The Psychological Record, 2001, 51, 589-603

EXEMPLAR TRAINING AND A DERIVED TRANSFORMATION OF FUNCTION IN ACCORDANCE WITH SYMMETRY: II

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The main purpose of the present study was to determine whether exemplar training in symmetry relations would readily facilitate the transformation of function in accordance with symmetry, when subjects were not provided with explicit name training. The study also examined whether pretraining that was formally similar to the symmetry test, but did not reinforce symmetry relations, would have the same facilitative effect as exemplar training. Sixteen children, aged between 4 and 5 years, were employed across three experiments (i.e., 4 children each in Experiments 1 and 2, and 8 children in Experiment 3). In Experiment 1, subjects were trained in an action-object conditional discrimination using familiar actions and objects (e.g., when the experimenter waved, choosing a toy car was reinforced, and when the experimenter clapped, choosing a doll was reinforced). Subjects were then exposed to a test for derived object-action symmetry relations (e.g., experimenter presents toy car→child waves and experimenter presents doll→child claps). Across subsequent sessions, a multiple-baseline design was used to introduce exemplar training (i.e., explicit symmetry training) for those subjects who failed the symmetry test. Experiment 2 replicated Experiment 1, except that the trained and tested relations were reversed (i.e., train object-action, test action-object relations). Experiment 3 replicated Experiment 1, except that subjects were exposed to object-action pretraining. Across Experiments 1 and 2, none of the 8 subjects show derived object-action (Experiment 1) or action-object (Experiment 2) symmetry until they received explicit symmetry training. Pretraining object-action responding in Experiment 3 appeared to facilitate symmetry, but only for 4 of the 8 subjects. For the 4 subjects who failed, symmetry emerged following exposure to exemplar training. Overall, the data are consistent with Relational Frame Theory.

This work was conducted as part of a PhD research program undertaken by Yvonne Barnes-Holmes, funded by the National University of Ireland, Maynooth. Requests for reprints and correspondence should be directed to Yvonne Barnes-Holmes, Department of Psychology, National University of Ireland, Maynooth, Maynooth, Co. Kildare, Ireland. (E-mail: Yvonne.Barnes-Holmes@may.ie).

Relational Frame Theory (RFT) has been offered as one possible way to interpret stimulus equivalence and other examples of derived stimulus relations, such as opposite, difference, more-than/less-than, and so on. According to this theory, exemplar training constitutes a useful means of establishing or facilitating repertoires of derived relational responding (see Barnes, 1994, 1996; Barnes & Holmes, 1991; Barnes & Roche, 1996; Hayes, 1991, 1994; Hayes & Hayes, 1989). From this perspective, derived relational responding or relational frames are considered to be generalized operant response classes that are established by a history of reinforcement across exemplars. Once established, any stimulus event (regardless of form) may participate in a relational frame, under the control of the relevant contextual cues. Various patterns of derived relational responding have been observed in the laboratory, and they are said to possess three generic properties: mutual entailment, combinatorial entailment, and transformation of stimulus function (e.g., Hayes, 1991, 1994; Hayes & Hayes, 1989, 1992). Given an explicitly reinforced A-B relation, mutual entailment involves deriving a B-A relation. Given explicitly reinforced A-B and B-C relations, combinatorial entailment involves deriving A-C and C-A relations. One example of a transformation of function involves a derived relation between A and B, and a transformation of function in A based on this relation. For instance, if A and B participate in the mutually entailed relation of symmetry, and an eliciting function is established for B, the previously neutral function of A may be transformed into an eliciting function.

Relational Frame Theory has generated a range of studies that could all be described loosely as demonstration research. Some of these studies developed experimental procedures for demonstrating complex patterns of derived relational responding in human adult subjects (e.g., Dymond & Barnes, 1995, 1996; Roche & Barnes, 1996, 1997; Steele & Hayes, 1991; Wulfert & Hayes, 1988), whereas others attempted to demonstrate a correlation between relational framing and specific natural language abilities (Barnes, Browne, Smeets, & Roche, 1995; Barnes, McCullagh, & Keenan, 1990; Devany, Hayes, & Nelson, 1986; Lipkens, Hayes, & Hayes, 1993). Although this research has provided evidence in favor of RFT, there have been very few published studies concerned with how relational framing might be facilitated when it fails to emerge (e.g., Barnes-Holmes, Barnes-Holmes, Roche, & Smeets, 2001).

