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EMERGENT WORD-OBJECT MAPPING BY CHILDREN: FURTHER STUDIES USING THE BLANK COMPARISON TECHNIQUE

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Two experiments examined the emergent mapping phenomenon in Portuguese-speaking children aged 3-13. This phenomenon is relevant to developmental psychologists' interest in "fast mapping" of new word-referent relations and also to behavior analysts' interest in behavior that emerges without explicit conditioning. We studied 52 children, using the "blank comparison" matching-to-sample technique described by Wilkinson and McIlvane (1997). The technique allows direct measurement of the stimulus control bases of emergent mapping, for example, to determine whether new words and their referents are related directly or via rejection (i.e., exclusion) of previously defined referents. Children demonstrated both types of controlling relations. These studies systematically replicate prior emergent mapping research in a large cohort of non-English-speaking children. Also found were apparent developmental differences between older and younger children. Although all children tended to relate novel stimuli, the tendency appeared to decline as children aged. This study confirms the utility of the blank comparison technique in emergent mapping research and also provides the first data set from school-aged children.

Developmental psychologists have long been interested in how children relate novel (or otherwise undefined) words with corresponding objects or other environmental events. The experimental literature (Carey, 1982; Dixon 1977; Vincent-Smith, Bricker, & Bricker, 1974) reports a robust, highly reliable phenomenon that may be important in developing

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an adequate account of such word learning: Presented with an array that includes one or more learned (defined) objects and one that has not yet been defined, the child will respond to an undefined word by selecting the undefined object. For the purpose of this report, we will use the descriptive term "emergent mapping" to refer to performances like these.

In experimental work, the matching-to-sample procedure has often been chosen to study basic behavioral processes that might also be important in the natural environment in which language develops. Indeed, most research on emergent mapping has used some type of matching to sample procedure. Recent research has emphasized the need to specify better the basis for children's matching-to-sample responses, particularly with respect to the emergent matching phenomenon. Some psychologists have emphasized the possibility that children *reject* previously defined comparison items when they hear a novel, undefined sample name. In the behavior analysis literature, for example, rejection of defined items in response to novel names has been termed "exclusion" (Dixon, 1977), because performance is thought to be governed by the following rule: If object A is related to spoken word A, then object B (undefined or not) is to be related to another spoken word (see Dixon, Dixon, & Spradlin, 1983, for further details). In the developmental literature, the same phenomenon has been termed "mutual exclusivity" (Markman, 1989) with a similar rationale; it is thought that very young children assume that each object has only one name.

An alternative to the exclusion/mutual exclusivity account is the proposition that children may relate new spoken words with new objects directly, without necessarily involving a process of exclusion or elimination. In this account, emergent matching selections are thought to be based on novelty, a property that both the spoken word and the selected object share. This has been termed the N3C account (novel name-nameless category) by developmental psychologists (Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992) and the "novelty account" by behavior analysts (e.g., Dixon et al., 1983).

The exclusion and novelty accounts were proposed as plausible ways by which children might accomplish emergent mapping. Until recently, however, no one had used procedures to test directly the stimulus control bases of emergent mapping performances. The first such test was reported by Wilkinson and McIlvane (1997). They reported a "blank comparison" matching-to-sample method that permitted children to demonstrate (a) explicit rejection of previously defined comparison items in relation to novel sample names (i.e., exclusion) and/or (b) direct relation of novel samples and comparisons. The method was used with 8 typically developing children aged 3 to 5 years. Not only did the children exclude defined comparison stimuli in response to undefined samples, but they also related novel samples and comparisons directly, given the opportunity to do so. This initial study, therefore, suggested that children may routinely exhibit both types of stimulus control relations.

The present study was conducted to assess the generality of the

findings reported by Wilkinson and McIlvane (1997). Two experiments were conducted. Experiment I was a systematic replication of the earlier study using 17 comparably aged children. The apparatus, visual stimuli, and basic procedures were the same as in the original study. Major differences included the larger sample size, study of Portuguese-speaking Brazilian children rather than North Americans, and samples spoken in Portuguese rather than English. Replication of Wilkinson and McIlvane's findings with non-English-speaking children from another country would be reasonably strong evidence of their generality. Experiment II, also conducted with Brazilian children, tested the performance of older children (aged 6 to 13) on the same procedures, a different generality test.

