both directions. The data from the animal literature point to the difficulty of finding equivalence in nonhumans with the possible exception of sea lions (see Schusterman & Kastak, 1993). Schusterman and Kastak observed emergent equivalence performances in a sea lion after explicitly reinforcing symmetry and transitivity across multiple stimulus sets. In interpreting these results, Hayes et al. (2001) suggest that they could be an example of MET in mutual and combinatorial entailment resulting in equivalence, whereas Horne and Lowe (1996) point out that they could be due to simpler learning processes.

Studies that have attempted to show equivalence in humans with minimal language repertoires also have not been conclusive about the role of MET of speaker and listener repertoires in obtaining derived relational responding. For example, in Carr, Wilkinson, Blackman, and McIlvane (2000), subjects were taught (receptive training) to identify visual stimuli (B) upon dictated names (A). This was followed by identity matching training with the visual stimuli (B) and then a procedure wherein the B stimuli were gradually transformed into C stimuli. In subsequent testing, three severely developmentally delayed adults (no significant vocal naming but with receptive identification and manual gestures) showed symmetry and equivalence. Conversely, in the same study, other subjects were trained in a visual–visual MTS task with a guide procedure (but no receptive training), and only the subject with advanced vocal skills showed a gradual emergence of equivalence.

In Brady and McLean (2000), only 2 of 4 developmentally delayed adults (nonspeakers but gesture users) participating in MTS training (name–object and object–lexigram) showed transitivity (name–lexigram), and these were the two nonspeakers who were able to comprehend the names of the objects at the outset of the experiment. According to the authors, this could mean that either receptive or expressive language may be sufficient to support the emergence of equivalence.

In another study, Devany, Hayes, and Nelson (1986) established visual–visual conditional relations using an MTS paradigm, but only the language-able children (both normal and developmentally delayed) demonstrated emergent or untrained relations. The language-disabled children (no receptive or expressive abilities) did not show those emergent relations. Similarly, Barnes, McCullagh, and Keenan (1990) analyzed equivalence class formation by normal-hearing and hearing-impaired children, finding that both groups were able to show equivalence, with the exception of a hearing-impaired girl whose verbal abilities were very limited (verbal age below 2 years). All of these studies point out the need to further study the relationship between language abilities and derived equivalence.

Longitudinal studies with normally developing infants also have focused on analyzing the impact of listener and speaker repertoires. Lipkens, Hayes, and Hayes (1993) obtained equivalence with a 23 month 20 day (23m20d) infant with names, pictures, and sounds as stimuli. Equivalence occurred after obtaining receptive (17m7d) and productive (19m8d) symmetry with a limited set of pictures and names that were used repeatedly for training and testing, including vocal imitative training of the specific names used in the experimental tasks.

In a recent series of studies, Lowe, Horne, and colleagues (Horne & Lowe, 2000; Horne et al., 2004; Lowe et al., 2002; Lowe et al., 2005) explored the role of listener, echoic, and tacting repertoires in generating naming and on the formation of arbitrary stimulus classes in young children. These studies reported naming (e.g., responding to ''What's this?'' in the presence of an object) when the children were trained to echo the objects' names in the presence of the actual objects, but not when they were trained only to point to objects upon hearing their name or to echo the names in the absence of the actual objects. These studies also have shown that teaching participants to produce a common name for several stimuli is effective in generating arbitrary stimulus classes (Lowe et al., 2002; Lowe et al., 2005) as well as transfer of functions within stimulus classes (Lowe et al., 2005). In contrast, training common listener responses to several stimuli (or receptive language) did not serve to establish arbitrary stimulus classes, which were obtained only after tact training with those stimuli (Horne et al., 2004). Additionally, two studies (Barnes-Holmes, Barnes-Holmes, Roche, & Smeets, 2001a, b) that compared the impact of MET and naming on the emergence of symmetry-based transfer of functions with 4 year olds, found that most subjects did not show the emergence of such transfer until after they had received explicit symmetry training.

Although all the studies described above provide very valuable information, it is necessary now to go further in identifying the contingencies that give rise to generalized symmetrical responding (or mutual entailment) and to the emergence of derived equivalence, especially with visual–visual relations in infants. First, the role of generalized listener behavior has not yet been isolated in studies with normal and developmentally delayed subjects. Specifically, in the study with the youngest infant (Lipkens et al., 1993), listener training occurred only with limited sets of stimuli (i.e., it was not proper multiple-exemplar training), and listener behavior was tested immediately and with the same stimuli employed during training. Consequently, it seems necessary to test generalized listener behavior with novel stimuli and longer delays. This would more closely match natural language training by the verbal community. Secondly, most studies have employed both auditory and visual stimuli to test for equivalence. This is likely due to the fact that derived relations have been found to be more difficult to obtain (at least at an early age or with developmentally delayed subjects) with visual–visual stimuli than with auditory–visual stimuli (Green, 1990; Sidman, Willson-Morris, & Kirk, 1986; Smeets & Barnes-Holmes, 2005). In principle, however, although more like natural language training, auditory–visual preparations seem less able to isolate the effects of naming from that of generalized listener behavior, in the sense that the very experimental procedure supplies names that can be employed by the child in the manner hypothesized by Naming Theory. Consequently, it seems reasonable to attempt the apparently more difficult task of working with visual–visual relations to test derived equivalence. The rationale is that in such cases, the experimental procedure supplies no names to be employed, and consequently a more sophisticated naming repertoire would be necessary to show equivalence than if auditory stimuli were used. It can reasonably be assumed that such a sophisticated repertoire is missing in very young children.

The present study addresses these issues in three experiments with a single participant. The first experiment began when the child was 15m24d. It attempted to demonstrate the effect of a history of MET in immediate and delayed receptive symmetry on the emergence of delayed generalized receptive symmetry (tested at 16m25d with novel stimuli) with concurrent tests of naming. The second experiment began 5 days later (17m) and finished at 19m. It aimed to test for visual–visual equivalence relations with a two-comparison MTS procedure. Pre-post tests for naming and receptive symmetry with novel stimuli were included. The third experiment began when the child was 22m. It was like the second, but with a three-comparison MTS procedure.

GENERAL METHOD

Participant, Experimenter, and Experimental Setting

Gloria, who was 15 months and 24 days (15m24d) old at the beginning of the study, was the sole participant. She was a healthy, first-born infant and the only child in the family at the time of the study. According to Gloria's parents' reports, she was a happy, restless and curious child. No formal language assessment was conducted using standardized tests because the most relevant responses (listening and naming) were explicitly tested throughout the experiments, as will be seen later. However, several language abilities were informally assessed by the parents, both at the beginning of and during the experiments. Specific guidelines were provided to the parents stipulating the behaviors to be observed and recorded. These behaviors included: imitation, pointing to or naming objects or persons, completing puzzles, following instructions, and identifying objects (either by pointing to or by saying their name) when presented as a whole or just with their parts. This assessment revealed four important findings about Gloria's verbal abilities at the beginning of the experiment: 1) Gloria's vocal imitations were not frequent and were under specific instructional control; 2) She communicated primarily by pointing to objects and persons in her environment, and by picking up objects and handing them to other people; 3) She was able to name a few common objects and people (e.g., her ''mum'' and ''dad'', the family dog, and a teddy bear; and 4) She was not very skilled at completing puzzles.

Gloria's mother was the experimenter. She is a behavioral psychologist with expertise in discrimination procedures with children. At the time of the study, she was unaware of the purposes of the experiment and unfamiliar with the literature on stimulus equivalence. Gloria's father was not a psychologist, but he agreed to record Gloria's responses during the experiment. He was specifically trained to accomplish this task (as described in the Procedure section). The family living room served as the experimental setting. It was a big room with typical furniture: a TV, sofas, a big table and chairs. Trials were conducted either on a rug on the floor or at a small table specifically placed in the living room for that purpose.