In the study by Barnes-Holmes et al. (2001) the researchers attempted to determine whether exemplar training would readily facilitate the transformation of function in accordance with symmetry. Sixteen children, aged between 4 and 5 years, were employed across four experiments. In one experiment, subjects were first trained to name two actions and two objects by demonstrating listening, echoic, and tacting behaviors. This name training served to establish that each of the subjects could clearly discriminate the experimental stimuli. Subjects were then trained in an action-object conditional discrimination using the previously named actions and objects (e.g., when the experimenter waved, choosing a toy car was reinforced, and when the experimenter clapped, choosing a doll was reinforced). Subjects were then reexposed to the name training, before exposure to a test for derived object-action symmetry relations (e.g., experimenter presents toy car→child waves and experimenter presents doll→child claps). Across subsequent sessions, a multiple-baseline design was used to introduce exemplar training (i.e., explicit symmetry training) for those subjects who failed the symmetry test. In total, 13 out of 16 subjects failed to show derived object-action (Experiments 1-3) or action-object (Experiment 4) symmetry until they received explicit symmetry training. These data were consistent with Relational Frame Theory.

Although a clear facilitative effect for the exemplar training on derived symmetry was shown, two important questions were raised by the foregoing study. First, given that all of the subjects were trained to name the actions and objects used in the experiments, one might ask whether the name training played an important role in the clearly facilitative effect of the exemplar training. Some researchers, such as Horne and Lowe (1996), have argued that naming constitutes the key process in symmetry and equivalence responding, and thus one might expect name training to promote the production of symmetry. An important question arising from the Barnes-Holmes et al. study, therefore, is whether subjects, in the absence of name training, would still show derived symmetry only after exemplar training? Experiments 1 and 2 of the current study were designed to address this question.

The second question that arose from the Barnes-Holmes et al. study was as follows. An interesting feature of their data is that only one or two training exemplars were required before subjects showed symmetry on a subsequent set of actions and objects. The absence of an acquisition curve for symmetry responding across many exemplars could be taken to indicate that the exemplar training was in some way discriminative for an already established behavioral repertoire (i.e., bidirectional stimulus relations were not established for the first time in the Barnes-Holmes et al. study). Indeed, the authors argued that from the perspective of RFT, the study almost certainly did not establish a repertoire of symmetry responding *ab initio*, but the exemplar training *did* establish the experimental context as a cue for producing the preexperimentally established repertoire of symmetry responding. One interesting implication of this RFT interpretation, the authors argued, is that it may be possible to facilitate symmetry in the context of their experimental procedures with means other than explicit symmetry training. For example, perhaps for some children the explicit symmetry training established the procedure as a cue for symmetry simply by providing a history of reinforcement for responding on a task that was formally similar to one that was used during testing. More informally, the children may not have realized that they were required to emit one of two actions when presented with an object, for example, until after they had received the explicit symmetry training. If this was the case, then it may be possible to establish symmetry responding in at least some children by pretraining object-action relations *alone* (i.e., not symmetry relations) before exposure to the experimental procedures using *novel* actions and objects. Experiment 3 of the current study was designed to address this issue.

The basic procedure in Experiment 1 involved training 4- to 5-year-old children to pick one of two familiar objects conditional upon the action of the experimenter (action-object training). During a subsequent test, the objects were presented to the subjects to determine whether they would show a transformation of function in accordance with symmetry. In effect, having been trained to pick Object A when the experimenter waved, would the function of Object A be transformed in accordance with symmetry during the test, such that it would now control waving (i.e., object-action testing)? Experiment 2 replicated Experiment 1, except that the training and testing trial-types were reversed. In effect, subjects were trained to emit specific responses in the presence of particular objects (i.e., object-action training) and were then tested for a transformation of functions in accordance with symmetry (i.e., action-object testing). Experiment 3 replicated Experiment 1, except that subjects were exposed to object-action pretraining (using actions and objects not used in the experiment), to determine whether this would facilitate symmetry as readily as explicit symmetry training. The reader should note, that for ease of communication the term *symmetry* will sometimes be used instead of *transformation of function in accordance with symmetry* (see Barnes, 1996, for a detailed discussion of why the latter term is more accurate from a relational-frame perspective).

GENERAL METHOD

Subjects

Sixteen children, 8 male and 8 female, aged from 4 years and 1 month to 5 years and 2 months, participated in the study. Experiments 1 and 2 each employed 4 children (2 male and 2 female), and Experiment 3 employed 8 children (4 male and 4 female). The children were enrolled in "Primary One" classes in two separate public schools in County Dublin, Ireland. The children were selected from volunteers following classroom announcements; they were chosen on the basis that neither their mainstream schoolteachers nor parents had identified them as presenting a learning difficulty.

