Revista Mexicana de Análisis de la Conducta
Mexican Journal of Behavior Analysis
1994, vol. 20, núm. 2, diciembre (december), pp. 146-166

Assessing Pre-existing Linguistic Relations Via Stimulus Equivalence

La evaluación de relaciones lingüísticas prexistentes vía la equivalencia de estímulos

Linda J. Hayes (1),[1] Kurt G. Brenner (2)and Steven C. Hayes (3)

University of Nevada (1), Northwestern University (2) and University of Nevada (3)

RESUMEN

Se entrenó a adultos normales en discriminaciones condicionales A-B, A-C y D-C utilizando un procedimiento de igualación de la muestra. Los estímulos A, B y C fueron formas visuales arbitrarias. Los estímulos D para un grupo de diez sujetos consistieron en tres palabras: "fiesta," "funeral" y "tortura." Para otro grupo de diez sujetos los estímulos D consistieron en tres retratos de una cara con expresión feliz, triste y mala. Las relaciones de equivalencia se probaron entre los estímulos D y los estímulos A, B, y C (D-B, B-D, A-D, C-D) pero empleando los estímulos D vistos por el otro grupo en entrenamiento. Así, los sujetos entrenados con caras fueron probados con palabras y viceversa. La equivalencia substitutiva emergió para la mayor parte, pero no todos los sujetos que mostraron equivalencia no substitutiva (la relación B-C y C-B). La equivalencia substitutiva emergió más rápidamente en los sujetos entrenados con palabras y probados con caras que viceversa. Se discuten las implicaciones de estos hallazgos para el análisis de las relaciones lingüísticas pre-existentes.

Palabras clave: historia extra-experimental, significado, humanos normales, referencia, equivalencia de estímulos, conducta verbal.

Abstract

Normal adults were trained in A-B, A-C, and D-C conditional discriminations using a matching-to-sample procedure. The A, B, and C stimuli were arbitrary visual forms. D stimuli for one group

1 This research was supported by a grant from the Natural Science and Engineering Research Council of Canada to Saint Mary's University, Linda J. (Parrott) Hayes, principle investigator and was conducted as a Master's thesis by the second author. Preparation of this manuscript was also supported in part by a grant from the National Institute of Health, National Institute on Drug Abuse, grant number 1 R01 DA08634-01. Requests for reprints may be sent to Linda J. Hayes, Department of Psychology, University of Nevada, Reno, NV 89557-0062.

of ten subjects consisted of three words: "holiday," "funeral", and "torture." For another group of ten subjects the D stimuli consisted of three pictures of a face with a happy, sad, and mean expression. Equivalence relations were tested between the D stimuli and the B, A, and C stimuli (D-B, B-D, A-D, C-D) but using the D stimuli seen by the other group in training. Thus, subjects trained with faces were tested with words and viceversa. Substitutional equivalence emerged for most, but not all, subjects who showed non-substitutional equivalence (the B-C and C-B relation). Substitutional equivalence emerged more readily for subjects trained with words and tested with faces than viceversa. The implications of these findings for the analysis of pre-existing linguistic relations are discussed.

Key words: *Extra-experimental history, meaning, normal humans, reference, stimulus equivalence, verbal behavior.*

The relation between stimulus equivalence and language has been the subject of considerable discussion in the behavior analysis literature (e.g., Catania, 1984; Lazar, 1977; Dugdale & Lowe, 1990; Hayes & Hayes, 1992; Sidman & Tailby, 1982). The basis of this interest seems to be the degree to which stimulus equivalence models important aspects of linguistic behavior (e.g., Hayes, 1991; Hayes & Hayes, 1989). For example, derived symmetry in an equivalence procedure might be said to resemble the referential relations obtaining between words and objects. This relation has been supported by a variety of studies, from the very beginning of research in the area, that have used equivalence procedures to train reading or other linguistic skills (e.g., Sidman, 1971; Sidman & Cresson, 1973).

A less examined, but potentially important role for the equivalence procedure is its use in identifying and studying extra-experimentally established linguistic relations. For example, suppose a word such as "upset" were used as a comparison, along with other novel non-linguistic stimuli, in the conditional discrimination training of an equivalence procedure; and during testing, this word were replaced with other words such as "anxious" or "angry." Under these conditions, test results would reveal the degree of functional substitutability among these terms, and by extension, something of their natural language function or meaning (see Kohlenberg, Hayes & Hayes, 1991, for an example).

The use of the equivalence procedure may go beyond mere identification of pre-existing stimulus relations to examination of their properties. The present study used an equivalence procedure to explore the extent to which a stimulus similar to one typically encountered in a particular setting would function as a substitute for a verbal description of that setting in its absence; and, conversely, whether a verbal description of a setting in which a particular stimulus is typically encountered would function as a substitute for that stimulus in its absence. To put it another way, we examined the extent to

which particular stimuli had acquired functions of their settings and settings had acquired functions of the stimuli found in them, in the extra-experimental histories of our subjects.

These categories of setting and stimulus events are interesting in part because there is an apparent asymmetry between them. A setting constitutes a boundary or limiting factor of sorts. As such, given a verbal description of a setting, the number of stimuli brought to bear is relatively small. For example, if I say "comedy club," you might imagine (i.e., see to yourself) a smiling face more readily than a crying one. Conversely, given a particular facial expression, the number of settings to which it might be related, and which might thereby be brought to bear by it, is relatively large. A smiling face might be found in a comedy club, at a celebration, a party, on holiday, in a fishing boat, and so on. Thus one might expect that it would be easier to substitute faces given settings than to substitute settings given faces.

The stimulus equivalence procedure provides a precise method for the examination of such relations. In the present study, pictures of faces bearing distinct expressions were involved in conditional discrimination training. During the symmetry and equivalence tests for this group, the faces were replaced by words for settings in which the facial expressions might have been encountered. For example, if the face bore a smile, the replacement word was "holiday." A second group was trained with these words and tested with the faces. Differences in the ease with which the faces and words would substitute for one another would provide evidence for differences in the extra-experimental relations in which they participate.