Experiment 1

Method

Participants

Data were collected from typically developing children ranging in age from 3:5 (years:months) to 5:11 (mean: 3:11). Participants were 4 girls and 13 boys. All were developing normally and had no visual or auditory impairments. The leftmost column of Figure 1 presents the participants' initials, age, and gender.

Setting and Apparatus

Sessions were conducted in a quiet room in the Laboratório de Estudos do Comportamento Humano at the Universidade Federal de São Carlos (Brazil). Data collection was sometimes accomplished in a single session, but two or more sessions were often required. Sessions typically lasted 20 to 30 minutes and presented about 130 matching-to-sample trials. Intertrial interval was 1.5 seconds in duration. For a few children, more than one session was scheduled in the same day, separated by an intersession break.

Testing was conducted with software written especially for research of this type (Dube, 1991). Experimental stimuli were presented by an Apple Macintosh Performa 6360. Its 15-inch touchscreen displayed comparison stimuli (pictures) on any three of four predefined 5-cm squares, displayed in the four corners of the computer screen. Sample stimuli were experimenter-dictated digitized words, presented through a speaker attached to the computer.

Stimuli

Baseline pictures were those used by Wilkinson and McIlvane (1997): dog, house, and tree. Sample words were dictated in Portuguese: "cachorro," "casa," and "árvore." Novel visual stimuli were also the same as those used by Wilkinson and McIlvane; novel auditory stimuli were nonsense words made up of Portuguese phonemes.

The computer program arranged differential consequences for

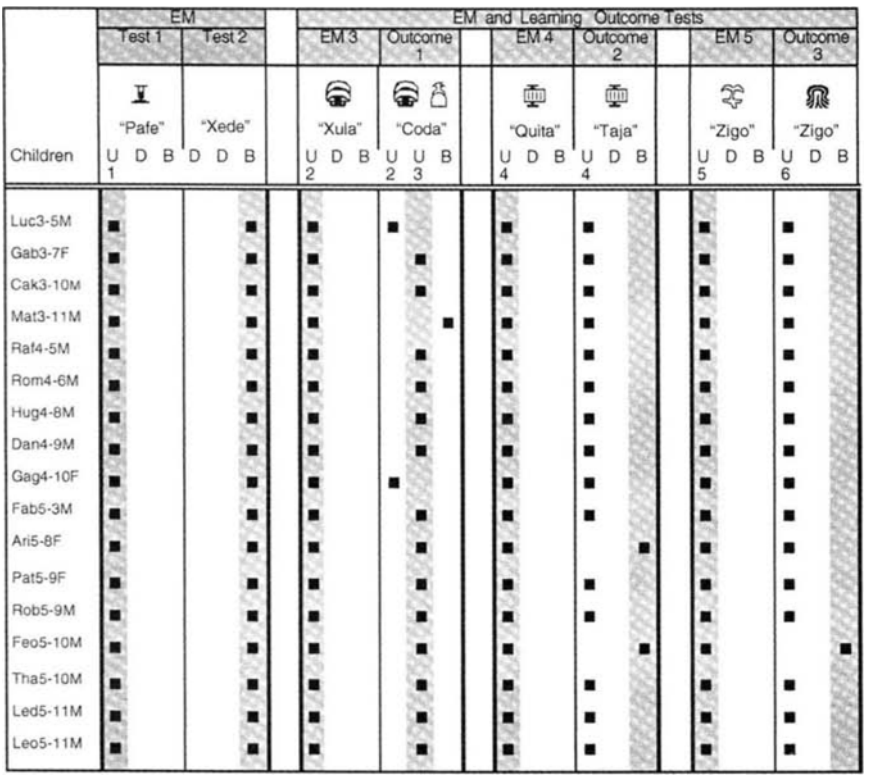

Figure 1. Individual responses on each emergent mapping and learning outcome test in Experiment 1. For each test trial, the top lines display the undefined picture or pictures, the dictated word (in quotes), and the three comparison stimuli. U stands for undefined pictures and digits indicate a specific picture; D stands for defined pictures; and B indicates the blank comparison. The left column gives each child's initials, chronological age (y-m), and gender. Gray highlighting of individual columns indicates certain expected emergent mapping selections and outcome results that could be consistent with learning 1:1 relations on emergent mapping

correct and incorrect responses. Correct responses were followed by a 2-second animated visual display composed of stars with an accompanying musical phrase. Incorrect responses were followed by 2 seconds of a black screen, and no music. Two different schedules of consequences were used. Initially, every correct matching selection was followed by the auditory-visual display (CRF). Later in the experiment, every other selection on average produced the display (VR 2).