Stimuli and Materials

None of the stimuli used were familiar to Gloria. For Experiment 1, 25 objects were used as visual stimuli. Ten of these (numbered from 4 to 13) were used for training (see Table 1 for a description of the stimuli), and the remaining 15 (1 to 3 and 14 to 25) were used in testing. Spoken sounds were used as vocal names for some of the objects, and different hand movements served as nonvocal names for the remaining objects. Gloria's mother produced both vocal and nonvocal names as part of the experimental procedures.

For Experiments 2 and 3, two different sets of unfamiliar objects with different shapes, colors, and sizes were used as visual stimuli. Six objects were used for Experiment 2, and nine for Experiment 3. Each was identified with an alphanumeric label for procedural purposes (see Table 1). A pasteboard box was used to present stimuli in Experiment 1, and an opaque plastic box was used to present comparison stimuli in Experiments 2 and 3. An opaque plastic bag was used to hide sample stimuli from trial to trial in all three experiments.

EXPERIMENT 1: MULTIPLE EXEMPLAR TRAINING IN RECEPTIVE SYMMETRY

The question asked in this experiment was whether multiple-exemplar training (MET) in immediate and delayed receptive symmetrical responding (listener behavior) would result in generalized delayed receptive symmetry (or derived mutual entailment), and whether naming of new objects would be present in such a case. That is, the experiment evaluated whether presenting a new object–sound relation [A–B: given an object (A) and given its name (B) by the experimenter] would result

Table 1

Objects (the object description in Spanish is given in parenthesis), auditory stimuli (shown in capital letters), and hand movements used in Experiment 1, and the visual stimuli used in Experiments 2 and 3.

EXPERIMENT 1	
Test 1:	
1. A metal spring (muelle)	''TO''
2. A corkscrew (sacacorchos)	both hands in front of the face simulating wings
3. A lantern (linterna)	''TERNA''
Training (ten objects):	
4. A ceramic made figurine of an owl (figura de un búho pequeño en cerámica)	''BUHO''
5. A wooden puzzle piece (pieza de puzzle de madera)	''PUZZLE''
6. A small grey bobbin of thread (bobina de hilo)	''HILO''
7. An electronic calculator (calculadora)	''CALCULADORA''
8. A leather bracelet (pulsera de cuero)	''PULSERA''
9. A metallic screw (tornillo)	''TORNILLO''
10. A plastic syringe (jeringa)	''JERINGA''
11. A radish (rábano)	''RABANO''
12. A small cowbell (pequeño cencerro)	''CENCERRO''
13. A pair of binoculars (prismáticos)	''PRISMÁTICOS''
Test 2:	
14. A small stapler (grapadora)	''GRAPADORA''
15. A spinning top (trompo)	''TROMPO''
16. ViewMaster 3-D glasses (gafas de cine)	''CINE''
17. An artichoke (alcachofa)	''ALCACHOFA''
18, A letter opener with duck shape (abrecartas decorado)	''ABRECARTAS''
19. A measuring tape (una tira larga para medir)	''METRO''
20. A pearly earring (un pendiente)	''PIC''
21. A padlock (candado)	opening and closing the hand imitating a bird
Test 3:	
22. A nail clipper (cortauñas)	''YUC''
23. A paper drill (taladro de papel)	moving the hand and fingers with the thumb placed on the nose and the hand perpendicular to the face
Test 4:	
24. A small can opener (abrelatas)	''POIN''
25. A mouthpiece of a watering hose (boquilla manguera agua)	both hands on the temples, moving them like wings
EXPERIMENT 2	
A1. A patch of red cloth (un aro de tela de color rojo)	
A2. A glass mat with drawings (un posavasos con dibujos)	
B1. A light blue plush bunny (un conejito de peluche de color azul)	
B2. A beige teddy bear (un osito de peluche de color beige)	
C1. A little plastic toy Dalmatian dog (un perrito dálmata de plástico)	
C2. A yellow plastic construction block (un bloque de plástico amarillo)	
EXPERIMENT 3	
A1. A yellow mold of plastic with starfish form (estrella de mar en plástico y amarilla)	
A2. A green mold of plastic with turtle form (tortuga verde en plástico)	
A3. A blue mold of plastic with shell form (caracola azul en plástico)	
B1. A metallic coffeepot in miniature (cafetera metálica en miniatura)	
B2. A short thick piece of wood (taco de madera)	
B3. A white flower of cloth (flor de tela blanca)	
C1. A ceramic miniature pig (cerdito de cerámica en miniatura)	
C2. A nut of metal (tuerca de metal)	
C3. An empty red and white box of staples (caja roja y blanca de grapas vacía)	

in two different, new relations after a delay. More specifically, we asked: (1) Given a request for an object previously named (B), and in the presence of several different objects, would the child pick up the requested object (A) (derived delayed receptive symmetry)? and (2) Given the object previously named (A) and a request for its name, would the child approximately name it either vocally or nonvocally (naming)? The introduction of delays during training and testing was done in order to test for generalized listener behavior and naming in a way which more closely resembles natural learning conditions, where infants are asked for objects whose names were presented some time ago.

The MET was similar to that used in other studies to establish generalized response classes, for example, imitation (Baer, Peterson, & Sherman, 1967), attention (Luciano & Polaino-Lorente, 1986; McIlvane, Dube, & Callahan, 1996), say–do correspondence (Luciano, Barnes-Holmes, & Barnes-Holmes, 2002; Luciano, Herruzo, & Barnes-Holmes, 2001), and arbitrary relational responding (Barnes-Holmes, Barnes-Holmes, Smeets, Strand, & Friman, 2004).

Procedure

Prior to the experiment, Gloria's parents were invited to participate in a set of experiments that would help their child learn to relate words and objects. A week before the experiment, Gloria's parents were asked to pay particular attention to Gloria's spontaneous vocal imitation and her vocal and nonvocal communication. For that purpose, they were given a form to record whether such behaviors occurred during the week. After that, a set of unfamiliar objects was selected for use only during the experiment. The mother then was instructed in the experimental procedures. To do this, the senior author demonstrated and practiced the specific trials in each of the experimental phases. She also explained to both parents how to record relevant events during the experiment.

For every trial, the parents were instructed to record date and time, objects presented, vocal imitative responses, time of intended delay (between object presentation and object request), the mother's request to the child (either immediate or delayed), Gloria's immediate and delayed response, and consequences delivered. In addition, the first author met with the mother almost every day to monitor the implementation of the experimental procedures. Moreover, they talked by phone after every session and even between trials when the mother considered it necessary. Trials were regularly interspersed amidst the family's regular activities at the parents' convenience. Specific descriptions of the testing and training phases are presented next.

Test 1. Testing for naming and receptive symmetrical responding took place consecutively with objects 1, 2, and 3. First, vocal and nonvocal naming relations were respectively tested after a 30-min delay for Objects 1 and 2. Receptive symmetry relations were tested with Object 3 after 1- and 3-min delays. The sequence proceeded as follows: To teach object–sound relations, the mother sat on the floor facing Gloria and asked her to attend to Object 1, which she held up in her hand while she said its name (e.g., ''Gloria, look at this'', and when visual contact occurred she said, ''Very good, Gloria, this is TO''). No specific consequences were administered, and after the mother named the object, it was put inside the opaque plastic bag. This was repeated two more times with the same object with 5- to 10-min intertrial intervals. Thirty min after the last presentation, vocal naming was tested by presenting Object 1 and asking for its name (''Gloria, look at this'', and then, ''What is it?'').