Membership of stimuli in naturally occurring equivalence relations is not always nor even usually a product of idiosyncratic circumstances. On the contrary, equivalence relations very often are cultural or conventional. Conventionality is necessary for the operation of natural language. So, for example, under most circumstances, for most people in our culture, a smiling face and the word "happy" are members of the same class. Other things and events may also be part of the happy-smiling class such as "celebration," "winning," or "holidays," at least under some conditions. Another way of saying this is that a person in our culture may think "happy" upon seeing a smiling face; and having brought "happy" into the present situation by this means, may think about celebrations, holidays, etc. —each of which may, in turn, bring about other reactions sharing membership in the same or in overlapping relational classes. The present study took advantage of culturally probable equivalence relations, using them in the establishment of new relations.

METHOD

Subjects

Twenty college students, 10 males and 10 females, served as subjects. A session lasted approximately one hour, and each subject participated in two sessions. Subjects were paid approximately minimum wage for their participation.

Setting and Apparatus

Subjects sat before a panel consisting of a rear projection slide screen, three response keys, and green and red lights. The experimenter was situated in an adjacent room. He manipulated a slide advance button, and buttons operating the subjects' green and red lights. Subjects' responses operated lights in the experimenter's room corresponding to the positions of the response keys. The Experimenter recorded subjects' responses on a data sheet.

Stimulus Materials

Five sets of three stimuli were used. Those in sets A, B and C were non-representative figures, drawn in black ink on a white background. The stimuli in set D (for Ss 1-10) and Dsub (for Ss 11-20) were the words HOLIDAY, FUNERAL, and TORTURE, in black ink on a white background. The stimuli in set Dsub (for Ss 1-10) and D (for Ss 11-20) were pictures of an actual female face with the expressions happy, sad and mean, as selected from Ekman's (1976) Pictures of Facial Affect. Subjects were randomly assigned to one of these two conditions. During a trial, a sample stimulus appearing at the top of the screen, and three comparisons appeared in a row a the bottom.

General Procedure

Subjects were told that their task was to select the stimulus at the bottom that went with the one at the top by pressing the response key situated below the one selected. They were also told that on some of the trials they would be given correct and incorrect feedback in the form of the green and red lights, respectively, and that on other trials no feedback would be given.

Training. During training, a trial began with the projection of a stimulus configuration on the slide screen. The subject selected one of the comparisons by pressing the corresponding response key. The trial ended with the

flashing of either the green light for a correct match, or the red light for an incorrect match. The next trial followed immediately.

Training began with 24 reinforced reflexivity trials, in which the stimuli making up sets A, B, C, and D were each presented twice in random order. Immediately following this training, nine conditional discriminations were trained by the same procedure, over 5 phases of training. In each block of training trials, component relations were presented an equal number of times, in random order. For example, during the first training phase, 3 conditional discriminations, A1-B1, A2-B2 and A3-B3 were presented in 30-trial blocks, with 10 presentations of each relation, until a criterion of 29 correct per 30-trial block was reached. The A-C relations were trained during the second phase, followed by mixed A-B and A-C trials. During the fourth phase, the D-C relations were trained. The final phase of training mixed A-B, A-C, and D-C trials in 45-trial blocks. The sequence of training phases, the trial types involved in each phase, the number of trials of each type appearing in a trial block, and the mastery criteria in effect for each phase are shown in Table 1.

TABLE 1
TRAINING SEQUENCE
Reinforced comparisons are emboldened

PHASE	TRIAL TYPES		# TRIALS/BLOCK	CRITERION
	Sample	Comparisons		
1	A1	**A1** A2 A3	2	23/24 correct
	A2	A1 **A2** A3	2	
	A3	A1 A2 **A3**	2	
	B1	**B1** B2 B3	2	
	B2	B1 **B2** B3	2	
	B3	B1 B2 **B3**	2	
	C1	**C1** C2 C3	2	
	C2	C1 **C2** C3	2	
	C3	C1 C2 **C3**	2	
	D1	**D1** D2 D3	2	
	D2	D1 **D2** D3	2	
	D3	D1 D2 **D3**	2	
2	A1	**B1** B2 B3	10	29/30 correct
	A2	B1 **B2** B3	10	
	A3	B1 B2 **B3**	10	
3	A1	**C1** C2 C3	10	29/30 correct
	A2	C1 **C2** C3	10	
	A3	C1 C2 **C3**	10	
4	A1	**B1** B2 B3	5	29/30 correct
	A2	B1 **B2** B3	5	
	A3	B1 B2 **B3**	5	
	A1	**C1** C2 C3	5	
	A2	C1 **C2** C3	5	
	A3	C1 C2 **C3**	5	
5	D1	**C1** C2 C3	10	29/30 correct
	D2	C1 **C2** C3	10	
	D3	C1 C2 **C3**	10	
6	A1	**B1** B2 B3	5	43/45 correct
	A2	B1 **B2** B3	5	
	A3	B1 B2 **B3**	5	
	A1	**C1** C2 C3	5	
	A2	C1 **C2** C3	5	
	A3	C1 C2 **C3**	5	
	D1	**C1** C2 C3	5	
	D2	C1 **C2** C3	5	
	D3	C1 C2 **C3**	5	

Table 1

Testing. Upon completion of training, a series of 6 tests began in which unreinforced test trials of particular types were inserted into reinforced baselines. For example, to test for B-C equivalence, unreinforced B-C trials were inserted into a reinforced baseline of previously acquired A-B and A-C trials. In a given testing phase, each tested relation appeared equally often, in random order. The sequence of test phases, the trial types involved in each phase, and the ratio of test to baseline trials in each phase are shown in Table 2.