Procedure

The procedures were very similar to those reported by Wilkinson and McIlvane (1997) except for use of Portuguese sample stimuli.

Training Phase

Baseline training consisted of a series of matching-to-sample trials to

teach the child to select the dog when "cachorro" was dictated, the house when "casa" was dictated, and the tree when "árvore" was dictated. Verbal instructions were used because (a) the children readily understood these instructions and (b) the target spoken word-picture relations were already defined prior to the experiment. Thus, the experimenter's task was merely to teach the children to exhibit already learned matching relations on the apparatus. Comparison pictures were initially presented one at a time, then two at a time, and finally all three together. Criterion for completing baseline training (and all subsequent training) was perfect matching on 15 successive three-comparison matching-to-sample trials.

Blank comparison matching-to-sample training was initiated immediately after baseline training. The goal of the training was to establish the following performance: On every trial, two of the three baseline pictures were displayed along with a gray square (the blank comparison). If the dictated sample corresponded to one of the two displayed baseline pictures, then the child was to select that picture. However, if the dictated sample corresponded to neither picture, then the child was to reject the pictures and select the blank comparison. Picture-correct and blank-correct trials were presented equally often.

The blank comparison procedure is a matching-to-sample analog of a "Yes"-"No" task: If the sample matches either of the pictures, select the match (Yes); if the sample matches neither picture, select the blank (No). Thus, the procedure provides unambiguous data on whether the child relates directly or does not relate a given pair of stimuli. It is appropriate, therefore, for evaluating experimentally whether emergent mappings are based on the novelty/N3C principle (direct relation), the exclusion/mutual exclusivity principle (relation by rejecting other stimuli), or both.

The blank comparison baseline was established via stimulus control shaping procedures that were presented in detail by McIlvane, Kledaras, Lowry, and Stoddard (1992). Briefly, over a series of 16 shaping steps, the gray square was superimposed over progressively more of one picture on each teaching trial. The square covered positive comparison stimuli on half of the trials and negative comparison stimuli on the other half. When the child touched correctly either the picture or a gray square, the square disappeared and the picture was "uncovered." Ultimately, a square completely obscured one picture on every trial, and the child's responses were followed merely by removal of all stimuli, the intertrial interval, and reinforcing consequences, as appropriate. Subsequently, the schedule of reinforcement was changed from CRF to VR2 in preparation for the testing phase, which followed immediately.

Test Phase

These tests introduced new "pictures" and dictated words on probe trials to test for emergent mapping and learning outcomes. Probe stimuli are shown at the top of the last six columns in Figure 1.

Emergent Mapping Tests 1 and 2. Two test trials were inserted among 12 blank-comparison baseline trials on the 3rd and 10th trial of a testing

block. Responses on probe trials were followed only by removal of stimuli and the intertrial interval (i.e., no differential consequences). The dictated sample on the first probe trial (the third trial of the block) was "Pafe," and the comparison stimuli were a defined picture, a novel picture (Undefined 1), and the blank comparison. Because both the sample and one of the pictures were novel, this test allowed the child to relate novel stimuli (i.e., a test of the novelty/N3C principle).

The sample on the second probe (the 10th trial of the block) was "Xede," and the comparison stimuli were two defined pictures and the blank. This probe trial tested the exclusion/mutual exclusivity principle.

Emergent Mapping Test and Learning Outcome 1. This test was conducted in the following test block. Again, two probe trials were presented along with 12 blank comparison baseline trials, one in the first half of the block and one in the second half. On the first probe, "Xula" was dictated and the comparison stimuli were a defined picture, an undefined picture (U2), and the blank. This probe was procedurally identical to Emergent Mapping Test 1 and potentially allowed the child to learn something about "Xula" and the undefined picture. That possibility was evaluated on a subsequent probe trial that presented the dictated word "Coda," the U2 picture, a novel picture (U3), and the blank. If the child selected U3, that performance would demonstrate discrimination of U2 from U3 and would suggest discrimination of "Coda" from "Xula." The following two tests were conducted to provide further data for evaluating the latter possibility.

