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Reorganization of Equivalence Classes: Analysis of Reversed Baseline Relations

Reorganização de Classes de Equivalência: Análise do Número de Relações de Linha de Base Revertidas

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Abstract
The reorganization of equivalence classes may depend on the number of reversed baseline relations. To investigate this hypothesis, 28 undergraduate students distributed in four groups were exposed to a matching-to-sample procedure to establish conditional relations between stimuli and the emergence of five equivalence classes with five stimuli each. The procedure for each group differed by the number of reversed baseline relations (one, two, three or four) followed by a new equivalence test to evaluate the possible reorganization of the classes. The reorganization of the equivalence classes occurred independently of the number of reversed relations. It was concluded that stimuli equivalence classes may be established and subsequently modified, what does not dependent on the number of reversed relations.
Keywords: Stimulus Equivalence Classes; Reorganization of Equivalence Classes; Reversed Baseline Relations; Discrimination Reversal; Matching-to-sample; College Students.

Resumo
A reorganização de classes de equivalência pode depender do número de relações de linha de base revertidas. Para investigar essa hipótese, 28 estudantes universitários, distribuídos em quatro grupos, foram submetidos ao procedimento de escolha de acordo com o modelo para o estabelecimento de relações condicionais entre estímulos e a emergência de cinco classes de equivalência com cinco estímulos cada uma. O procedimento para cada grupo diferiu quanto ao número de relações de linha de base revertidas: uma, duas, três ou quatro, seguidas por um novo teste de equivalência para verificar a eventual reorganização das classes. A reorganização das classes de equivalência ocorreu independentemente do número de relações revertidas. Conclui-se que classes de estímulos equivalentes podem ser estabelecidas e modificadas subsequentemente, o que não dependeu do número de relações revertidas.
Palavras-chave: Classes de Estímulos Equivalentes; Reorganização de Classes de Equivalência; Relações de Linha de Base Revertidas; Reversão de Discriminação; Emparelhamento com o Modelo; Universitários.

Behavior analysts explain the origin of operant behavior by the principle of selection by consequences, which is based on variation, selection and retention. According to this principle, variations in behavior produce differential consequences, which affect the likelihood of this behavior. Thus, operant behavior is defined as behavior that is modified and maintained by it's the consequences. To investigate procedures that alter the probability of behavior is, therefore, extremely important, and based on this knowledge it is possible predict and control the behavior of organisms.

The control of operant behavior can be established not only by the manipulation of its consequences, but also by changing the contingencies that produce stimulus discrimination and generalization. Operant responses reinforced in the presence of a certain stimulus (S^D) and non-reinforced or punished in the presence of another stimulus (S^Δ) are more likely to be controlled by stimulus in the presence of which the response was reinforced and, also, in the presence of stimuli similar to it. Another aspect relevant to the prediction and control of behavior is that stimulus discrimination also can be placed under the stimulus control, through the conditional discrimination procedure (Sidman, 1986, 1994, 2000). Conditional discriminations, according to Catania (1999, p. 369), "are discriminations in which reinforcement in the presence of stimuli depend, or are conditional to, the presence of another (conditional) stimuli". The conditional stimulus is termed "sample" and the discriminative stimuli are the "comparison stimuli." This type of stimulus control generates a conditional relationship of *If ..., then ...* between the sample and comparison stimuli (Sidman, 1994).

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A commonly used conditional discrimination procedure is the matching to sample procedure (MTS), which can be programmed in different ways: simultaneous or delayed, with and/or without the presence of reinforcement, by identity or arbitrarily (Cumming & Berryman, 1965). By using the MTS procedure, one can establish arbitrary conditional relations between stimuli. By establishing such a conditional relationship, the functions of comparison stimuli (S^D and S^Δ) are defined by the sample. If we consider, for example, two comparison stimuli, B1 and B2, the selection of stimulus B1 will be reinforced if the sample is A1; the selection of stimulus B2 will be reinforced if the sample is A2.

According to Bortoloti and de Rose (2007) and de Rose (1988), studies on stimulus equivalence produced considerable advancement in explaining the emergence of new behaviors and symbolic behaviors. In the early 1970s, Sidman (1971), Sidman and Cresson (1973), and Spradlin, Cotter, and Baxley (1973), demonstrated that by teaching two or more arbitrary conditional relations with at least one element in common, stimulus equivalence classes emerge, that are defined by empirical verification of the properties of reflexivity, symmetry, transitivity, and symmetry of transitivity (Sidman & Tailby, 1982). A procedure that enables the demonstration of this kind of result, considering A1, B1, C1, and A2, B2 and C2 as events with conditional or discriminative stimuli functions, is as follows: (a) if the sample is A1, selection of B1 and not B2 is reinforced (A1B1– the first stimulus, i.e., A1 in this example, always refers to the sample and the second, i.e., B1 in this example, to the comparison stimulus), (b) if the sample is A2, selection of B2 and not B1 is reinforced (A2B2), (c) if the sample is B1, selection of C1 and not C2 is reinforced (B1C1), (d) if the sample is B2, selection of C2 and not C1 is reinforced (B2C2). After this training procedure, the emergence of conditional relations is tested with the reflexivity test (selection of A1 and not of A2, given A1 as sample – A1A1, and so on for all the other possible identity conditional relations of stimuli – B1B1, C1C1, A2A2, B2B2, C2C2); the symmetry test (the selection of A1 and not A2, given B1 as sample – B1A1, and so forth, for all relations in which the functions of S^D and conditional stimulus established during training are reversed – B2A2, C1B1, C2B2); the transitivity test (the selection of C1 and not C2, given A1 as sample – A1C1 and the selection of C2 and not C1, given A2 as sample – A2C2); and the symmetric transitivity test (selection of A1 and A2, given C1 as sample – C1A1, and selection of A2 and not A1, given C2 as sample – C2A2), with the last being ". . . the definitive test of the formation of equivalence classes" (Moreira, Todorov, & Nalini, 2006, p. 202). If all emerging relations are demonstrated in the tests, it is considered that two three stimuli equivalence classes were formed, which can be briefly summarized as classes A1B1C1 and A2B2C2. It should be noted that teaching conditional relations between stimuli can establish equivalence classes with more than three stimuli, as demonstrated by Sidman, Kirk, and Willson-Morris (1985).

