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NAMING AND CATEGORIZATION IN YOUNG CHILDREN: III. VOCAL TACT TRAINING AND TRANSFER OF FUNCTION

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Following pretraining with everyday objects, 10 children aged from 1 to 4 years were given common vocal tact training with a set of three pairs of arbitrary stimuli of differing shapes; Set 1. Nine children learned to tact one stimulus as ''zog'' and the other as ''vek'' in each pair, and all passed subsequent pairwise tests for the corresponding listener behavior to each listener stimulus (i.e., /zog/ and /vek/, respectively). The children were next trained to clap to one stimulus of Pair 1 and wave to the other, and all then showed name-consistent transfer of these behaviors to the stimuli of Pair 2 and Pair 3. Seven children also were given a test of listener responding to experimenter-modeled clap and wave gestures, respectively, which they all passed. Four of the children next participated in a category match-to-sample test for the Set 1 stimuli; all 4 passed. For each pair of two additional six-stimuli sets, Set 2 and Set 3, 3 children were trained to wave to one stimulus and to clap to the other. For each set, all 3 children showed perfect transfer of the vocal tacts trained to Set 1, and of listener behavior both to the auditory stimuli /zog/ and /vek/ and to experimenter-modeled clap and wave gestures. They also sorted the stimuli perfectly in category match-to-sample tests for Set 2, Sets 1 and 2 combined, Set 3, and Sets 1, 2, and 3 combined. The results show that even in very young children, naming is a powerful means of generating new category relations among as many as 18 arbitrary stimuli.

Key words: naming, vocal tacting, transfer of function, categorization, stimulus classes, category match to sample, children

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Humans have prodigious classifying skills. We partition our environment into complex categories, many of which are nested in yet further categories. How we generate such a proliferation of classes, whose members often have no common physical features, is still very much the focus of debate not only within the behavior-analytic literature (e.g., Hayes & Hayes, 1992; Horne & Lowe, 1996, 1997; Lowe & Horne, 1996; Sidman, 1994, 2000; Zentall, Galizio, & Critchfield, 2002) but also in other domains of psychological research (see Rakison & Oates, 2003 for an overview). To establish conventional categories, children need to learn, for example, not only that creatures as diverse as cats, elephants, and turtles are ''animals'' whereas trains, cars, and airplanes are ''vehicles,'' but also that whereas animals eat, sleep, and procreate, vehicles exhibit none of these behaviors. Any convincing theoretical account of categorization must therefore explain how even young children may group particular arbitrary stimuli together without all possible relations between those stimuli having been directly trained, and it also must explain how a novel but category-relevant behavior that is trained to only one member may, without training, occur to all other category members (Gelman & Koenig, 2003).

To date, behavior-analytic studies of how novel behavior transfers within classes or categories have reported mixed outcomes in human adults and children (Dougher & Markham, 1996). Some studies have found transfer of various functions among members of preestablished stimulus classes in humans (e.g., Barnes, Browne, Smeets, & Roche, 1995; Barnes & Keenan, 1993; Dougher, Auguston, Markham, Greenway, & Wulfert, 1994; Kohlenberg, Hayes, & Hayes, 1991; Lazar & Kotlarchyk, 1986; Wulfert & Hayes, 1988), whereas others have reported transfer failures (e.g., Bones et al., 2001; Fields, Landon-Jimenez, Buffington, & Adams, 1995; Greenway, Dougher, & Markham, 1995; Sidman, Wynne, Maguire, & Barnes, 1989). The converse is also true. In some experiments, the subjects have first been trained to emit a common behavior to several arbitrary stimuli;

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when the latter were then embedded in match-to-sample procedures, the subjects have not always passed tests of ''stimulus equivalence'' (e.g., Smeets, Barnes, & Roche, 1997).

One reason for these discrepant outcomes may be the use of match-to-sample procedures to study categorization and behavior transfer. It is interesting, for example, that the difficulty young children frequently show in learning baseline relations with the match-to-sample procedures that are often employed in such studies (Pilgrim, Jackson, & Galizio, 2000) does not reflect their normal progress in learning verbal behavior and categorizing in nonexperimental environments (e.g., Anisfeld, 1984; Vihman, 1996). Although verbal behavior and categorizing undergo extensive development even in the first few years of childhood (Nazzi & Gopnik, 2001), there have been relatively few behavior-analytic studies to date that have focused on the role of verbal behavior, either as a dependent or independent variable, in category transfer of novel behaviors. This relationship, however, is the central focus of the naming account of Horne and Lowe (1996). Incorporating some of the operants from Skinner's (1957) comprehensive theoretical taxonomy of verbal behavior, Horne and Lowe proposed that naming, a bidirectional speaker-listener relation, has the functional properties required to establish the categorizing behaviors many see as being unique to humans. The aim of their account is to take forward Skinner's work on rule governance, and to promote a renewed focus within the behavior-analytic tradition on how basic verbal operants are learned (and see also Palmer, 1996; Smith, Michael, & Sundberg, 1996; Sundberg, Michael, Partington, & Sundberg, 1996; Vaughan & Michael, 1982), and how they give rise to new category relations.

According to Horne and Lowe (1996), naming may establish category relations between disparate stimuli given that they each occasion the same name. The key questions arising from this developmental perspective concern how speaker and listener behavior are first learned, how they become functionally interrelated, and how the resulting bidirectional name relation confers generative properties to human behavior. Horne and Lowe propose that the functional properties of these common name or category relations may be assayed in two ways: (a) by category sorting among sets of arbitrary stimuli that have common names, and (b) by transfer of function within but not between members of common-name relations. In a study of the relation between naming and category sorting, Lowe, Horne, Harris, and Randle, (2002) have shown that when children aged from 2 to 4 years learn two 3-member common tact relations, they also produce the corresponding listener behavior without being trained to do so; that is, they learn not only tacting but common name relations.

According to the naming account the children should, given that they name the arbitrary stimuli when they see them, also sort the stimuli into common name categories without being directly trained to do so, and this is indeed what occurred in this study in subsequent category match-to-sample tests. Six of the 12 children sorted correctly when given one of the stimuli and asked to give the experimenter ''the others,'' whereas the remaining 6, who failed to do so initially, succeeded when they were asked to name the sample before sorting the remaining stimuli. However, in a second study (Horne, Lowe & Randle, 2004), when 7 children of a similar age were trained on common listener relations with the same arbitrary stimuli, all the children failed to sort the stimuli correctly in the subsequent category match-to-sample test. Following training of the corresponding common tact relations, however, 5 of the 7 children went on to pass the category tests. Taken together, these two studies provide strong empirical support for two main predictions of the naming account: That common listener training is not sufficient, and that the full bidirectional name relation is necessary for the establishment of arbitrary stimulus category relations in young children.

The naming account also predicts that naming is a powerful means of transferring novel behaviors among common name members. For example, having learned to name several shoes as ''shoe,'' a child may then learn the new behavior of putting her foot in one of them. This new behavior is integrated into the name relation as follows: Because the child continues to name the shoe as she learns how to put her foot into it (a behavior that is reinforced by the child's caregivers, and by automatic consequences; see Horne & Lowe, 1996, pp. 203–204; Palmer, 1996; Vaughan & Michael, 1982), this new behavior may come under the discriminative control of the listener stimulus the child produces when she says "shoe." Thereafter, when the child sees a physically different shoe but one that is already in her shoe name relation, she may name it, and the listener stimulus she thereby produces may occasion the listener behavior of putting her foot into it. In this way, the novel behavior transfers to other objects in the child's existing shoe name relation and to other physically similar shoes.

