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Using the Operant MTS Procedure as a Masking Task for Respondent Acquisition of Stimulus Classes

Utilización del procedimiento MTS como una tarea de interferencia durante la adquisición respondiente de clases de estímulos

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Abstract

A functional class refers to a circumstance in which responding is controlled by features of stimuli that are common to all the class members. It is argued that an analysis of substitution of stimulus functions is needed to account for the acquisition of functional classes of different varieties. We examined the acquisition of classes of comparison stimuli presented in a standard matching to sample (MTS) preparation by exposing participants to three tests in which a contextual cue provided the basis for the formation of these classes. In this preparation the equivalence training and test phases served as a masking task that prevented the interference of naming processes or the development of rules describing the commonalities among target class members (comparison stimuli). Most of the participants showed responding with respect to one or more comparison classes even in the absence of specific operant training. Findings suggest that the function shared by a given set of stimuli may be acquired by another stimulus in the absence of operant reinforcement and without the involvement of verbal rules.

Key words: stimulus equivalence, masking task, respondent equivalence, function transfer, substitution of functions, contextual cues

Resumen

Se habla de adquisición de clases funcionales cuando el comportamiento es controlado por aquellas propiedades de los estímulos que son comunes a todos los miembros de la clase. Un análisis en términos de sustitución de funciones es necesario para explicar la adquisición de varios tipos de clases funcionales. En este estudio se examinó la adquisición de clases de estímulos comparadores en un entrenamiento estándar de igualación a la muestra, mediante la inclusión de un estímulo contextual diferente para cada clase de comparadores. Las fases de entrenamiento y pruebas de equivalencia sirvieron como una tarea de enmascaramiento para prevenir la interferencia de respuestas verbales con respecto a las relaciones entre el estímulo contextual y los comparadores durante el entrenamiento. Hubo respuestas respecto a una o más clases de comparadores para la mayoría de los participantes. Los hallazgos indican que la función compartida por los miembros de una clase puede ser adquirida por un estímulo arbitrario en ausencia de refuerzo y de respuestas verbales.

Palabras clave: equivalencia de estímulos, tareas interferentes, claves contextuales, transferencia de funciones, sustitución de funciones.

Many years of research have resulted in theories aimed at accounting for the emergence of relations observed in equivalence studies using the standard MTS procedure. Among the most prominent theories are those of Sidman (1992, 1994, 2000), the Relational Framing Theory (RFT) of Hayes, Barnes-Holmes and Roche (2001), and the Naming Theory of Horne and Lowe (1996, 1997). These theories have two things in common: (a) they assume verbal behavior or symbolic behavior to be fundamentally implied in the emergence of equivalence relations and (b) they contend that, equivalence relations and verbal behavior (whatever the specificities of their relations), are the product of operant conditioning processes. On the other hand, the differences among these three major accounts pertain to the ways in which verbal behavior is related to the acquisition, outcome and process of equivalence.

While Sidman (1992, 1994) understands equivalence as a basic learning process and a prerequisite for the acquisition of verbal behavior, Horne and Lowe (1996) describe it as an experimental outcome that is facilitated by the acquisition of listener and speaker repertoires developed early in childhood. In other words, in their view, it is because of naming that equivalence relations are observed. Finally, RFT contends that the three main properties of relational frames (i.e., mutual entailment, combinatorial entailment and transformation of functions), are also essential characteristics of linguistic phenomena (Hayes, Barnes-Holmes & Roche, 2001).

Naming theory (as well as RFT), attributes success in equivalence tests to a history of reinforced matching of names with objects or events. According to Horne and Lowe (1996), better performances on equivalence tests are observed when participants name each stimulus in the class, and/or when they name the stimulus class itself, which is to say, when participants say the same word in the presence of each of the class members (Dugdale & Lowe, 1990; Fields, 1996; Wulfert, Dougher & Greenway, 1991).

Naming implies a linear, yet circular process between sources of stimulus control (a caregiver saying car), the behavior of the individual as listener (orienting towards the object or seeing the object or in its absence) and the behavior of the individual as a speaker (saying car). Because the individual can act both as a speaker and as a listener of his own speaker behavior, saying car can also serve as a source of stimulus control (in absence of the caregiver's verbal behavior "where is the car"), which evokes listener behavior with respect to a car. This process is symmetrical in that seeing a car will also be discriminative for emitting the verbal response car (Horne & Lowe, 1996).

In other cases, participants use the same name for all objects in the class as when saying "up" for all comparisons (Bn, Cn) reinforced in the presence of a nodal sample stimulus (An) resembling the shape of an arrow pointing upwards. This is similar to learning an abstract concept such as the word red or chair (Skinner, 1974). Names referring to a class of events should also be substitutable for each of the class members. If the relation between the verbal stimulus and the set of events to which it refers were not symmetrical, one would not be able to say chair in the presence of any type of chair or to orient oneself to different types of chairs when one hears the word chair. As has been proposed elsewhere (Delgado & Hayes, 2007; Kantor, 1958; Parrot, 1984; Parrot, 1987), the verbal stimulus substitutes for the shared functions of all the class members. These shared functions may consist of commonalities in the physical properties of the stimulus objects, commonalities defined by their spatial or temporal relations, or commonalities in their stimulus functions, wherein the same responses are observed with respect to objects of the same class regardless of similarities in their formal properties.