A great amount of research was developed from the initial studies conducted in the 1970s (for reviews see Barros, Galvão, Brino, Goulart, & McIlvane, 2005; de Rose, Kato, Thé, & Kledaras, 1997; Moreira et al., 2006; Sidman, 1994), which demonstrated that the phenomenon is consistent and robust. Data about variables that change the equivalence classes, however, are limited. One of the procedures that modify equivalence classes consists of rearranging the baseline contingencies, establishing different conditional relations from those that were originally trained, producing the emergence of new equivalence classes, that is, changes on the relational responses to the post-reversal tests are observed – reorganization of equivalence classes (cf. Garotti & de Rose, 2007; Pilgrim & Galizio, 1990, 1995; Spradlin, Saunders, & Saunders, 1992; Wirth & Chase, 2002). To reorganize equivalence classes, it is necessary that these classes are established initially, through training of conditional baseline relations (e.g., A1B1, A2B2, B1C1 and B2C2) and by testing symmetry, transitivity, and symmetric transitivity relations (reflexivity is often assumed with verbally competent human participants – cf. Saunders & Green, 1992), demonstrating the formation of two equivalence classes (A1B1C1 and A2B2C2). New conditional relations are then trained with the same stimuli recombined in new relations (e.g., A1B1, A2B2, B1C2, and B2C1), and finally, another test of emerging relations is conducted – the reorganization of equivalence classes test. The expected result is the modifications of symmetry, transitivity, and symmetrical transitivity relations in the second test, with the formation of reorganized equivalence classes (A1B1C2 and A2B2C1). According to Wirth and Chase (2002), these results are predicted from the theoretical formulations of Sidman and Tailby (1982) and, otherwise, the concept of equivalence classes as an integrated behavioral unit would be questioned.

Studies on the possibility of reorganization of equivalence classes, however, produced conflicting results. There are data that permit the conclusion that reorganization is possible, such as those obtained by Folsta and de Rose (2007), Garotti and de Rose (2007 – Experiment 2), Garotti, de Souza, de Rose, Molina and Gil (2000), Saunders, Drake and Spradlin (1999), Smeets, Barnes-Holmes, Akpinar and Barnes-Holmes (2003), Spradlin et al. (1973), Wilson and Hayes (1996) and Wirth and Chase (2002). Smeets et al. (2003), for example, demonstrated in seven experiments the reorganization of equivalence classes when one stimulus relation of each of the two classes of stimuli was reversed with the reorganization procedure, as described in the preceding paragraph. On the other hand, there are studies with contrary results. For example, Saunders, Saunders, Kirby, and Spradlin (1988) found that after the formation of two equivalence

classes with eight members each, the reversal of a conditional relation of each class produced no changes in the responding of any participant. Resistance to change was also observed by Pilgrim and Galizio (1990), after the reversal of one or two conditional relations of each of two equivalence classes. The reversal of the relations produced a response modification in the reorganization test of symmetry relations, but not transitivity. Similar results were obtained by Garotti and de Rose (2007 - Experiment 1), Pilgrim, Chambers and Galizio (1995), and Pilgrim and Galizio (1995).

A possible explanation for the difference in the results of these two different research outcomes was presented by Folsta and de Rose (2007), and Spradlin et al. (1992), who suggested that an important variable for the reorganization of equivalence classes may be the proportion of reversed relations based on the total number of relationships taught at baseline. This allows one to hypothesize that the greater the number of relations reversed in relation to the total number taught, the greater the likelihood of reorganization of equivalence classes, "that is, derived relations are most likely to change according to changes in baseline conditions" (Spradlin et al., 1992, p. 41). A review of the literature on the subject, summarized below, indicates that there are results that support this hypothesis and others that do not.

Among the studies that provide evidence for this hypothesis is that of Spradlin et al. (1973), who conducted three experiments with three adolescents, each with atypical development. In Experiment 1, the relations A1B1 and A2B2 were pretrained, and after this the relations A1C1, A2C2, B1C1, B2C2, A1D1, A2D2 were trained, followed by a test of the emergence of B1D1 and B2D2 relations. In Experiment 2, the pretraining was excluded, maintaining the training of the remaining conditional relations and test of the emergent relations. In Experiment 3, the pretraining was reintroduced, but the training of relations A1C1, A2C2, B1C1, B2C2 was excluded. The nine participants from the three experiments formed the two equivalence classes. Two participants in Experiment 1 and three in Experiment 2 were submitted to the training in a subsequent phase in which the contingencies of all baseline relations were reversed. It was observed that the five participants changed their responses according to the new contingencies, that is, equivalence classes were reorganized. In Experiment 3, only one relation between stimuli of each of the classes was reversed and there were no changes in the reorganization test. Further evidence that the reversal of all conditional relations of equivalence classes allows the reorganization of those classes was obtained by Wilson and Hayes (1996), in a study on the resurgence of equivalence classes, in which conditional relations were trained that led to the formation of three classes with four stimuli.