In addition, however, because performance of this listener behavior requires the child to visually guide her foot into the shoe, she will once again see the shoe and name it. This establishes the conditions for the novel behavior itself to evoke the name response. So, if when the child encounters a novel shoe, or even an object that does not resemble a conventional shoe (e.g., a box), it evokes the action of her placing her foot into it, the child may respond to her own behavior by saying "shoe," and so will incorporate the new object into her shoe name relation. Because the bidirectional nature of the name relation can encompass a variety of listener behaviors, it follows that not only should new behaviors transfer through a common name but also that these, in turn, may then serve as a means, thereafter, by which to extend the common name (Horne & Lowe, 1996, pp. 201–202; and see pp. 209–210 on intraverbal transfer). If name relations transfer novel functions across all category members when a new behavior is trained to only one or two of them, then common naming will be shown to be an extremely effective and economic means of extending young children's behavioral repertoires. The central focus of the present study was to establish whether naming is indeed effective in bringing about transfer of function, and how naming relates to category sorting.

In Experiment 1, children aged from 1 to 4 years were trained to produce the tact "zog" to each of three arbitrary stimuli and the tact "vek" to another three. A subset of the children was then given tests for the corresponding listener behavior; the remaining children received the listener test after all other procedures were completed. Next, the children were trained to produce a new behavior to one member of each common tact relation, for example, waving to Zog 1, and clapping to Vek 1. The children's transfer of the clapping and waving responses to the remaining zog and vek stimuli was then tested, following which there were tests of listener behavior to the experimenter's claps/waves; a subset of the children was then given category match-to-sample tests. Three of the children participated in Experiment 2, which investigated class extension via only common function (clap/wave) training with two further six-stimulus sets.

Table 1

Participants' sex, age at start of procedure, age at first category test, and score on the Griffiths Mental Development Scale (GMDS).

Subject	Sex	Age at start (years/ month)	Age at testing (years/ month)	GMDS general quotient
JJ	M	1/7	1/10	*
AF	F	1/10	2/3	*
LN	M	2/1	2/4	*
RC	F	2/6	2/7	112
JA	M	2/8	3/3	103
CS	F	3/0	3/0	109
BH	F	3/0	3/7	132
CH	F	3/6	3/8	121
EW	F	3/7	3/7	129
TO	M	3/10	—	109

* Data not available.

EXPERIMENT 1

METHOD

Subjects

Subjects were 6 girls (AF, RC, CS, BH, CH, and EW) and 4 boys (JJ, LN, JA, and TO) who attended the Daycare Nursery and Center for Child Development at the University of Wales, Bangor. The children were aged from 1 year 7 months to 3 years 7 months at the start of the study (see Table 1). None of them had previously participated in conditional discrimination research. A Griffiths Mental Development Scales (Griffiths, 1954) assessment was conducted with 7 of the children, all of whom scored within the normal range for children of their age group (see Table 1). The 3 remaining children, who left the nursery before they completed the developmental tests, showed no sign of developmental delay. One child, Subject TO, did not learn the prerequisite tact relations for arbitrary stimulus Pair 2; data are reported only for the remaining 9 children who reached the arbitrary stimulus category-testing phase (see Table 1).

Apparatus and Stimuli

The setting and apparatus were as described in Lowe et al., (2002). The experimental stimuli were of two types: (a) six everyday objects—three different hats and three different cups; and (b) 18 arbitrary green wooden shapes (for examples, see Lowe et al., 2002, Figure 1). The main scheduled reinforcer was social praise, supplemented occasionally with stickers. At the end of each session, the children were permitted either to choose several stickers for their personal sticker books, or to play for a few minutes with a teddy bear of their choice.

Procedure

An outline of the scheduled procedure is presented in Figure 1; exceptions are noted below in the relevant sections.

Everyday objects. Experimenter 1 first established a good rapport with the children during unstructured daily play sessions, following which they were taken into the experimental room one at a time. During the first session, the experimenter introduced ''Teddy,'' a hand puppet, to the child and said, ''Teddy would like to learn the names of some of these toys. Do you think you could help him?'' For each child, the everyday objects, three hats and three cups, were randomly divided into three pairs, each of which consisted of one stimulus from each category. Each child's training pairs remained constant throughout the experiment. Experimental sessions throughout the study varied in duration from 5 to 20 min, dependent on the individual child. The children's verbal behavior was recorded during all phases.

Tact overtraining in pairwise trials. Using the procedure described in Lowe et al. (2002), the child was trained to tact the hat and cup in each of the three everyday object pairs. The learning criterion was three out of four correct tact responses for each of the stimuli within an eight-trial block over two consecutive blocks.

Conventional function overtraining: Pair 1. Only the Pair 1 stimuli were employed in this phase. The two stimuli were placed in front of the child, the experimenter pointed to either Hat 1 or Cup 1 and said, ''Look at this; it goes like this.'' The experimenter then modeled the conventional function appropriate for that particular stimulus. For the hat, this was putting it on his head; for the cup, he modeled drinking from it. The experimenter then asked the child, ''Can you show me how this goes?'' If the child responded correctly, the experimenter delivered social praise; if the child did not respond or responded incorrectly, the experimenter gave corrective feedback saying, ''It goes like this [the experimenter modeled the correct action]; can you show me how it goes?'' Once the child had responded to this instruction correctly over one block of trials for both the Hat 1 and Cup 1 stimuli, subsequent instructions were abbreviated to, ''Can you show me how this one goes?'' The scheduling of trials within a block and the learning criterion were as in pairwise tact training.

Category transfer-of-function test: Pairs 2 and 3. This stage was designed to establish correct responding to the instructions that would be later employed during testing with the arbitrary objects. The screen was placed on the table between the child and the experimenter, who reached through the aperture to place the Pair 2 stimuli on the table in their predetermined positions in front of the child, then pointed to either the hat or the cup and said, ''Can you show me how this one goes?'' Each stimulus was targeted four times in one randomized and counterbalanced block of eight test trials. The same procedure was then carried out with the Pair 3 stimuli. No feedback was given during this test. If any child failed the test, the conventional hat and cup behaviors were to be trained to Pair 2 and/or Pair 3, as required.

Arbitrary Stimuli: Tact training in pairwise trials—Initial pairs. For each child, a set of six stimuli was selected at random from the pool of wooden shapes. The nonsense names ''zog'' and ''vek'' were employed as target tact responses (see Lowe et al., 2002). The experimenter randomly divided the six stimuli into three initial pairs; in each pair, one stimulus