Later in the day (2 hr later), the mother presented an object–movement trial. While holding Object 2 in her hands, she said: ''Look at this'' and when visual contact occurred, she said, ''Very good, Gloria, this is,'' and she made a hand movement simulating flying wings before putting the object inside the bag. As with Object 1, this sequence was repeated two more times. Thirty min later, nonvocal naming was tested with Object 2 (by presenting the object and asking for its nonvocal name or gesture).

On the next day, Object 3 (named ''TERNA'') was presented in the same way except that testing was conducted for delayed receptive symmetry relation after only 1 and 3 min after the last object–sound presentation. On this test trial, Object 3 was presented inside a closed box with two other objects (1 and 4), and Gloria was asked to pick up the object previously named (e.g., ''Gloria give me

TERNA'') while the mother opened the box. When opening the box, the mother lifted the box lid, which prevented her from seeing the objects inside the box (the opaque box lid served as a visual barrier that controlled for experimenter cueing for correct responding). Because no correct vocal or nonvocal naming and no receptive symmetrical responses occurred (see Figure 1, Test 1), multiple-exemplar training proceeded.

MET in immediate and delayed receptive symmetry. Training was conducted with 10 different objects (numbered from 4 to 13, see Table 1). A trial involved the presentation of an object and its name by the mother (object–sound relation) with subsequent immediate and delayed presentations of the reverse sound–object relation. Training proceeded with different delay intervals between object–sound and sound–object presentations, increasing from immediate and 3-min delays in the first 16 trials, up to immediate and 1-hr delay, plus 3- and/or 12-hr delays in some cases (see Figure 1 for a detailed sequence of training and test trials and the delays employed on each particular trial). On a typical trial (e.g., with Object 4), the mother asked Gloria to look at the object in her hand by saying, ''Gloria, look at this''. Once visual contact occurred, the mother said ''Very good, Gloria. This is BUHO,'' and then she put the object inside a box with two other objects (in this case, with Objects 3 and 5[1]). Immediately after that, the mother said, ''Gloria, give me BUHO,'' while opening the box. Positive feedback and social praise (''Yes, it is BUHO, very good.'') as well as playful activities (e.g., jumping like a horse, tickling), followed correct responses. Approximately 3 min later, the same request was presented, and the trial was then completed. When Gloria failed to pick up the correct object (as happened in the second trial with Object 4) the mother empathically said ''No, it's not that!'' She then picked up the correct object herself, closed the box, and said, ''This is BUHO,'' which served as the object–sound presentation for the next trial. Then, Gloria's mother put the object in the box and asked for it again, while she rotated the box in order to see the correct object and point to it. After this first prompted response, and in order to reduce possible inattentive and negative behaviors, each incorrect response was followed by the presentation of the same object again. It was then placed alone in the box. Correct responding here was considered prompted. After training with Object 4, the playful activities after each correct response were eliminated. For the first 16 training trials, a maximum of two trials per day were conducted. After that, just a single trial per day was conducted. Training continued until the criterion of seven consecutive correct trials with at least 6 of 10 different training objects.

Test 2. Testing for generalized delayed receptive symmetry and naming with eight new objects began at 16m25d and ended 6 days later. This test comprised a total of 15 trials distributed as follows: 7 trials for receptive symmetry with six new objects (numbered from 14 to 19—see Table 1—with Object 17 repeated once) with a 3-hr delay; 6 trials with already trained objects with a 3-hr delay, conducted between novel tests with Objects 18 and 19; and finally, 2 naming trials with new objects (20 and 21) with a 30-min delay. Each novel object used in the tests for receptive symmetry was presented with a previously used object and another new object as comparisons (e.g., for Object 14, comparisons were Objects 1 and 20). Between test trials, Gloria was allowed to play with toys that she was asked to pick up and give to her mother. This was done in order to prevent the possibility on delayed tests of Gloria simply picking the last stimulus named and presented.

Test trials were conducted as in Test 1, with two exceptions: the basic object–sound relation was presented only once (instead of three consecutive times), and all of the receptive symmetry trials had longer delays (i.e., 3-hr instead of 1- and 3-min delays). Correct responding was followed by the mother saying ''Very good, it is (object name).'' No feedback was provided for not responding or for incorrect responding.

Tests 3 and 4. After the completion of Test 2, Gloria began Experiment 2. Test 3 was implemented right after Experiment 2, and Test 4 took place right after Experiment 3. Accordingly, they will be described after each of these experiments.

[1] One previously employed object and one novel object served as incorrect comparisons. This was done to preclude the possibility that Gloria selected the correct comparison on the basis of some form of exclusion. A detailed description of the comparisons employed in each trial is available from the first author upon request.