The results of studies that are not in agreement with the hypothesis formulated herein are those presented by Pilgrim and Galizio (1995), in which two equivalence classes, each with three stimuli, were trained (Phase 1) and a conditional relation for each of the classes was reversed (Phase 2). In Phase 3, reorganization tests were conducted; in Phase 4, the classes were expanded to include an additional conditional relation; in Phase 5, a second conditional relation was reversed; in Phase 6, there was a return to the original baseline relations. The participants maintained, in transitivity tests, responses consistent with the original baseline, and in the symmetry test, started to respond in accordance with the new contingencies, regardless of the number of relationships reversed. On the other hand, Garotti et al. (2000), who conducted a systematic replication of the Pilgrim and Galizio experiment, found that eight of the nine participants began to respond according to the reversed contingencies in both tests for symmetry and transitivity.

As can be seen in the above description, the results of the literature do not allow concluding that the greater the number of relations reversed, the greater the likelihood of reorganization of equivalence classes, because the results are conflicting. In the research reviewed here, however, a comparison of the effects of different numbers of reversed relations on participants' performance on equivalence class reorganization tests in which most of the variables that can affect the reorganization had been controlled in a same experiment was not carried out. Variations of procedural characteristics are probably related to the differences in results.

One of the variables that can probably affect the reorganization of equivalence classes is the structure of training, defined as the order and arrangement with which the baseline conditional relations are taught. The basic structures are: linear (LIN), comparison-as-node (CaN) and sample-as-node (SaN). These different types of structures can be combined into a single procedure (complex structures). According to Fields, Adams, and Verhave (1993), in the case of linear structures, increasing the number of stimuli of equivalence classes increases the nodal distance between some stimulus relations and some emerging relations, which affects the likelihood of their emergence. Saunders and Green (1999), in contrast, argued that, probably, the training structures lead to differences in performance because they determine the number of simple successive and simultaneous discriminations taught in the training of conditional relations and, consequently, produce differences in the results tests of emergence of equivalence classes. So, if this variable affects the formation and reorganization of equivalence classes (cf. Carrigan & Sidman, 1992), it must be controlled to investigate the effect of other experimental variables.

Another important variable to be controlled in experiments of reorganization of equivalence classes is the number of comparison stimuli presented in MTS procedure. Carrigan and Sidman (1992) warned that when

only two comparison stimuli are presented in an MTS, there may be different types of control in the relation sample-comparison, which can be by selection, rejection or heterogeneous – whether by selection or by rejection. Control by selection is one in which performance is established by the relationship between sample and the "correct" comparison stimulus. The control by rejection is one in which the performance is under control of the relationship between the sample and the "incorrect" comparison stimulus. The participant rejects the "incorrect" stimulus, choosing the "correct" comparison. In equivalence class reorganization procedures, the effect of this variable may be even greater, since, by reversing a relation, a change in control from selection to rejection, and vice versa, can occur. This alteration could produce unexpected results in line with changes in the contingencies, because changing the control of the relation sample-comparison "are accompanied by changes in the composition of classes" (Carrigan & Sidman, 1992, p. 202).

The lack of data in the literature on the effects of the number of reversed baseline relations on the reorganization of equivalence classes led to the planning of this study, which aimed to investigate the effect of this variable on participants' performance on stimulus equivalence class reorganization tests, using a group design. The procedure resembled, in part, the study of Folsta and de Rose (2007), in which the effect of equivalence class size on reorganization was investigated. Group 1 participants were taught three conditional relations between stimuli for the formation of two equivalence classes, each with four stimuli, and Group 2, seven conditional relations to form two equivalence classes with eight stimuli each. The conditional relations were taught by a MTS with SaN training structure and after reaching the equivalence classes formation criteria in the test session, one conditional relation for each of the two equivalence classes was reversed, and after reaching the equivalence classes formation criteria in this phase, the reorganization test was carried out. The main difference between this study and that of Folsta and de Rose is that, in the present study, each group was exposed to a different number of baseline reversed relations, holding constant the size of the classes to be formed. Five classes of five stimuli each were taught, and five comparison stimuli were presented on each trial. The arrangement of five comparison stimuli allowed permutation of all of the conditional relations for Group 4, which had all the relations reversed.

Method

Participants

All the undergraduate students in two courses in a public university were invited to participate. Among those who applied to participate, 28 were randomly selected, initially. Of these 28, six failed to meet the criteria of class formation in Phase 1 of the procedure and three dropped out before completing the tasks. As participants dropped out or failed to complete all the phases of the procedure, additional participants were randomly selected. Altogether 37 were randomly selected, of whom 28 remained (8 men and 20 women), aged between 19 and 25 years. Participants who completed all the experimental tasks received .5 point on one of their course exams in their respective courses.

Experimental Setting and Equipment

The experimental sessions were carried out in cubicles of approximately 2 m^2 of the Laboratory of Experimental Analysis of Human Behavior. Each cubicle contained a desk, a chair, a fan, and a Pentium microcomputer. The Software Equivalência ("Equivalence Software", developed by Edson Cordeiro dos Santos in 2001) allows programming MTS procedures with the sample in the center of the screen and the comparison stimuli distributed equidistantly around the sample, in windows that measured 4 x 4 cm. The software was configured to present the five comparison stimuli as follows: one in each of the four corners of the screen and one at the bottom center. In addition, the software was programmed to, after positioning the cursor over the sample and clicking the mouse (observing response), present the comparison stimuli, and, after clicking on one of the comparison stimuli, to produce or not produce consequences in the form of messages and images. These messages were: "you're right" and the image of a smile or "you missed" and a picture of a hand with the thumb pointing down. After the presentation of this feedback, a new trial occurred immediately. A trial is recorded by the software as: the presentation of the sample; the occurrence of the observing response followed by the presentation of comparison stimuli; the selection of a comparison stimulus in the presence of the sample and the occurrence of the consequences, when this was programmed. Four familiar figures (star, pencil, phone and flag) were used in the pre-training, and in the training and tests of conditional relations, 25 letters of the Greek alphabet.