Tonneau, Abreu and Cabrera (2004) present a demonstration of this case. The authors showed that when placed in a room with several tokens having labels that referred to things, children acted differentially with respect to the tokens corresponding to the things to which the labels referred. This finding suggests that the word or label chair substituted for some of the functions of the object chair, including the possibility that one may even sit on the word chair (Tonneau et al., 2004). The same logic applies to the substitutability of functions among members of a broader category of class members, such as furniture or plants (Delgado & Hayes, 2007).

In spite of the compelling empirical evidence in favor of the naming account there is also evidence to suggest that naming is not necessary for the formation of classes. A number of studies using masking tasks have shown that participants perform successfully in tests of derived relations when verbal behavior with respect to the stimuli involved in the task is impeded (Olson & Fazio, 2002; Tonneau & Gonzáles, 2004; Walther, 2002). Such interference is usually arranged by having participants be engaged in a concurrent and unrelated activity requiring continuous emission of a verbal response. The use of masking tasks has been reported in some studies of equivalence using the respondent-type procedure (Tonneau & Gonzáles, 2004) and in respondent conditioning studies of human behavior in general (Olson & Fazio, 2002; Walther, 2002).

Masking tasks were introduced to contest the validity of the results obtained in classical conditioning studies of human behavior. It has been argued that the main reason for accurate responding with respect to functions shared by previously exposed stimulus pairs is that, in using standard S-S pairing procedures, the purpose of the experiment becomes readily apparent for the participants. Because during training participants anticipate what they'll be tested on and therefore, develop rules which facilitate responding, respondent conditioning might not be clearly demonstrated (see Page, 1964, 1974; Staats & Staats, 1958; Walther, 2002).

Such alleged awareness of the S-S associations involved in respondent procedures may pose procedural problems similar to those involved in operant MTS preparations. Specifically, it has been suggested that failure to observe equivalence in non-human animals and non-verbal individuals may be due to the experimental characteristics of the MTS task and not to the operation (or lack thereof) of an exclusively human psychological process (Hayes, 1992; Lionello De-Nolf, 2009; Rehfeldt & Hayes, 1998; Sidman, 2000).

Because of their verbal history of describing events as things that go together on the basis of a particular criterion, humans show faster acquisition during training and emergence of untrained relations during tests. Hence, the development of rules and names necessarily implies being aware of the purpose of the task and adjusting behaviorally to one's verbal descriptions. In studies of transfer of affective value, participants are exposed to pairings of different types of events and words having a positive or a negative valence. Findings show that using a masking task during trials of S-S presentations does not hinder transfer of functions (Olson & Fazio, 2002). Furthermore, Walther (2002) reported that using a masking task (e.g., repeating an eight digit sequence while observing the pairings) resulted in greater conditioning effects. In sum, the findings seem to suggest that participants respond with respect to classes of stimuli in the absence of verbal rules or naming processes.

The studies mentioned above indicate that derived relations do not require of a verbal repertoire or a history of reinforced conditional discrimination trials. Several studies have compared the effectiveness of the Respondent-Type procedure, based on presentation of stimulus pairs in the absence of reinforced trials, versus that of the traditional MTS procedure (Clayton & Hayes, 2004; Leader & Barnes-Holmes, 2001; Tonneau & Gonzáles, 2004). Although the results of these studies have been inconsistent (probably due to methodological differences), it is clear that stimulus classes are formed in the absence of a history of reinforced conditional discriminations. Thus, the emergence of relations between stimuli may occur in the absence of a history of reinforced responding with respect to stimulus pairs of the same class, and without the aid of previously acquired verbal substitutes for the stimuli involved.

Alternatively, we suggest that a sufficient condition for acquisition of behavior with respect to classes is that stimuli share some of their functional properties, be they physical or relational. The purpose of this study is to provide evidence to support this view. We examined if participants behave with respect to a stimulus class that is not explicitly reinforced during training. Specifically, we investigated if participants categorize the sets of comparisons (e.g., A1, A2 and A3) of a standard MTS equivalence preparation as members of the same class without specific training for doing so.

We postulate that class membership may be established on the basis of a shared contextual cue (on each trial, each set of comparisons is presented against a different colored background). Notice that in this preparation, training and testing for equivalence classes (A1, B1, C1) is used as a masking task that prevents describing the relations among sets of comparisons (A1, A2 and A3) and controls for the history of "relating" or "selecting" implicated in the MTS preparation. If our assumptions are wrong, that is, if behavior with respect to classes and emergence of relations are sufficiently explained by the reinforcement contingency then participants will classify stimuli into equivalence classes exclusively. That is, they will not also classify comparison stimuli as members of the same class in the presence of the contextual stimulus alone.