Emergent Mapping Test and Learning Outcome 2. This test had the same basic format as the preceding one, but the experimental question was somewhat different. The first probe trial was like Emergent Mapping Test 1. The novel sample "Quita" was dictated, and the comparison stimuli were a defined picture (tree), another novel picture (U4), and the blank. On the second probe trial, the sample was "Taja," and the comparison stimuli were a defined stimulus (house), U4, and the blank. Had the child learned specifically to relate U4 with "Quita" on the first probe trial? Such learning would be indicated if the child selected the blank comparison. Selection of U4, by contrast, would suggest merely that the child indiscriminately related the novel sample "Taja" with the relatively novel picture, U4.

Emergent Mapping Test and Learning Outcome 3. Again the probe format was similar to the prior one, but the question was slightly different. After an emergent mapping trial (sample: "Zigo," comparisons: dog, novel picture U5, and the blank), a subsequent probe trial presented "Zigo" *with* a defined picture (tree), another novel picture (U6), and the blank. Had the child learned specifically to relate "Zigo" with U5 on the first probe trial? Such learning would be indicated if the child rejected the new novel stimulus, U6, and instead selected the blank comparison. Selecting U6, by contrast, would suggest that the child indiscriminately related the relatively novel sample "Zigo" with the novel comparison, U6.

Results

Baseline Training

All 17 children reached 100% accuracy on the final block of baseline trials. Four completed the training and test sequence in a single session; the remaining 13 required two to four sessions. For 15 children, criterion performance on the blank-comparison procedure was established within 1-3 training blocks. The remaining 2 children required a remedial procedure, which was conducted in a tabletop format. For these children, the same displays that had been presented on the computer were reproduced on sheets of paper. On each trial, one of the three alternatives was covered by a cardboard square, and a sample word was dictated. After the child selected a comparison picture, the experimenter removed the card, uncovering the picture. For both children, a single 16-trial training block proved sufficient to establish stimulus control by the blank comparison; when similar trials were then presented on the computer, both children immediately responded with high accuracy. Performance on baseline trials remained highly accurate throughout testing (mean: 98.4% correct).

Emergent mapping tests. Figure 1 shows individual responses on each emergent mapping and learning outcome probe. Probe stimuli are shown along the top. The gray column indicates expected selections on (a) emergent mapping trials and (b) outcome trials, had the child learned a 1:1 relation involving the emergent mapping probe sample and visual stimulus that had been selected in its presence.

When the novel word "Pafe" was dictated on the first probe trial (Test 1), all participants selected the undefined picture U1, thus relating the two novel stimuli (i.e., novelty/N3C principle). When "Xede" was dictated and no novel comparison was available (Test 2), all children selected the blank comparison (i.e., exclusion/mutual exclusivity). On the subsequent Emergent Mapping Tests 3-5, no child failed to select the novel comparison, thus confirming the regularity and generality of this performance.

Learning outcome tests. Following selection of the novel comparison in response to "Xula" on Emergent Mapping Test 3, 14 of 17 children subsequently selected a different novel form when "Coda" was dictated on Outcome Test 1; thus, they discriminated at minimum the novel stimuli from the recently introduced stimuli. Results of Outcome Tests 2 and 3 demonstrated that, for most children, a single emergent mapping response did not suffice to establish a 1:1 relation between the novel words and the selected visual stimuli. Figure 1 shows that all but 3 children selected the novel or recently introduced stimulus rather than the blank (i.e., the selection that would have indicated a 1:1 relation).

Discussion

Emergent mapping data from this larger sample of children replicated systematically the findings of Wilkinson and McIlvane (1997). Indeed, the

results were virtually identical: The "blank comparison" method permitted children not only to exclude defined comparison stimuli in response to undefined samples, but also to relate novel samples and comparisons directly, given the opportunity to do so. That the children were Portuguese-speaking South Americans further attests to the usefulness of the methods and the generality of the findings. It would be interesting to test whether similar results would be obtained in non-Western children. One might predict positive findings, extrapolating from the limited cross-cultural data that exist on performances resembling the ones we studied here (e.g., Kagan, 1981).