Procedure

Before beginning the experimental procedure, all of the participants signed a consent form, approved by the Research Ethics Committee of the authors' institution (Parecer 025/2008). Participants were distributed randomly into four groups with seven participants each, being exposed to experimental sessions of approximately 60 minutes. The number of sessions depended on the participants' performance. The pretraining and Phase 1 were identical for all participants in all groups, and Phase 2 differed for the four groups. The procedure of each phase is described in detail below. SaN was the structure of training in Phase 1 and Phase 2.

Table 1 summarizes the distribution of blocks of the Steps 1 and 2. As in each trial there were always five comparison stimuli, the training of the relation A1B1, for example, involved the sample A1 and the five class B comparison stimuli that were B1, B2, B3, B4 and B5. In this case, the comparison stimulus B1 was the correct responses as specified by the experimenters (A1: B1 B2 B3 B4 B5). The training A2B2 correspond to the trial A2: B1 B2 B3 B4 B5; the training A3B3 correspond to the trial A3: B1 B2 B3 B4 B5; the training A4B4 correspond to the trial A4: B1 B2 B3 B4 B5; the training A5B5 correspond to the trial A5: B1 B2 B3 B4 B5. The same type of conditions were valid for all other conditional relations trained and tested, and it should be noted that each type of trial was repeated five times with the comparison stimuli randomized in the different positions on the computer screen.

Pretraining. The pretraining consisted of a MTS to establish two conditional relations between stimuli: the selection of the star picture was reinforced when the picture of a flag was the sample, and the selection of the picture a pencil was reinforced when the picture of a phone was the sample. Written instructions were presented during the first trial on the monitor screen. These instructions indicated which of two comparison stimuli should be chosen in the presence of the first sample, indicating "If this" above the first sample and "choose this" above the comparison stimulus to be chosen. After selecting one of the comparison stimuli and the presentation of the feedback to the response, the second conditional relation was presented, also accompanied by instructions. Positive feedback was composed, as indicated previously, "you're right" and a smile, as reinforcement, and the negative feedback was "you missed" with the figure of a hand with the thumb pointing down, as punishment.

Ten training trials, five for each of the two conditional relations were presented in randomized succession. The criterion for termination of pretraining was 100% correct, as in the study by Garotti et al. (2000). If the criterion was not reached, the block of pretraining was repeated.

Phase 1 – Establishing the Original Baseline and Tests of Equivalence Classes. At this phase, initially, participants were taught the arbitrary conditional relations A1B1, A2B2, A3B3, A4B4 and A5B5, with five trials each, with a total of 25 trials. To simplify the naming of the set of conditional relations trained or tested, the alphanumeric specifications of the relations will be represented only by letters. For example, the conditional relations A1B1, A2B2, A3B3, A4B4 and A5B5 are referred to as "AB relations."

The training blocks contained 25 trials, involving a sequence of random presentations of samples. The five comparison stimuli in each trial were presented in random positions in five windows around the sample. Each training block was repeated until the criterion of at least 23 correct trials among the 25 presented was reached (approximately 90% correct, as in Folsta & de Rose, 2007). Concluding the training block AB, the training blocks AC, AD and AE (25 trials in each block), were presented in the same manner and with the same criterion of repetition. Upon completion of the correct response criteria in training block AE, a training block consisting of 100 mixed trials, containing all 20 conditional relations was taught (five from each of AB, AC, AD and AE relations), with the same correct responses criteria. Then, symmetry and transitivity tests were conducted (Formation Test), with three trials of each of the 20 symmetry relations (BA, CA, DA and EA), and of the 60 transitivity relations (BC, CB, BD, DB, BE, EB, CD, DC, CE, EC, DE, ED). In this test block, participants had to achieve a compound criterion: an index equal or above 90% correct responses (216 correct trials in a total of 240 trials) and no more than one incorrect specific relation. This second criterion was added to the equal or above 90% correct responses criterion because each conditional relation was tested only three times, and if there were more than two errors of a given relation, it could not be said that in the Reorganization of Classes Test, the relation was reversed. When this compound criterion was not met, the test was presented again immediately with no additional training. If the criterion was not reached in the second test, all the training, from teaching AB relations, was repeated. This repetition of training was conducted twice at most. If the participant did not reach the compound criteria in the second repetition of the procedure, they were replaced. These participants did not know the replacement criteria, and were only informed that their participation was completed.