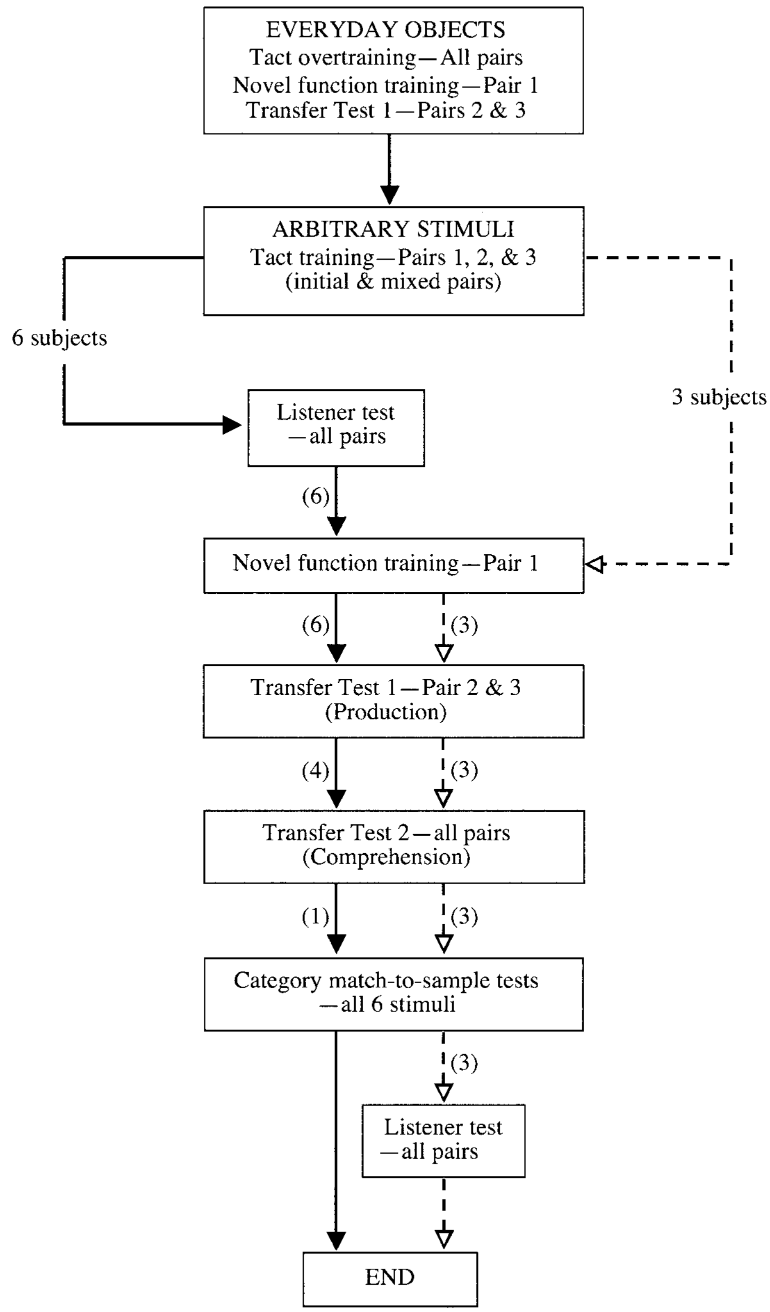

Fig. 1. The sequence of training and testing phases in Experiment 1. Listener testing was conducted for 6 subjects (see solid arrows) immediately after tact training and for the remaining 3 subjects (see broken arrows) after their final category match-to-sample test. Numbers of subjects completing each phase are shown in parentheses.

was designated to serve as a zog and the other as a vek. For each stimulus pair, the experimenter pointed to either the zog or the vek stimulus and said, "Look at this, it's a zog [vek], can you say zog [vek]?" The general pairwise tact training procedure was otherwise as described for the everyday objects. In order to consolidate the children's tact relations, while at the same time preventing their becoming bored with the tact trials, the children next proceeded to tact training with mixed pairs. The only exception to this was Subject LN who, because he was due to leave the nursery, proceeded directly to listener behavior Test 1 (see below).

Tact training in pairwise trials—Mixed pairs. The experimenter reorganized the stimuli into three new mixed stimulus pairs so that each zog stimulus had a new vek pair member. The stimuli remained in the mixed pairs arrangement for the remainder of the study during which they were designated for reporting purposes as Pair 1 (Zog 1/Vek 1), Pair 2, (Zog 2/Vek 2) or Pair 3 (Zog 3/Vek 3). The training procedure and the learning criterion for these new mixed pairs were the same as for initial pairs training.

Reduction in reinforcement rate. The purpose of this stage was to maintain responding under the extinction conditions employed in all subsequent test procedures. The child was presented with one block of tact trials under zero reinforcement. If performance was not maintained at criterion level, a variable-ratio 2 schedule was introduced until criterion was reached; following this, performance under zero reinforcement was again tested. If tacting was at criterion for Pair 1, the same reinforcement reduction procedure was implemented for the Pair 2 and Pair 3 stimuli. In all other respects, the procedure was identical to that of the previous training stages.

Listener behavior Test 1. At this stage, 6 subjects (CH, BH, JA, LN, AF, and JJ) were given a listener test in which their listener responses to the auditory stimuli /zog/ and /vek/ were tested under zero reinforcement; the remaining 3 subjects were given this listener test after all category testing had been completed. To minimize the possibility of experimenter cueing, Experimenter 2 was introduced at this stage; she was known to the children but was not acquainted with the specifics of the study. Experimenter 2 placed one of the stimulus pairs on the table and said, "Can you give me the zog [vek]?" The child was given approximately 4 s to respond, and if he or she did not select one of the stimuli, the question was repeated and a further 4-s response interval ensued. The next scheduled trial was then begun.

Pair 1 stimuli were presented on four trials in which, in a prespecified quasi-random order, the auditory stimuli /zog/ and /vek/ were each presented twice and the target stimulus was located an equal number of times on the right and on the left. This was followed by four trials with Pair 2, and then with Pair 3, arranged in the same manner. This procedure was repeated until each stimulus had been targeted four times making 24 trials in total. The listener behavior criterion was 9 out of 12 correct responses for each of the two potential stimulus classes. The probability of scoring 75% correct by chance is .05 (the probability of scoring 18 or more correct over 24 trials is .008).

Novel function training: Pair 1. Clapping and waving were selected as the novel behaviors to be trained to Zog 1 and Vek 1. These are common behaviors in the repertoires of most children and are often under various forms of stimulus control. These novel relations were trained only with the Pair 1 stimuli. For each child, one of the behaviors (either clapping or waving) was randomly assigned to the Zog 1 stimulus and the other to Vek 1. The two Pair 1 stimuli were placed in front of the child; Experimenter 1 pointed to one of them and said, "Look at this; it goes like this." The experimenter then modeled the action for that particular stimulus (i.e., waving or clapping as appropriate). This was followed by, "Can you show me how it goes?" If the child responded correctly, the experimenter delivered social praise or, otherwise, provided corrective feedback. Once the child had responded reliably to the above instruction across one block of trials, the experimenter shortened subsequent instructions to, "Can you show me how this one goes?" The scheduling of trials and performance criterion were the same as Pair 1 everyday objects conventional behavior training.

Reduction in reinforcement rate. The child's production of the novel functions with the Pair 1 stimuli was next tested under zero reinforcement. If performance remained at criterion level, the child progressed to category transfer-of-function testing; otherwise the reinforcement reduction procedures described for tact training were implemented.

Category transfer-of-function Test 1: Novel behavior production. This was completed in two stages. Step 1, conducted prior to each of the test sessions, ensured that all the trained relations were intact. Experimenter 1 conducted four tact test trials with each of the three stimulus pairs followed by four test trials of the novel behavior trained to Pair 1 (two with Zog 1 and two with Vek 1). The experimenter provided no reinforcement or corrective feedback during this stage; the criterion was 100% correct responses.

Step 2 was the category transfer-of-function Test 1 and was conducted by Experimenter 2 who, following a random sequence, placed either Pair 2 or Pair 3 on the table in front of the child, and while pointing to the scheduled target stimulus and having ensured that the child was attending, said, ''Look at this; can you show me how it goes?'' Trials were organized into blocks of eight and were counterbalanced within each block with the constraint that the same trial type did not occur twice in succession. When the child had responded, the next trial was begun and so on until each of the four stimuli had been targeted eight times, four times on the left and four times on the right, that is, 32 test trials in all. If the child did not respond within 4 s, Experimenter 2 repeated the instruction and waited a further 4 s. If the child still did not respond, the trial was marked as incorrect, as were trials in which the child produced the wrong response. No reinforcement or corrective feedback was given during test sessions. The criterion was 12 out of 16 (75%) correct responses per common tact category; the probability of scoring 12 or more correct for each common tact category by chance is .02 (the probability of scoring 24 or more correct over 32 trials is .002).

On her initial Test 1, Subject CH did not perform the target behaviors but instead produced the conventional behaviors for the hat and cup stimuli employed in the everyday objects pretraining phases (i.e., on zog trials she put the wooden stimulus she named ''zog'' on her head, and on vek trials she placed the vek stimulus to her mouth). Following this, a further block of Pair 1 novel function (i.e., clap/wave) training was conducted (as described in the novel function-training phase). She was then given a repeat of the category transfer-of-behavior Test 1 before proceeding to Test 2. Two subjects, LN and AF, left the nursery after they completed Test 1.

