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EVIDENCE FOR A SPATIAL BIAS IN THE DISCRIMINATION LEARNING OF YOUNG CHILDREN

EVIDENCIA DE PREDISPOSICIÓN ESPACIAL EN EL APRENDIZAJE DE DISCRIMINACIÓN EN NIÑOS PEQUEÑOS

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ABSTRACT

Developmental change in attention to spatial versus nonspatial dimensions of stimuli was studied in children and adolescents. Subjects were trained to select one of three different stimuli on a card and then tested with changed stimulus positions. Selecting a training stimulus indicated nonspatial attention; selecting a training position indicated spatial attention. Experiment 1 found no spatial bias with shape, color, or picture stimuli in 6 children, 4- to 6-years old. Experiment 2 employed a wider range of ages, from 1 to 15 years, in 18 children and 3 adolescents, and a simplified procedure testing only shape stimuli. This experiment found a reliable spatial bias in younger children (logistic, $r=0.61$, $p<0.005$), and an estimated transition to shape bias at 2.75 years. The spatial bias in young children parallels that found in other species; findings are discussed in relation to failures to find symbolic stimulus relations in some individuals.

Key words: spatial learning, non-spatial learning, discrimination, attention, naming, development, children, adolescents

RESUMEN

Se estudiaron cambios en el desarrollo de la atención hacia dimensiones

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espaciales vs. no-espaciales del estímulo en niños y adolescentes. Se entrenó a los sujetos para seleccionar uno de tres estímulos diferentes que estaban en una tarjeta y posteriormente se cambió la posición del estímulo. La selección del estímulo que fue entrenado indicó la atención a atributos no espaciales; la selección de la posición del estímulo de entrenamiento indicó la atención a los atributos espaciales. En el Experimento 1 no se encontró ninguna predisposición espacial, por la forma, el color o la figura del estímulo en 6 niños de 4 a 6 años de edad. En el Experimento 2, donde se utilizó un rango más amplio de edades, de 1 a 15 años, en 18 niños y 3 adolescentes, así como un procedimiento simplificado para evaluar sólo la predisposición espacial y la forma, se encontró una predisposición espacial confiable en los niños más pequeños (regresión logística, $r^2=0.38$, $p<0.005$), estimándose una transición hacia la predisposición por la forma a los 2.75 años de edad. La predisposición espacial en los niños más pequeños es paralela a lo que se ha encontrado en otras especies. Estos hallazgos son discutidos de acuerdo a los errores particulares de los sujetos para demostrar relaciones de estimulo de tipo simbólico

Palabras clave: aprendizaje espacial, aprendizaje no-espacial, discriminación, atención, nombrar, desarrollo, niños, adolescentes

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Many species, including humans, show highly developed spatial learning and memory skills (Ellis, 1990; Foreman, Foreman, Cummings, & Owens, 1990; Gill & Wolf, 1977; Olton, 1978; Spetch & Honig, 1988). *Spatial* behavior is observed when organisms learn to locate food or other goals by orienting themselves to landmarks. In contrast, *nonspatial* behavior, such as distinguishing between edible and non-edible stimuli, is established independently of location cues.

Spatial and nonspatial behavior can be experimentally dissociated by training one repertoire to the exclusion of the other (Jarrard, 1993). When contingencies contain both spatial and nonspatial features, however, a *bias* toward spatial learning frequently emerges, tending to retard or prevent nonspatial learning (for a review of early findings with rats see Mackintosh, 1974). In a recent study, for example, Iversen (1997) found that rats trained in identity matching-to-sample had learned to respond on the basis on spatial configurations of stimuli instead of on the basis of identity. During training trials, rats were required to make an observing response to a central sample stimulus, left and right comparison stimuli were then presented (the matching comparison position varied between trials), and finally a response to the matching comparison produced food. There were two stimuli in the task, steady and blinking lights, permitting the rats to learn two identity relations (one for each stimulus) or four spatial configurations (two comparison positions for each sample) (see other discussions of this problem in Carter & Werner, 1978; Sidman, 1994). Iversen found that the rats failed a test in which the trained sample and comparison locations were exchanged --instead of learning the two nonspatial identity relations, the rats' responses were based on the four spatially defined configurations of stimuli.