TABLE 2
EQUIVALENCE AND SYMMETRY TEST SEQUENCE
"Correct" testing comparisons and reinforced baseline comparisons are emboldened

TEST PHASE	TEST TRIALS Sample	Comparisons	BASELINE TRIALS Sample	Comparisons	Test to Baseline Trials
4-stage substitutional equivalence	Dsub1 **B1** B2 B3		A1	**B1** B2 B3	30:90
	Dsub2 B1 **B2** B3		A2	B1 **B2** B3	
	Dsub3 B1 B2 **B3**		A3	B1 B2 **B3**	
			A1	**C1** C2 C3	
			A2	C1 **C2** C3	
			A3	C1 C2 **C3**	
			D1	**C1** C2 C3	
			D2	C1 **C2** C3	
			D3	C1 C2 **C3**	
4-stage substitutional equivalence	B1	**Dsub1** Dsub2 Dsub3	A1	**B1** B2 B3	30:90
	B2	Dsub1 **Dsub2** Dsub3	A2	B1 **B2** B3	
	B3	Dsub1 Dsub2 **Dsub3**	A3	B1 B2 **B3**	
			A1	**C1** C2 C3	
			A2	C1 **C2** C3	
			A3	C1 C2 **C3**	
			D1	**C1** C2 C3	
			D2	C1 **C2** C3	
			D3	C1 C2 **C3**	
3-stage substitutional equivalence	A1	**Dsub1** Dsub2 Dsub3	A1	**C1** C2 C3	30:90
	A2	Dsub1 **Dsub2** Dsub3	A2	C1 **C2** C3	
	A3	Dsub1 Dsub2 **Dsub3**	A3	C1 C2 **C3**	
			D1	**C1** C2 C3	
			D2	C1 **C2** C3	
			D3	C1 C2 **C3**	
3-stage equivalence	B1	**C1** C2 C3	A1	**B1** B2 B3	30:60
	B2	C1 **C2** C3	A2	B1 **B2** B3	
	B3	C1 C2 **C3**	A3	B1 B2 **B3**	
			A1	**C1** C2 C3	
			A2	C1 **C2** C3	
			A3	C1 C2 **C3**	
3-stage equivalence	C1	**B1** B2 B3	A1	**B1** B2 B3	30:60
	C2	B1 **B2** B3	A2	B1 **B2** B3	
	C3	B1 B2 **B3**	A3	B1 B2 **B3**	
			A1	**C1** C2 C3	
			A2	C1 **C2** C3	
			A3	C1 C2 **C3**	
Substitutional symmetry	C1	**Dsub1** Dsub2 Dsub3	D1	**C1** C2 C3	30:30
	C2	Dsub1 **Dsub2** Dsub3	D2	C1 **C2** C3	
	C3	Dsub1 Dsub2 **Dsub3**	D3	C1 C2 **C3**	

Table 2

The first two tests assessed the emergence of 4-stage substitutional equivalence. In substitutional tests, the stimuli did not consist of the D stimuli but of the Dsub stimuli. Subjects trained with the words HOLIDAY, FUNERAL, and TORTURE, in stimulus set D were tested with happy, sad, and mean faces; while subjects trained with faces were tested with words. For instance, in the first 4-stage substitutional equivalence test (Dsub-B), the sample for subjects trained with words (set D) were the faces (Dsub). The comparisons were the B stimuli. These comparison were related to the A stimuli via symmetry, the A to the C stimuli via direct training, and the C to the D stimuli via symmetry. The Dsub stimuli were related to the D stimuli, when they were, via an extra-experimental history. The Dsub-B test was then followed by a B-Dsub test. In both cases, test trials were randomly inserted into a baseline of mixed A-B, A-C and D-C training trials, at a ratio of 30:90, for a total of 120 trials.

In a similar fashion, the third test assessed the emergence of 3-stage substitutional equivalence (A-Dsub). Test trials were inserted into a baseline of A-C and D-C trials, at a ratio of 30:60, for a total of 90 trials. The fourth and fifth test assessed the emergence of the 3-stage non-substitutional equivalence relations B-C and C-B. Test trials of these sorts were inserted into baselines of A-B and A-C trials, at a ratio of 30:60, for a total of 90 trials each. The sixth test assessed the emergence of substitutional symmetry (C-Dsub). These test trials were inserted into a baseline of D-C trials, at a ratio of 30:30, for a total of 60 trials.

The strategy in this testing sequence was to test for the most highly derived relations first, followed by various underlying relations. Tests proceeded in this sequence in order to minimize the acquisition of highly derived substitutional equivalence via prior testing of the less highly derived relations (both substitutional and non-substitutional). If, however, a 4-stage substitutional equivalence relation had not been shown at criterion levels (90% "correct" was the testing criterion used throughout the experiment) during initial testing and criterion-level substitutional symmetry (C-Dsub) was observed in the sixth equivalence test, the original Dsub-B equivalence test was re-administered to assess for the emergence of these relations over the testing period.

A graphic representation of the relations trained and tested is presented in Figure 1. In this figure, the solid arrows indicate trained relations; the broken arrows indicate tested relations. During testing the stimuli in set D were replaced by those in set Dsub, as repesented in the diagram. An example of the stimuli making up each of the 5 sets involved in the procedure is presented in the lower portion of the figure.