Apparatus

The experimental room contained one desk and two chairs. Subjects sat at the desk facing the experimenter. All of the experimental stimuli and actions employed across Experiments 1 to 3 are described in Table 1. The allocation of stimuli to alphanumeric labels was counterbalanced across subjects; for instance, for 2 subjects A1 was the car and A2 was the doll, whereas for the other 2 subjects these labels were reversed. Henceforth, the stimuli are referred to using alphanumeric labels (e.g., toy car may be referred to as A1 and doll as A2), and subjects never saw these labels.

Additional materials were also placed near the child. These included a tray with beads and an upright glass jar, showing a mark. Filling the glass jar to the level of the mark required 50 beads.

Table 1

Stimuli and Actions and Trained and Tested Relations Employed Across Experiments 1-3

Session No.	Stimuli /Actions	Description of Stimuli	Trained Action-Object Relations	Tested Object-Action Relations
I	A1 and A2	Toy Doll: approx. 4 in. tall. Toy Car: approx. 4 in. in length.	Wave-A1 & Clap-A2	A1-Wave & A2-Clap
	Waving Clapping	Waving hand or arm through air. Clapping both hands together.		
II	B1 and B2	Storybook: children's, approx. 4x4 in. Flower: plastic, approx. 3 in. in length.	Arms Out-B1 & Arms In-B2	B1-Arms Out & B2-Arms In
	Arms Out Arms In	Holding both arms out perpendicular to body. Holding both arms at sides of body.		
III	C1 and C2	Toy Bear: approx. 4 in. tall. Building Block: approx. 2 in. square.	Pulling Ear-C1 & Pulling Nose-C2	C1-Pulling Ear & C2-Pulling Nose
	Pulling Ear Pulling Nose	Pulling either left or right ear with fingers. Touching nose with fingers.		
IV	D1 and D2	Cup: plastic, approx. 4 in. tall. Shoe: children's, approx. 5 in. in length.	Rubbing Head-D1 & Scratching Tummy-D2	D1-Rubbing Head & D2-Scratching Tummy
	Rubbing Head Scratching Tummy	Rubbing the top of the head with hand. Scratching tummy with fingers.		
V	E1 and E2	Pencil: wooden, approx. 6 in. long. Schoolbag: approx. 12 x 12 in.	Touching Feet-E1 & Flapping Arms-E2	E1-Touching Feet & E2-Flapping Arms
	Touching Feet Flapping Arms	Touching both feet with fingers. Flapping arms outward and inward from body.		
VI	F1 and F2	Hat: woolen, approx. 12 in. round. Plate: plastic, approx. 6 in. wide.	Hands Behind Back-F1 & Hands Over Eyes-F2	F1-Hands Behind Back & F2-Hands Over Eyes
	Hands Behind Back Hands Over Eyes	Placing both hands behind back. Placing both hands over both eyes.		

Experimental Design

The intervention in the current series of experiments involved explicit symmetry training across one or more exemplars. This training was introduced according to a multiple-baseline design across subjects in each of the three experiments. Assuming that subjects failed the test for a transformation of function in accordance with symmetry, in Experiments 1 and 2 the first subject was introduced to the explicit symmetry training after the first failure, the second subject after the second failure, the third subject after the third failure, and the fourth subject after the fourth failure. A variation of this experimental design was employed in Experiment 3. The exemplar training was introduced according to a multiple-baseline design to determine whether symmetry would emerge only after explicit symmetry training (and not simply following repeated exposures to the experimental procedures).

Inter-observer reliability. Twenty-five percent of training trials and all testing trials across all experiments were observed by two independent observers, who had no knowledge of experimental psychology. The observers were positioned on either side of the room, slightly to the rear of the child. The observers could not see each other's data sheets during the experimental sessions. They each recorded the subjects' responses, in terms of the actions they engaged in or the objects they selected, and scored these as either correct or incorrect responses. Agreement between the observers' recordings was always 100%.

Experiment 1

Procedure

Experimental sequence. Subjects completed all experimental procedures individually. They were exposed to between one and six sessions of training and testing. Each session consisted of between two and four phases, with each phase lasting between 5 and 20 minutes. Subjects were exposed to between one and four phases per day, with 5-minute breaks between phases (the children were allowed to play in an adjacent room during these breaks). Each child continued with the next phase, or with the first phase of the next session, on the next weekday (availability permitting). The Follow-Up Session, however, was conducted approximately 2 months after the first sequence of training and testing (except in Experiment 3, where the Follow-Up Session was conducted 1 month later). In Experiment 1, all subjects required two or more sessions.