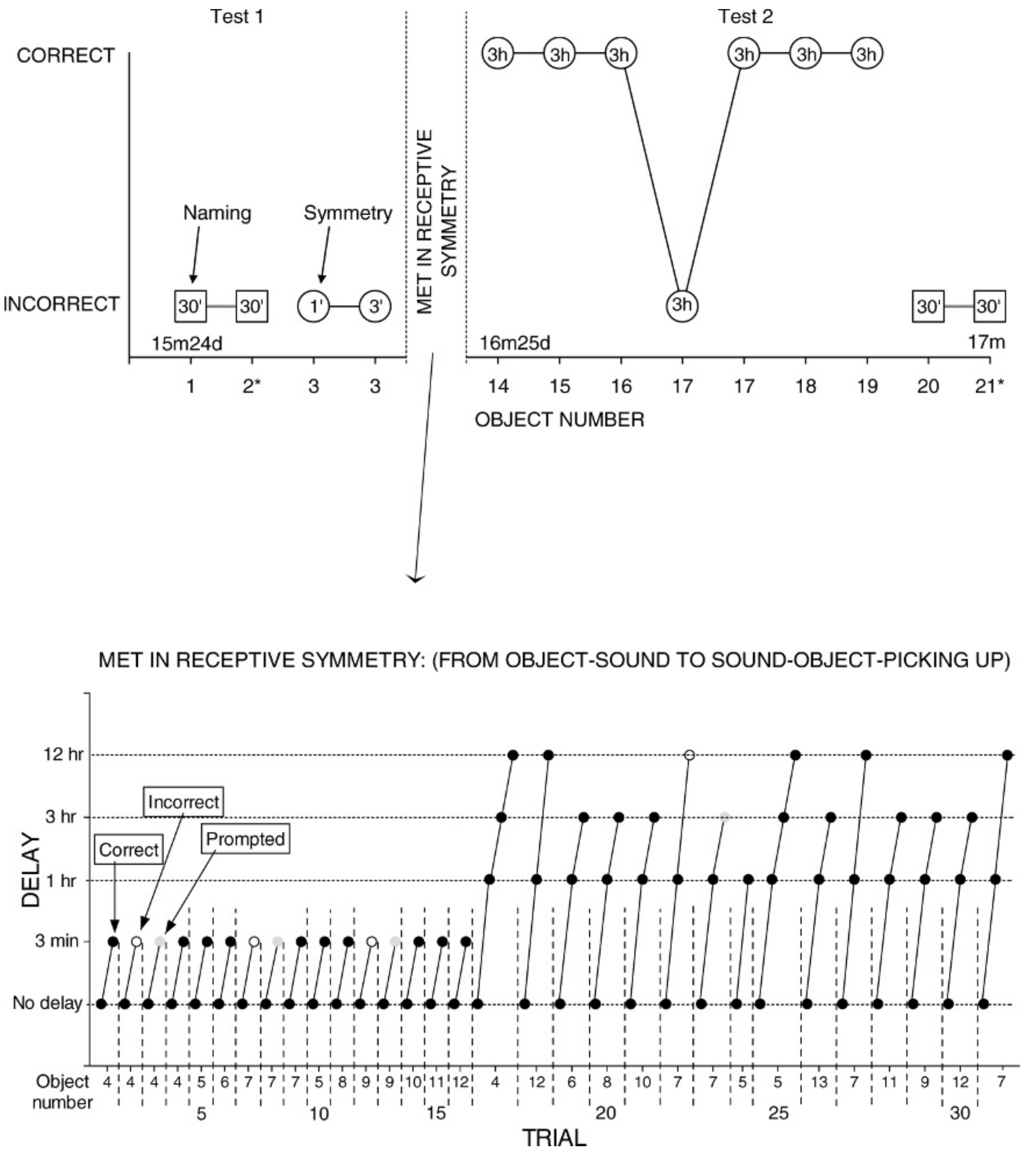

Fig. 1. Data for tests 1 and 2 in Experiment 1. The upper graph shows the temporal sequence of naming and receptive symmetry tests with several objects at different delays, both before and after receptive symmetry training. Squares depict naming tests, and circles depict receptive symmetry tests. Asterisks on the horizontal axis indicate trials with a nonvocal name (see Table 1). The lower graph shows multiple-exemplar training in receptive symmetry with different objects and different delays. The subject's responses (incorrect, prompted, and correct) to each stimulus at different delays are shown (trials are separated by vertical dashed lines).

Results and Discussion

Interobserver agreement between the mother and father's records was calculated on a trial-by-trial basis (agreements divided by agreements plus disagreements, multiplied by 100) for the following events: objects and names presented, imitation of the name presented, delayed symmetrical responses, and consequences delivered. Calculations were performed for all test trials, yielding 100% interobserver agreement for all categories, and for 72% of the training trials, yielding 100% agreement for all categories except for consequences, where agreement was 91%.

Training in immediate and delayed receptive symmetry took 1 month. The lower panel of Figure 1 shows that a total of 78 responses were needed to achieve criterion (70 responses out of 78 were correct, 4 were prompted, and 4 were incorrect). The 78 responses were distributed over 31 trials with 10 different stimuli, each trial involving receptive symmetrical responding both immediately and with at least one delay. Specifically, the first 16 trials involved responding immediately and with a 3-min delay. The remaining 15 trials involved responding immediately, with a 1-hr delay, and with additional, longer delays (from 3 to 12 hr). No imitative responses were recorded during training or testing.

The upper part of Figure 1 shows the results before and after MET. In Test 1, Gloria did not respond correctly either on receptive symmetry or naming tests with several short delays. In Test 2, however, Gloria showed derived receptive symmetry with five of six new objects. Importantly, no approximations of vocal or nonvocal naming occurred. Results from Tests 3 and 4 will be presented with the results of Experiments 2 and 3 (see Figure 3).

At the age of 15m24d Gloria showed no trace of either receptive symmetry or naming after the presentation of a new object and its name by the mother. However, MET in receptive symmetry with 10 objects, both immediately and with increasingly longer delays, resulted in delayed generalized receptive symmetrical responding with five out of six new objects at 16m25d. This suggests that MET is at least sufficient, if not necessary, to generate delayed derived symmetry with novel stimuli (i.e., generalized listener behavior) as a generalized operant in the absence of any evidence of naming.

There are several caveats regarding the present procedures that temper this conclusion. One is that the mother might have inadvertently cued Gloria's correct responding on the tests. However, the fact that the mother had extensive expertise in implementing discrimination procedures with children, the presence of the opaque box lid as a visual barrier, and the constant monitoring of the mother's activity by the first author, all argue against this possibility. Moreover, both parents willingly and reliably recorded Gloria's incorrect responses as well as instances of her inattention and refusals to perform, which apparently would minimize experimenter bias. Another possible limitation is that correct responding on test trials was explicitly positively reinforced. It is important to note, however, that derived symmetry occurred with the first presentation of five of the six novel stimuli. Since reinforcement had never been delivered for responding to these stimuli, it is hard to see how it could have accounted for Gloria's behavior on these trials. These results extend those of previous studies (Horne et al., 2004; Lipkens et al., 1993) where children were trained in listener behavior but did not show delayed receptive behavior with new stimuli.

In spite of the emergence of receptive symmetry, Gloria was unable to name the objects upon request after novel object–name presentations. Thus, symmetrical responding emerged in the apparent absence of naming. These data are consistent with previous studies that have found that although listener training is not sufficient to generate speaker responding, tact training (i.e., training to respond vocally to stimuli when asked ''What is it?'') does serve to generate listener behavior (Horne et al., 2004; Lipkens et al., 1993; Lowe et al., 2002). However, it could be possible that for very young children with a generalized, spontaneous imitative repertoire (i.e., that enables the child to repeat something even if not required to), perhaps the brief bidirectional training in receptive symmetry employed here could have been sufficient for deriving naming. In other words, the interaction between an already established generalized spontaneous imitative repertoire and this sort of receptive training could generate naming, given brief training in responding to the questions ''What is it?'' or ''What's the name of it?'' Apparently, this also was the case for 2 participants in a study by Horne and Lowe (2000). Nevertheless, this was not the case in our study, where no spontaneous imitation occurred during training or testing, and where, according to the parents' informal observations, Gloria imitated only when instructed to do so. This level of imitation in