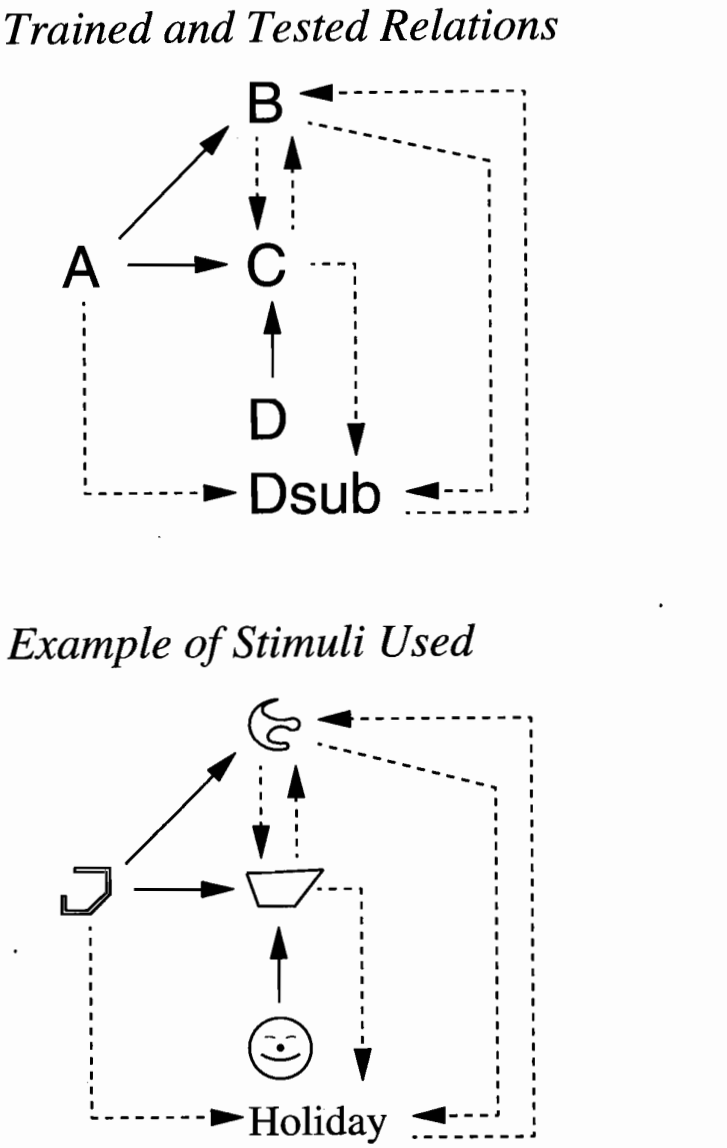

Figure 1. The upper portion of the figure shows the trained relations (indicated by solid arrows) an the tested relations (indicated by broken arrows). The lower portion of the figure is an example, illustrating the types of stimuli making up the five sets A, B, C, D and Dsub. This specif example is taken from the "Training with faces-Test with words" group. The smiling face and word were switched in the other group. The line drawing of a face represents the picture of an actual face used in the experiment.

Reliability of Subject's Responses

A second observer recorded subject's responses during 20% of the sessions, selected randomly. This observer was situated in the experimenter's room in such a way as to prevent observation of the principle experimenter's data sheet. In addition, the subjects' red and green feedback lights were shielded from the observer's view during reliability sessions. For each trial the subjects response was recorded by both experimenters. An "agreement" was defined by the recorded topography of the subject's responses —not by whether or not it was "correct" or "incorrect." Agreement and disagreement data for all intervals were analyzed using the following formula: [Agreements/(Agreements + Disagreements)] x 100. By this formula, interobserver agreement was 99.8%.

RESULTS

For purposes of exposition in the following discussion of individual subjects' performances, we have adopted a test mastery criterion of 90% correct, analogous to the training criterion. Individual data for each subject will be considered first, followed by group data relevant to the main experimental questions.

Subjects Trained with Words and Tested with Faces

Training and testing data for Subjects 1 through 10 are presented in Figure 2. Since virtually all performances were at 100%, reflexivity data are not included on this figure.

Subject 1. Reflexivity trials were completed without error. Conditional discrimination training of relations A-B, A-C and D-C was completed in 225 trials. Baseline performances remained at 100% accuracy during the ensuing test phases.

Criterion levels of performance were not achieved by this subject for any of the tested relations. Scores on the 4-stage substitutional equivalence tests of relations Dsub-B and B-Dsub were both at chance levels of 33.3% correct. The 3-stage substitutional equivalence test of relation A-Dsub also showed a chance level of correct responding. Test scores on 3-stage non-substitutional equivalence of relations B-C and C-B were better than chance but below criterion, at 66.7% and 73.3%, respectively. The score for the substitutional symmetry test of C-D was 76.7%

During debriefing, the subject reported that her selection of comparison stimuli during test trials was based on constructed formal similarities between the sample and the select comparison, and not on the basis of a relationship between them derived from the previous conditional discrimination training.

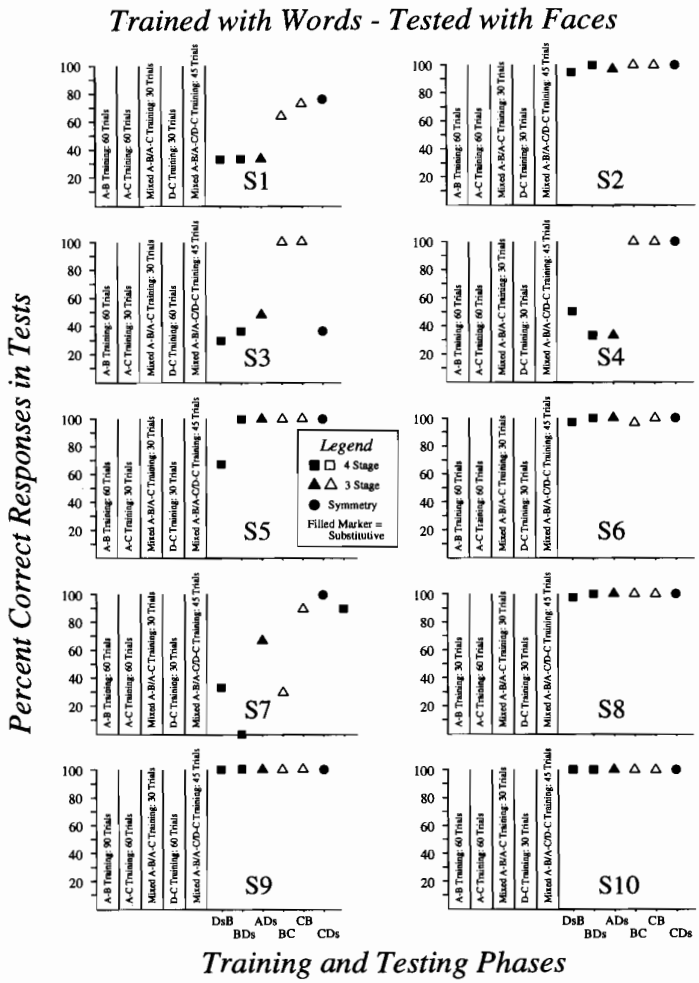

Figure 2. Training and testing data for individual Subjects 1-10 of the Trained with Words-Tested with Faces group are presented. The number of training trials to reach criterion for each of the conditional discriminations is shown in the vertical bars at the left of each figure. The markers to the right of each figure show the scores achieved on the 4 (squares) and 3-stage (triangles) equivalence tests and the symmetry test (circles). Filled markers indicate scores on tests involving substitution.

Subject 2. Reflexivity trials were completed without error. Conditional discrimination training was completed in 255 trials. Baseline performances remained at 100% during the ensuing test phases.