Also replicated systematically were certain aspects of the outcome test data, particularly that of Outcome Tests 1 and 3. Again, the findings were virtually identical to those of the previous study. Not replicated in this larger sample, however, was Wilkinson and McIlvane's report of a possible correlation between child age and performance on Outcome Test 2. Each of their 4 children aged 4 years or greater selected the blank on this test; all 4 of their younger children selected the recently introduced stimuli. In the present study, by contrast, only 2 of 11 children older than 4 years selected the blank. Although further study is needed to account for this proportional difference, it seems likely that the previously reported finding may be an artifact of the small sample that Wilkinson and McIlvane (1997) studied.

As for the potential learning from an emergent mapping history, the results of our outcome tests suggest that a single emergent mapping exposure is insufficient to establish a 1:1 relation for children in this age range under the test conditions imposed here. Rather, the children's matching selections appeared to be influenced mainly by the common property of novelty or relative novelty shared by undefined sample and comparison stimuli. It is has been well established that novelty is a particularly salient stimulus characteristic for children in this age range (e.g., Stevenson, 1972). Thus, the findings lead naturally to an inquiry about the performance of older children on these procedures. Experiment 2 pursued such an inquiry, again with children from Brazil.

Experiment 2

Method

Participants

Participants were 35 children, 21 girls and 14 boys, ranging in age from 6:1 (years:months) to 13:9 (mean: 9:6; median: 9:9); each age was represented by at least 4 children. All were developing normally and had no visual or auditory impairments. The leftmost column of Figure 2 presents the participants' initials, age, and gender.

Setting and Apparatus

The setting and general procedures were identical to those described for Experiment 1.