Method

Participants

Participants were 56 undergraduate psychology students. Participation in the study was entirely voluntary and extra-credit for undergraduate classes was granted upon completion of the experiment regardless of participants' performance. Informed consent was obtained from all participants prior to their participation in the experiment.

Setting and apparatus

Experimental sessions were conducted in a room with three tables, chairs and desktop computers. Each table was separated from the rest by a wall divider. Participation consisted of using a computer mouse to click on figures displayed on a computer monitor. All instructions were displayed on the computer screen and data for each session were saved automatically in an Excel file.

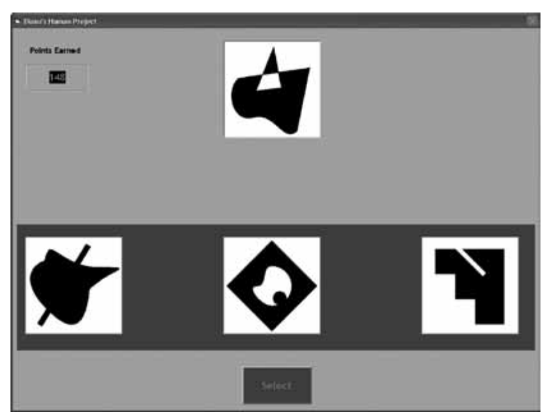
Procedures

The experiment was conducted in one session lasting approximately 45 min. Subjects were divided into three groups distinguished by the procedures employed in the final phase of the study. The experiment consisted of four phases: (1) Conditional discrimination training; (2) Test for derived symmetrical relations; (3) Test for equivalence relations; and, (4) Tests for other derived relations. The procedures used in this final test varied across groups of participants. The first group (n = 12) was exposed to a Sorting test; the second group (n = 25) was exposed to a Forced-choice test prior to the Sorting test. The Forced-choice test was conducted as a means of examining different aspects involved in responding to relations among class members. For the last group (n = 19) the Sorting test was followed by a test that examined the inverse/symmetrical relation between the contextual stimulus and the class members.

Conditional Discrimination Training and Test for Derived Relations

During the conditional discrimination training and the tests for derived symmetry, transitivity and equivalence relations, the sample stimulus appeared at the top of the computer screen. Below the sample, three comparison stimuli appeared next to each other, in randomized positions across trials, and against a colored rectangular background. The color of the background was specific to each of the four sets of comparisons. The samples and comparison stimuli consisted of arbitrary symbols drawn in black against a square white background. There were 12 stimuli arranged into four sets (A, B, C and D) of three stimuli (e.g., a1, a2, a3; b1, b2, b3; c1, c2, c3 and d1, d2, d3). When appearing as comparisons, the stimuli in group A were presented inside a green rectangle; the comparisons in group B inside a blue rectangle, and the comparisons in groups C and D inside yellow and red rectangles, respectively (Figure 1).

During conditional discrimination training, feedback was provided in the form of a "*Correct", or "Incorrect"* sign that appeared at the top right corner of the screen. In addition, points were added or subtracted for correct or incorrect responses. Points appeared at the top-left corner of the screen. One point was added for each correct response and three points were subtracted for each incorrect response. Before the experiment started, instructions as to how to proceed were displayed on the screen. Participants were instructed to figure out the way to earn the maximum number of points.



Group B- Presented on blue rectangle

Figure 1. Example of stimulus displays presented during conditional discrimination training trials. Comparisons corresponding to the B stimulus set are framed in a blue rectangle. Points earned are shown at the left top corner of the screen

There was a minimum of 40 trials for training comparisons from one set of stimuli to samples from another set. Three incorrect responses reset the number of training trials to zero. The first set of conditional relations involved samples from group A to comparisons from group B with correct matches being a1-b1, a2-b2, and a3-b3. Upon meeting the mastery criterion of 37 out of 40 correct selections, the A to C relations were trained. Following this, participants were trained in the A to D relations. Once the mastery criterion was met, mixed trials of A to B and A to C, were presented. Following mastery in the mixed trials, tests for derived relations of symmetry, and equivalence were conducted. Each test consisted of 18 non-reinforced trials. The test for symmetry involved the relations B to A, C to A and D to A. The test for equivalence involved the relations B to C, and C to B.