Test scores for all relations were above criterion levels. The less than perfect scores achieved in the Dsub-B and A-Dsub test were the result of errors on the first one or two trials of each test type, after which all responses were correct.

Subject 3. Reflexivity trials were completed without error. Conditional discrimination training was completed in 225 trials. Baseline performances remained at 100% accuracy during the ensuing test phases.

Four-stage substitutional equivalence was not achieved with scores of 30% and 36.7% on relations Dsub-B and B-Dsub respectively. Likewise, the three-stage substitutional equivalence was not achieved, with a score of 46.7% on the A-Dsub relation. Three-stage non-substitutional equivalence was shown without errors on both the B-C and C-B relations. Substitution remained a problem for this subject, however, as the substitutional symmetry test score of 36.7% shows. A fine grained analysis of errors during the tests involving substitute stimuli revealed consistent responding, suggesting an idiosyncratic response strategy.

A debriefing session following the experiment confirmed this suggestion. The subject reported that during the test phases comparisons were initially selected at random until a pattern had developed which was then maintained, even after he became aware of an association between the words and faces during the final test for symmetry.

Subject 4. Reflexivity trials were completed without error. Conditional discrimination training was completed in 225 trials. Baseline performances throughout the test phases remained accurate with only three errors occurring.

This subject failed the four and three-stage substitutional equivalence tests with scores of 50% (on Dsub-B), 33.3% (on B-Dsub), and 33.3% (on A-Dsub). Three-stage non-substitutional equivalence was achieved without error, as was the test of substitutional symmetry.

This subject reported an awareness of the relation between the faces and the words during a debriefing session, but responded on the basis of self-constructed relations between the faces and formal properties of the non-representative shapes. It is possible that an awareness of the relation between the faces and the words was not present until the final test for symmetry, accounting for the perfect score achieved on this test compared to the poor scores achieved on the other tests involving the substitute stimuli. This possibility would normally been assessed via a retesting on the 4-stage substitu-

tional relation. Unfortunately, this subject declined to continue and withdrew from the experiment prior to the final test.

Subject 5. Reflexivity trials were completed without error. Conditional discrimination training was accomplished in 195 trials. Baseline performance remained accurate during the test phases with only one error occurring.

With the exception of the initial four-stage substitutional equivalence relation Dsub-B, all other relations were performed without error. The Dsub-B relation was scored at 66.7%.

The subject began the Dsub-B test phase by selecting B2 in the presence of Dsub1, and B1 in the presence of Dsub2 consistently. About halfway through the phase a shift to correct responding occurred. In debriefing, the subject indicated that he suddenly realized the relation between the faces and the words mid-way through this test phase.

Subject 6. Reflexivity trials were completed without error. Conditional discrimination training was completed in 225 trials. Baseline performances remained accurate during the test phases with only one error occurring.

Test scores for all relations were above criterion levels. The only errors occurring during the test phases were on the first Dsub-B and BC trials.

This subject reported becoming aware of the relation between the words and the faces upon the completion of the first test trial.

Subject 7. Reflexivity trials were completed without error. Conditional discrimination training was accomplished in 225 trials. Baseline performances were maintained at 100% accuracy during the ensuing test phase.

Four-stage substitutional equivalence was not demonstrated initially, with scores of 33.3% on Dsub-B and 0% correc on B-Dsub test trials. Three-stage substitutional equivalence was also not achieved with a score of 66.7%. Non-substitutional equivalence was achieved to criterion however, as was the test of substitutional symmetry. A subsequent test of the Dsub-B relation revealed acquisition of the 4-stage substitutional equivalence.

During the debriefing session this subject reported responding during the test trials on the basis of self-constructed relations between the faces and formal properties of the nonrepresentative shapes. A fine grained analysis of the data revealed a pattern of responding consistent with his account during some of the test phases.

Subject 8. Reflexivity trials were completed without error. Conditional discrimination training was completed in 195 trials. Baseline performances remained at 100% accuracy during the ensuing test phases. Test scores for all relations were above criterion levels.

Subject 9. Reflexivity trials were completed without error. Conditional discrimination training was completed in 285 trials. Baseline performances remained at 100% accuracy during the ensuing test phases. Test scores on all relations were at 100%.

Subject 10. The reflexivity score was 95.8% (an error was made on the first trial, after which all trials were completed without error). Conditional discrimination training was completed in 225 trials. Baseline performances remained accurate during the test phase with only one error occurring. Test scores on all relations were at 100%.

Subjects Trained With Faces and Tested With Words

Training and testing data for subjects 11 through 20 are presented in Figure 3. Reflexivity data are not included in this figure.

Subject 11. Reflexivity trials were completed without error. Conditional discrimination was completed in 255 trials. During the ensuing test phase 8 errors were made on baseline trials for a baseline performance accuracy score of 97.5%.

This subject demonstrated only one equivalence relation, the 4-stage substitutional equivalence relation of B-Dsub was achieved with a score of 100%. Scores on the remaining equivalence relations were below criterion with 4-stage substitutional equivalence of Dsub-B at 60%, 3-stage substitutional equivalence of A-Dsub at 13.3%, and the non-substitutional equivalence of B-C and C-B at 50% and 73.3% respectively. Substitutional symmetry was achieved to criterion.

During debriefing the subject reported no awareness of the relation between the faces and the words prior to the symmetry test. As such, it is possible that the apparent acquisition of 4-stage substitutional equivalence of B-Dsub is a coincidental finding produced by an idiosyncratic response strategy of some sort. A retest of the Dsub-B relation following the successful symmetry test was not possible because the subject refused to participate further.

Subject 12. Reflexivity trials were completed without error. Conditional discrimination training was completed in 255 trials. Baseline performances remained accurate during the ensuing test phase with only two errors occurring. Test scores on all relations were 100% with the exception of the initial Dsub-B test on which the exception of the initial Dsub-B test on which a score of 33% was achieved.

During debriefing this subject reported an awareness of the relation between the faces and the words, as well as a strategy employed during the Dsub-B trials based on a self-constructed relation between the faces and formal properties of the nonrepresentative shapes.

Subject 13. Reflexivity trials were completed without error. Conditional discrimination training was completed in 315 trials. Baseline performances remained accurate during the ensuing test phase with only one error occurring. Test scores for all relations were above criterion.

