Forming of classes of equivalence through a one-phase training procedure [1]

Carmen Caballero Hermosín
Mayte Gutiérrez Domínguez
Andrés García García
María Ruiz Pérez
José Luis Ruiz Noguero[2]
Faculty of Psychology
University of Seville, Spain

Abstract

This main objective of this study was to increase the number of procedures that allow the formation of classes of equivalence. The possible influence of three factors during training was analysed: 1) discrimination type (conditional discrimination with pairing *vs.* chained conditional discrimination); 2) the type of stimulus used (image or word); and 3) participants' level of studies (primary, middle school or university studies or higher). At the same time, their influence –or lack of same– on the derivation of relations was tested. A multivariate factorial design was used. We concluded that participants' educational level plays a key role in the speed at which training is acquired, and that it also influences the derivation of relations. The study also found that "chained conditional discrimination" facilitates deriving relations more than "conditional discrimination with pairing", although it seems that the structure of the procedure used for training does not significantly affect the derivation of relationships. These results encourage designing research that focuses on the pre-requisite abilities that promote the derivation of relations in order to obtain an effective teaching method for complex abilities in humans.

Key words: L*earning, classes of equivalence, chained conditional discrimination, conditional discrimination with pairing, adults.*

Resumen

El objetivo principal de este estudio era aumentar el número de procedimientos que permiten la formación de clases de equivalencia. Se analizó la posible influencia de tres variables durante el entrenamiento: 1) el tipo de discriminación (discriminación condicional con emparejamiento vs. discriminación condicional encadenada); 2) el tipo de estímulo utilizado (imagen o palabra); y 3) el nivel de

[1] La referencia del artículo en la Web es: http://conductual.com/articulos/Forming of classes of equivalence through a one-phase training procedure.pdf
[2] Correspondencia: José Luis Ruiz Noguero, Castilleja de la cuesta, 41950, Seville, Spain. Email; joseluisruiznoguero98@gmail.com.

estudios de los participantes (primaria, secundaria, universitarios o superiores). Al mismo tiempo, se comprobó su influencia -o falta de ella- en la derivación de relaciones. Para ello, se usó un diseño factorial multivariante. Se llegó a la conclusión de que el nivel de estudios de los participantes desempeña un papel fundamental en la velocidad de adquisición de la formación, y que también influye en la derivación de relaciones. El estudio también encontró que la "discriminación condicional encadenada" facilita más la derivación de relaciones que la "discriminación condicional con emparejamiento", aunque parece que la estructura del procedimiento utilizado para el entrenamiento no afecta significativamente a la derivación de relaciones. Estos resultados animan a diseñar investigaciones que se centren en las habilidades previas que promuevan la derivación de relaciones con el fin de obtener un método de enseñanza eficaz para las habilidades complejas en humanos.

Palabras clave: A*prendizaje, clases de equivalencia, discriminación condicional encadenada, discriminación condicional con emparejamiento, adultos.*

Equivalence is a psychological phenomenon that makes it possible to accelerate learning by establishing relations of equality among a set of stimuli. In this case, training a minimal number of relations among the stimuli enables people to derive the others. The present study emerged from this interest, as part of a search to develop new, valid procedures for teaching and studying complex abilities in humans.

The study of equivalence relations began with Professor Murray Sidman who used the sample equivalence procedure to study reading comprehension in a patient who, at the outset, was illiterate (Sidman, 1971, 1994). Through this procedure, the subject learned to match pictures with written words and *vice versa* and acquired the ability to read written words. Sidman demonstrated that this approach was valid for deriving reading comprehension and oral reading (García and Benjumea, 2002).

In the sample equivalence procedure, when presented with a sample stimulus, participants must select a discriminative stimulus from among various comparison stimuli (Green and Saunder, 1998). In a training phase, the correct selections according to the criterion established by the experimenter are reinforced. In the subsequent testing phase, other relations are tested without feedback. These are called derived relations because they have not been trained directly (Fiorentini, Arismendi and Yorio, 2012; Sidman, 1971). In this way, subjects learn to respond by pairing, since only one discriminative stimulus of the various comparison stimuli presented corresponds to the stimulus given as the target (Fiorentini, Vernis, Arismendi, Primero, Argibay, Sánchez, Tabullo, Segura and Yorio, 2013).

One of the common designs in this approach is shown in Figure 1 (Brodsky and Fienup, 2018). It entails training some conditional relations of the type A-B and others of the type A-C, separately, such that a new relation, B-C –not previously trained– emerges directly. For example, if subjects are taught to associate a drawing with a written word (A with B) –using a sample equivalence technique– and then that same drawing with a different word (A with C), then on the test trials a new relation between the two written words should become evident (*i.e.*, B with C) (Valero and Luciano, 1992).

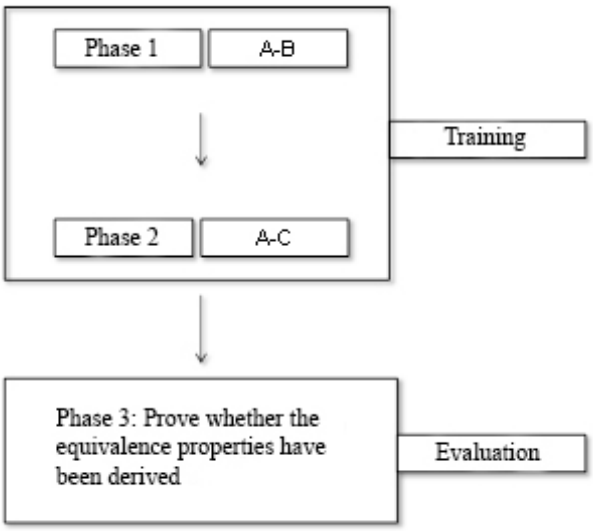

Figure 1. Classic procedure in research on equivalence.