Tests for Other Derived Relations

Sorting Test. This part of the experiment consisted of testing for emergence of untrained relations among the stimulus members of sets A, B, C and D. The 12 stimuli in these sets appeared in an array at the bottom of the screen in random positions. Above this array were four colored boxes. The colors of these boxes corresponded to the rectangular frames that served as the background for the comparison sets during the previous phases (Figure 2, Panel a). Participants were instructed to sort the stimuli that appeared at the bottom of the screen into the four colored boxes in a different way from that of the previous training. If the sorting was incorrect, then the stimuli were reset at the bottom of the screen and a message box with the words "Try again" was shown on the screen. Two opportunities for correct sorts were available. If the sorting was still incorrect, then three additional opportunities were presented. However, on these three trials, if a set of three stimuli was correctly grouped together, those stimuli stayed fixed in the boxes at the beginning of the next and subsequent trials. This phase of the experiment ended when the participant reached a correct solution or after five trials were completed.

Forced-Choice Test and Sorting Test. Participants in this group were given the Forced-choice-test prior to the Sorting test. In the Forced-choice test, a sample was presented on the left side of the screen and two comparisons were presented on the right side of the screen separated by a vertical dotted line (Figure 2, Panel b). The sample was a member of one of the four classes of comparison stimuli. Each stimulus in each class (e.g., a1, a2, a3, b1, b2, b3, etc.) was presented randomly as a sample on each trial. The two comparisons in each trial included a stimulus member of the same class as the sample stimulus. For example, if the sample was a3, either a1 or a2 were presented as one of the comparisons. The other comparison was any other stimulus that was not part of the same equivalence class as the sample. The positioning of the correct comparison was varied randomly (right/left). Six trials were presented for groups A, B, C and D, in that order. Feedback was not provided for correct or incorrect responses. Upon completion of the Forced-choice test participants completed the Sorting test as described above.

a)
b)
c)

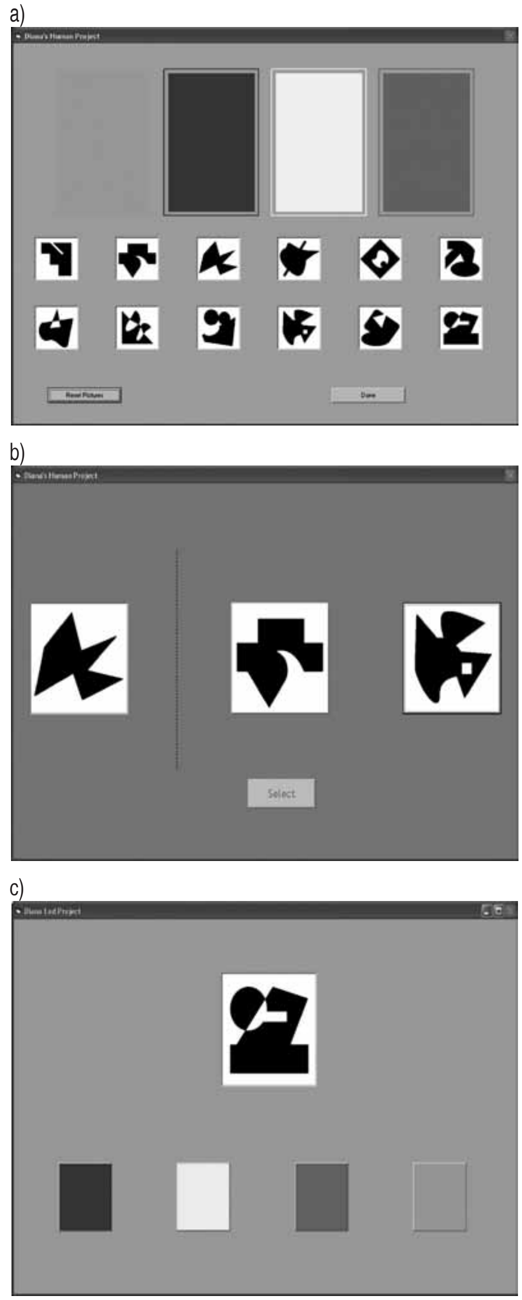


Figure 2. Tests for other derived relations. Panel a) Sorting test: Rectangles appear in the order: (A) green, (B) blue, (C) yellow, (D) Red; Panel b) Forced-choice test; Panel c) Test for inverse relations: the squares at the bottom correspond to each of the four color boxes. These were presented in random order in each trial

Sorting Test and Test for Inverse Relations. An extended version of the Sorting test was designed to examine the inverse relations between the contextual stimulus (i.e., the background color), and the members of each class of comparisons. First, participants completed the Sorting test as described above. In the test for inverse relations one stimulus was presented in the middle of the screen on each trial and four colored buttons were presented below (Figure 2, Panel c). Participants were instructed to click on the button that they considered to be correct for each stimulus. No feedback was provided for correct or incorrect selections. All stimuli were presented randomly and each stimulus was presented twice. A correct response was registered when the participant responded accurately to both presentations of each stimulus.