Programmed consequences. At the beginning of Session 1, the experimenter placed the bead containers on the table and the subject was told that (a) she or he was going to play a game in which a bead would be awarded for each correct response, and (b) the beads could be exchanged for a preselected picture when the mark on the glass jar (50 beads) had been reached (Smeets, Barnes, & Luciano, 1995). Correct responses during all training trials were followed by the words "Yes, you are correct. Good girl/boy. Take a bead." Incorrect responses during training were followed by the experimenter saying: "No, this is not right. No bead." No beads could be selected after an incorrect response had been emitted. No programmed consequences followed any test trial.

Session I: Phase 1. Action-object training. Subjects were first introduced to the action-object conditional discrimination training. This training consisted of two trial-types. These were presented in a quasi-random order, with each trial-type presented four times in each block of eight trials. Stimuli A1 and A2 were placed horizontally across the table from one another (the left-right positions of these stimuli were randomized across trials). The instructions were as follows: "When I wave/clap at you, I want you to pick (e.g., the car) (A1) or (e.g., the doll) (A2). I will tell you if you have chosen the right or wrong one." The same procedure was used for all subsequent training trials, except that the verbal instruction was omitted after the first four trials. Selecting A1 in the presence of the experimenter waving (*wave*-A1) and A2 in the presence of the experimenter clapping (*clap*-A2) were reinforced. When subjects responded correctly on eight consecutive trials, it was assumed that the action-object relations were established, and they proceeded to Phase 2.

Phase 2. Test for derived object-action relations. The test for derived object-action relations consisted of two trial-types, each of which was presented four times in a quasi-random order across a block of eight trials. Stimulus A1 (or A2) was placed in the center of the table. The experimenter remained silent, and looked directly down at the near edge of the table, so that the subject could not see the experimenter's face. During all test trials, two independent observers, seated to the rear of the child, recorded the subject's responses (the observers could not see each other's data sheets). The experimenter only looked up when a response had been recorded (an independent observer signaled the end of each trial by saying "Continue"). A 10-s interval was allowed for the child to respond (i.e., clap or wave). If the subject failed to clap or wave during this interval the trial was recorded as incorrect (in fact, this rarely occurred across any of the three experiments). Because this was a test phase, no feedback was given. Stimulus A2 (or A1) was then presented, and the procedure was repeated appropriately. If eight consecutively correct responses (A1-*wave* and A2-*clap*) were demonstrated, it was assumed that the derived object-action relations were established, and the subject's participation in the experiment was terminated for the time being. If, however, eight consecutively correct trials were not achieved, the multiple-baseline design required that Subjects 2, 3, and 4 were immediately reexposed to Phase 1 (i.e., the action-object training) before proceeding to the next session (in fact, all subjects in the current study who were reexposed to Phase 1, always completed this training in the minimum number of trials). If Subject 1 failed the test, however, she was exposed immediately to Phase 3.

Phase 3. Explicit object-action (symmetry) training. The test procedure outlined above for the derived object-action relations was repeated, but programmed consequences were now delivered after each response, or at the end of the 10-s interval if no response occurred. In other words, object-action relations (A1-*wave* and A2-*clap*) were explicitly trained. Note however, that no instructions were provided (i.e., the child was not told what to do at the beginning of a trial). This constituted the first exemplar in symmetry training. Eight consecutively correct trials were required to complete this phase. After reexposure to Phase 1 (Subjects 2, 3, and 4) or exposure to Phase 3, the subjects then proceeded to Session II.

Sessions II, III, IV, V, and VI. The procedures outlined in Phases 1 and 2 of Session I were repeated in Session II, but novel stimuli and actions were employed (see Table 1). Assuming that subjects did not pass the symmetry test, the multiple-baseline design required that Subjects 3 and 4 were immediately reexposed to Phase 1 (i.e., the action-object training) before proceeding to the next session. If Subjects 1 and/or 2 failed the test, however, they were exposed immediately to Phase 3 (symmetry training). The same general strategy was adopted for Sessions III and IV, except that (a) novel stimuli and actions were employed for each session and (b) Subject 3 and then Subject 4 were provided with explicit symmetry training (assuming that they failed the symmetry tests). Session V, like the others contained novel stimuli and actions, but it did not contain Phase 3 (see Table 1).

Three of the subjects were available to participate in Session VI, a 2-month Follow-Up Session. This was identical to Session V, but novel stimuli and actions were employed (see Table 1). This was the end of Experiment 1.

Results and Discussion

The data from Experiment 1 are presented in Table 2. In brief, all 4 subjects passed the test for derived object-action relations only after explicit symmetry training. Subject 2 was the only subject who required two separate exposures to the explicit symmetry training (failing the first test by only one incorrect response). Follow-up data taken from 3 subjects (1, 2, & 4) demonstrated that these performances remained in the children's repertoires. For illustrative purposes, consider the results obtained from Subject 2.