Spatial biases show degrees of specificity between species and tasks. For example, Broadbeck and Shettleworth (1995) compared species of birds by reinforcing pecks to one of three stimuli defined by both color and spatial orientation. A test for attention to color or location was conducted by swapping stimulus positions (analogous to the procedure of Iversen, 1997). They found that seed-storing birds were more likely to peck at the previously reinforced position rather than at the color, demonstrating a spatial bias (see also Krebs, Healy, & Shettleworth, 1990). Task-specific differences in the spatial bias of a single species were found by Iversen, Sidman, and Carrigan (1986) in rhesus monkeys. The monkeys were first trained on identity matching in a conventional three-response task with line and color stimuli. In tests with changed sample and comparison positions, they showed nonspatial identity relations with colors but spatial learning with lines. These and related findings show that spatial repertoires are specialized predispositions in some species (Ellis, 1990; Foreman et al., 1990; Gill & Wolf, 1977; Menzel, 1973; Olton & Samuelson, 1976).

The present experiments investigated the presence of a spatial bias in the discrimination learning of children and adolescents. Finding a spatial bias in children would be important in understanding the course of early human development. But it also might provide a more parsimonious non-linguistic interpretation for difficulties in demonstrating symbolic learning in non-humans, pre-linguistic toddlers, and nonverbal subjects with mental retardation (Devany, Hayes, & Nelson, 1986; Horne & Lowe, 1996). An important symbolic relation not yet demonstrated in these subjects is *symmetry*. An example of symmetry involves training a subject to select a lower-case *a* given an upper-case *A*, and then testing if the subject selects the upper-case *A* given the lower-case *a* (Sidman et al., 1982). Explanations for successful demonstrations of symmetry in these subjects have appealed to language abilities in general (Devany et al., 1986) and more recently to "naming" behavior in which a vocal naming response mediates responding between ostensively matched stimuli (Horne & Lowe, 1996). If pointing to comparison *a* comes to be controlled in any way by its spatial relation to sample *A*, however, the subject would not be expected to show symmetry when sample and comparison positions are switched (Sidman, 1994). The immediate purpose of the present experiments was not to resolve the reasons for failures to find symbolic behavior, but instead to examine whether these spatial biases arise in simpler discriminations.

EXPERIMENT 1

Stimuli have many independent dimensions such as color, shape, size, and texture, in addition to spatial orientation (Landau, Smith, & Jones, 1988; Reynolds, 1961; Ruff, 1984). The first experiment pitted spatial attention against (1) different colors, (2) shapes, and (3) familiar linguistic categories (e.g., drawings of fish, houses, and flowers). Colors and shapes were included because of the finding that rhesus monkeys show spatial biases in discriminations based on line orientation but not colors (Iversen et al., 1986). Linguistic categories were included because learning the name of an object produces stimulus control by shape that overshadows responding on the basis of the object's other properties. For example, in experiments by Landau et al. (1988) children were told that an unfamiliar object was a "dax" and then were asked to choose between objects of the same size, texture, or shape. Two- and three-year-old children matched the object with the same shape at greater than chance levels, with older children showing a significantly greater preference for the same shape than younger children. It might be anticipated, therefore, that responses controlled by familiar objects would show less overshadowing by their spatial location.

Tests were carried out with a paper-and-pencil adaptation of the Broadbeck and Shettleworth (1995) procedure used to study spatial biases in birds. In the present experiment, the child was trained to mark an "X" on one of three stimuli drawn on a card. Stimuli were defined both by spatial and nonspatial attributes, their position and appearance, respectively. Attention to spatial or nonspatial aspects of stimuli was tested by shuffling the stimuli. A nonspatial bias was indicated if the child marked the training stimulus in the new position; a spatial bias was indicated if the child marked the stimulus in the training position. This experiment employed four- and six-year-old children because we experienced difficulty in training younger children in this task and, in the absence of previous experiments on spatial biases with children, we were optimistic about finding differences in these two age groups.

METHOD

Subjects and Setting

Participants were six typical children recruited from local pre- and primary schools. Three girls served in the four-year-old group ($\underline{\bar{x}}=4.3$; range, 4.1 to 4.4 years) and two boys and one girl served in the six-year-old group

($\bar{X}$ = 6.4; range, 6.0 to 6.8 years). Sessions were conducted in an office, separating children from their classroom and play areas. Children were studied singly during their play periods; they completed the experiment in a single session.