Results

Conditional Discrimination Training and Derived Relations

All 56 participants advanced through all the sets of trials of the conditional discrimination phases by responding accurately to 37 or more of the 40 trials. All participants also showed derived symmetrical relations. For relations C-A and B-A, 51 and 52 participants respectively showed between 94 and 100% accuracy (i.e., 17 or 18 correct responses out of a total of 18 trials). The same level of performance was observed in 39 participants for the B-C equivalence, and in 47 for the C-B test. A level of accuracy below 77% (i.e., 14 correct responses in 18 trials) in both equivalence tests was observed for 19 participants. Only two participants show accuracy below 77% in both symmetry tests. The summarized results of derived symmetry and equivalence according to levels of accuracy are shown in Table 1.

Table 1
Number of participants according to their performance on tests for derived symmetry and equivalence

% Accuracy	Symmetry C-A	Symmetry B-A	Equivalence B-C	Equivalence C-B
94- 100%	51	52	39	47
83-94%	4	3	6	1
66-77%	1	0	6	3
< 66%	0	1	5	5

N = 56

Tests for other derived relations

Sorting test. All participants were exposed to the Sorting Test for conceptual relations. Figure 3 summarizes the data for the first two groups of participants, i.e., those exposed to the Sorting Test only and those exposed to the Forced-choice Test previous to the Sorting Test. The results of these two groups are presented together to determine if the Forced-choice Test facilitated the emergence of conceptual classes in the Sorting Test. The bar graph compares the number of derived conceptual classes that participants obtained in each group. Note that because making three sorts implies also making the fourth sort, the graph shows the percentage of participants who correctly derived 0, 1, 2 or 4 conceptual classes.

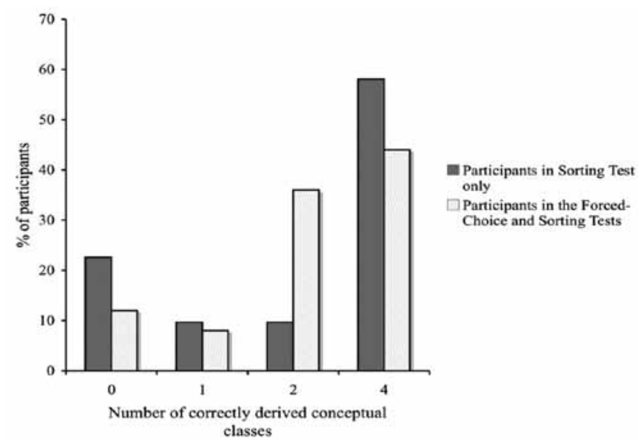


Figure 3. Percentage of participants who showed class formation in the Sorting Test (n = 37)

The formation of classes of comparisons was demonstrated by the fact that for both groups the highest percentage of participants corresponds to those who correctly grouped the four sets of comparisons. In the group exposed to the Forced-choice Test, 12% of the participants did not form any conceptual class; 8% correctly derived 1 class only, 36% grouped stimuli correctly into three classes and 44% did so for the four conceptual classes. In the group exposed to the Sorting Test only, 22.5% did not group the stimuli correctly into any classes, 9.67% correctly derived one class, the same percentage derived two classes, and 58.06% of the participants correctly organized all the stimuli into four classes. As the graph shows (Figure 3), the number of correct classes formed by participants who were previously exposed to the Forced-choice Test, varies more than in the group exposed to the Sorting Test only.

By contrast, most of the participants in the latter group responded correctly to the four stimulus classes but very few organized stimuli properly into one or two classes.

From all the participants exposed to the Sorting Test (N = 56), 46 or 82.1% correctly grouped at least one stimulus class in at least one of the five trials. As shown in Table 2, errorless derived conceptual relations (i.e., correctly grouping the stimuli into the four conceptual classes) were demonstrated on at least one of five attempts by 29, out of 56 participants. Table 2 shows the number of participants who correctly grouped the stimuli into the four conceptual classes, A, B C, and D on each of the five sorting trials. Values in the Color-match row correspond to the number of participants who correctly grouped all the stimuli into the appropriate color boxes. Values in the Color mismatch row show the number of participants who correctly grouped all the members of a conceptual class together but in one or more incorrect color boxes.

Correct organizations of stimuli into the four stimulus classes and into the appropriate colored background were observed in 16 participants. Although, the remaining 13 participants correctly sorted the stimuli into the four classes (i.e., A, B, C and D), the members of each class were not always matched with their corresponding color box. As it is shown in Table 2, 24 out of 29 participants arranged the three comparison stimuli into the four sets within the first three attempts, i.e., before correct sorts were retained at the end of a trial.