Category transfer-of-function Test 2: Novel behavior comprehension. All three of the stimulus pairs were used to test for the emergence of listener behavior (comprehension) to the novel behaviors trained only to the Pair 1 stimuli. Pair 1 was included in this test because only production, and not comprehension, of the novel behaviors had been trained directly to the Pair 1 stimuli. Prior to each of the test sessions, trained behaviors were reviewed (as in Step 1 of Category Test 1). Then, in each trial, Experimenter 2 presented one of the three stimulus pairs, in a prespecified random order. She asked the child, ''Can you give me the one that goes like this?'' and modeled either a clap or a wave gesture. The child was given a maximum of two opportunities per trial to respond, as in Test 1. Over 24 test trials, each of the six possible relations (i.e., see a novel behavior—select arbitrary object) was tested four times, counterbalanced across trials, with the target object presented twice on the left and twice on the right. The trials were otherwise conducted in the same manner as for category transfer-of-function Test 1. The criterion was 9 out of 12 (75%) correct responses for each common tact category; the probability of scoring nine or more correct for each common tact category by chance is .05 (the probability of scoring 18 or more correct over 24 trials is .008). Subjects JA, CH, and BH left the nursery after completing Test 2.

Category match-to-sample test. The 4 remaining children, JJ, RC, EW, and CS participated in the category match-to-sample test. Prior to the test trials with the arbitrary stimuli, it was necessary, as in other test phases, to ensure that the participants could respond appropriately to the experimental instructions. For this reason, Experimenter 2 first conducted the category-match-to-sample procedure with the familiar objects as in Lowe et al. (2002). The criterion was correct sorting of the hats and cups by giving the other two hats when a hat was sample, or the other two cups when a cup was sample, in all six trials. If any of the children did not pass all six trials, training trials were conducted (see Lowe et al., 2002); otherwise, the children progressed to the arbitrary stimulus category match-to-sample test.

The procedure for the category match-to-sample test was the same as for the everyday stimuli except that the six arbitrary stimuli were employed; each of these served as sample three times (18 trials in all). Trials were classified as correct if, when presented with a vek [zog] stimulus as sample, the child selected the remaining two veks [zogs] from the five stimulus array; all other responses, such as giving more or fewer than the required two stimuli, and/or giving stimuli from the other designated category, were classified as incorrect. The mastery criterion on this test was four correct category sorts from nine for each category; the probability of producing four or more correct sorts by chance is .008.

Following their completion of the category match-to-sample tests, Subjects RC, CS, and EW were given the listener test which was conducted in the same way as for the 6 subjects who were tested for listener behavior immediately after tact training.

Interobserver reliability. An independent observer scored all trials in a randomly selected 25% of all training sessions; interobserver agreement on these trials was 96.4%. Similarly, 100% of test trials were scored; interobserver agreement on these trials was 100%. The independent observer reported no discrepancies between the scheduled and implemented procedures.

Results

Everyday Objects

Tact overtraining and category transfer-of-behavior training. All 9 children completed the pairwise tact overtraining to criterion, with an average number of trial blocks to criterion of 4.8 (range 3 to 13). All learned the conventional functions trained with the Pair 1 objects to criterion in one trial block, except for Subject JJ, who required two. All subsequently passed the category transfer-of-function test with the Pair 2 and Pair 3 objects.

Arbitrary Objects

For the 6 subjects who were tested for listener behavior *prior* to the category tests, Figure 2 shows numbers of tact training trials, performance on the listener test (unfilled bars), numbers of Pair 1 novel function training trials, performance in category transfer-of-function Test 1 (light gray bars) and Test 2 (dark gray bars), and the category match-to-sample test (black bars). Figure 3 shows comparable data for the 3 subjects who were presented with the listener test *after* the category tests. Subjects' task relevant verbalizations throughout the study are shown in Table 2; Subjects LN and CH, from whom no task-relevant verbal responses were recorded, are excluded.

Tact training in pairwise trials: Initial pairs, mixed pairs, and reinforcement reduction. For all 9 subjects who completed tact training, the average number of trials to reach criterion on the Initial Pairs 1, 2, and 3, was 72.8, 26.4, and 22.4, respectively. Subjects RC and EW met the criterion in the minimum number of training trials (16) on Pairs 2 and 3, and Subject CS did so on Pair 3. The mean number of trials to criterion for the 8 subjects trained on Mixed Pairs 1, 2, and 3, at 100% reinforcement, was 28, 26, and 18, respectively. Four subjects (JA, RC, EW, and CS) met the criterion for all three mixed pairs in the minimum number of trials; JJ did so for two pairs and CH for one pair. A mean number of 10 trials was required for all subjects to meet the mixed pairs criterion under zero reinforcement for each of the three pairs. Six subjects JA, JJ, AF, RC, EW, and CS completed this stage in the minimum number of trials for all three pairs. Subject BH, alone, produced extra-experimental names for some of the stimuli (see Table 2).

Listener behavior test. All subjects passed this test whether given before or after category testing, with only 2 (JA and CH) making any errors.

Novel function training: Pair 1. The mean number of trials required to learn the novel behaviors (i.e., clap and wave) for the Pair 1 stimuli was 77.33 (range 24 to 304). When the scheduled reinforcement was reduced to zero, 8 subjects maintained criterion in the minimum of one 8-trial block, whereas JA required one additional block. Though not required to do so, Subject BH correctly named the functions (see Table 2); for example, when presented with each stimulus she asked, "Is it going to clap [wave]?" Some children, on the other hand, named the arbitrary stimuli. Subject JJ named the zog and vek target stimuli on 11 trials, Subject JA named the zog stimulus on six trials, Subject AF named Zog 1 on five trials, and Subject RC named the Vek 1 stimulus "vek" before she waved.

Category transfer-of-function Test 1: Novel behavior production. All 9 subjects met the mastery criterion on both the zog and vek stimuli. Subject CH produced hat and cup