Subject 2 completed the conditional discrimination training of the action-object relations in 18 trials. Subsequently, he was tested for the derivation of object-action relations, but failed to pass, producing six correct responses. He was then reexposed to the conditional discrimination (action-object)

Table 2

Training Trials and Correct Responses During Test Trials for Each Subject in Experiment 1

Subjects	1	2	3	4
Session I				
Ph. 1 - Action-object training:	22	18	14	23
Ph. 2 - Test derived object-action:	2/8	6/8	1/8	4/8
Ph. 3 - Object-action training:	10	—*	—*	—*
Session II				
Ph. 1 - Action-object training:	12	14	15	18
Ph. 2 - Test derived object-action:	8/8	3/8	5/8	4/8
Ph. 3 - Object-action training:	—	10	—*	—*
Session III				
Ph. 1 - Action-object training:	—	12	13	9
Ph. 2 - Test derived object-action:	—	7/8	5/8	2/8
Ph. 3 - Object-action training:	—	8	9	—*
Session IV				
Ph. 1 - Action-object training:	—	11	9	10
Ph. 2 - Test derived object-action:	—	8/8	8/8	1/8
Ph. 3 - Object-action training:	—	—	—	11
Session V				
Ph. 1 - Action-object training:	—	—	—	12
Ph. 2 - Test derived object-action:	—	—	—	8/8
Session VI (2-Month Follow-Up)				
Ph. 1 - Action-object training:	13	14	—	10
Ph. 2 - Test derived object-action:	8/8	8/8	—	8/8

Note. * Indicates that the subject was reexposed to action-object training. In all cases, subjects completed the training in eight trials (i.e., the minimum number required).

training with the stimuli employed in Session I. In Session II, Subject 2 successfully completed the conditional discrimination training, with novel actions and objects, in a total of 14 trials, but again failed to pass the test for the derivation of object-action relations (three correct responses). This subject was then immediately exposed to the explicit symmetry (i.e., object-action) training, using the stimuli employed in Session II, which he completed in 10 trials. Subject 2 began Session III using another novel set of actions and objects. He required 12 trials of conditional discrimination training, but failed the symmetry test by only one response (seven correct). He was again exposed to explicit symmetry training using the stimuli from Session III, which he completed in eight trials. In Session IV he was successfully trained in 11 trials using a novel set of actions and objects, and immediately passed the symmetry test without error. Two months later, he was exposed to the Follow-Up Session involving a new set of actions and objects. He required 14 trials to complete the conditional discrimination training, and then immediately passed the test for the transformation of function in accordance with symmetry without error.

Experiment 2

Procedure

Experiment 2 replicated Experiment 1, except that the trained and

Table 3

Training Trials and Correct Responses During Test Trials for Each Subject in Experiment 2

Subjects:	5	6	7	8
Session I				
Ph. 1 - Object-action training:	14	20	12	21
Ph. 2 - Test derived action-object:	5/8	7/8	6/8	2/8
Ph. 3 - Action-object training:	9	—*	—*	—*
Session II				
Ph. 1 - Object-action training:	11	13	11	10
Ph. 2 - Test derived action-object:	8/8	3/8	5/8	6/8
Ph. 3 - Action-object training:	—	10	—*	—*
Session III				
Ph. 1 - Object-action training:	—	9	11	8
Ph. 2 - Test derived action-object:	—	8/8	5/8	3/8
Ph. 3 - Action-action training:	—	—	9	—*
Session IV				
Ph. 1 - Object-action training:	—	—	8	12
Ph. 2 - Test derived action-object:	—	—	8/8	4/8
Ph. 3 - Action-object training:	—	—	—	10
Session V				
Ph. 1 - Object-action training:	—	—	—	9
Ph. 2 - Test derived action-object:	—	—	—	8/8
Session VI (2-Month Follow-Up)				
Ph. 1 - Action-object training:	—	—	16	11
Ph. 2 - Test derived object-action:	—	—	8/8	8/8

Note. * Indicates that the subject was reexposed to object-action training. In all cases, subjects completed the training in eight trials (i.e., the minimum number required).

tested relations were reversed (see Barnes-Holmes et al., 2001, for rationale). In effect, we now trained object-action relations and tested for action-object relations (see Barnes-Holmes et al., 2001, for a detailed description of training object-action and testing action-object relations).

Results and Discussion

The data from Experiment 2 are presented in Table 3. The patterns of test performance emitted by all 4 subjects were similar to those produced by subjects in the previous experiment. That is, action-object tests were only passed after subjects received explicit symmetry training (only one such exemplar was required by each subject). Follow-up data taken from 2 subjects (7 & 8) demonstrated that their performances remained stable. These data provide clear evidence that reversing the trained and tested relations does not reduce the facilitative effect of explicit symmetry training on derived symmetry responding.