Phase 2 – Recombination of the Conditional Relations and Reorganization of Stimulus Equivalence Class Tests. At this phase, a different number of reversed conditional relations were taught to each group. In the description given below, the letter "r" with the letters that represent these relations marks reversed relations. The training was done with the same stimuli as Phase 1, according to a similar procedure (see Table 1). Each of the relations between stimuli, whether recombined or maintained in its original form, was trained in a single block, that is, first the relation AB, followed by AC, AD and AE. All conditional relations were reverted for Group 4 (ABr, ACr, ADr and AEr), three for Group 3 (ACr, ADr and AEr), two for Group 2 (ADr and AEr), and one for Group 1 (AEr). In Table 1, each of the specified new relations trained are shown, with the stimuli that were altered in each type of conditional relation in italics. The criterion for repetitions of the blocks, the equal or above 90% correct responses criterion in the training blocks and the compound criteria in the Reorganization Test in Phase 2, were the same as in Phase 1. When the participant reached the criteria in the Reorganization Test, their participation

Table 1
Distribution of Training and Tests Blocks, and Trained Relations in Each Phase of the Procedure and Number of Trials per Block

	Training and Tests Blocks				
	Group 1	*Group 2*	*Group 3*	*Group 4*	*Nº Trials*
Phase 1	Training A1B1, A2B2, A3B3, A4B4, A5B5				25
	Training A1C1, A2C2, A3C3, A4C4, A5C5				25
	Training A1D1, A2D2, A3D3, A4D4, A5D5				25
	Training A1E1, A2E2, A3E3, A4E4, A5E5				25
	Mixed Training (all the 20 relations AB, AC, AD, AE)				100
	Formation Test (all the 20 symmetry relations BA, CA, DA, EA and the 60 transitivity relations BC, CB, CD, DC, EC, CE, BD, DB, BE, EB, DE, ED)				240
Phase 2	Training A1B1, A2B2, A3B3, A4B4, A5B5	Training A1B1, A2B2, A3B3, A4B4, A5B5	Training A1B1, A2B2, A3B3, A4B4, A5B5	Training A1B2[a], A2B3[a], A3B4[a], A4B5[a], A5B1[a]	25
	Training A1C1, A2C2, A3C3, A4C4, A5C5	Training A1C1, A2C2, A3C3, A4C4, A5C5	Training A1C3[a], A2C4[a], A3C5[a], A4C1[a], A5C2[a]	Training A1C3[a], A2C4[a], A3C5[a], A4C1[a], A5C2[a]	25
	Training A1D1, A2D2, A3D3, A4D4, A5D5	Training A1D4[a], A2D5[a], A3D1[a], A4D2[a], A5D3[a]	Training A1D4[a], A2D5[a], A3D1[a], A4D2[a], A5D3[a]	Training A1D4[a], A2D5[a], A3D1[a], A4D2[a], A5D3[a]	25
	Training A1E5[a], A2E1[a], A3E2[a], A4E3[a], A5E4[a]	Training A1E5[a], A2E1[a], A3E2[a], A4E3[a], A5E4[a]	Training A1E5[a], A2E1[a], A3E2[a], A4E3[a], A5E4[a]	Training A1E5[a], A2E1[a], A3E2[a], A4E3[a], A5E4[a]	25
	Mixed Test (all the 20 relations AB, AC, AD, AE)				100
	Reorganization Test (all the 20 symmetry relations BA, CA, DA, EA and the 60 transitivity relations BC, CB, CD, DC, EC, CE, BD, DB, BE, EB, DE, ED)				240

[a]Altered stimulus in each relation.

was terminated. Otherwise, the test was repeated and the participants were exposed to the complete training of Phase 2 for a maximum two times.

Results

Table 2 shows the percentages of correct responses in the Formation Test and Reorganization Test of stimulus equivalence classes of the four groups of participants. It can be seen in this table that most of the participants in Groups 1, 2 and 3, and two in Group 4 (P41 and P43), met the criteria for finishing the phase in the first presentation of the Formation Test, and four (P16, P17, P21 and P26) reached the criteria in the second presentation. The other participants reached the criteria only after retraining the baseline relations, seven (P13, P23, P37, P44, P45, P46 and P47) in the third, and two (P35 and P42) in the fourth presentation of the Formation Test. Similar results were observed in the Reorganization Test, in which the majority of participants in Groups 1, 2, 3 and 4 reached the criteria of reorganization in the first presentation of the test, and two participants (P15 and P26) in the second presentation. Retraining the reversed baseline relations was required for six participants (P13, P27, P32, P44, P45 and P46), which reached the criteria of reorganization in the third presentation of the test. Thus, it is observed that all participants formed and, subsequently, met the criteria of reorganization of the stimulus equivalence classes in a manner consistent with the changes made in the contingencies, regardless of the number of relations reversed. Statistical analysis performed through the Kruskal-Wallis test demonstrated that the difference between the percentages of correct responses of the groups in the Formation Test and Reorganization Test of classes is not significant. In the Formation Test, it was obtained $H = 1.414$ ($p > .05$) and in the Reorganization Test, it was obtained $H = .7024$ ($p > .05$).

Table 2
Percentages of Correct Responses in Stimulus Equivalence Classes Formation Tests and Reorganization Tests