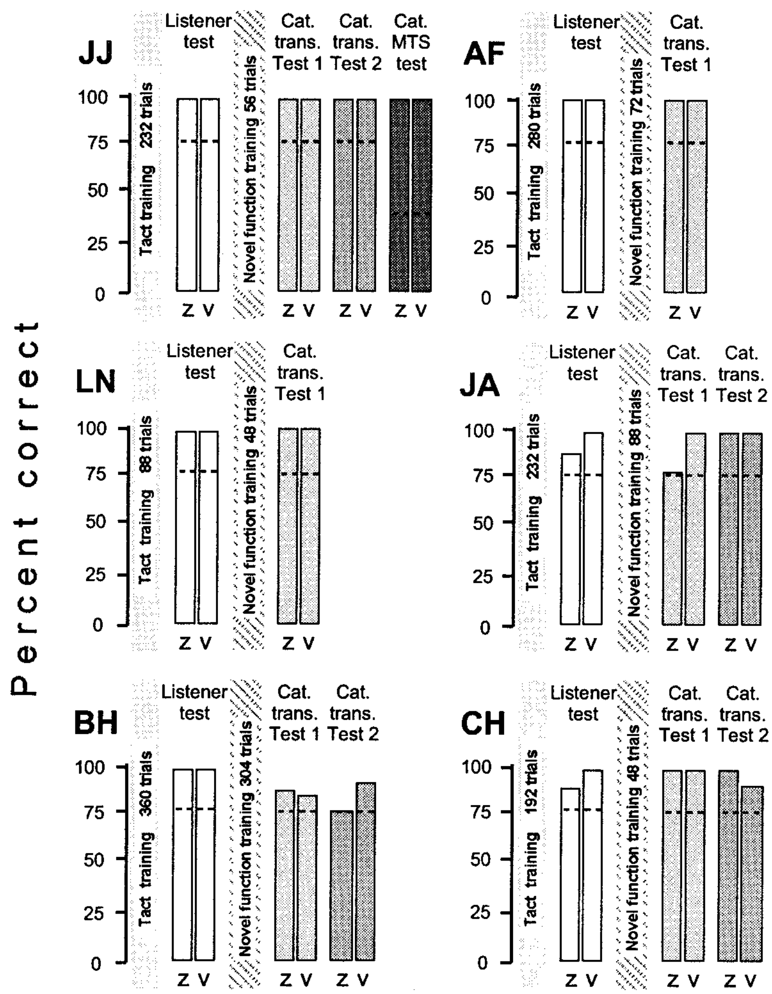

Fig. 2. Performance in each experimental phase for the 6 subjects tested for listener behavior immediately following tact training with the arbitrary stimuli. Numbers of tact training trials to criterion are shown in the first column followed, in the next pair of columns, by percentage correct selection of the zog (z) and vek (v) stimuli in the 24-trial listener test. Numbers of novel function training trials to criterion are shown in the next column followed, in the next two pairs, by performance in the 32-trial category transfer Test 1 (all subjects), and the 24-trial category transfer Test 2 (Subjects JJ, JA, BH, and CH), respectively. For Subject JJ, performance in the 18-trial category match-to-sample test is shown in the final pair. The criterion on all test trials is shown as a horizontal broken line.

behaviors instead of clap and wave responses in her first test (see *Procedure* subsection). Following further Pair 1 novel behavior training, she scored 100% on the second test (shown in Figure 2). Five of the subjects (JJ, AF, LN, CH, and EW) made no errors on the test. On five of the eight occasions when Subject BH was presented with the Zog 2 stimulus (to which the correct response was for her to wave) she said, "It's not going clap, no?"

Category transfer-of-function Test 2: Novel behavior comprehension. All 7 subjects who reached this stage passed the test; with 5 of them (JJ, JA, RC, CS, and EW) making no errors. When asked, "Can you give me the one that goes like this?" Subject JJ correctly named the target stimulus before he selected it in 20 of the 24 trials; on two occasions he not only named the target correctly but also said, "vek [goes] like this" and then waved before selecting the correct vek stimulus.

Category match-to-sample test. All 4 subjects' performances exceeded the mastery criterion for each of the experimentally defined cate-

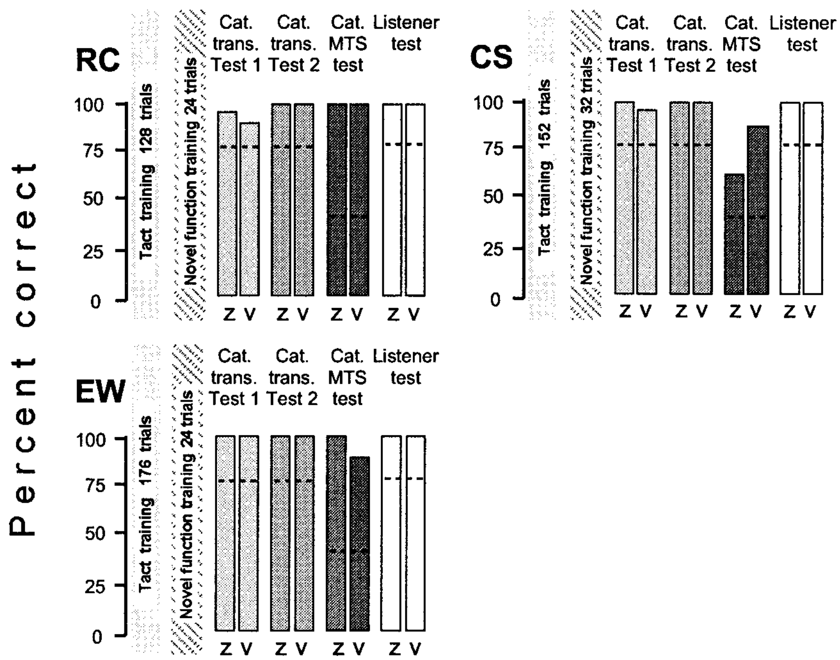

Fig. 3. Same as for Figure 2, except that the 3 subjects were given the listener test after the category match-to-sample test.

gories. Subjects JJ (the youngest in the study) and RC made no errors. Though not asked to do so, Subject JJ correctly named the sample stimulus on all 18 trials and Subject EW named the vek stimulus on two trials. On one test trial in which a zog stimulus was the sample, Subject RC said, "clapping"; clapping was the function that had been trained to the zog stimuli. In another trial when Zog 3 was the sample, Subject RC said "the same" while selecting the correct comparisons.

Discussion

Nine children aged 1 year 7 months to 3 years 7 months at the start of the study learned the two 3-member common tact relations in relatively few trials. Aged from only 1 year 7 months to 2 years 1 month, 3 of the children (JJ, AF, and LN), were even younger than those who were trained with similar common tact relations in the study by Lowe et al. (2002). Although ostensibly only the tact relations were trained, all 9 children in the present experiment also produced the corresponding listener behavior on subsequent test trials. This was the case regardless of whether listener performance was tested immediately after tact training (6 children) or several weeks later after several sessions of category testing (3 children). Lowe et al. (Experiment 2) also tested 3 children for listener behavior following category tests and reported similar results. The data from the 9 subjects here, together with those of Lowe et al., confirm that tact training in normally developing children establishes not simply tacting but also naming (Horne & Lowe, 1996, p. 201).

Following learning of the two common name relations (i.e., "zog" and "vek"), many more new behavioral relations emerged. The children, though directly trained only, for example, to wave to Zog 1 and clap to Vek 1, went on to wave to the other stimuli they named "zog" and to clap to the other stimuli they named "vek." According to the naming account (Horne & Lowe, 1996), once the children had learned to name the zogs they should have continued to say "zog" while they next learned to wave to Zog 1; likewise for the veks. This conjunction would be ideal for the prepotent name responses to acquire selective discriminative control over the corresponding manual behaviors. When any stimulus from Pair 2 and Pair 3 was next presented and the children were asked, "How

Table 2

The task-relevant verbal responses of each subject to individual stimuli during each phase of Experiments 1 and 2. When an utterance occurred more than once the appropriate number is indicated (e.g., zog × 3). Data are for the Set 1 stimulus set except where indicated as Set 2 (in parenthesis).

Subject	Stimulus	Phase	Verbalization
JJ	Zog 1	Novel function training	zog × 11
	Vek 1	Novel function training	vek × 11
	Zog 1	Cat. transfer-of-function Test 2	zog × 3
	Vek 1	Cat. transfer-of-function Test 2	vek × 3
	Zog 2	Cat. transfer-of-function Test 2	zog × 4
	Vek 2	Cat. transfer-of-function Test 2	vek goes like this; vek × 2
	Zog 3	Cat. transfer-of-function Test 2	zog × 4
	Vek 3	Cat. transfer-of-function Test 2	vek like this; vek × 2
	Zog 1	Cat. match-to-sample test	zog × 3
	Vek 1	Cat. match-to-sample test	vek × 3
	Zog 2	Cat. match-to-sample test	zog × 3
	Vek 2	Cat. match-to-sample test	vek × 3
	Zog 3	Cat. match-to-sample test	zog × 3
	Vek 3	Cat. match-to-sample test	vek × 3
AF	Zog 1	Novel function training	zog × 5
RC	Vek 1	Novel function training	vek
	Zog 1	Cat. match-to-sample test	clapping
	Zog 3	Cat. match-to-sample test	the same
JA	Zog 1	Novel function training	zog × 6
BH	Vek 1	Tact training	circle × 2; Look, it's a ring
	Vek 2	Tact training	It's a headband
	Zog 1	Novel function training	Is it going to wave?; It's wave, yes?
	Vek 1	Novel function training	Is it going to clap?; It's not a wave, no?
	Zog 2	Cat. transfer-of-function Test 1	It's not going clap, no? × 5
EW	Vek 1	Cat. match-to-sample test	vek × 2
RC (Set 2)	Wave 1	Manual behavior training	zog
	Clap 3	Manual behavior training	vek
CS (Set 2)	Clap 1	Manual behavior training	Is that a zog?
	Clap 2	Manual behavior training	What is it though?
EW (Set 2)	Wave 1	Manual behavior training	bye bye × 6; yes, that's the vek