Table 2
Number of participants that showed formation of classes of comparisons across Sorting Test trials

Color Match/ Mismatch	Correct placements not retained			Correct placements retained		
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Total
Color-match	9	3	2	1	1	16
Color-mismatch	7	2	1	1	2	13
Total	16	5	3	2	3	29

N = 56

Probability analysis. It could be said that some of the correct sorts were due to chance and not to the acquisition of a particular type of relation, especially in the cases where only one set of stimuli was correctly grouped and after failure to obtain positive results in any of the previous four opportunities. We calculated the odds of sorting a correct group of three stimuli out of all possible combinations of 12. Results showed that such probabilities were remote. We determined in terms of odds, ratios and percentages, the calculated probability of sorting a correct category due to chance, given different scenarios. The odds to make a proper set in the first attempt due to chance were 1/55, which is equivalent to a 1.8% chance. That was also the case once one of the four selections had been successfully made and there were only 9 remaining stimuli to sort into three groupings. The odds to make 0 sets with the nine remaining are 252/280 which equals to a 90% chance. The odds to make one set with the nine remaining are 27/280, which equals to a 9.64% and the odds to make two sets with the nine remaining are 1/280, which corresponds to 0.36%.

Forced-choice-test. This test was presented before the sorting task to a group of 25 participants. Because the probability of a correct selection is 0.5 in each trial, most participants obtained an average of 3 or 4 correct responses per group of stimuli, which is not considered indicative of discriminative control. One or less errors per set of six trials were interpreted as indicative of behavior with respect to a comparisons' class. Of the 25 participants in this group, only 14 met this criterion for at least one of the conceptual classes. However, of the participants who demonstrated conceptual relations in the Forced-choice Test, 11 demonstrated more than one conceptual relation, but only one participant demonstrated three or more. The bar graph in Figure 4 shows the stimulus classes to which most participants responded correctly. While very few participants matched correctly the class members of conceptual class A, 12 of 14 participants correctly matched the stimulus members in stimulus class D.

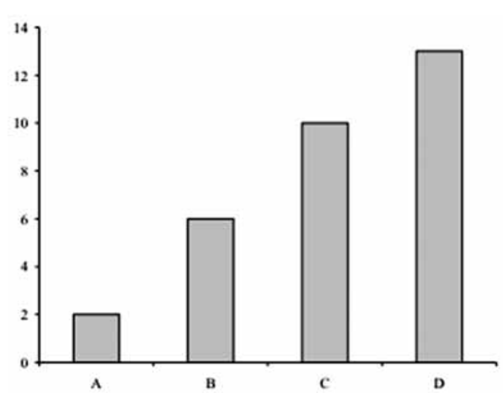


Figure 4. Number of participants who responded correctly to each comparison class on the Forced-Choice Test

Test for Inverse/Symmetrical Relations. In this test, subjects demonstrated reciprocal relations between the class members (comparison stimuli) and the contextual stimulus by matching individual stimuli to appropriate color boxes. The 12 stimuli (i.e., a1, a2, a3, b1, b2… d1, d2, d3) were presented in random order and each stimulus was presented twice. The members of each class (e.g., a1, a2, a3) correctly matched to its appropriate color box are shown in Table 3. Each row of Table 3 contrasts a participants' performance in the Sorting Test and in the Test for Inverse Relations. The values in each cell correspond to the number of stimuli in each class that were correctly matched with the color box.

Table 3
Number of stimulus members correctly matched to its corresponding class (i.e., color box) in the Test for Inverse Relations (n = 19)

	Participants	A	B	C	D
Participants demonstrating all four correct groupings (A, B, C and D) in the Sorting Test	1	2/3	2/3	3/3	3/3
	2		2/3		
	3			3/3	
	4			1/3	
	5	3/3	3/3	1/3	2/3
	6	3/3	3/3	3/3	3/3
	7				3/3
	8				1/3
	9	3/3	3/3	3/3	3/3
Participants demonstrating two correct groupings (B, D)	1		3/3	1/3	3/3
Participants demonstrating two correct groupings (A, B)	2	1/3	3/3	2/3	2/3
Participants demonstrating one correct grouping (A)	1		3/3	2/3	1/3
Participants demonstrating zero correct groups	1		2/3	1/3	1/3
Participants demonstrating zero correct groups	2	1/3	2/3	1/3	
Participants demonstrating zero correct groups	3	2/3	1/3	1/3	1/3

Data from shown in the first four rows correspond to those participants of this group (n = 19) that in the Sorting Test grouped stimuli correctly into one or more classes (12/19). The three last rows however, show data from participants that matched at least one of the comparisons in each class, with its appropriate color box, but that did not sort correctly the stimuli in any of the classes in the Sorting Test. In the Test for Inverse Relations, these participants selected the correct color box for two of the stimuli in each class (e.g., a1 and a2) in one of the four classes, and showed at least one correct match for three of the four classes of comparisons. Of the 12 participants that matched the stimuli to their appropriate color box, 9 correctly sorted the stimuli into the four classes in the Sorting test. Of these 9 participants, 4 selected the correct color box for 1, 2 or 3 stimulus members in all four classes.

Discussion

The purpose of this study was to examine: (a) if participants could respond to an arbitrary contextual stimulus having acquired the functions shared by a set of stimuli presented in the same context; (b) if this substitute relation between the contextual stimulus and its class members could be acquired in the absence of explicit operant training; and (c), if such relations could be acquired among each set of comparisons presented during a standard equivalence task, and a color background representing the arbitrary stimulus.