Experiment 3

Procedure

Experiment 3 was similar to Experiment 1 in that training and testing involved action-object and object-action relations, respectively (see Table 4). Eight subjects (9-16) were first exposed to pretraining of object-action relations using Set 1 (i.e., A1 & A2, car & doll). This pretraining was identical to the explicit symmetry training in object-action relations that had been used previously. Subjects were trained on these relations until eight consecutively correct responses were emitted. They were subsequently exposed to action-object training with a novel set of actions and objects, followed immediately by a test of the object-action relations (i.e., training and testing with Set 2). Because subjects had been pretrained in object-action relations, without explicit symmetry training, we expected that some, but not all subjects would pass on the first symmetry test. If sufficient subjects indeed failed this test, it was planned that they be exposed to one of two experimental sequences. Some subjects would receive explicit symmetry training (on Set 2), and would then be trained and tested on a new set (Set 3) of action-object relations. The remaining subjects, who had also failed the symmetry test, would be reexposed to the pretraining (using Set 1). Once they reached the mastery criterion again, they would then be exposed to training and testing on a novel set of actions and objects (i.e., Set 3). If the subjects again failed the symmetry test, they would receive explicit symmetry training. Following this, they would be reexposed to action-object training and object-action testing involving another novel set of actions and objects (i.e., Set 4). If subjects were available, they would be exposed to a 1-month follow-up using a novel set of actions and objects.

Table 4

Trained and Tested Relations Employed in Each Session of Experiment 3

Session No.	Trained Action-Object Relations	Tested Object-Action Relations
I (Pretraining)	Wave-A1 & Clap-A2	A1-Wave & A2-Clap
I	Arms Out-B1 & Arms In-B2	B1-Arms Out & B2-Arms In
II	Pulling Ear-C1 & Pulling Nose-C2	C1-Pulling Ear & C2-Pulling Nose
III	Rubbing Head-D1 & Scratching Tummy-D2	D1-Rubbing Head & D2-Scratching Tummy
IV (Follow-Up)	Touching Feet-E1 & Flapping Arms-E2	E1-Touching Feet & E2-Flapping Arms

Results and Discussion

The data from Experiment 3 are presented in Table 5. As expected, a greater proportion of subjects who received object-action pretraining passed the first symmetry test with a new set of actions and objects than had been observed in the previous experiments (i.e., 4 out of 8 versus 0 out of 8 subjects). The remaining 4 subjects (10, 12, 13, & 15) who failed the symmetry test were divided into two pairs. Two subjects (10 & 15) were immediately exposed to explicit symmetry training using the same set of actions and objects (Phase 3). The other two subjects (12 & 13) were reexposed to object-action pretraining using Set 1. Both subjects, who received the explicit symmetry training on the same set, were then trained on a novel set and immediately passed the symmetry test (in Session II). However, both of the subjects who were reexposed to the object-action pretraining, and were trained on a novel set, then failed the symmetry test for the second time. These subjects were then immediately exposed to explicit symmetry training using the same set of actions and objects as used in Phases 1 and 2. After training on a new set, they immediately passed the symmetry test (in Session III). Four subjects (9, 12, 15, & 16) were available for a 1-month follow-up session, and all demonstrated that the derived symmetry performances remained stable.

The results from this experiment showed that it was possible to establish symmetry responding in some children by pretraining object-action relations alone (i.e., not symmetry relations) before exposure to the experimental procedures using novel actions and objects. However, for 4 of the children this pretraining was not effective. Even after two exposures to object-action pretraining, 2 of these subjects continued to fail the symmetry test. After receiving explicit symmetry training with the same set, however, they immediately produced derived symmetry responding. These results indicate that when object-action pretraining fails to generate derived symmetry, explicit symmetry training may prove to be more effective in this regard than simply repeating the pretraining procedure.

Table 5

Training Trials and Correct Responses During Test Trials for Each Subject in Experiment 3

Subjects	9	10	11	12	13	14	15	16
Session I								
Object-action pretraining:	16	24	14	18	22	22	21	26
Ph. 1 - Action-object training:	12	16	16	20	15	19	24	29
Ph. 2 - Test derived object-action:	8/8	2/8	8/8	5/8	3/8	8/8	2/8	8/8
Ph. 3 - Object-action training:	—	12	—	—*	—*	—	14	—
Session II								
Ph. 1 - Action-object training:	—	12	—	10	18	—	10	—
Ph. 2 - Test derived object-action:	—	8/8	—	1/8	3/8	—	8/8	—
Ph. 3 - Object-action training:	—	—	—	10	14	—	—	—
Session III								
Ph. 1 - Action-object training:	—	—	—	12	16	—	—	—
Ph. 2 - Test derived object-action:	—	—	—	8/8	8/8	—	—	—
Session IV (1 Month Follow-Up)								
Ph. 1 - Action-object training:	24	—	—	15	—	—	11	21
Ph. 2 - Test derived object-action:	8/8	—	—	8/8	—	—	8/8	8/8

Note. * Indicates that the subject was reexposed to object-action pretraining. In all cases, subjects completed the training in eight trials (i.e., the minimum number required.) Objects and actions used in pretraining were never used in Phases 1, 2, or 3, across any of the sessions.