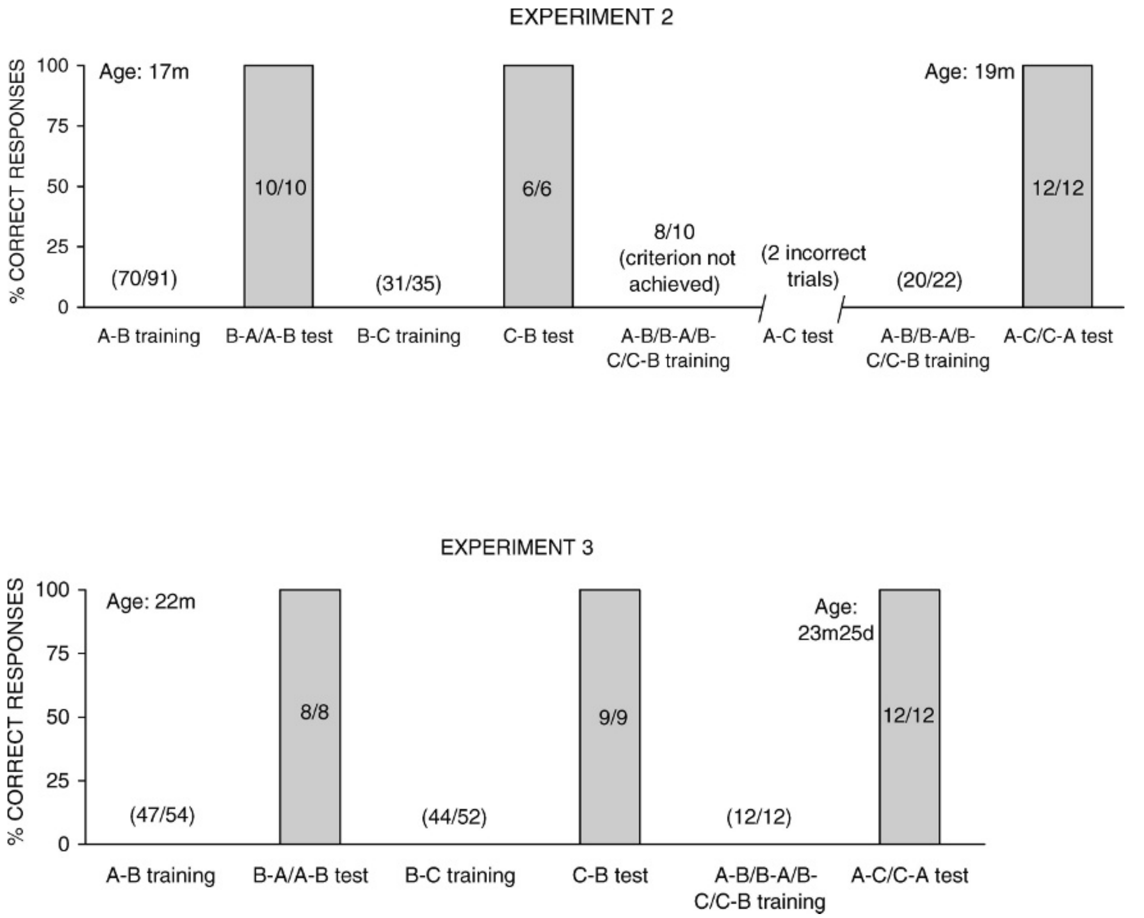

Fig. 2. Data for relations trained and tested during Experiment 2 (from 17m to 19m—upper graph) and Experiment 3 (from 22m to 23m25d—lower graph). These graphs show both the number of correct responses out of the total for each relation, and percentage correct responding for tested relations.

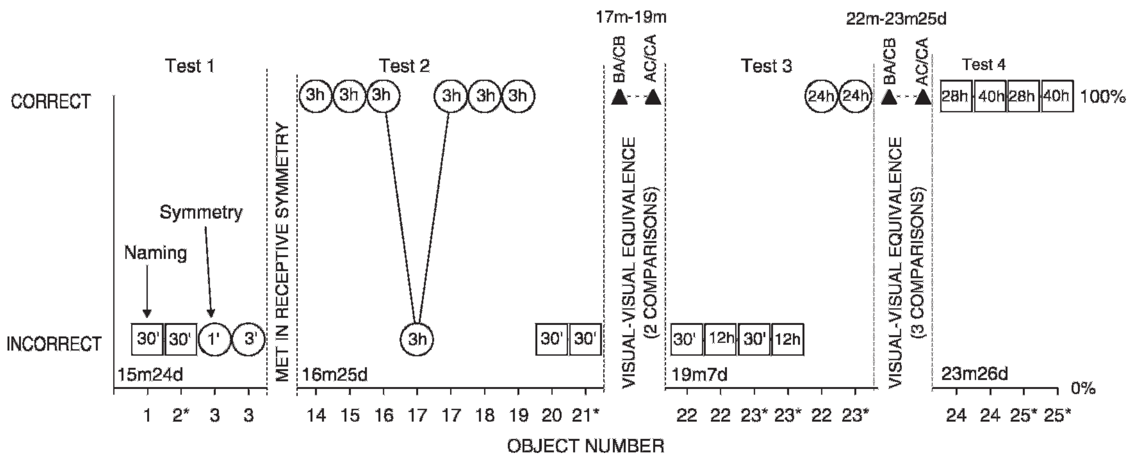

Fig. 3. Graphic depiction of the overall results of all three experiments. The graph includes Tests 1, 2, 3, and 4, and receptive symmetry training in Experiment 1: Squares (with time delay) depict naming tests; circles (with time delay) depict receptive symmetry tests (correct or incorrect). Also included are data from tests for visual–visual symmetry (BA/CB) and transitivity/equivalence (AC/CA) in Experiments 2 and 3: Triangles depict 100 % correct responses on all tests.

Gloria is in accordance with the literature on imitation, which suggests that generalized spontaneous imitation develops slowly around the second year and requires hundreds of exposures to different echoic interactions and specific reinforcement (Horne & Lowe, 2000; Moerk, 1992; Poulson, Kymissis, Reeve, Andreatos, & Reeve, 1991). Thus, in the absence of a spontaneous imitative and naming repertoire, this experiment seems to be the first demonstration of generalized symmetry in an infant established through MET.

EXPERIMENTS 2 AND 3: VISUAL–VISUAL EQUIVALENCE RELATIONS

Once a generalized bidirectional listener repertoire was established for Gloria in the absence of naming, Experiment 2 attempted to establish visual–visual equivalence responding with two comparisons. As stated previously, the ability to name the experimental stimuli has been invoked as a necessary step for the emergence of equivalence relations. However, its role is difficult to isolate because naming training itself involves training in equivalence relations, as can be deduced from Horne and Lowe's data (2000, Studies 3 and 4). As already noted, visual–visual equivalence relations have been identified as more difficult to obtain than auditory–visual relations (Green, 1990; Lipkens et al., 1993; Sidman et al., 1986; Smeets & Barnes-Holmes, 2005), but they could be a good way to isolate the role of naming in very young children. The reason is that in experimental preparations using visual–visual relations, names for the stimuli are not usually supplied and, consequently, only the use of already existing or spontaneously generated names would support a naming-based account of equivalence performances. Provided that only unfamiliar objects were used, the only alternative for a naming-based account of emergent equivalent performances would be the use of spontaneously generated names by the child. Apparently, very young children are not able to do so unless explicitly trained (see Horne et al., 2004). This approach was taken in the present experiments.

Experiment 2 began at the age of 17m, immediately following Test 2 of Experiment 1, and finished at 19m. The question addressed was whether training four visual–visual conditional discriminations (A1–B1, B1–C1, A2–B2, B2–C2) presented in an MTS format with two comparisons would result in derived equivalence responding (the emergent relations A1–C1, A2–C2, C1–A1, C2–A2). At the end of Experiment 2, a new test for symmetry and naming (Test 3) was conducted. Experiment 3 was conducted 3 months later using similar procedures to those used in Experiment 2, but with three comparisons instead of two. A final test for naming (Test 4) was conducted at the end of Experiment 3.

Experimental Sequence and Procedure

Four conditional discriminations were trained directly using an MTS procedure with six different objects as visual stimuli (see Table 1). That is, given sample A1 and comparisons B1 and B2, picking up B1 was consequated with social praise. The same procedure was applied to relate A2 with B2, B1 with C1, and B2 with C2. Special care was taken to increase the probability of correct responding in order to reduce corrective consequences that might have made the experimental tasks aversive. This was achieved by presenting alone the correct comparison in order to prompt correct responding on the first two trials of each trained relation, and then gradually incorporating the other comparison(s). The specific sequence was as follows for Experiment 2:

A–B training. First, two trials of A1B1 with only the correct comparison (B1) were presented. Then A1 was presented with two comparisons (B1 and B2), the positions of which changed randomly across trials. After two consecutive correct trials, the same sequence followed for the A2–B2 relation. After that, the two relations were mixed, that is, both A1–B1 and A2–B2 trials were presented randomly until Gloria achieved the criterion of 20 consecutive correct trials.

B–A testing. Four blocks of two B–A trials each (one B1–A1 and one B2–A2) were presented with two training trials (one A1–B1 and one A2–B2) presented after the second block.

B–C training. This training proceeded as described for the A–B relation.

C–B testing. Three blocks of two C–B trials each (one C1–B1 and one C2–B2) were presented (without interspersed BC training trials).

Mixed training trials. Mixed A–B, B–A, B–C and C–B trials were presented until the criterion of 16 consecutive correct responses (two blocks of eight trials, two per relation randomly presented per block) was achieved.

A–C and C–A testing. Three consecutive blocks of four trials each (two A–C trials followed by two C–A trials) were presented.