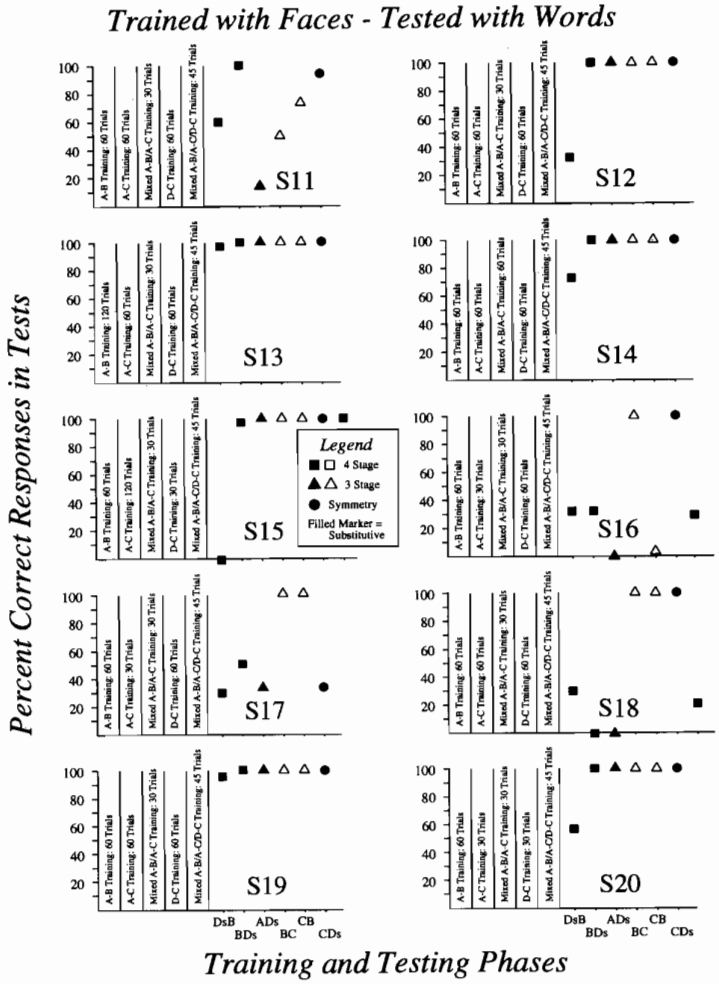

Figura 3. Training and testing data for individual Subjects 11-20 of the Trained with Faces-Tested with Words group are presented. The number of training trials to reach criterion for each of the conditional discriminations is shown in the vertical bars at the left of each figure. The markers to the right of each figure show the scores achieved on the 4 (squares) and 3-stage (triangles) equivalence tests and the symmetry test (circles). Filled markers indicate scores on tests involving substitution.

Subject 14. Reflexivity trials were completed without error. Conditional discrimination training was completed in 255 trials. Baseline performances during the test phase remained al 100% accuracy.

Test scores on all relations were 100% with one exception. The score on the 4-stage substitutional equivalence relation of Dsub-B was 73.3%. This score represents a shift from random responding early in this test phase to correct responding during the later trials.

Subject 15. Reflexivity trials were completed without error. Conditional discrimination training was completed in 285 trials. Baseline performance during the ensuing test phase remained accurate with only one error occurring.

Test scores met criterion on all relations with one exception, the 4-stage substitutional equivalence of Dsub-B. The score for this relation was 0% correct. In a subsequent retest of the Dsub-B relation, a perfect score was obtained.

During debriefing the subject reported responding on an arbitrary but consistent basis during the first set of Dsub-B test trials. Upon becoming aware of the relation between the faces and the words she abandoned this strategy.

Subject 16. Reflexivity trials were completed without error. Conditional discrimination training was completed in 225 trials. Baseline performances remained accurate during the ensuing test phase with only one error occurring.

Substitutional equivalence was not shown by this subject, achieving scores of 33.3% on the Dsub-B test, 33.3% on the B-sub test and 0% on the A-Dsub test. Three-stage substitutional equivalence was demonstrated on the B-C test but not on the C-B test. Substitutional symmetry was achieved. A final retest of the Dsub-B 4-stage substitutional equivalence was failed with a score of 30%.

The subject reported responding on the basis of self-constructed relations between the words and formal properties of the nonrepresentative shapes. No knowledge of the relation between the words and faces was reported. It is thus possible that the symmetrical performance was a result of a coincidental idiosyncratic response strategy.

Subject 17. Reflexivity trials were completed without error. Conditional discrimination training was accomplished in 225 trials. Baseline performance remained at 100% accuracy during the ensuing test phase.

This subject failed all of the tests involving substitution, achieving scores of 30% on the Dsub-B, 50% on the B-Dsub, 33.3% on the A-Dsub, and 33.3% on the C-D test. Three-stage non-substitutional equivalence was demonstrated with 100% accuracy.

The subject reported no awareness of the relation between the faces and words prior to the symmetry test. He continued to respond on the basis of a self-constructed relation between the words and formal properties of the non-representative shapes throughout the symmetry test as in all previous tests so as to remain consistent.

Subject 18. Reflexivity trials were completed without error. Conditional discrimination training was completed in 255 trials. Baseline performances remained at 100% accuracy during the ensuing test phase.

This subject failed all tests of equivalence relations involving substitution, achieving scores of 30% on B-Dsub, 0% on B-Dsub, 0% on A-Dsub, and 20% on a retest of Dsub-B. Three-stage non-substitution equivalence and substitutional symmetry were achieved at 100% accuracy. A retest of 4-stage substitutional equivalence of Dsub-B achieved a score of 20%.

During debriefing this subject reported responding on the basis of a self-constructed relation between the words and formal properties of the non-representative shapes. No knowledge of the relation between the words and faces was reported. The perfect symmetrical score was a coincidental result of an idiosyncratic response strategy.

Subject 19. Reflexivity trials were completed without error. Conditional discrimination training was completed in 255 trials. Baseline performances remained accurate throughout the test phase, with only one error occurring. Test scores for all relations were above criterion.

The subject reported an immediate realization of the relation between the words and the faces.