does this go?'' the stimulus should have evoked the name and in turn the appropriate manual behavior. In other words, once they have given a common name to a number of objects, humans respond not simply to those objects but also to other elements of the name relation in which those stimuli feature. The experimenter's instruction, ''Show me how this goes,'' is then a prompt not only to show how the object itself goes, but also to show how the ''zog'' goes. Henceforth, any stimulus that gives rise to the common name ''zog'' should be expected to occasion zog behavior (i.e., waving); and similarly, clapping should occur to stimuli named ''vek.'' That is, indeed, what we see for all the children in the present study. Even though they were not required to do so, 4 of the subjects (i.e., JJ, AF, JA, and RC) uttered the common names aloud during novel behavior training or testing and BH named the target clap and wave behaviors; much verbal behavior may also have occurred covertly.

Not only did the novel function transfer to other stimuli in the same category but also when, in Test 2, the novel function itself was presented as a discriminative stimulus, it gave rise to selection of the corresponding objects. In all 7 subjects tested, zog behavior (i.e., waving or clapping) occasioned selection of the zog stimuli, and vek behavior occasioned selection of the vek stimuli, although in neither case were these behaviors ever directly trained with these stimuli. This is again what would be expected from the naming account. Given the repeated conjunction of the child waving and, for example, saying ''zog'' during Pair 1 novel behavior training, the wave itself should become a discriminative stimulus for the child's ''zog'' response. So upon hearing the experimenter's question, ''Which one goes like this?'' the child may say ''zog'' (as

JJ did overtly; see Table 2) and then respond as a listener by orienting to and selecting any stimulus that she has previously learned to call ''zog.''

There are, of course, other naming routes that could yield the same outcomes in Test 1 and Test 2. For example, during the novel function training with Pair 1, some of the subjects may have named not only the object but also their wave response to produce the intraverbal ''zog wave,'' in which saying ''zog'' would evoke ''wave'' and with self-echoic repetition ''wave zog'' (see Horne & Lowe, 1996, pp. 209–210, pp. 218–221). Direct evidence that subjects may indeed have named the functions comes from Subject BH who, on several occasions in training and testing, correctly referred to them as ''wave'' and ''clap,'' and from Subject RC who responded ''clapping'' when presented with the Zog 1 stimulus in the category match-to-sample test. So when in Test 1 the subjects were given a stimulus from Pair 2 or Pair 3 and instructed to ''Show me how it goes,'' their intraverbal naming ''zog wave'' should evoke the listener response of waving. Similarly, in Test 2, when they responded to the experimenter's wave with the name ''wave,'' this would also occasion ''zog,'' and in turn, the listener behavior of selecting zogs.

It is also possible that simple rules such as ''zog is wave'' and ''vek is clap'' may have been produced during novel behavior training. If so, then when presented with, for example, Zog 2 in Test 1, the subject would wave, and when in Test 2 the experimenter waving was the discriminative stimulus, the child would select zog stimuli.

It is a feature of research with human subjects who have learned language that their verbal behavior, and hence their categorization behavior, is not always under experimental control nor is it entirely predictable (Horne & Lowe, 1996; Lowe, 1979). This is illustrated by Subject CH who, in the first test for transfer of function, did not wave or clap but instead put the stimuli she had named ''zog'' on her head, just as, in pretraining, she had done with the hats; she put the vek stimuli to her mouth as, in pretraining, she had done with the cups. This occurred despite there being no physical similarity either between the zog stimuli and hats or between the vek stimuli and cups. Although her consistent and differential transfer of ''novel'' behavior to the zog and vek stimuli, respectively, did clearly show that she had established zogs and veks as categories, the function transferred was not what the experimenters had expected. It may be that in Test 1 it was the presence of the screen, last used in pretraining with hats and cups, that set the occasion for the recurrence of the hats and cups behaviors. The basis for the child's differential allocation of these behaviors to zog and vek stimuli, respectively, is harder to determine. It is possible that, presented with the Vek 2 stimulus for the first time, she named it ''vek'' and then formulated a rule such as, ''I drink the veks,'' which she followed throughout the test. By exclusion, she may also have formulated a corresponding rule such as, ''I put zogs on my head.'' However, because CH produced no overt verbal behavior, this is speculation. Whatever the source of control, it appeared to be relatively fragile because after retraining to produce the clap and wave responses to Pair 1, she no longer produced the hat and cup responses but, in a repeat of the category transfer-of-function Test 1, clapped or waved appropriately to the Pair 2 and Pair 3 stimuli. Her initial Test 1 performance is similar to that reported in other studies (e.g., Green, 1990; R. Saunders, Saunders, Kirby, & Spradlin, 1988; Sidman, Willson-Morris, & Kirk, 1986) in which mentally retarded adults and children also gave names to arbitrary stimuli in a manner that was consistent but at odds with the experimenter-defined contingencies.

As well as showing several new relations in both transfer-of-function tests, a subset of 4 children all succeeded on the category match-to-sample test. Additional evidence that they used common naming to do so comes from Subjects JJ and EW who named the sample stimuli before selecting the correct comparisons. For these subjects, and under this common naming procedure, both measures of categorization—transfer of function and category match-to-sample—were consistent. The findings from the category match-to-sample test are in line with those reported by Lowe et al. (2002), although some of the present subjects (JJ, AF, LN) were younger than any of those in the earlier study, the youngest here being Subject JJ who was only 1 year 10 months at testing.

EXPERIMENT 2

Experiment 1 showed that when very young children learned a common vocal name for arbitrary stimuli, a novel manual behavior established with one member of the common-named class transferred to other members of the class. When presented by the experimenter, the novel manual behavior itself was also shown, in Test 2, to evoke selection of the corresponding arbitrary stimuli. Three of the subjects who had learned these relations participated in Experiment 2, which was designed to investigate whether the stimulus classes could be extended by training, not the common vocal tacts (''zog'' and ''vek''), but the common manual behaviors (wave and clap), to new sets of stimuli. For example, if a child who had learned to tact three Set 1 stimuli as ''zog'' and to wave to one of these was then trained to wave to a new set of stimuli, would these new stimuli then be included in the zog category? In this experiment, six new stimuli were first introduced and the children were trained to wave to three of them and to clap to the other three. They were then tested to see whether the vocal tacts, ''zog'' and ''vek,'' transferred to the stimuli to which the children waved or clapped. In addition, they were tested to see whether if asked, ''Give me the zog [vek]'' they would show the appropriate listener behavior of selecting the wave or clap stimuli. They were also given category match-to-sample tests with the new Set 2 stimuli and with all 12 stimuli from Set 1 and Set 2 combined. Finally, for Set 2, they were tested for appropriate listener behavior to the manual behaviors by the experimenter waving or clapping and asking, ''Which one goes like this?''

In the final phase of the study, a third set of six arbitrary stimuli, Set 3, was introduced. Training and testing was the same as for Set 2 but, in addition, category match-to-sample tests were conducted with all 18 stimuli (Sets 1, 2, and 3 combined). That is, the children, when presented with a sample wooden shape, were required to select the remaining eight stimuli in the class from an array of 17.

Method

Subjects

Three of the subjects (RC, CS, and EW) who completed all phases of Experiment 1 participated. They were aged between 2 years 8 months and 3 years 8 months when the study began, which was immediately following Experiment 1.