Materials

Stimuli were printed on 8x10 cm cards. Each card contained three colored disks, black-outline shapes, or drawings of familiar categories arrayed in one of three patterns. Examples of three cards are presented in Figure 1 (all nine cards are described in the Appendix). The left card shows an example of (1) *color* in a horizontal array, the middle card shows (2) *shape* in a vertical array, and the right card shows (3) *category* in a triangular array. Stimuli were laser printed, black-line drawings on white paper. Colored stimuli were always circles with colors added manually with felt-tip markers; shapes were presented as black outlines; and categories were always black line drawings. Each stimulus card had unique colors, shapes, and categories—stimuli were not repeated between cards.

Three different sets of stimulus materials were assembled. Each set contained one card with colors, one with shapes, and one with categories (one such set is shown in Figure 1). Counterbalancing was achieved by,representing each type of stimulus (color, shape, and category) in one pattern (horizontal, vertical, and triangular). Each stimulus set was used in the training and testing of one child--one child was exposed to horizontal-colors, vertical-shapes, and triangular-categories; another child was exposed to horizontal-categories, vertical-colors, and triangular-shapes; and so on. Different stimulus sets did not duplicate a pattern-type combination.

Procedure

Children were familiarized with the procedure by informing them that they were going to play a game in which they could earn beans (dried black beans) to purchase toys and candy. They were then shown a box containing small play items and candy that they were told they could purchase with the beans (toys included small plastic dinosaurs, pencil sharpeners, etc.; candy included caramels, hard candy sprinkled with dried chile, etc.).

Children were taught how to mark stimulus cards prior to training with experimental stimuli. The training card contained only two horizontally aligned stimuli, a white circle and a striped circle containing a black dot. The card and a pen were presented to the child with instructions to put an "X" on the black dot: "Can you put an 'X' on the dot, please." Once they did this they were presented with the same stimulus card but with the dot removed from the striped circle and they were instructed to place an "X" as they had just done: "Can you put an 'X' on this card, please." If they marked the striped circle they began the experimental procedures; if not, the training was repeated. The training reinforced neither spatial nor nonspatial attention because the "X" was always placed on the same stimulus and position.

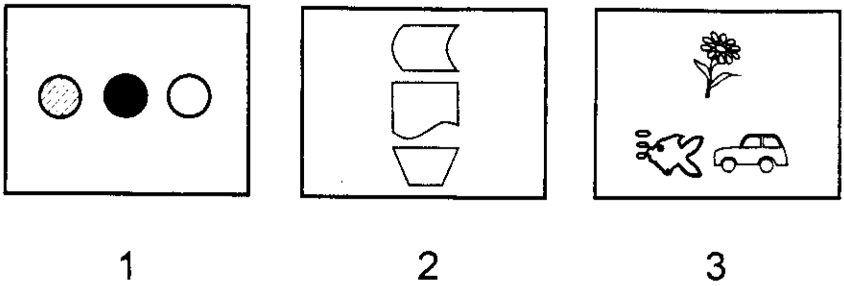

Figure 1. Examples of three training stimuli employed in Experiment 1 showing a horizontal array of colored circles, a vertical array of shapes, and a triangular array of categories. See Appendix for a complete list of stimulus materials.

Pairs of four- and six-year-old children were matched on the same set of stimulus materials and sequence of training colors, shapes, and categories; each pair of children was presented with a different sequence of training colors, shapes, and categories. Several steps were taken during familiarization and experimental conditions to control demand characteristics and potential cueing by the experimenter. First, to avoid biasing by the experimenter, the instructions were standardized between subjects. The instructions used to establish the response were always, "Can you put an 'X' on the dot, please," and "Can you put an 'X' on this card, please." There was no mention of stimuli or their location. Second, the experimenter sat behind the subject, did not make eye contact during task trials, and always placed cards in front of the subject by holding its lower-right edge. Third, a new stimulus card was used in each trial. The experimenter kept all marked cards in the order they were presented to the child, keeping an accurate record of all aspects of the child's performance.