	Participants	*Formation Tests*				*Reorganization Tests*		
		1º	*2º*	*3º*	*4º*	*1º*	*2º*	*3º*
Group 1	P11	98.8	-	-	-	100.0	-	-
	P12	97.9	-	-	-	100.0	-	-
	P13	78.3	81.3	99.6	-	90.4	90.4	100.0
	P14	96.7	-	-	-	99.2	-	-
	P15	99.6	-	-	-	94.2	98.8	-
	P16	97.1	99.6	-	-	95.8	-	-
	P17	97.5	97.9	-	-	99.6	-	-
Group 2	P21	92.5	97.5		-	99.6	-	-
	P22	97.5	-	-	-	99.6	-	-
	P23	90.4	95.8	99.2	-	97.9	-	-
	P24	100.0	-	-	-	100.0	-	-
	P25	98.3	-	-	-	98.8	-	-
	P26	89.6	97.5	-	-	97.9	99.2	-
	P27	99.2	-	-	-	96.7	35.0	98.8
Group 3	P31	99.6	-	-	-	99.6	-	-
	P32	99.6	-	-	-	95.0	92.5	99.2
	P33	97.1	-	-	-	99.6	-	-
	P34	97.5	-	-	-	100.0	-	-
	P35	68.8	57.5	96.7	100.0	98.3	-	-
	P36	98.8	-	-	-	99.6	-	-
	P37	82.9	85.8	99.6	-	97.5	-	-
Group 4	P41	97.9	-	-	-	99.2	-	-
	P42	92.5	98.3	97.1	100.0	98.8	-	-
	P43	99.2	-	-	-	99.2	-	-
	P44	97.5	97.1	99.6	-	97.5	80.8	97.5
	P45	97.1	97.1	99.2	-	91.7	93.3	100.0
	P46	96.3	94.2	98.8	-	95.0	97.9	98.3
	P47	91.3	78.3	98.8	-	100.0	-	-

Table 3 shows the number of times the participants performed the training blocks and tests before they reach the criteria in Steps 1 and 2 of the procedure. It can be seen in this table that, in Phase 1, the number of times that the training blocks were conducted ranged from 2 to 19 and eight participants (two in Group 1, two in Group 2, three in Group 3, and one in Group 4) completed a training block, at most, four times. In Phase 2, a given training block was conducted no more than 10 times. Five participants in Group 1, four in Group 2, three in Group 3, and five in Group 4, performed the same training block no more than four times. The total number of blocks needed to achieve the criteria in the Formation Test was similar for the four groups, but in the Reorganization Test, the total number of blocks needed by Groups 1 and 2 to reach the criteria was lower (65 and 95 respectively) than the number that required by Groups 3 and 4 (123 each). However, the statistical analysis made through the Kruskal-Wallis test showed no significant difference between groups in the number of blocks required to achieve the test criteria in the Reorganization Test (H = 1.571, p> .05), just as was observed in the Formation Test (H = 3.929, p> .05).

Table 3
Number of Repetitions of Each Training and Tests Blocks of Phases 1 and 2

		Phase 1					*Phase 2*					
	Part.	*AB*	*AC*	*AD*	*AE*	*Misto*	*Form*	*AB or ABr*	*AC or ACr*	*AD or ADr*	*AEr*	*Mixed*	*Reorg*
Group 1	P11	5	3	3	3	2	1	1	1	1	2	1	1
	P12	4	4	3	3	2	1	1	1	1	2	1	1
	P13	8	7	9	6	4	3	2	2	2	3	2	3
	P14	7	6	12	7	3	1	1	1	1	3	1	1
	P15	4	3	3	3	2	1	1	1	1	2	1	2
	P16	19	15	8	7	3	2	1	1	1	5	1	1
	P17	4	5	4	4	1	2	3	3	3	8	3	1
Group 2	P21	7	5	5	4	3	2	2	2	3	3	2	1
	P22	5	3	3	4	2	1	2	2	3	3	2	1
	P23	18	14	19	10	6	3	2	2	5	4	2	1
	P24	4	3	3	2	1	1	2	2	3	3	1	1
	P25	9	4	5	4	2	1	2	2	4	4	2	1
	P26	4	4	3	3	2	2	2	2	6	3	2	2
	P27	8	4	4	3	2	1	2	2	4	6	2	3
Group 3	P31	4	4	3	3	2	1	2	3	3	3	2	1
	P32	6	6	4	5	3	1	3	6	5	4	3	3
	P33	4	4	3	4	2	1	2	4	5	4	2	1
	P34	8	2	2	5	1	1	3	5	4	3	1	1
	P35	16	18	12	12	2	4	4	7	10	8	4	1
	P36	3	2	2	3	1	1	2	3	4	3	2	1
	P37	5	4	4	6	3	3	1	2	3	2	1	1
Group 4	P41	12	8	9	7	3	1	4	4	4	3	2	1
	P42	5	6	5	4	3	4	3	3	2	1	1	1
	P43	3	2	2	2	1	1	3	3	3	3	2	1
	P44	5	5	5	5	3	3	7	5	5	5	4	3
	P45	6	7	5	5	4	3	3	3	3	3	2	3
	P46	5	5	6	6	3	3	4	3	2	3	2	3
	P47	6	7	7	4	3	3	7	6	6	5	4	1

Note. The number of blocks includes retraining, which were made every two tests in which the criterion was not met.

Table 4 shows the number of incorrect responses presented by each participant on each of the 16 conditional relations tested (symmetry and transitivity), in the first presentation of the Reorganization Test. It can be observed that six participants (P11, P12, P24, P33, P34 and P47) performed the test without errors, and the errors that others' presented were predominantly in the reversed relations. Three participants in Group 1 and one in Group 2 had relations errors that were not reversed. The errors on the reversed relations were dispersed, occurring once at most.

Discussion

Considering the results of the experiment developed by Folsta and de Rose (2007), in which a larger number of participants responded to the Reorganization Test in accordance with the reversed relations when the stimuli classes were smaller (with four stimuli) than larger classes (with eight stimuli), they concluded that:

> Larger classes involve a larger number of trained and emerging relations between class members. Therefore, for larger classes, training the reversal of a single relation changes a smaller proportion of relations. It is possible that an important factor influencing the probability of rearranging classes is the relation between the number of reversed relations and the total number of relations. (p. 5).