The experimental activities were termed ''Playing the Box Game.'' This ''game'' was an analogue of the typical MTS procedure used in equivalence experiments, but it was devised specifically to be consistent with Gloria's existing repertoire. Trials were presented as part of Gloria's daily activities. Periodically, the mother announced to Gloria that it was time to play the Box Game. No similar boxes were in the home at the time of the experiment. On the first training trials, Gloria sat in her father's lap, but later, Gloria and her mother sat on the floor. One to three, but usually two experimental sessions were conducted per day with two or three trials per session. Intertrial intervals lasted about 2 min at the beginning of training, except after an incorrect response, which was followed by an immediate correction trial. As training progressed, intertrial intervals were reduced systematically to the point of conducting three trials in immediate succession in order to have time to run three trials per session.

Except for the first two trials of each directly trained relation, in which only the correct comparison was inside the box, a typical trial was as follows: Gloria and her mother sat in front of each other with a closed box containing two objects (e.g., B1 and B2) between them and a bag containing various objects behind the mother. The mother took an object (A1) out of the bag, held it up at the level of Gloria's eyes, and asked her to look at the object. If Gloria did not look at the object or moved away, the trial was stopped, and the mother waited until Gloria looked at her again or sat in front of her again. The mother waited for approximately 2 min to prompt Gloria to come back and sit with her to play. Then the trial resumed. In any given trial, when Gloria looked at the object, her mother said ''Very good'' and then opened the box and asked Gloria to pick up one of the objects by saying ''Give me the one that goes with this'', while focusing her gaze on Gloria's mouth. As in Experiment 1, the box lid served as a visual barrier to prevent experimenter cueing. When Gloria picked up the correct comparison and presented it, her mother praised her (e.g., ''All right, very good'') while showing both objects together. Then, she put the comparison-object in the box, closed it, and put the sample stimulus in the bag. If the response was incorrect, the mother said ''No, it doesn't,'' put the incorrect comparison behind her, closed the box and hid the sample in the bag. The next trial was a correction trial and started immediately with the same sample. However, on correction trials, only the correct comparison was inside the box.

A procedural mistake occurred when the mother initiated A–C test trials before Gloria met criterion on the mixed training trials (16 consecutive correct responses). After two A–C trials where Gloria responded incorrectly, followed by the scheduled consequences (i.e., the experimenter saying ''No, it does not''), Gloria refused to continue playing. At that point, the mother stopped A–C testing to check with the senior author on how to proceed. It was then realized that the mixed training trials criterion had not been achieved. It also was realized that Gloria's refusal to continue playing after two incorrect responses could be due to the fact that the experimental consequences might be easily discriminable for her (most correct responses were followed by the mother saying ''Very good, very well done'' whereas all incorrect responses were followed by the mother saying ''No, it does not''). Consequently, mixed-trials training resumed the next day, and the consequences were changed. Now, looking at the sample when the mother said ''Gloria, look at this'' was always positively consequated, whereas correct responses were followed by the experimenter saying either ''Very good, you are playing with the Box game very well''(social praise), or most frequently just ''And now Gloria, this one, look at this,'' while keeping the box closed, taking a sample stimulus out of the bag, and presenting it in front of Gloria. Finally, on the last trial of each session, correct responding was followed by saying ''And now, the game is over, let's go and play with daddy.'' In this way, there were explicit consequences for attending to the objects, but no specific consequences for picking up the correct comparison. Incorrect responding was no longer followed by negative feedback, but only by an immediate correction trial. That is, after an incorrect response, the mother said; ''Gloria, and now this one, give the one that goes with this,'' while only the correct comparison was in the box.

It took about 2 months for Gloria to achieve criterion in mixed trials training, after which tests for transitivity-equivalence (A–C/C–A relations) began. Test trials were conducted for 3 days with two sessions per day and two trials per session. The consequences presented on test trials were as indicated above for mixed-trials training, except that correct responding was not followed by social praise. Following this, Test 3 was presented.

Test 3 was like Test 2 (see Experiment 1), but with new stimuli and an additional 24 hr delay. Specifically, two new objects (22 and 23) were used to test for naming (vocally with Object 22 and nonvocally with Object 23) with both 30-min and 12-hr delays. Provided that Gloria showed no signs of naming, receptive responding was again tested with these same objects after a 24-hr delay.

Three months later, at the age of 22 months, Experiment 3 began. It ended when Gloria was 23m25d. Experiment 3 was identical to Experiment 2 with the following exceptions: A–B training was implemented with the gradual introduction of three comparisons instead of two; B–A testing was conducted with three blocks of two trials each, instead of four; C–B testing was conducted with three interspersed training trials; and the criterion in the mixed block of all four training relations was 12 consecutive correct trials, instead of 16. After equivalence testing, a final naming test (Test 4) was conducted with two new objects (Objects 24 and 25) and longer delays (28 and 40 hr) after object-name presentation.

Results

Interobserver agreement between the parents' recordings of samples presented, objects in the box, the child's response, and consequences delivered were calculated on a trial-by-trial basis (number of agreements divided by number of agreements plus disagreements, multiplied by 100) for all test trials in both Experiment 2 and 3, for 87% of training trials in Experiment 2, and for 66% of training trials in Experiment 3. Agreement was 100% for all tests, and 94% and 92% for training in Experiments 2 and 3, respectively.

Figure 2 presents the results of Experiments 2 and 3. Figure 3 presents the summarized depiction of the complete experimental sequence across the study, including the data from the equivalence tests (Experiments 2 and 3), as well as the symmetry and naming tests (Tests 1, 2, 3, and 4).

The upper part of Figure 2 shows the results of Experiment 2. Gloria needed a total of 91 A–B trials to achieve the criterion of 20 consecutive correct trials, with 70 correct, 8 prompted, and 13 incorrect responses. Responses on the test for B–A symmetry trials were all correct (8 B–A and 2 A–B trials). Thirty-five B–C training trials were necessary to meet criterion (31 correct, 3 prompted, and 1 incorrect response). Responses on the subsequent 6 C–B test trials were all correct. Mixed training with all four relations was terminated before achieving criterion after only eight correct, one prompted, and one incorrect response. Then, two A–C tests were conducted, but Gloria refused to continue playing after two incorrect responses. Mixed-trials training started again, and the criterion (16 consecutive correct trials with all four relations) was achieved after 22 trials. An incorrect response occurred in the fifth trial, followed by a prompted trial and then a whole new 16-trial block. Subsequent responses on the test for A–C and C–A equivalence relations were all correct (12 correct responses in three blocks of four trials). In summary, a total of 188 trials (with 157 correct, 13 prompted, and 18 incorrect responses) were conducted when Gloria finished Experiment 2 at the age of 19m. At the end of Experiment 2, Gloria maintained correct responding on delayed receptive symmetry tests with new objects, but still no naming with new stimuli had appeared (see Figure 3, Test 3).

The lower part of Figure 2 shows performance in Experiment 3. A total of 54 A–B trials were needed to achieve the criterion of 20 consecutive correct responses (with 47 correct and 7 prompted responses). Responses on the B–A test were all correct (six test trials and two A–B trials), and B–C training involved 52 trials, with 44 correct and 8 prompted responses. Responses on the six C–B test trials and three interspersed B–C trials were all correct. Then, Gloria achieved without errors the criterion for the 12 mixed training trials, and her responses on the tests for transitivity/equivalence were all correct. At that point, Gloria was 23m25d. This experiment required a total of 147 trials to complete, with 132 correct and 15 prompted responses. No errors occurred either during training or testing of new relations. Finally, naming emerged with new stimuli in Test 4 (see Figure 3).