Training began by presenting the first stimulus card in the set chosen for that child (e.g., horizontal colors). The card appeared as in Figure 1 except that one of the stimuli contained a black dot (the position of the dot varied between the three stimulus sets, for example, each triangle configuration required marking a different corner). Once the child marked the stimulus with the dot, the child was asked to mark a card without the dot. The training instructions and procedure were repeated until the child performed correctly. New examples of the card without the dot were then presented until the child marked the designated stimulus-location five times in a row. At that point the next card in the set was trained in the same way (e.g., vertical shapes); when criterion was reached on the second card, the third card in the set was trained. Correct responses during the familiarization task and training earned the child beans. Errors were consequated by telling the child that their choice did not earn a bean and asking them to try again.

Training was followed by a review of training stimuli and a test. Reinforcers were presented after the review and again after the test in order to avoid influencing test results by reinforcing test responses (Broadbeck & Shettleworth, 1995; Krebs et al., 1990; Sidman et al., 1982). The reason for the pretest review was to evaluate the effect of removing reinforcers. In the review, the child was presented with another set of the training cards to mark. The child was told that he would now receive his beans after marking all the cards, not after marking individual cards as before. The review contained three trials of each type (color, shape, and category) with the same cards and order used in training. If all of the pretest responses were correct, the child proceeded to the test; if there were errors, training with feedback was repeated for that stimulus (as above) and the entire review was carried out again. In either case, the child received the number of beans corresponding to the number of correct answers.

Test trials were arranged in two consecutive six-card blocks. Each test block included one training trial for each of the color, shape, and category stimuli, and one corresponding test trial in which the stimulus positions of the training card were switched. For example, if the color-training card required marking the red stimulus at the apex of a triangular configuration, then the test card placed the red stimulus at the lower right of the triangular configuration. Both test cards were identical. Each block presented the three pairs of training and test stimuli in different orders but the trials were arranged so that a training stimulus always preceded a corresponding test stimulus.

RESULTS AND DISCUSSION

Differences in spatial bias were not apparent in these age groups. The right columns in Table 1 present the training and test results. The number of trials to reach the five-correct training criterion is presented in the *Train* column, the next column shows number of correct pre-test trials, and the two columns on the right show the number of test trials in which the child marked the correct stimulus for training and test stimuli, respectively. In none of these measures were there obvious or even suggestive differences between groups. Only two children showed any spatial responding, one in each age group. The four-year-old child, F1, showed almost complete control by stimulus location; while the six-year-old child, S1, only showed control by location when stimuli were shapes. The pattern shown by the older children is suggestive of that found in monkeys by Iversen et al. (1986) to the extent that there was nonspatial stimulus control by colors and not shapes, but the experiment does not permit a conclusion regarding the reliability of this finding. Although it might be argued that the failure to find a result was due to a small sample size, we had anticipated a more obvious effect.

EXPERIMENT 2

There are several potential explanations for the failure to find evidence for spatial biases in Experiment 1. A plausible guess is that there is no difference between children at these ages and that spatial biases might only be found in children younger than four years. This is suggested by the findings of Landau (1988) indicating that name learning comes predominantly under stimulus control of shape between two and three years. Experiment 2 addressed this concern by including a greater range in the age of children and adolescents. Additional changes were introduced after a two-year-old pilot subject could not control the marking response and showed habituation to the reinforcer after the first stimulus was trained. The problem with the marking response was that it was not possible to stop the child from marking the entire stimulus card. This was solved by switching to a simple pointing response. The problem of habituation was that the child did not wish to participate beyond the first training phase. This was solved by restricting training and testing to shapes. It was anticipated that a spatial bias would be more likely to be seen with shapes than with colors or categories because of the Iversen et al. (1986) finding in monkeys that spatial biases were seen in line discriminations but not in color discriminations.

METHOD

Subjects and Setting

Participants were 18 typical children recruited from local pre- and elementary schools, and three adolescents from a local secondary school. The ages and genders of the children are presented in Table 2. An attempt was made to study three children at each year. Other details were as in Experiment 1.

Table 1. Summary of individual performances in Experiment 1, presented by ascending age (months are converted to their decimal equivalent).