Evidence of derived relations was evidenced in 42 of 56 participants (75%); and errorless performance was observed for 29 participants (52%). These findings suggest that behavior with respect to stimulus classes develop in a large number of cases in the absence of operant training, and in spite of exposure to contingencies conducive to the formation of alternative classes of the equivalence sort.

The findings showed more accurate responding in the Sorting test than on the Forced-choice test. Probably the Sorting test was more conducive to the formation of derived relations because the color acquired the shared stimulus functions by virtue of which the class was defined. However, as observed in the group of participants exposed to the test for inverse relations, most of the participants who sorted the stimulus members into the appropriate color box also performed well when tested for the inverse relation. That is, given a class member, participants correctly identified the event that substituted for the shared functions of all the class members, namely, what could be called a categorical stimulus.

Control by the contextual stimulus is demonstrated by the fact that subjects were not explicitly instructed to sort the 12 stimuli into the four colored boxes or to try to match the color of the box with the color of the background frame in which the stimuli appeared together. The only possible prompt to this effect occurred in trials involving the stimuli in class D (i.e., d1, d2, and d3). Participants had less exposure to stimuli in this class by virtue of having not been tested for derived symmetry and equivalence. The fact that this was not one of the classes most frequently grouped correctly suggests that this prompt did not have an appreciable effect on derived responding.

A few participants sorted the stimuli according to other criteria, namely, on the basis of the acquired equivalent classes or according to their physical properties. We were able to examine these cases based on reports of their performance provided upon debriefing. Some participants reported responding to the stimuli in terms of the likeness of some shapes and angles, in terms of the patterns of black and white or by generated relations of likeness with respect to familiar objects. What may account for the weak control exerted by the color stimuli in those cases are effective verbal strategies used by the participants to learn the conditional discriminations. These strategies may have generalized to performance in other tests thus overshadowing control by the color background.

A type of carry-over effect might explain the cases in which stimuli were grouped according to their membership in equivalence classes. The Forced-choice test was designed to control for the contiguity of exposure to the two procedures, namely, MTS and the Sorting test. We hypothesized that if the Sorting test immediately followed the equivalence phase, subjects would be more likely to sort the stimuli on the basis of their equivalence class membership.

Summarizing, the Forced-choice test was designed to examine whether participants selected a member of a comparison class when presented with an exemplar of the same class and a non-member. Given that the non-member was also not a member of the same equivalence class with either the sample or the comparison, correct responding could have occurred by exclusion. The fact that the defining feature of the class (i.e., the color) was not physically present during this test may explain why only half of the participants exposed to this test showed accurate responding. However, a strong case for the emergence of the comparison class is made by the participants who showed errorless discrimination for some of the comparison classes in this test.

By contrast, the Sorting test tested for the acquisition of behavior with respect to comparisons as class members when the color served as a prompt. The analysis of errors after each of the five opportunities to group the stimuli indicated that in some cases correct grouping of all the class members did not occur because of the misplacement of a few stimuli. Correctly sorting two stimuli out of three, in all or most of the conceptual classes, showed the acquisition of this relation even though performance was not completely accurate. The low probability that the stimuli could be correctly grouped by chance further supported this conclusion.

Another interesting observation was that on several occasions, participants grouped the stimuli correctly but placed them in incorrect color boxes. Even though the color evoked responses with respect to a shared property of stimuli, that function may not have served a discriminative function for the classification of stimulus members. This may suggest that, in some cases, the function of the colored background was that of highlighting the relation of spatial and temporal proximity among the comparisons. Once this relation was acquired, matching the colors to the corresponding classes may have been irrelevant. In short, it may be that it was the proximity relation and not the color itself that controlled behavior with respect to conceptual class membership.

In the third group exposed to the Sorting Test it was interesting to note that most of the participants who grouped the stimuli into the correct color boxes also showed the derived reversed relation between the conceptual stimulus and the class members. Relations of substitution of stimulus functions between the color boxes and each of the class members need to be studied in more depth. Because relations of this sort may be hierarchical, some of the procedures used in this experiment may not have been well suited to examine symmetry between the color stimulus and the members of a class of comparisons.

Although one could say that a1 = b1 and b1 = c1 in terms of their shared functions, it could not be said that a1= A. To illustrate, an apple could be said to be functionally equivalent to an orange. Although one could say that an apple is a fruit (a1 = A), it is a mistake to say that a fruit is an apple (A = a1). Strictly speaking, neither relation (a1 = A or A = a1) is true however. The relation is one of inclusion, not one of equality. Greater conceptual clarity as to the properties that characterize relations of inclusion and the conditions under which they are acquired is needed.