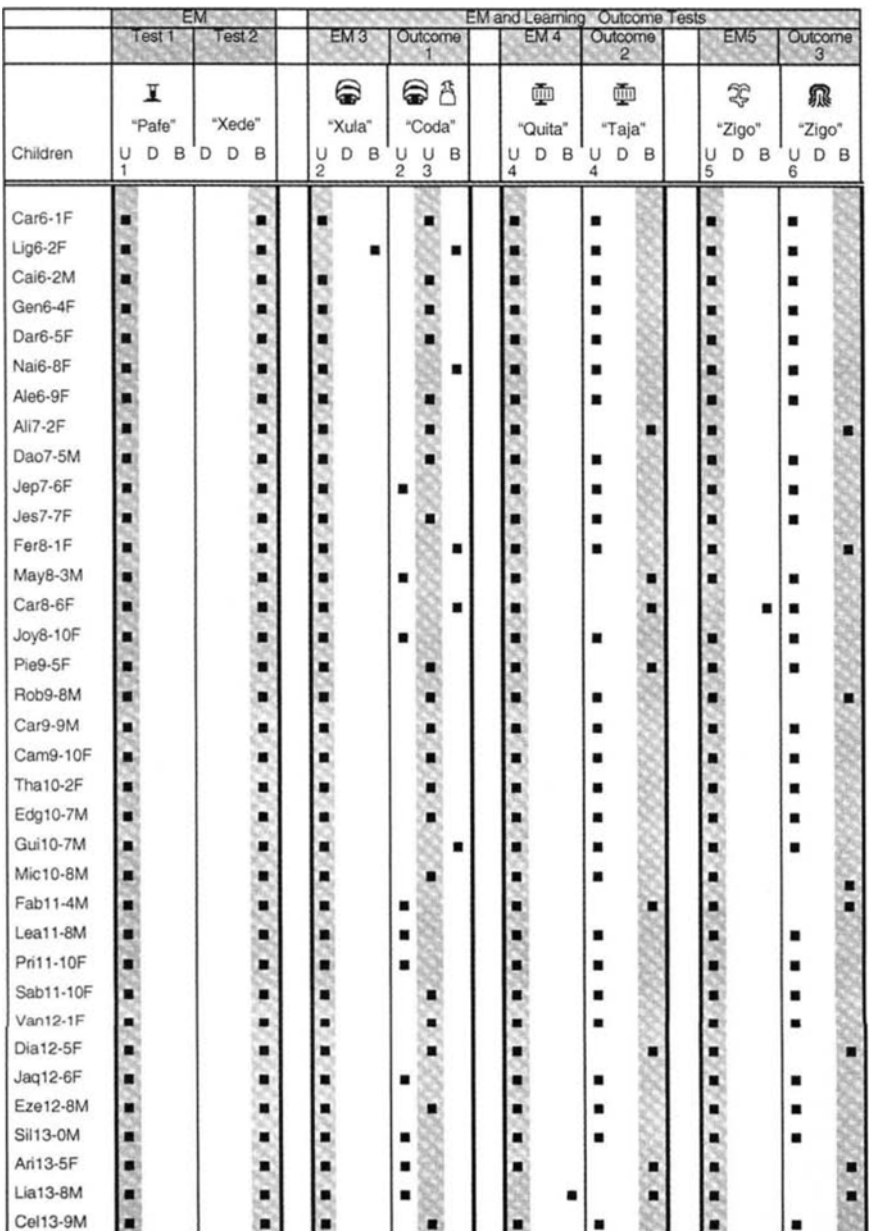

Figure 2. Individual responses on each emergent mapping and learning outcome test in Experiment 2. (See Figure 1 for details).

Results and Discussion

Baseline Training

All but 1 child completed the sequence of training and tests in a single session. Only 3 children required a second stimulus control shaping block, and all achieved 100% accuracy on the final block of baseline trials with the VR2 schedule. Performance on baseline trials (not shown) remained highly accurate throughout testing (mean: 99.1%).

Emergent mapping tests. Figure 2, presented in the same format as Figure 1, shows that the performance of these older children was virtually identical to that of the younger cohort on the tests. Overall, 172 of 175 probe selections were of the expected variety (i.e., selections of stimuli other than the defined comparison stimuli).

Learning outcome tests. Figure 2 shows that the majority of these older children behaved in the same manner as the younger cohort, but there were numerous exceptions. Outcome Test 1 was the most discordant; many children selected the recently introduced stimulus U2 rather than the novel U3 in response to the novel sample "Coda," a tendency that appeared particularly pronounced in the oldest children. Other children chose the blank comparison. Overall, the results of Outcome Test 1 suggest that, for these older children, the test presented an ambiguous choice, which children resolved in a variety of ways.

By contrast, results on Outcome Tests 2 and 3 were more consistent; children divided their selections between the undefined comparison and the blank in a roughly 5:1 proportion. Did children's selection of the blank comparison indicate that the single emergent mapping trials had been sufficient to establish a 1:1 relation between novel samples and the novel or recently introduced comparison stimuli? That seems possible, especially for certain older children who were the most consistent in their responding. In fact, for older children, one is somewhat surprised that there was not greater evidence of learning. Had the test trials been followed by differential consequences (i.e., explicit feedback on performance), it seems likely that the pattern of learning outcome results would have been somewhat different.

Interpreting Outcome Tests Results

The outcome tests were directed at the second fundamental question in emergent mapping research: What does the child learn when he or she selects an undefined item in the presence of an undefined word (*e.g.*, Ferrari, de Rose, & McIlvane, 1993)? Does the participant merely relate the two undefined stimuli because they are novel or does he or she learn a conditional relation involving those specific stimuli?

Figure 3 summarizes results of Learning Outcome Tests 1-3 from both experiments. It plots the distribution of children's test selections as a function of three age ranges 3-5, 6-9, and 10-13 (17, 19, and 16 children, respectively). Overall, Figure 3 shows a strong tendency to relate novel dictated words with novel or recently introduced comparison stimuli. It

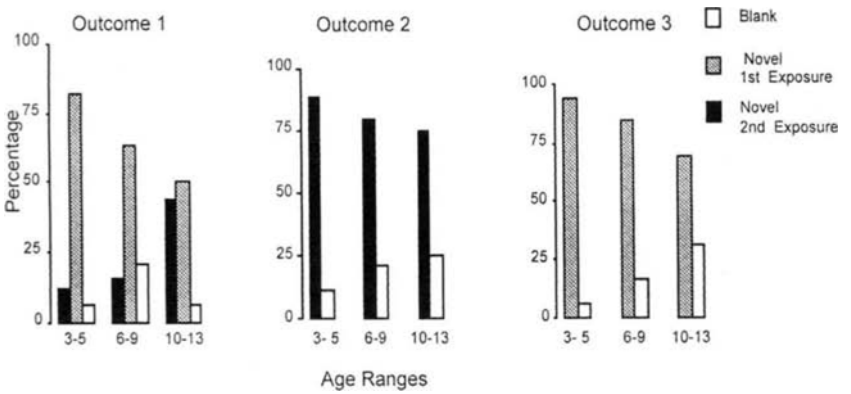

Figure 3. Distribution of participants (Experiments 1 and 2 combined), in each age range, according to their selections on the learning outcome tests. Bars indicate selections of stimuli that were novel (gray), had appeared once before (black), or were blank (white).

also shows that the proportion of children selecting the novel or recently introduced comparison stimulus tends to decrease with age, with selections of the blank comparison showing a complementary increase.