This hypothesis is consistent with what was proposed by Spradlin et al. (1992), which, based on their relational network model, argued that because the conditional relations between stimuli are multipurpose, a particular reversed relation "is not the only determinant of any other relation" (p. 38), even being fundamental in establishing the network of relations. These statements by Folsta and

Table 4
Number of Incorrect Responses by Choosing the Stimuli on Symmetry and Equivalence Conditional Relations of the First Reorganization Test

	Part.	*Conditional relations tested*															
		BA	BC	BD	BE[a]	CA	CB	CD	CE[a]	DA	DB	DC	DE[a]	EA[a]	EB[a]	EC[a]	ED[a]
Grupo 1	P11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	P12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	P13	0	0	0	3	0	0	0	3	0	0	0	4	2	4	4	3
	P14	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
	P15	0	2	0	3	2	2	0	0	0	0	0	0	0	3	1	1
	P16	0	0	0	2	0	0	0	1	0	0	1	1	2	0	1	2
	P17	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
		BA	BC	BD[a]	BE[a]	CA	CB	CD[a]	CE[a]	DA[a]	DB[a]	DC[a]	DE[a]	EA[a]	EB[a]	EC[a]	ED[a]
Group 2	P21	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	P22	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	P23	0	0	1	0	0	0	1	0	0	1	0	1	0	1	0	0
	P24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	P25	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
	P26	0	0	0	2	0	0	0	0	0	0	0	2	0	1	0	0
	P27	0	0	2	0	0	0	2	0	1	0	1	1	0	0	0	1
		BA	BC[a]	BD[a]	BE[a]	CA[a]	CB[a]	CD[a]	CE[a]	DA[a]	DB[a]	DC[a]	DE[a]	EA[a]	EB[a]	EC[a]	ED[a]
Group 3	P31	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	P32	0	0	1	0	0	0	1	1	0	4	2	1	0	0	0	0
	P33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	P34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	P35	0	0	1	0	0	0	0	0	0	1	0	1	0	1	0	0
	P36	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	P37	0	0	0	0	1	1	0	0	1	1	0	1	0	0	1	0
		BA[a]	BC[a]	BD[a]	BE[a]	CA[a]	CB[a]	CD[a]	CE[a]	DA[a]	DB[a]	DC[a]	DE[a]	EA[a]	EB[a]	EC[a]	ED[a]
Group 4	P41	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
	P42	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
	P43	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
	P44	0	0	1	1	0	0	0	1	0	2	0	0	1	0	0	0
	P45	3	3	3	3	0	3	1	0	0	2	0	0	0	1	0	1
	P46	3	1	1	4	0	1	0	0	0	0	1	0	0	1	0	0
	P47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[a]Relations modified in the training of reorganization in Phase 2. Each of these data is related to five different pairs of stimuli (e.g., B1C1, B2C2, B2C3, B4C4, B5C5) that were repeated three times each in the tests, totalizing 15 trials.

de Rose (2007) and Spradlin et al. (1992) made it possible to formulate the rationale of the present study, that it would be more likely that the participants exposed to a higher proportion of reversals of baseline relations would rearrange the equivalence classes with higher probability. Thus, to verify if the proportion of reversals of baseline relations affected the participants' performance, the number of blocks required on the test for the reorganization of equivalence classes occurred based on a composite criterion was considered. The experiment showed that there was no difference between the groups in the Reorganization Test. Therefore, the number of reversed relations did not affect the participants' test performance in the reorganization of the stimulus equivalence class.

One possible explanation for this result could be based on the assumption that the task presented to participants, who were undergraduate students was very easy and that all could complete the task successfully regardless of the number of reversed relations. However, the results did not confirm this hypothesis because 9 of the 37 students randomly selected for the study initially gave up (two in Phase 1 and one in Phase 2) or did not meet the specified criteria (six in Phase 1), suggesting that the task might

have been difficult for some of them. For those participants that were maintained in the study, it can be stated that the task was easier, but was not trivial, since the majority had to repeat the blocks of training of individual conditional relations more than twice and the block of mixed training more than once. The Formation Test and Reorganization Test also were repeated by a large number of participants, and only 6 of the 28 participants did not emit incorrect responses in Reorganization Test, and another 6 of the 28 participants had to be reexposed to the training of the entire sequence of baseline relations.

Although the task is likely to have had some degree of difficulty, all four groups of participants reached the composite criteria of reorganization of equivalence classes. This aspect could be related to the possibility that there had been an exchange of information between them, because all were of the same grade level. However, some care was taken to ensure that they could not instruct one another. One was conducting the experiment with all groups simultaneously, rather than one group at a time. As there were differences in the procedure for each group and the participants did not know to which group they were assigned, if one of them had instructed another, possibly, one would present incorrect information. Additionally, details of the procedure, such as the fact that the classes involved a large number of relations between stimuli (four baseline, four of symmetry, and 12 of transitivity, totaling 100 conditional relations when considering the five equivalence classes), probably hindered the description of the relations to be formed, thereby ruling out the exchange of information as a possible interference. Additional data to discard this possibility is that the types of incorrect response given by participants on the Reorganization Test (see Table 4) varied greatly from participant to participant, that is, there were no systematic errors by comparing data from several participants.