Subject 20. Reflexivity trials were completed without error. Conditional discrimination training was completed in 195 trials. Baseline performance remained accurate throughout the test phase with only 2 errors occurring.

Test scores on all relations were 100% with one exception, the 4-stage substitutional equivalence relation Dsub-B. The score achieved on this test was 56.7%.

During debriefing the subject reported being confused by the appearance of the faces in the Dsub-B test phase, and initially responsed randomly on these trials, becoming aware of the relation between the faces and the words midway through the Dsub-B test.

The Frequency of Substitutional Equivalence

One major issue examined in this experiment was whether substitutional equivalence would be commonly found. This question focuses on those subjects showing non-substitutional equivalence, since there would be little

reason to expect substitutional equivalence in the absence of equivalence shown with stimuli actually used in training. To minimize the effects of testing per se, the primary group of interest when interpreting the results of the 4-stage and 3-stage substitutional equivalence tests are those showing 3-stage non-substitutional equivalence on the fist test of that relation (B-C). Because it is well-known that equivalence testing per se can help give rise to equivalence (e.g., Devany et al., 1986; Sidman & Tailby, 1982), subjects who showed 3-stage non-substitutional equivalence only on the second test of that relation (C-B) are of primary interest only in the interpretation of the following substitutional symmetry test and subsequent retesting of the 4-stage substitutional equivalence (Dsub-B).

Group trained with words and tested with faces. Of the 10 subjects trained with words and tested with faces, eight subjects (S# 2, 3, 4, 5, 6,8, 9, 10) showed equivalence on the initial 3-stage non-substitutional equivalence test (B-C). These are the primary subjects of interest in this group. Five of these eight subjects (S# 2, 6, 8, 9, 10) reached criterion in the initial 4-stage substitutional equivalence test (Dsub-B), with one additional subject (S5) reaching criterion in the second such test (B-Dsub). All of these same subjects showed 3-stage substitutional equivalence. One of the two subjects (S# 7) not showing 3-stage non-substitutional equivalence in the first test (B-C) did so in a second test (C-B). When later tested on 4-stage substitutional equivalence (Dsub-B), this subject then reached criterion. Eight of the nine subjects eventually showing non-substitutional equivalence (S# 2, 4, 5, 6, 7, 8, 9, 10) showed substitutional symmetry in the test that followed. The only subject (1) failing to show non-substitutional equivalence also failed to show substitutional equivalence. Only one subject (S3) showed non-substitutional equivalence and yet failed to show any evidence for substitutional equivalence.

Group trained with faces and tested with words. On the 10 subjects trained with faces and tested with words, nine subjects (# 12-20) showed equivalence on the initial 3-stage non-substitutional equivalence test (B-C). These are the primary subjects of interest in this group. Two of these nine subjects (S# 13, 19) reached criterion in the initial 4-stage substitutional equivalence test (Dsub-B), with one five additional subjects (S# 11, 12, 14, 15, 20) reaching criterion in the second such test (B-Dsub). All but one of these same subjects showed 3-stage substitutional equivalence (S11 did not). Of the eight subjects showing non-substitutional equivalence on the second test (S# 12, 13, 14, 15, 17, 18, 19, 20) all but one (S17) showed substitutional symmetry in the test that followed. Four subject (S# 11, 16, 17, 18) failed to show clear evidence of non-substitutional equivalence. Three of these (S# 11, 16, 18) showed substitutional symmetry, however.

Summary. Taken overall, there is fairly strong tendency to show substitutional equivalence, once equivalence with the trained stimuli had formed. Of the 16 subjects showing 3-stage non-substitutional equivalence at criterion levels on both tests, 12 (S# 2, 5, 6, 8-10, 12-15, 19, 20) showed 4-stage and 3-stage substitutional equivalence. Four subjects (S# 3, 4, 17, 18) did not. The two subjects not showing 3-stage non-substitutional equivalence at criterion levels on either test, failed to show 4-stage and 3-stage substitutional equivalence.

Asymmetries in the Ease With Which Substitutional Equivalence is Formed

A second major issue examined in this experiment was whether there is an asymmetry in the development of substitutional equivalence relations from settings to stimulus events compared to the reverse. As with the earlier question, this focuses on those subjects showing non-substitutional equivalence in the first test of that relation. The primary measure of the ease with which substitutional equivalence emerged is the performance on the first substitutional equivalence test (4-stage Dsub-B substitutional equivalence). The first test is of greatest importance to this question because both substitutional and non-substitutional equivalence emerges over repeated testing, approaching ceiling levels for both groups.

Scores on the first substitutional equivalence test were thus examined for all subjects in each group who showed non-substitutional equivalence on the first B-C test (we will term these "target subjects"). In the group trained with words and tested with faces, five of the eight target subjects reached criterion levels on the first test of 4-stage substitutional equivalence (Dsub-B). In the group trained with faces and tested with words, two of the nine target subjects similary reached criterion. Scores on the initial 4-stage substitutional equivalence test by target subjects in both groups were ranked and were analyzed using a Mann-Whitney U. Subjects trained with words and tested with faces showed a significantly greater likelihood of showing substitutional equivalence in its initial test compared to subjects trained with faces and tested with words ($U=18$, p .05, two tailed test).

DISCUSSION

Most, but not all, subjects show substitutional equivalence between verbal descriptions of settings events and the stimuli likely to have been encountered in such settings. Non-substitutional equivalence is a necessary but not suffi-

cient condition for this emergence. Subjects apparently have a pre-experimental history that enables the display of substitutional equivalence under some experimental conditions.

Consider the relevant history that might permit a smiling face to substitute for the word "holiday": The subject can be assumed to have seen a smiling face while in the circumstance of "being on holiday." The term "holiday" is in an equivalence relation with these circumstances. The spatio-temporal and functional relations between holidays and smiles permit the derivation of a linguistic relation between "holidays" and smiling faces. The face can function as the word in a subsequent situation in which neither the word nor the circumstances to which it refers is present, and thus behavior previously coordinated with the circumstance (ad the word for it) is now available with respect to the face. For example, upon seeing a smiling face, one might hear the word "holiday," imagine Acapulco, feel relaxed, taste tequila, and so on. Similary, upon seeing a smiling face, one might select B1 over B2 or B3.