General Discussion

The current study addressed two questions that arose from the research reported by Barnes-Holmes et al. (2001). The first question concerned the role of the name training that they employed throughout their study. Although Barnes-Holmes et al. demonstrated a clear facilitative effect for exemplar training on the transformation of function in accordance with symmetry, all of the subjects were first trained to name every action and object. Consequently, this experimental naming history may have played an important role in generating the facilitative effect of the exemplar training. The current study removed the name training from the experimental procedures, and yet it produced similar results. The present work therefore clearly answers the first question raised by our earlier study—the experimental name training is *not* needed for exemplar training to have its facilitative effect.

The second question concerned whether it would be possible to facilitate symmetry, in the current context, with means other than explicit symmetry training. To address this question, subjects in Experiment 3 of the current study were exposed to object-action pretraining which was designed to provide a history of reinforcement for responding on a task that was formally similar to one that was used during testing, but without explicitly training a symmetry relation. Although a greater proportion of subjects (50%) in this experiment passed the first symmetry test, in comparison to our previous six experiments across the two studies (12.5%), the exemplar training still proved to be highly effective for those subjects who failed. Once again, therefore, exemplar training appears to be the most effective method for establishing a transformation of functions in accordance with symmetry using our experimental procedures.

Although the current data provide further evidence to support the efficacy of exemplar training in generating derived relational responding in young children, it would be unwise to assume that exemplar training is the only relevant behavioral process responsible for these effects. Most of the actions and objects that were used in the current study were familiar to the children, and thus these stimuli may well have participated in preexperimentally established name relations. Insofar as this was the case, this history of preexperimental naming may have played an important role in generating the derived symmetry performances. On balance, it should be noted that none of the children consistently named aloud all of the actions and objects during the experiments, and furthermore some of the children failed to name any of the stimuli throughout their participation in the study. Nonetheless, it could be argued that private or covert naming occurred, and thus we must be cautious in dismissing any role for naming in accounting for the observed performances. However, adopting this particular stance renders the naming hypothesis, as articulated by Horne and Lowe (1996), almost unfalsifiable (i.e., it is notoriously difficult to monitor reliably the private verbal behavior of research participants; see Hayes, 1986).

Perhaps a broader theoretical issue is more relevant in the current context. When the current findings are considered alongside the data reported by Barnes-Holmes et al. (2001), Horne and Lowe's naming hypothesis, relative to RFT, appears to be the weaker account. From the perspective of RFT, naming behavior makes available large numbers of stimuli and responses (i.e., heard and spoken words) by which numerous examples of bidirectional responding may be explicitly trained. Specifically, RFT suggests that explicitly reinforced name-object and object-name relations provide a history of explicit symmetry training. In this way, naming provides one important way in which the generalized operant of derived symmetry may be established across exemplars (see Barnes, 1994, 1996; Barnes & Holmes, 1991; Barnes & Roche, 1996; D. Barnes-Holmes & Y. Barnes-Holmes, 2000; Hayes, 1991, 1994; Hayes & Hayes, 1989). From this RFT perspective, therefore, naming does not produce symmetry directly, but instead provides the type of history and some of the contextual cues that control the relational operant of symmetry. Accordingly, a history of naming may enhance symmetry responding, but it is neither necessary nor sufficient for such responding to occur (Hayes, 1996). The key process is symmetry training, not naming *per se.* The naming hypothesis and RFT, therefore, make different predictions regarding the facilitative effect of naming on symmetry responding. The former predicts that naming should normally function as a very powerful intervention for remediating deficits in derived symmetrical responding. In contrast, RFT predicts that exemplar training should be the most powerful intervention in this regard. Clearly, the current research, and that reported in our previous article, provides strong support for RFT, in that explicit symmetry training proved to be far more effective in generating derived symmetry than name training.