						Pre-	Correct test tr.	
Subject	Sex	Age	Test	Config.	Train	Test	Train	Test
F1	f	4.1	Color	Triangle	5	2	4	0
			Shape	Horizontal	5	2	4	0
			Category	Vertical	6	2	4	1
F2	f	4.4	Color	Horizontal	18	2	4	2
			Shape	Vertical	12	2	4	2
			Category	Triangle	7	2	4	2
F3	f	4.4	Color	Vertical	10	2	4	2
			Shape	Triangle	5	2	4	2
			Category	Horizontal	29	2	4	2
S1	m	6.0	Color	Vertical	5	2	4	2
			Shape	Horizontal	5	2	4	2
			Category	Vertical	6	2	4	0
S2	f	6.3	Color	Horizontal	8	2	4	2
			Shape	Vertical	8	2	4	2
			Category	Triangle	8	2	4	2
S3	m	6.8	Color	Vertical	5	2	4	2
			Shape	Triangle	5	2	4	2
			Category	Horizontal	29	2	4	2

Procedure

The procedure was the same as in Experiment 1. The only differences were that children were now required to point to the correct stimulus, each subject was studied on just one spatial configuration employed in Experiment 1 (stimuli were the three Shape card described in the Appendix), and the review of training stimuli was removed. The first training instruction was now, "Can you point to the dot, please," and, "Can you point again, please," once the dot was removed. Three spatial configurations varied between subjects (see Table 2). As before, the test presented two training stimuli and two test stimuli.

Table 2. Summary of individual performances in Experiment 2, presented by ascending age (months are converted to their decimal equivalent).

					Correct Tests	
Subject	Sex	Age	Config.	Train	Train	Test
1A	f	1.7	Horizontal	11	2	0
1B	f	1.8	Triangle	5	2	0
1C	f	1.9	Vertical	5	2	0
2A	m	2.1	Horizontal	5	2	0
2B	m	2.8	Vertical	5	2	2
2C	m	2.8	Triangle	5	2	2
3A	f	3.0	Horizontal	5	2	0
3B	m	3.1	Vertical	7	2	2
3C	m	3.2	Triangle	5	2	0
4A	f	4.1	Horizontal	5	2	2
4B	m	4.5	Vertical	5	1	2
4C	f	4.8	Triangle	5	2	2
5A	m	5.4	Vertical	5	2	0
5B	f	5.5	Vertical	5	2	0
5C	f	5.6	Triangle	5	2	2
6A	f	5.8	Horizontal	5	2	2
6B	f	5.8	Triangle	8	2	2
6C	m	5.8	Horizontal	5	2	2
AA	m	14.1	Vertical	5	2	2
AB	f	14.2	Triangle	5	2	2
AC	m	15.8	Horizontal	5	2	2

RESULTS AND DISCUSSION

The children complied with procedures without any difficulties. Results show a spatial bias in younger children with a developmental trend toward nonspatial responding. The trend is visible in the presentation of age-ranked test data in Table 2. The right data column in Table 2 shows that the four youngest subjects chose the training response location on both tests, the seven oldest subjects always chose the training stimulus, and intermediate-aged subjects show a positive relation between age and tendency to select the training stimulus. It is further striking that subject's test choices were exclusively controlled by shape or location; there are no intermediate cases. That is, individual children were revealed as either "spatial" or "nonspatial" organisms.

Figure 2 shows age plotted against percent selection of shape. The appropriate function to describe these results is not completely evident but it is clear that the relation between age and the probability of control by shape is not adequately described by a line (however, Pearson $r=0.54$, $df=19$, $p<0.05$). Instead, there is progression between complete spatial responding and complete nonspatial responding. An appropriate model is a transition function, such as a logistic equation [$y=a + b/(1+(x/c)^{d})$]. These equations are designed to describe "S"-shaped dose-response functions or psychophysical thresholds in which few subjects show effects at lower values of a dependent variable, but as the value of the independent variable is increased, all subjects show an effect (Harvey, 1986). The solid curve in Figure 2 shows the best-fitting logistic line calculated with all subjects' data ($df=19$, $r=0.61$, $p<0.005$; $a=-942.97$, $b=1037.25$, $c=0.51$, $d=-1.84$). There are other functions that might better describe these data but the successful fit of the logistic function is theoretically interesting since it supports the notion of a transition between a spatial bias and nonspatial responding.