DISCUSSION

Gloria showed equivalence responding after visual–visual conditional discrimination training without naming at the age of 19 months. These results were obtained after MET in symmetry to establish generalized listener behavior (symmetrical responding with new stimuli) in Experiment 1 and conditional discrimination training with visual–visual relations. These findings are remarkable for several reasons. First, this is the earliest age at which equivalence responding has been reported to date. Second, equivalence was obtained with visual–visual relations which, according to previous studies, are more difficult to obtain than auditory–visual equivalence. These visual–visual equivalence relations appeared after prior MET in auditory–visual symmetry, but in the absence of a direct history of reinforcing multiple exemplars of transitivity and equivalence relations, unlike the case in the sea lion study (Schusterman & Kastak, 1993). Most importantly, they appeared in the absence of naming, as shown in Tests 2 and 3.

One set of factors that may have led to the establishment of equivalence responding at such an early age may have been procedural. These procedural factors include: (1) using an already established and common response topography for infants at this age; (2) the initial use of a single comparison to prevent errors; and (3) the presentation of a small number of trials per session in order to prevent fatigue and boredom. All of these allowed the experiments to be run in Gloria's natural environment as well as for easy data recording and close monitoring of the experimental procedures. These naturalistic procedures were implemented after previous unsuccessful attempts with standard equivalence procedures (e.g., to point to pictures on a board), and they may be useful for future research on verbal behavior with young children.

Some caveats could be raised, however, in relation to the present findings. In the absence of a preexperimental test for equivalence, it could be argued that Gloria may have already had an equivalence repertoire before generalized listener behavior was established in Experiment 1, or that equivalence may have emerged in Experiment 2 independently of prior MET. Several factors render these possibilities unlikely. Equivalence involves bidirectional responding (Hayes et al., 2001; Sidman & Tailby, 1982), and the emergence of derived relations seems to follow a predictable order, with symmetry consistently emerging before transitivity or equivalence (Bush, Sidman, & de Rose, 1989; Dube, Green, & Serna, 1993; Fields, Adams, Verhave, & Newman, 1990; Pilgrim & Galizio, 1995). Also, given that auditory–visual relations are acknowledged to be more easily established than visual–visual relations (Green, 1990; Sidman et al., 1986; Smeets & Barnes-Holmes, 2005), and that MET was necessary to establish auditory–visual relations simpler than equivalence, the existence of a preexisting visual–visual equivalence repertoire to account for the performances observed in Experiment 2 seems implausible. Finally, given that Gloria showed no evidence of vocal or nonvocal naming in Tests 2 and 3, it seems that naming also can be ruled out as an explanation of the present results. Although we did not conduct a formal language assessment beyond parental reports, Gloria's vocabulary of a few words for everyday objects and persons (mum, dad, etc.) is clearly not sufficient to qualify as naming (see Horne & Lowe, 2000). A recent paper by Horne et al. (2004) illustrates this point. The authors pretrained listener behavior with familiar toys ''that resembled everyday objects that many young children have learned to name by the time they are 2 years of age'' (p. 272) prior to proper listener training with novel arbitrary objects and names. The critical question was whether the listener training would enable derived categorization of objects with novel stimuli. It did not. The fact that the children were able to name familiar objects did not mean that they were able to name novel objects, even after hearing their common names. Indeed, the average age at which this happens in normal development is not clearly identified in standard language-assessment instruments (e.g., Bzoch, League, & Brown, 2003; Fenson et al., 1993). Nevertheless, the most important point in analyzing the role of naming in the emergence of arbitrary visual–visual equivalence is that, according to the Naming Theory, the emergence of equivalence depends on being able to generate names and apply them to several stimuli as common labels. Given Gloria's early age (19 months) and her limited naming repertoire, she must not have been able to spontaneously (and privately) give a common name to the unnamed visual stimuli, which then would have served to mediate responding in the equivalence test. This seems a highly unlikely possibility. The available evidence (Horne & Lowe, 2000; Horne et al., 2004; Lowe et al., 2005) clearly shows that such an ability has to be trained explicitly in the experimental context in order to find derived performances in children considerably older than Gloria. In the end, there is no reason to presume that a child as young as Gloria would have had such a generalized repertoire unless explicitly trained, and this was not the case. This conclusion, however, does not preclude the need to identify the conditions under which Gloria passed from generalized listener behavior (bidirectional object–sound relations) to derived visual–visual symmetry and transitivity/equivalence.

Finally, it is unclear to what extent Gloria's performance in Experiment 3 may have been influenced by naming. Although the results of Experiment 2 show that equivalence is possible without naming (as shown in Tests 2 and 3), naming emerged at some point between Test 3 and the end of Experiment 3 (as shown in Test 4). Given that naming facilitates equivalence responding (e.g., Eikeseth & Smith, 1992), the possibility that the emergence of equivalence in Experiment 3 was influenced by naming can not be discarded.

GENERAL DISCUSSION

The conditions that give rise to equivalence responding have been identified by many researchers as a critical theoretical and empirical issue (Galizio, 2003; Hayes & Barnes-Holmes, 2004; Horne & Lowe, 1996; Luciano, Barnes-Holmes, & Barnes-Holmes, 2001; Palmer, 2004). The experiments presented in this paper, although in need of replication, not only provide evidence of the emergence of generalized symmetry and of visual–visual equivalence at a very early age, but these results successfully pass two tests required to support the view that derived relational responding is a generalized operant established through a history of MET (Boelens, 1994; Horne & Lowe, 1996). The first experiment used multiple exemplar training in order to establish symmetrical responding as an operant class, such that given a novel object-sound relation, the infant will—after a delay and given the name by others— correctly respond by orienting towards, pointing to, picking up the object, etc. Previous research has documented the acquisition of listener behavior (e.g., Horne et al., 2004; Lipkens et al., 1993), but not of generalized listener behavior as already discussed in Experiment 1. The results of the second experiment meet the conditions proposed by Horne and Lowe (2000) as necessary to disprove their naming account, that is, the emergence of equivalence responding after listener training, without a speaker component or naming repertoire. In summary, these findings, although to be taken with caution, are in line with an account of the development of equivalence and derived relational responding based on a history of bidirectional training with multiple exemplars (Hayes et al., 2001). Nevertheless, questions still remain regarding the specific, basic relations established through this training.

An explanation of how generalized listener behavior (auditory–visual symmetry) may have influenced the emergence of visual–visual symmetry and equivalence appears to be more complicated. Given the experimental history provided in our first experiment, an attempt to describe the conditions responsible for the emergence of visual–visual symmetry and equivalence in Experiment 2 would only be speculation.

Replication of the present results as well as further experimental analyses of the conditions that establish the emergence of generalized relational responding and the transfer of functions in infants without naming clearly are needed. We hope that this series of experiments will be an initial step in that direction.

REFERENCES

Baer, D. M., Peterson, R. F., & Sherman, J. A. (1967). The development of imitation by reinforcing behavioral similarity to a model. *Journal of the Experimental Analysis of Behavior, 10*, 405–416.

Barnes, D., McCullagh, P. D., & Keenan, M. (1990). Equivalence class formation in non-hearing impaired children and hearing impaired children. *The Analysis of Verbal Behavior, 8*, 19–30.

Barnes-Holmes, Y., Barnes-Holmes, D., Roche, B., & Smeets, P. M. (2001a). Exemplar training and a derived transformation of function in accordance with symmetry. *The Psychological Record, 51*, 287–308.

Barnes-Holmes, Y., Barnes-Holmes, D., Roche, B., & Smeets, P. M. (2001b). Exemplar training and a derived transformation of function in accordance with symmetry: II. *The Psychological Record, 51*, 589–604.

Barnes-Holmes, Y., Barnes-Holmes, D., Smeets, P. M., Strand, P., & Friman, P. (2004). Establishing relational responding in accordance with more-than and less-than as generalized operant behavior in young children. *International Journal of Psychology and Psychological Therapy, 4*, 531–558.