Apparatus and Stimuli

The setting was identical to that of Experiment 1. Each child was allocated six new stimuli (i.e., Set 2), from the original pool of 18 arbitrary stimuli employed in Experiment 1. The remaining six stimuli were assigned to serve as Set 3.

Procedure

Except where indicated below, the general procedure was the same as in Experiment 1. There was no repetition of the pretraining with familiar objects.

Manual behavior training with the Set 2 stimuli. The six stimuli were divided into three pairs; the subjects were trained to produce a wave response to one member of each pair and to clap to the other. For reporting purposes, the three Set 2 pairs are designated as Pairs 4 (Wave 1/Clap 1), 5 (Wave 2/Clap 2) and 6 (Wave 3/Clap 3).

Manual behavior training in pairwise trials: Initial pairs. The experimenter ensured the child was attending, pointed to the target stimulus and said, ''Look at this; it goes like this.'' The experimenter then modeled the manual tact response assigned to the target stimulus and said, ''Can you show me how it goes?'' Manual behavior training was conducted in the same way and to the same criterion as in Set 1 vocal tact training, Experiment 1. When criterion had been reached with the Pair 4 stimuli, the procedure was repeated with Pair 5 and then with Pair 6.

Manual behavior training in pairwise trials: Mixed pairs. The stimuli in the initial pairs were assigned to three new mixed pairs, each consisting of one wave and one clap stimulus, and training was conducted to the zero reinforcement criterion as in the corresponding stage of vocal tact training in Experiment 1.

Category transfer-of-function Test 1: Vocal tact. Prior to each test session with Set 2, Experimenter 1 conducted unreinforced review trials with the Set 1 stimuli to ensure the vocal tact relations (''zog'' and ''vek'') that had been trained in Experiment 1 were still in place. If performance was 100% correct for the two trials per stimulus, the child proceeded to the next test; otherwise the vocal tacts were retrained as in Experiment 1. The child was next tested in the same way for maintenance of the Set 1 novel functions (the clap and wave responses).

One of the three Set 2 test pairs was then placed on the table in front of the child, and while pointing to the prespecified target stimulus, Experimenter 2 said, ''Look at this; can you tell me what it is?'' Experimenter 2 waited for the child to respond, and when he or she had done so, removed the stimuli from the table. This continued until 48 test trials had been conducted and each of the six stimuli that comprised Set 2 had been targeted eight times, four times on the left and four times on the right. In all other respects, the procedure was as for category transfer-of-function Test 1, Experiment 1.

Category transfer-of-function Test 2: Vocal comprehension. As with Test 1, prior to each of the test sessions unreinforced trials were conducted to ensure all the Set 1 vocal listener behavior baseline relations were in place (see listener behavior test, Experiment 1). Experimenter 2 then presented one of the three pairs and asked, ''Can you give me the zog [vek]?'' In all other respects the procedure was as for category transfer-of-function Test 2, Experiment 1.

Category match-to-sample test: Set 2. The procedure was the same as the category match-to-sample test, Experiment 1, except that the Set 2 stimuli were employed.

Category match-to-sample test: Set 1 and 2. The procedure was as for Set 2 except that in each sorting trial all 12 stimuli that comprised Set 1 and Set 2 were presented. Over 12 trials, each of the 12 stimuli served once as the sample and the child was required to select five stimuli from among the 11 comparisons. The criterion was 2 of 12 correct sorts; the probability of producing two or more correct sorts by chance is less than .001.

Manual behavior listener test: Set 2. The children were next given a pairwise listener test to determine whether, in each trial, they would select the appropriate stimulus when the experimenter asked, ''Which one goes like this?'' and then either clapped or waved. In all other respects the procedure was as for the listener behavior test, Experiment 1.

Manual behavior training with the Set 3 stimuli. The six stimuli were divided into three pairs, as for Set 2, with a wave being trained to one stimulus in each pair and a clap to the other. Training and testing was the same as for the Set 2 stimuli except that following the category match-to-sample test with the Set 3 stimuli, all three stimulus sets were combined to form an 18-stimulus category match-to-sample test. In six trials, one stimulus from each category (zog/vek) and from each stimulus set (Sets 1, 2, and 3) was selected on a random basis to serve as the sample and the child was required to select eight comparisons from among the 17 stimuli. The criterion was one of six correct responses; the probability of one or more correct sorts by chance is less than .001.

RESULTS

Set 2 Stimuli

Manual behavior training. Both Subject EW and CS achieved criterion in the minimum number of trials (16) for each of the initial pairs, whereas RC required an additional eight trials on Pair 4. All 3 subjects achieved the mixed pairs criterion under 100% reinforcement in the minimum of 16 trials and the zero reinforcement criterion in the minimum of eight trials, with the exception of RC, who required an additional eight trials on Pair 4. When subjects observed the experimenter waving or clapping, their overt verbalizations were consistent with their naming histories in Experiment 1. For example, if a subject had previously been trained to wave to a stimulus she named ''zog,'' here she occasionally responded to the wave by saying ''zog'' (see Table 2). In addition, Subject EW said ''bye bye'' on six occasions as she waved.

Category tests. All 3 children performed errorlessly on all 32 trials of the transfer-of-function Test 1 (vocal tact) and on all 32 trials of Test 2 (vocal comprehension). They also sorted 100% correctly on all 18 trials of the category match-to-sample test with the Set 2 stimuli and on all 12 trials with the combined Set 1 and Set 2 stimuli. They also passed the manual behavior listener test without any errors.

Set 3 Stimuli

Manual behavior training. The 3 children reached criterion in the minimum (16) number of trials for each initial pair, and each mixed pair, except for RC who required eight additional trials for each of Initial Pairs 1 and 2. Similarly, the children met the zero reinforcement criterion for each of the mixed pairs in the minimum of eight trials, except for RC who required an additional eight trials on Pair 1.

Category tests. Again, all 3 children performed errorlessly on all three category tests. In Test 1, the vocal tact trained only to the Set 1 stimuli transferred consistently to the manual behavior counterparts of Set 3, as did the appropriate listener behavior to the auditory stimuli /zog/ and /vek/ in Test 2. The children also produced perfect category sorting performances with the six Set 3 stimuli (18 trials) and with the 18 combined stimuli from Sets 1, 2, and 3 (six trials).

Manual behavior listener test. The 3 children selected the correct stimulus in all 24 trials.

Discussion

Tests 1 and 2 showed that when the 3 children were trained to wave to some stimuli (i.e., as many as six) and clap to others, they went on to name these stimuli with the corresponding common names (''zog'' and ''vek'') they had learned in relation to waving and clapping during Experiment 1. According to the naming account, the foundations for the transfer of function were established in Experiment 1, during which waving and clapping became discriminative for saying either ''zog'' or ''vek,'' respectively. When, for example, subjects who had previously learned to respond to a wave by saying ''zog'' learned in this experiment to wave to each of six further stimuli (Sets 2 and 3), it follows that as they did so they should also name these as ''zog,'' and as they learned to produce the clap response to each of the remaining six stimuli, to name them ''vek.'' All 3 subjects named the stimuli in this manner on at least one occasion (see Table 2). It also is possible, however, that the functions themselves were named, establishing the conditions under which intraverbal relations between each vocal name and its corresponding function name (e.g., zog/wave) could be learned. Subject EW is interesting in this regard. When presented with the Set 2 stimuli not only did she respond with the appropriate class name but also on six occasions responded ''bye bye.'' In children, ''bye bye'' is a typical tact response to waving. Though intraverbal name relations may have served to link the common functions and common vocal names (and see Subjects BH and RC in Experiment 1), verbal rules such as ''zog goes with wave'' could play a similar role (see Horne & Lowe, 1996, pp. 212–213, 221).