The finding of a transition to a nonspatial bias implies a threshold age at which children become nonspatial learners. The logistic function for the present data estimates that 50% of children show a transition to nonspatial responding at 2.75 years of age. This is a significant age in language development since it marks the beginning of the "naming explosion" when the rate of word learning is at its lifetime highest (Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992; Landau et al., 1988; Woodward, Markman, & Fitzsimmons, 1994). It is further significant because it is the age at which children begin to show a shape bias in name learning: they identify the name of an object with its shape and not its other attributes (e.g., size, color, or texture: Landau et al., 1988). Moreover, the shape bias is not perceptual in nature but appears to be the by-product of generalized name-learning skills. The implication for the present findings is that between two and three years of age, children may learn to distinguish stimuli on the basis of their shapes and that this learning overshadows a spatial bias.

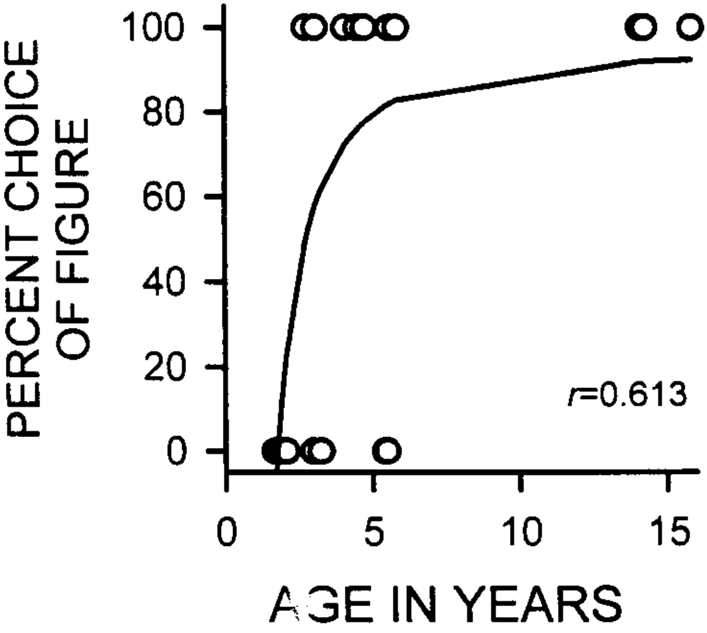

Figure 2. Scatter plot showing data from all subjects in Experiment 2 fit by a logistic function (solid line).

GENERAL DISCUSSION

Results of the first experiment were inconclusive, but the second experiment found developmental evidence of a declining spatial bias in very young children. The bias is consistent with that found in many other species, and it may be significant that it declines at about the same time as children begin to show generalized word-learning skills. Although a causal connection between these two events is speculative, the coincidence is compelling because learning the name of an object implies stimulus control by shape, a nonspatial stimulus dimension (Landau et al., 1988). The reason for the initial dominance of the spatial bias is uncertain but the Broadbeck and Shettleworth (1995) procedure employed here has been found to produce results consistent with open-field foraging situations. This implies that the spatial bias shown in this task is simply a general tendency to learn the spatial layout of consequences in the environment (Ellis, 1990).

The present experiment revealed the spatial bias in young children and proposed a plausible explanation for why symbolic stimulus relations are more likely to be found if stimuli are given vocal labels (see review by Horne & Lowe, 1996). Naming an object might permit symmetry to the extent that the name was under control of the nonspatial properties of the stimulus and not its position. This is a simple alternative to the "naming" theory proposed by Horne and Lowe (1996) to explain symbolic learning. In their theory, symmetry occurs because symbols share a vocal name that directly mediates between them (i.e., saying "a" to sample *A* and then pointing to comparison *a* leads to symmetry if a subject is inclined to say "a" when *a* is a sample and *A* is a comparison). If, however, failures to find symbolic behavior result from interference by spatial biases, then symbolic behavior may be a byproduct of how naming reduces spatial control and not a direct result via mediation.