In the Forced-choice Test, participants made more correct selections for stimulus class D than for the other classes. As mentioned above, this may be due to the fact that participants selected the correct comparison by exclusion. In the Sorting Test however, the prompt provided by the color boxes may have exerted control over derived responding in a more specific manner. In addition, in the Forced-choice Test as well as in the Test for Inverse Relations, fewer derived responses were observed with respect to stimulus class A than to any of the other classes. This may have occurred because the members of class A (i.e., a1, a2 and a3) were less frequently presented together in the conditional discrimination training and in equivalence tests. Because the preparation was such that relations A to B and A to C were trained, there were more opportunities in which each class member of A was presented alone as the sample, and less opportunities for the three members of the class to appear together as comparisons.

Theoretical Implications and Future directions

The findings of this study showed that behavior with respect to stimulus classes can be acquired without a history of reinforcement particular to the stimuli in these classes, that is, in the absence of conditional discrimination training. To account for behavior with respect to stimuli that are not temporally or causally fitted into the three-term contingency paradigm (i.e., derived relations), one does not need to say that such behavior is verbally controlled. That processes of function transfer may also contribute to the study of verbal behavior does not mean that such processes are specific to the domain of complex human behavior. However, that the same performances are not observed in humans and non-human animals when a similar experimental preparation is used may indicate the interference of verbal behavior in the operation of a general behavioral process.

In an experimental situation, humans will try to perform as expected by the experimenters and as specified by the instructions of the task. Traditionally, the training phase of an MTS task is preceded by a screen instructing the subjects to make a selection between the stimuli below, given the figure presented above. Some instructions explicitly tell participants to select the figure *that goes with* the one above. By contrast, non-human animals lack that history of responding with respect to such arrangements of stimuli in the context of an experimental situation. Yet, under the appropriate conditions, behavior with respect to classes has been widely demonstrated across a variety of species and experimental settings.

For example, several studies have shown that once animals learn to respond differentially to pictures of exemplars and non-exemplars (S+ and S-) their behavior generalizes to novel stimuli (Herrnstein & Loveland, 1964; Herrnstein, Loveland & Cable, 1976; Vaughan, 1988). Without appealing to behavior of a special sort (e.g., abstraction, concept formation, etc.), these observations have been explained in terms of generalization within classes and discrimination between classes (Herrnstein & Loveland, 1964). Although high variation within stimulus classes may make it unlikely for a single property to acquire generalized control over responding, significant variation across classes may make it more likely for subjects to acquire differential responding with respect to each class (Vonk & MacDonald, 2002). A number of authors in this line of research contend that non-human animals organize stimuli into classes just as humans acquire a repertoire of verbal categories (Cook, 2002; Sutton & Roberts, 2002).

Furthermore, transitive relations among class members have been demonstrated in non-human animals within the classical conditioning literature long before the operant literature undertook the investigation of relations that were not under the control of reinforcement contingencies. In addition, given the appropriate experimental arrangements, symmetrical relations have been observed in pigeons, rats, lions and other non-human animals (see Lionello, 2009, for a review). The point we are making is that behavior with respect to classes of stimuli that we may refer to behavior with respect to concepts, categories, or abstractions, does not constitute a special type of behavior that is exclusive to human organisms and therefore, necessitates invoking a different behavioral process.

Neither the naming account nor RFT or Sidman's theoretical views on equivalence explain the emergence of relations in non-human animals in the absence of verbal behavior and/or in the absence of operant contingencies. In this experiment we demonstrate that behavior with respect to a stimulus class can be acquired when controlling for verbal rules, in the absence of operant contingencies, and in spite of a competing stimulus class acquisition process involving operant contingencies.

In our view, in the absence of reinforcement or rules that may act as reinforcers, the basic operating principle in accounting for acquisition of class membership and derived relations has to be something other than a history of exposure to operant contingencies, the acquisition of linguistic behavior, or both.

The key issue seems to be contiguity of space and time and systematic presentation of stimulus events within a particular context (Tonneau, Arreola & Martínez, 2006; Tonneau & Sokolowski, 1997). Experimental studies have shown that contextual cues may evoke classifying stimuli in a particular manner. This may be because the contextual cues acquire control over responding with respect to some shared properties by which events are classifiable (e.g., objects that are big, have sharp edges, etc.). In other words, responding with respect to these properties is reinforced in the presence of a contextual cue (Hayes et al, 2001). However, when reinforcement fails as an explanatory model, we could simply say that participants respond to contextual cues because the context acts as one of the shared functions by which stimuli are classified.

Future studies could further examine symmetrical relations between the categorical stimulus (i.e., the colored frame) and each of the stimuli within that class. Symmetrical relations among the class members were implied in the behavior of sorting the class members into the colored boxes. Theoretically, the difference between an event that comes to act as a substitute for any of the class members, and another member of the class remains unclear. Other studies could attempt to identify the conditions under which a stimulus acquires functions that substitute for all the shared functions of the class members and when it simply becomes another one of the class members. More generally, studies of class membership acquisition without reinforcement should continue to be conducted in non-human animals and other non-verbal organisms.

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