It should be noted that some methodological characteristics of the present study may have contributed to results that were obtained. One of these characteristics is that all trials during training and tests involved five comparison stimuli, while in most studies on the reorganization of equivalence classes only two were presented (e.g., Pilgrim & Galizio, 1990, 1995; Saunders et al., 1988). Sidman (1987) noted that the use of only two comparison stimuli allows the occurrence of selection by chance, limiting the validity of the results. In addition, Johnson and Sidman (1993) demonstrated that the use of only two comparison stimuli leads to the occurrence of different types of control of the relation sample-comparison: selection control can produce the formation of equivalence classes specified by the experimenters (e.g., A1B1C1D1 and A2B2C2D2), and rejection control can establish the formation of other classes (e.g., A1B2C1D2 and A2B1C2D1). Carrigan and Sidman (1992) did a critical analysis of the effect of this variable on the reorganization of equivalence classes, using data from the study of Pilgrim and Galizio (1990) as a reference. These authors clarified that, in a reorganization procedure of equivalence classes with only two comparison stimuli and whit the reversal of only one conditional relation, the probability of changing the type of control is high, which can produce the reorganization of the symmetry relations, but not transitivity relations. This aspect, according to Carrigan and Sidman, explains the results of Pilgrim and Galizio.

The use of five comparison stimuli in the present study, therefore, precluded the selection by chance. In one type of training with this number of comparison stimuli, the number of discriminations that must be learned to the occurrence of selection control is much smaller than when it involves rejection of control, suggesting that, probably, this type of choice was avoided. The fact that rejection control is avoided was demonstrated by Carrigan and Sidman (1992), who compared a procedure with three comparison stimuli to one with two stimuli. With three comparison stimuli and selection control, the participant only needs to learn to choose: given A1 as a sample, the comparison stimulus B1; given B1 as sample, the comparison stimulus C1; and so on for the other baseline relations to establish classes A2B2C2 and A3B3C3. As there are three samples to establish the relations A1B1, A2B2, A3B3 and three to establish the relations B1C1, B2C2 B3C3, the participant would have to learn to select six pairs of sample-comparison relations. However, if there is rejection control, the participant must learn to reject two comparisons for each of the six samples, for a total of 12 sample-comparison pairs. Therefore, one can conclude that the use of five comparison stimuli in the procedure of the present study prevented rejection control and the switching between types of control, when relations were reversed.

A third aspect of the procedure to be emphasized that contributed to all four groups of participants presenting reorganization of equivalence classes was the criteria of repetition throughout the training procedure, when the participant did not reach the criteria of at least 90% correct responses. For example, in the first Reorganization Test taken by P13, all responses were in accordance with the original classes, that is, in line with changes in the contingencies, but with repeated training, the participant changed the responses and reached the criteria required in the third Reorganization Test. In Saunders et al. (1988) study, for example, only the tests were repeated, and it may be assumed that, if the training had been repeated, participants could have reorganized the classes.

One last aspect to be considered for discussion, which may have contributed to the reorganization of equivalence classes regardless of the number of reversed relations, is the possibility of contextual control. Contextual control can be defined as the conditional control that a determined stimulus has on a conditional discrimination (Lopes & Matos, 1999). Sometimes, contextual control can be established even if there is no stimulus of this type designated by the experimenter (Spradlin et al., 1992), as the mere repetition of the Reorganization Test could

eventually indicate that the participant should modify their selection responses. Additionally, alterations in the contingencies can create new relations between stimuli, but not eliminate the relations previously learned. Thus, a change in contingencies reduces the frequency of a response pattern consistent with specific training, but this pattern is not abolished, it is merely supplanted and may recur in the future in appropriate circumstances (McIlvane, Serna, Dube, & Stromer, 2000). Thus, if a particular characteristic of the environment functions as contextual stimulus, this stimulus can control the participants' responses. In the study of Garotti and de Rose (2007), the reviews of the baseline relations were considered contextual cues that controlled responses, determining which of the two patterns should be presented. An environmental aspect can, therefore, control which of the equivalence classes should prevail, if the originally established or the reorganized.

In the present study, no reviews of the baseline relations were included before the test, as in the study of Garotti and de Rose (2007), to avoid contextual control. However, another characteristic may have exerted this kind of function. In training blocks in Phase 2, all conditional relations were taught to all groups. Participants in Group 1, for example, who had only the relations AE reversed in Phase 2, were exposed to the training of this relationship and of the original relations AB, AC and AD, which was done in isolated blocks for each relationship. This was done to make the number of training trials as similar as possible for the different groups. In previous studies in which the relations were not retrained independently, the procedure most commonly used was the inclusion of the changed relation in mixed training block that contained unchanged baseline relation trials (e.g., Pilgrim & Galizio, 1995). The use of only one mixed training block could allow the participant to achieve the criterion required in the Reorganization Test, despite the recombined relations not being learned.

The results of this study demonstrate that the equivalence classes can be established and subsequently modified, confirming previous results (Folsta & de Rose, 2007; Garotti & de Rose, 2007 – Experiment 2; Garotti et al., 2000; Saunders et al., 1999; Smeets et al., 2003; Wirth & Chase, 2002). By manipulating the number of reversed relations in a group-design it was found that this variable did not affect the reorganization of classes differentially. Thus, this aspect did not confirm the hypothesis derived from the suggestions of and Folsta and de Rose (2007), and Spradlin et al. (1992), according to which the number of reversed relations could affect the reorganization of stimulus equivalence classes. However, the fact that there was no difference between the results of the four groups in the present study may be due to contextual control, and the participants may have formed new stimulus equivalence classes in a five-term contingency (Bush, Sidman, & de Rose, 1989; Sidman, 1986, 2000). Further studies could assess the validity of the conclusion presented here, by manipulating the characteristics identified as potential interference in this investigation, namely, the contextual control caused by the presentation of blocks of retraining of the non-reversed conditional relations and retesting for those participants who did not reach the criteria of class reorganization.

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