A smiling face is a common stimulus encountered in any number of other circumstances, however. Because of this, we must account for the actualization of the functions of "holiday" in the equivalence test and not one of the other functions presumably inhering in a smiling face (e.g., the word "smiling" or positive feelings). In other words, why doesn't the smiling face bring to bear any number of other historical connections in the equivalence test and make it thereby impossible to match the previously unmatched comparisons?

To answer this question we appeal to the concept of context or setting. In general, and in this specific case as well, which function of a stimulus is actualized at a given time depends on the setting. The relevant setting in the present case seems to be the experimental situation. The equivalence test follows conditional discrimination training. The conditional discrimination training procedure is such as to prepare subjects to select comparison stimuli in a consistent, though arbitrary manner. The problem of incorporating three new and unexpected stimuli, a smiling face, a sad face, and a grimacing face, into a pattern of consistent responding is introduced with the onset of the equivalence test. It seems plausible that the appearance of the three faces, differing along the single dimension of affective state, actualizes the affective functions of the three words more so that the multitude of other functions inhering in them. The three verbally-described settings can also be ordered along an affective dimension. To the degree that affective functions are selected, the faces correspond to the words from the standpoint of their respective places in similar relational structures and may thereby be incorporated into a consistent pattern of responding in the equivalence test.

The same analysis can be made of the words as substitutes for the faces. In this case, however, the situation is more ambiguous. The words refer to circumstances differing along multiple dimensions, and thus the words cannot be assumed to have the same circumscribing effect on the functions of the faces, as the faces were suggested to have on the words. This may explain why subjects trained with faces and tested with words fared worse on the initial substitutional equivalence test than did those trained with words and tested with faces.

Our account is speculative. Other accounts are certainly possible, and we do not know the limiting conditions of this effect. One migh simply explain, for example, that training with words allow the words to be named, and that names are necessary for the derivation of equivalence relations (Dugdale & Lowe, 1990). Training with words might thus lead to greater substitutive equivalence.

The words and faces never appeared together in this experiment, ruling out the possibility of each having acquired the functions of the other in the experimental situation by means of experimentally-provieded histories, such as proximal or contiguous association. Thus, substitutional equivalence assesses the ways in wich pre-experimental histories are brought to bear on the experimental situation. In a word, we an examining the "meaning" of the words and faces (see Parrott, 1984, or Hayes, L. J., 1991, for further discussion). If they were without meaning the substitution we see in the present study could not have occurred.

The use of the equivalence procedure to assess pre-existing linguistic relations may permit the examination of important issues in natural language. In particular, it may permit a systematic study of the relation between contextual conditions and the application of previously acquired verbal relation or their functions. For example, in the present study the faces differed from one another along a single dimension. This may have been key to the selection of the particular functions of the words required for the demonstration of substitutional equivalence. Had the faces varied along several dimensions, the actualization of functions inhering in the words would likely have been more idiosyncratic. Suppose the faces varied not only in expression but also in age. In concert with their historical significance for individual subjects, these additional dimensions might have participated in the selection of words during the tests for substitution, especially if they provided a consistent basis for responding. For instance, had the smiling face also been an old face, the functions of "funeral" migh have been actualized instead of those of "holiday."

Network theories of meaning (Anderson, 1990) have struggled with the analysis of such contextual effects. The measurement technologies that

dominate in this area have minimized sensitivity to contextual issues and have maximized conventional meaning, however. For example, if a person is simply asked to rate a given word along several verbal dimensions, what may emerge is something more like the dictionary definition of a word that its meaning in use. The equivalence procedure may provide a much more subtle and yet precise method of assessing pre-existing linguistic relations. Furthermore, it may contribute to the direct experimental analysis of the contextual sensitiviy human subjects show to the application of linguistic relations and their functions.

REFERENCES

Anderson, J.R. (1990). *Cognitive psychology and its implications* (3rd ed.). New York: Freeman.

Catania, A.C. (1984). *Learning.* Englewood Cliffs, NJ: Prentice-Hall.

Dugdale, N., & Lowe, C.F. (1990). Naming and stimulus equivalence. In D.E. Blackman & H. Lejeune (Eds.), *Behavior analysis in theory and practice: Contributions and controversis* (pp. 115-138). Brighton, U.K.: Lawrence Erlbaum.

Ekman, P. (1976). *Pictures of facial affect.* Consulting Psychologists Press.

Hayes, L.J. (1991). Substitution and reference. In L.J. Hayes & P.N. Chase (Eds.), *Dialogues on verbal behavior* (pp. 3-14). Reno: Context Press.

Hayes, S.C. (1991). A relational control theory of stimulus equivalence. In L.J. Hayes and P.N. Chase (Eds.), *Dialogues on verbal behavior* (pp. 19-40). Reno: Context Press.

Hayes, S.C. & Hayes, L.J. (1989). The verbal action of the listener as a basis for rule governance. In S.C. Hayes (Ed.), *Rule-governed behavior: Cognition, contingencies, and instructional control* (pp. 153-190). New York: Plenum.

Hayes, S.C. & Hayes, L.J. (1992). Verbal relations and the evolution of behavior analysis. *American Psychologist, 47,* 1383-1385.

Kohlenberg, B.S., Hayes, S.C. & Hayes, L.J. (1991). The transfer of contextual control over equivalence classes through equivalence classes: A possible model of social stereotyping. *Journal of the Experimental Analysis of Behavior, 56,* 505-518.

Lazar, R. (1977). Extending sequence class membership with matching to sample. *Journal of the Experimental Analysis of Behavior, 27,* 831-392.

Parrott, L.J. (1983). Listening and understanding. *The Behavior Analyst, 7,* 29-39,

Sidman, M. (1971). Reading and auditory-visual equivalences. *Journal of Speech and Hearing Researh, 14,* 5-13.

Sidman, M., & Cresson, O., Jr. (1973). Reading and crossmodal transfer of stimulus equivalences in severe retardation. *American Journal of Mental Deficiency, 77,* 515-523.

Sidman, M. &Tailby, W. (1982). Conditional discrimination versus matching to sample: An expansion of the testing paradigm. *Journal of the Experimental Analysis of Behavior, 37,* 5-22.