Studies on word learning suggest that names do indeed mask spatial tendencies in very young children (Golinkoff et al., 1992; Woodward et al., 1994). In Golinkoff et al. (1992), for example, 12 children between two and three years-of-age were shown a familiar and unfamiliar object and asked to point to the "dax," a name that was unfamiliar to the children (cf. learning-by-exclusion: McIlvane et al., 1987). Children pointed to the unfamiliar object on 78% of test trials (chance was 25%), showing responding guided by exclusion of familiar objects. In generalization trials that followed, children asked to point to the "dax" continued to point to the unfamiliar object on 69% of tests in which it was presented *in new positions* with new familiar and unfamiliar objects. The finding of Golinkoff et al. (1992) provides substantial evidence that learning a category-label relation prevents spatial responding in children.

It is likely that more than one condition must be satisfied to obtain stimulus relations such as symmetry (and that there is more than one way to achieve formally defined symbolic relations); there is no reason why spatial interference is incompatible with the "naming" theory of Horne and Lowe (1996). But a spatial bias helps further to understand why another symbolic stimulus relation, *transitivity* (train choosing *B* given *A* and choosing *C* given *B*; test choose *A* given *C*), is not difficult to demonstrate in a variety of species (e.g., D'Amato, Salmon, & Colombo, 1985; Sidman, 1994). Transitivity tests may be passed because: (1) transitive responses always move away from the trained sample location and towards the trained comparison location, preserving the spatial topography of stimuli, and (2) transitivity preserves the order of the *A-B-C* response sequence. The latter sequential aspect of transitivity may make an important contribution in transitivity tests since response sequences are known to remain intact after removal of central elements (i.e., a pigeon trained to make the response sequence of A-B-C, will correctly go from A to C if B is not present; Terrace, Straub, Bever, & Seidenberg, 1977). Any tendency to learn response sequences, spatial or nonspatial, would interfere with symmetry but enhance transitivity. This additional consideration suggests that demonstrations of symmetry require a minimal degree of control by spatial *and* sequential aspects of contingencies.

The argument that the developmental progression from spatial to nonspatial biases is an effect of name learning calls for further research. The discussion of Experiment 2 implied that specific names for stimuli were not necessary to override the spatial bias, but that a shape bias emerged after a history of name learning, as argued by Landau et al. (1988). We can now ask whether such a history is really necessary; or instead, does a verbal label automatically overshadow a spatial bias? Whatever the answer, the present finding suggests additional questions. For example, adults reliably remember the location of a stimulus without training and without conscious effort (e.g., Ellis, 1990). This implies that a spatial bias is "automatic," in the lexicon of cognitive psychology, and is simply masked by developmental processes. But is this necessarily so--does the spatial bias interact differently with color and categories as studied in Experiment 1? Color may have a more nonspatial character—a sort of nonspatial "preparedness" bias in primates (e.g., as in fear conditioning; Cook & Mineka, 1989)--as suggested by the findings of Iversen et al. (1986).

REFERENCES

Broadbeck, D. R., & Shettleworth, S. J. (1995). Matching location and color of a compound stimulus: Comparison of a food-storing and a nonstoring bird species. *Journal of Experimental Psychology: Animal Behavior Processes, 21,* 64-77.

Farter, D. E., & Werner, T. J. (1978). Complex learning and information processing by pigeons: A critical analysis. *Journal of the Experimental Analysis of Behavior, 29,* 565-601.

Cook, M., & Mineka, S. (1989). Observational conditioning of fear to fear-relevant versus fear-irrelevant stimuli in rhesus monkeys. *Journal of Abnormal Psychology, 98,* 448-459.

D'Amato, M. R., Salmon, D. P., & Colombo, M. (1985). Extent and limits of the matching concept in monkeys (Cebus appella). *Journal of Experimental Psychology: Animal Behavior Processes, 11,* 35-51.

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

Ellis, N. R. (1990). Is memory for spatial location automatically encoded? *Memory and Cognition, 18,* 584-592.

Foreman, N., Foreman, D., Cummings, A., & Owens, S. (1990). Locomotion, active choice, and spatial memory in children. *Journal of General Psychology, 117,* 215-

of a sequence by pigeons. *Bulletin of the Psychonomic Society, 10,* 269.

Woodward, A. L., Markman, E. M., & Fitzsimmons, C. M. (1994). Rapid word learning in 13- and 18-month olds. *Developmental Psychology, 30,* 553-566.