A final issue concerns the fact that, like our previous study, only one or two exemplars of explicit symmetry training were required before subjects showed symmetry on a subsequent set of actions and objects. The limited number of exemplars needed in both studies could be taken to indicate that the exemplar training was in some way discriminative for an already established behavioral repertoire. Future research on exemplar training might focus, therefore, on establishing relational responding that is completely absent in the behavioral repertoires of young children. In a recent study in the Maynooth laboratory, for example, we have started to use exemplar training to establish relational framing in accordance with opposite relations in 4- to 5-year-old children.

The current study demonstrated that exemplar training may be used to establish a derived transformation of functions in accordance with symmetry with young verbally able children. Although much more work remains to be done, the importance of exemplar training has been clearly documented.

References

BARNES, D. (1994). Stimulus equivalence and relational frame theory. *The Psychological Record*, 44, 91-124.

BARNES, D. (1996). Naming as a technical term: Sacrificing behavior analysis at the altar of popularity. *Journal of the Experimental Analysis of Behavior*, 65, 264-267.

BARNES, D., BROWNE, M., SMEETS, P. M., & ROCHE, B. (1995). A transfer of functions and a conditional transfer of functions through equivalence relations in three- to six-year-old children. *The Psychological Record*, 45, 405-430.

BARNES, D., & HOLMES, Y. (1991). Radical behaviorism, stimulus equivalence, and human cognition. *The Psychological Record*, 41, 19-31.

BARNES, D., MCCULLAGH, P. D., & KEENAN, M. (1990). Equivalence class formation in non-hearing impaired children and hearing impaired children. *Analysis of Verbal Behavior*, 8, 1-11.

BARNES, D., & ROCHE, B. (1996). Relational frame theory and stimulus equivalence are fundamentally different: A reply to Saunders. *The Psychological Record*, 46, 236-256.

BARNES-HOLMES, D., & BARNES-HOLMES, Y. (2000). Explaining complete behavior: Two perspectives on the concept of generalized operant classes. *The Psychological Record*, 50, 251-266.

BARNES-HOLMES, Y., BARNES-HOLMES, D., ROCHE, B., & SMEETS, P. M. (2001). Exemplar training and a derived transformation of function in accordance with symmetry. *The Psychological Record*, 51, 287-308.

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

DYMOND, S., & BARNES, D. (1995). A transformation of self-discrimination response functions through the arbitrarily applicable relations of sameness, more-than, and less-than. *Journal of the Experimental Analysis of Behavior*, 64, 163-184.

DYMOND, S., & BARNES, D. (1996). A transformation of self-discrimination response functions in accordance with the arbitrarily applicable relations of sameness and opposition. *The Psychological Record*, 46, 271-300.

HAYES, S. C. (1986). The case of the silent dog—Verbal reports and the analysis of rules: A review of Ericsson and Simon's *Protocol analysis: Verbal reports as data. Journal of the Experimental Analysis of Behavior*, 45, 351-363.

HAYES, S. C. (1991). A relational control theory of stimulus equivalence. In L. J. Hayes & P. N. Chase (Eds.), *Dialogues on verbal behavior* (pp. 19-40). Reno, NV: Context Press.

HAYES, S. C. (1994). Relational frame theory: A functional approach to verbal events. In S. C. Hayes, L. J. Hayes, M. Sato, & K. Ono (Eds.), *Behavior analysis of language and cognition* (pp. 9-30). Reno, NV: Context Press.

HAYES, S. C. (1996). Developing and theory of derived stimulus relations. *Journal of the Experimental Analysis of Behavior*, 65, 309-311.

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

HAYES, S. C., & HAYES, L. J. (1992). Verbal relations and the evolution of behavior analysis. *American Psychologist*, 47, 1383-1395.

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.

LIPKENS, R., HAYES, S. C., & HAYES, L. J. (1993). Longitudinal study of derived stimulus relations in an infant. *Journal of Experimental Child Psychology*, 56, 201-239.

ROCHE, B., & BARNES, D. (1996). Arbitrarily applicable relational responding and human sexual categorization: A critical test of the derived difference relation. *The Psychological Record*, 46, 451-475.

ROCHE, B., & BARNES, D. (1997). A transformation of respondently conditioned stimulus function in accordance with arbitrarily applicable relations. *Journal of the Experimental Analysis of Behavior*, 67, 275-300.

SMEETS, P. M., BARNES, D., & LUCIANO, M., C. (1995). Reversal of emergent simple discrimination in children: A component analysis. *Journal of Experimental Child Psychology*, 60, 327-343.

STEELE, D., & HAYES, S. C. (1991). Stimulus equivalence and arbitrarily applicable relational responding. *Journal of the Experimental Analysis of Behavior*, 56, 519-555.

WULFERT, E., & HAYES, S. C. (1988). Transfer of a conditional ordering response through conditional equivalence classes. *Journal of the Experimental Analysis of Behavior*, 50, 125-144.