Given that nine of the stimuli from Sets 1, 2, and 3 were all named ''zog'' and the remaining nine ''vek,'' it follows from the naming account that this will bring about the corresponding nine-stimulus categories. This was shown to be the case for all 3 of the 2 to 4 year-old children on the category match-to-sample tests. Given any sample from an array of 18 wooden shapes, they selected the other eight in the class with perfect accuracy on every occasion. These are the largest and, given the manual-vocal crossover, most complex stimulus classes reported to date for children of this age.

GENERAL DISCUSSION

Previous studies (Horne et al., 2004; Lowe et al., 2002), using stimulus selection procedures such as category match-to-sample as their measure, have shown that common naming is highly effective in establishing arbitrary stimulus classes. The present experiments both confirm and extend these findings, showing that arbitrary stimulus classes occur with children as young as 1 year 7 months and with arrays of up to 18 arbitrary stimuli. Crucially, the present study also shows that naming is highly effective in bringing about transfer of function from one arbitrary stimulus to several others that have been given the same name, thereby satisfying a second measure of whether stimulus classes have been established. It also was found, for all 4 of the subjects tested, that success on the transfer of function tests was accompanied by success on the category match-to-sample tests. Indeed, having trained only the common naming and, for a subset of the stimuli, common functions, a great number of new untrained relations emerged. Considering only what was directly measured, 196 new untrained relations were established for each child in Experiment 2: 144 new object-object relations were shown in the 18-stimulus category match-to-sample tests; 30 new object-name/name-object relations, and 22 new object-function/function-object relations were shown in the category transfer of function and listener behavior tests.

Along with the study by Lowe et al. (2002), these findings show the extraordinary generative power of naming, even in very young children, and are entirely consistent with the naming account of categorization and rule governance. From a very early age children are taught to name features of their environment. This entails not simply their being able, when requested, to vocalize the name and to select the named object, but also to learn the range of conventional behaviors (functions) that are shown to that named object class in that particular verbal community. For example, as a child is shown a new item the child may be told, "This is a tool. It is called a screwdriver. You can make and mend things with it" (this may be accompanied by a demonstration of what the item can do) and then "Put it away in your toolbox." The child learns at one and the same time to identify the object (both as a "screwdriver" and as a "tool") and to show some of the functions related to these classes of objects (i.e., making and mending, and putting away in the toolbox, respectively). So when, in experiments like the present, we teach a child to name stimuli, we are, to a degree that is dependent on that particular child's age and learning history, capitalizing on the child's general extraexperimental history of learning to name object classes and to show the conventional behaviors that these names indicate. Naming does, indeed, serve to categorize the world and enable us to respond appropriately to the categories we have learned (Horne & Lowe, 1996).

Just how practically effective name training is in establishing categories was shown in both the present experiments. Three of the children, for example, having learned common naming in Experiment 1, learned the manual behavior relations for the two new stimulus sets in very close to the minimum number of trials and then went on to perform errorlessly in every test thereafter. The young children's relatively rapid learning of common tact relations observed both in Lowe et al. (2002) and the present study contrasts with frequently reported problems in the literature of establishing conditional discrimination and stimulus classes with traditional (visual-visual) match-to-sample procedures (Auguston & Dougher, 1991; Eikeseth & Smith, 1992; Pilgrim et al., 2000; K. Saunders, Saunders, Williams, & Spradlin, 1993; R. Saunders, Drake, & Spradlin, 1999; Schilmoeller, Schilmoeller, Etzel, & LeBlanc, 1979; Zygmont, Lazar, Dube, & McIlvane, 1992). As Pilgrim et al. (2000) have noted, the difficulties in training arbitrary matching using these procedures in normally developing children are not widely acknowledged. On the one hand, even when the prerequisite conditional discriminations have been established with match-to-sample procedures that do not incorporate naming, failures in stimulus class formation are frequently encountered (R. Saunders et al., 1999). The data presented here, as well as those in Horne et al. (2004) and Lowe et al. (2002) indicate, on the other hand, that common naming of stimuli may overcome many of these problems and be highly effective in generating stimulus classes not only with normally developing children but also with people who are mentally retarded (and see Eikeseth & Smith, 1992; Pilgrim et al., 2000; K. Saunders et al., 1993).

One of the early studies to investigate the effects of common tact training on transfer of function in young children (see also Jeffrey, 1953) was conducted by Birge (1941), who trained 152 children aged 8 to 9 years to name four boxes, each of which had a different arbitrary stimulus on its upper surface. The children learned to name each of two boxes "meef" and each of two others "towk." One meef and one towk were then presented in a simple discrimination task in which the children were required to learn which of the two boxes reliably had candy hidden under it. Then the remaining boxes, one meef and one towk, were presented in a transfer task in which the children were asked to identify which box they thought contained the candy. When the children were not asked to name the box before making their selection, their responding was at chance levels; when required to name the boxes before selection, however, 84% of them predicted the location of the candy correctly. This outcome differs to some extent from that in the present study in which the participants (aged from 1 to 4 years) transferred the functions and sorted the stimuli correctly without first being asked to name each stimulus (although some did so, nevertheless). It is possible that the relatively stringent mastery criterion employed in tact training in the present study may have increased the probability of the young children's overt and covert naming in the test trials and, in turn, their superior transfer performance.

More recently, Smeets et al. (1997) conducted a common response training study in which the 20 participants aged 4 to 5 years were first trained to produce a location response (e.g., R1) to each of two stimuli, A1 and B1, and an alternative location response (e.g., R2) to A2 and B2. In a separate context, the children were next trained new location responses to one member of each potential two-member functional class (e.g., R3 to A1 and R4 to A2). First, transfer of the new location responses to the other potential class member was tested. Three of the 18 children who learned the baseline relations failed to show the predicted within-class transfer of the R3 and R4 location responses, and in match-to-sample procedures that followed, a further 4 of 15 children failed to match the A and B stimuli within each functional class. All 4 of the children given further tests for untrained bidirectional relations passed the tests for R3-B1, R4-B2 relations (that functionally resembled the manual behavior listener test employed in the present study) but 2 failed tests of the relations R1-R3 and R2-R4. The authors concluded that, ''functional equivalence can imply but does not require stimulus equivalence'' (p. 1). These within-subject dissociations between transfer of function and match-to-sample performances may have arisen because the children were trained nonverbal co-location responses and not common name responses to establish the functional classes. Given that the subjects' naming was not controlled by the experimental instructions, it was free to vary and hence to have variable effects on test outcomes. In the present study, the 3 children who were trained to produce common name responses showed all the defining features of both functional and stimulus equivalence in the two 9-member classes thereby established.

The naming account explains the establishment of nine-member classes in children aged from 1 to 4 years not as the direct result of training unilinear common behavior relations—whether operant or respondent—but in terms of the bidirectional properties of common naming and other, more complex forms of verbal governance. Consistent with the naming theory of Horne and Lowe (1996), common naming is sufficient to account for the substantial novel behavior transfer and categorizing effects observed in the young children who participated in this study. The experiments, however, were not designed to differentiate the predictions of the naming account from those of Sidman's (1994) stimulus equivalence theory or the relational framing theory of Hayes and Hayes (1992). Whether common naming is necessary for these transfer of function outcomes remains to be determined. In contrast to the categorization successes reported by Lowe et al. (2002) in children given common tact training, Horne et al. (2004) have shown that 1- to 4-year-olds who learned three-member common listener relations without also learning the corresponding speaker behavior failed to categorize correctly in a subsequent category match-to-sample test; only when they were next trained the corresponding tact relations did most of the children go on to pass the category tests. In line with the naming account, the latter study shows that common listener behavior is not sufficient for children's sorting of arbitrary stimuli into categories as measured by category match-to-sample tests. How this difference in outcome across common name and common listener studies may be explained by the stimulus equivalence and relational framing accounts is presently unclear. A further critical test of the naming account, however, would be to investigate whether transfer of function occurs when very young children learn only common listener behavior but not common naming. Under such circumstances, the naming account clearly predicts that transfer of function, such as was observed throughout the present study, would not occur.

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