One exception was on Test 1 in which two novel comparisons were displayed. Here, the majority of children selected one of those two stimuli. There were increased selections of the blank in the 6-9 year age range, but it was not shown in the oldest group. Because the magnitude of the effect was fairly small, the finding may be artifactual. If the finding holds up to replication, however, that would suggest a complex interaction of developmental variables. For example, it is probable that the youngest children responded to stimulus novelty, a tendency that would be expected to decrease as children aged and consistent with increased selection of the blank. It seems unlikely that older children would be recaptured by novelty, but it does seem likely that their richer behavioral history would interact with the test conditions. For example, perhaps some children interpreted Learning Outcome Test 1 as a test of remembering which visual stimulus was to be selected when an undefined word was dictated. This ambiguity points out a future need to enrich our array of test trials. For example, one could follow the emergent mapping test with "Xula" with a second emergent mapping trial; "Coda" would be dictated with a single undefined comparison available, but different from the one selected when "Xula" was dictated. Then, learning outcome trials would present both recently introduced comparisons together to determine whether "Xula" and "Coda" would be related with the specific comparison stimuli that were selected on the emergent mapping trials (McIlvane & Stoddard, 1981). This conditional discrimination might be encouraged by providing explicit feedback for emergent mapping selections.

As shown in the middle panel and rightmost panels, a small but increasing proportion of the children selected the blank on Outcome Tests

2 and 3. Perhaps the most straightforward explanation is that an increasing proportion of children had learned specific conditional relations on the preceding emergent mapping trials (i.e., between "Quita" and the comparison stimulus selected on Emergent Mapping Test 4). As just mentioned, however, we may need more sensitive tests to differentiate indiscriminate relation of novel stimuli from other bases for responding.

General Discussion

Both experiments used the blank comparison procedure to elucidate the stimulus control bases for emergent mapping performance in a Portuguese-speaking sample. This sample was larger and broader than any studied thus far. The present results confirm the findings of Wilkinson and McIlvane (1997), demonstrating that the two plausible ways by which children might accomplish emergent mapping (i.e., via exclusion or relating novel stimuli) are not necessarily opposed or competing alternatives (cf. Catania, 1998): Children may routinely exhibit both types of stimulus control relations.

Perhaps the most important finding may have been the increasing heterogeneity of responding on learning outcome tests among older children. By contrast, Wilkinson and McIlvane's population of younger children displayed fairly homogeneous responding on most tests. A possibility for future research, therefore, is devising a test series for use with older children, which takes fuller advantage of the blank comparison procedure to differentiate sample-S+ from sample-S- responding. For example, prior research with college students has used the procedure to assess the effects of so-called "complex histories" in which sample and/or comparison stimuli were involved in multiple mapping relations (e.g., analogous to synonyms or category names; McIlvane et al., 1987). Based on findings thus far, there appear to be certain differences between college students and older individuals with developmental disabilities with mental ages scores in the range studied here (e.g., McIlvane et al., 1992). Open questions include whether typically developing children will show orderly developmental changes on complex history tasks and at what point their response profile comes to match that of normally capable adults.

As studies accumulate reporting successful use of the blank comparison technique in participants with developmental limitations, it may be useful to consider other ways in which it might be applied. For example, developmental psychologists may find it useful for studying the phenomenon of word under- and overextension (Kay & Anglin, 1982) for which there appear to be direct parallels in the present work (i.e., on Outcome Test 3). Behavior analysts may find the technique useful for a related purpose—analyzing the stimulus control of verbal repertoires (e.g., What are the critical controlling features when an individual tacts or mands? [Skinner, 1957]). More generally, research suggests the technique may be applied whenever one has need of a procedure for nonverbal assessment of whether stimuli are or are not members of a given stimulus class (e.g., Serna, Dube, & McIlvane, 1997; Serna, Wilkinson, & McIlvane, 1998).

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