Boelens, H. (1994). A traditional account of stimulus equivalence. *The Psychological Record, 44*, 587–605.

Brady, N. C., & McLean, K. S. L. (2000). Emergent symbolic relations in speakers and non-speakers. *Research in Developmental Disabilities, 21*, 197–214.

Bush, K. M., Sidman, M., & de Rose, T. (1989). Contextual control of emergent equivalence relations. *Journal of the Experimental Analysis of Behavior, 51*, 29–45.

Bzoch, K. R., League, R., & Brown, V. L. (2003). *Receptive-expressive emergent language test.* Austin, TX: Pro-Ed.

Cabello, F. (2005). *Aprendizaje relacional de distintas modalidades estimulares: Implicaciones de la conducta verbal. [Relational learning across different sensory modalities: Implications of verbal behavior]*. Unpublished doctoral dissertation. Universidad de Almería: Spain.

Cabello, F., & O'Hora, D. (2002). Addressing the limitations of protocol analysis in the study of complex human behavior. *International Journal of Psychology and Psychological Therapy, 2*, 115–130.

Carr, D., Wilkinson, M., Blackman, D., & McIlvane, W. J. (2000). Equivalence classes in individuals with minimal verbal repertoires. *Journal of the Experimental Analysis of Behavior, 74*, 101–114.

Devany, J. M., Hayes, S. C., & Nelson, R. O. (1986). Equivalence class formation in language-able and language-disabled children. *Journal of the Experimental Analysis of Behavior, 46*, 243–257.

Dube, W. V., Green, G., & Serna, R. W. (1993). Auditory successive conditional discrimination and auditory stimulus equivalence classes. *Journal of the Experimental Analysis of Behavior, 59*, 103–114.

Eikeseth, S., & Smith, T. (1992). The development of functional and equivalence classes in high-functioning autistic children: The role of naming. *Journal of the Experimental Analysis of Behavior, 58*, 123–133.

Fenson, L., Dale, P. S., Reznick, J. S., Thal, D., Bates, E., Hartung, J. P., et al. (1993). *MacArthur communicative development inventories: User's guide and technical manual.* San Diego, CA: Singular Publishing.

Fields, L., Adams, B. J., Verhave, T., & Newman, S. (1990). The effects of nodality on the formation of equivalence classes. *Journal of the Experimental Analysis of Behavior, 53*, 345–358.

Galizio, M. (2003). The abstracted operant: A review of *Relational frame theory: A post-Skinnerian account of human language and cognition,* edited by S. C. Hayes, D. Barnes-Holmes, and B. Roche. *The Behavior Analyst, 26*, 159–169.

Green, G. (1990). Differences in the development of visual and auditory-visual equivalence relations. *American Journal on Mental Retardation, 56*, 260–270.

Hayes, S. C., & Barnes-Holmes, D. (2004). Relational operants: Processes and implications: A response to Palmer's review of *Relational frame theory. Journal of the Experimental Analysis of Behavior, 82*, 213–224.

Hayes, S. C., Barnes-Holmes, D., & Roche, B. (Eds.) (2001). *Relational frame theory: A post-Skinnerian account of human language and cognition.* New York: Kluwer Academic.

Hayes, S. C., & Hayes, L. J. (1989). The verbal action of the listener as a basis for rule-governance. In S. C. Hayes (Ed.), *Rule-governed behavior: Cognition, contingencies, and instructional control* (pp. 153–190). New York: Kluwer Academic.

Horne, P. J., & Lowe, C. F. (1996). On the origins of naming and other symbolic behavior. *Journal of the Experimental Analysis of Behavior, 65*, 185–241.

Horne, P. J., & Lowe, C. F. (2000). Putting the naming account to the test: Preview of an experimental program. In J. Leslie, & D. E. Blackman (Eds.), *Issues in experimental and applied analysis of human behavior* (pp. 127–148). Reno, NV: Context Press.

Horne, P. J., Lowe, C. F., & Randle, V. R. L. (2004). Naming and categorization in young children: II. Listener behavior training. *Journal of the Experimental Analysis of Behavior, 81*, 267–288.

Lipkens, R., Hayes, S. C., & Hayes, L. J. (1993). Longitudinal study of the development of derived relations in an infant. *Journal of Experimental Child Psychology, 56*, 201–239.

Lowe, C. F., Horne, P. J., Harris, F. D. A., & Randle, V. R. L. (2002). Naming and categorization in young children: Vocal tact training. *Journal of the Experimental Analysis of Behavior, 78*, 527–549.

Lowe, C. F., Horne, P. J., & Hughes, J. C. (2005). Naming and categorization in young children: III. Vocal tact training and transfer of function. *Journal of the Experimental Analysis of Behavior, 83*, 47–65.

Luciano, M. C., Barnes-Holmes, Y., & Barnes-Holmes, D. (2001). Early verbal developmental history and equivalence relations. *International Journal of Psychology and Psychological Therapy, 1*, 137–149.

Luciano, C., Barnes-Holmes, Y., & Barnes-Holmes, D. (2002). Establishing reports of saying and doing and discriminations of say–do relations. *Research in Developmental Disabilities, 23*, 406–421.

Luciano, M. C., Herruzo, J., & Barnes-Holmes, D. (2001). Generalization of say–do correspondence. *The Psychological Record, 51*, 111–130.

Luciano, M. C., & Polaino-Lorente, A. (1986). Effects of the acquisition of prerequisite behavior on the learning of nonvocal verbal behavior and vocal imitation in children with severe retardation. *The Psychological Record, 36*, 315–332.

McIlvane, W. J., Dube, W. V., & Callahan, T. D. (1996). Attention: A behavior analytical perspective. In G. R. Lyon, & N. A. Krasnegor (Eds.), *Attention, memory, and executive function* (pp. 97–117). Baltimore, MD: Paul H. Brookes.

Moerk, E. L. (1992). *A first language: Taught and learned.* Baltimore, MD: Paul H. Brookes.

Palmer, D. C. (2004). Data in search of a principle: A review of *Relational frame theory: A post-Skinnerian account of human language and cognition. Journal of the Experimental Analysis of Behavior, 81*, 189–204.

Pilgrim, C., & Galizio, M. (1995). Reversal of baseline relations and stimulus equivalence: I. Adults. *Journal of the Experimental Analysis of Behavior*, *63*, 225–238.

Poulson, C. L., Kymissis, E., Reeve, K. F., Andreatos, M., & Reeve, L. (1991). Generalized vocal imitation in infants. *Journal of Experimental Child Psychology*, *51*, 267–279.

Schusterman, R. J., & Kastak, D. (1993). A California sea lion (*Zalophus californianus*) is capable of forming equivalence relations. *The Psychological Record*, *43*, 823–839.

Sidman, M. (1994). Equivalence relations and behavior: A research story. Boston, MA: Authors Cooperative.

Sidman, M., & Tailby, W. (1982). Conditional discrimination vs. matching to sample: An expansion of the testing paradigm. *Journal of the Experimental Analysis of Behavior*, *37*, 5–22.

Sidman, M., Willson-Morris, M., & Kirk, B. (1986). Matching-to-sample procedures and the development of equivalence relations: The role of naming. *Analysis and Intervention in Developmental Disabilities*, *6*, 1–19.

Smeets, P. M., & Barnes-Holmes, D. (2005). Auditory–visual and visual–visual equivalence relations in children. *The Psychological Record*, *55*, 483–503.

Wulfert, E., Greenway, D. E., & Dougher, M. J. (1991). Protocol analysis of the correspondence of verbal behavior and equivalence class formation. *Journal of the Experimental Analysis of Behavior*, *56*, 489–504.

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