The existence of equivalence between stimuli is confirmed when the following characteristic (Sidman and Tailby, 1982):

Reflexive relation: interchangeability of an element with itself (A=A).

Symmetric relation: inversion of the sample relation (if A=B, then B=A)

Transitive relation: transference between two mediated discriminations by some shared element (if A=B and B=C, then A=C).

When these three characteristics are present in the relationship between stimuli, they are said to be part of an equivalence class.

The interest in studying these relations stems from the importance of developing the ability to derive never-before trained relations from previously-established ones, which assumes significant progress in the study of complex forms of behaviour in humans (Gómez, García, Pérez, Gutierrez and Bohórquez, 2004). The paradigm of classes of equivalence has been widely used to analyse the acquisition of categories and concepts (Fiorentini, Arismendi, and Yorio, 2012), and has become an essential tool for studying symbolic behaviour and language, due to its potential importance as an experimental model (Dickins and Dickins, 2001; Hayes, 1986; Pérez-González 2001; Sidman, 1971; Sidman and Tailby, 1982). In addition, the phenomenon of equivalence has recently been studied in clinical contexts as a valid theoretical model for third-generation therapies (Virues, Descalzo and Vencesla, 2003; Fernández and Ferro, 2006; Ferro, Valero and López, 2009).

Another important generality that we deem fundamental for this specific study is the type of procedure employed during training. This variability goes from classic Linear Training (train A-B in order to train B-C later), through the One-to-Many procedure (A is the sample of two sets; in one, the comparisons belong to group B, in another, to group C), and the Many-to-One approach (sharing, in this case, the same group of comparisons, using B on one side as a sample and A on the other as a

comparison, and another in which C is a sample and A the comparison) (Gutiérrez and Bohórquez, 2004). In addition, Simple Discrimination (Roche and Barnes, 1997) and Simple Discrimination with Compound Stimuli (Mackay and Sidman, 1984) procedures, as well as Classic Conditioning procedures (in which A predicts the arrival of B) have all been used (Gutierrez and Benjumea, 2003, in all these procedures it is interesting to emphasise the role of stimulus pairings (Leader, Barnes and Smeets, 1996; Tonneau and González, 2004). Once the participant has had sufficient exposure to this training, she/he is shown a test in which B appears as a sample and she/he must select among A as a comparison. This is one way of exposing subjects to the symmetrical relation between A and B so that once A and B are paired, they could move on to test whether transfer B-A exists. The same would occur with the relation B-C, with the other properties of the classes of equivalence being tested later (Garcia, 2012; Gutierrez and Benjumea, 2003). Therefore, the training structure is linear series.

Diverse studies (Fiorentini, et al., 2012; Fiorentini et al., 2013) seem to indicate that there is no difference in relation to the structure of training in the formation of equivalence classes. On the other hand, it is true that there is a compilation of evidence showing that regardless of the stimuli used, learning takes place (García and Benjumea 2002). However, it is also true that there is evidence of differences between stimuli, at least in the training phase (Arntzen, Nartey and Fields, 2018; Randell and Remington, 1999). Similarly, studies show that even very young children or children with diversity are able to learn equivalency classes by the above-mentioned procedures. Of course, at different educational levels, differences in speed of acquisition, among others, are to be expected (Devany, Hayes and Nelson, 1986).

Given this diversity of approaches, the present study was designed to make it possible to establish this phenomenon using procedures that accelerate learning even more. Deriving relations that have not been trained previously supposes an advantage of a practical nature that permits greater speed in learning relations, which represents a direct benefit for learners. According to Smeets, Barnes and Luciano (1995), applying this strategy in the field of education would enhance both the performance of educational professionals and children's motivation, since they would draw larger benefits from learning at lower response costs. In addition, it would foster behaviours of a complex nature such as creativity, because it assumes, among other things, the appearance of a new, never-before reinforced, behaviour (Gómez, García, Pérez, Gutiérrez and Bohórquez, 2004).

As mentioned above, the present study arose from this interest. Its originality lies in its attempt to reduce the phases traditionally designed for these projects from two to just one, so that learners reduce their learning time by training two relations through the same discrimination.

The study posits four objectives:

1. To determine the efficacy of two new procedures for revealing the learning of the relations trained.

2. To determine whether both procedures make it possible to derive the properties of equivalence.

3. To prove the possible influence of the type of stimulus on the learning task and the derivation of relations in both procedures.

4. To analyse the influence of educational level on task performance, and on the derivation of the relations of equivalence.

The following hypotheses were derived from these research objectives:

One: both procedures will allow subjects to learn the relations trained.

Two: both procedures will allow subjects to derive the properties of equivalence.

Three: the type of stimulus will have no effect on the acquisition of discriminative learning, or on the speed with which this is acquired; nor will there be any difference in the derivation of relations. We expect no difference as both learning has taken place with both types of stimuli in previous studies (García, 2012, García and Benjumea, 2002)

Four: there will be no differences in the acquisition of relations according to educational level, as even with young children this learning has occurred (García and Benjumea, 2002). Even so, there will be differences in the speed with which subjects acquire them depending on this variable. We hypothesize that those with only "primary school" education will require more trials than the "Middle school" and "University studies" groups, and that the latter will need the lowest number of trials to meet the criterion.

Method

Participants

A total of 60 participants were recruited, 15 for each experimental group. They were selected on the basis of accessibility. Participants' ages ranged from 20 to 46 years. In each experimental condition, subjects were put in groups of five according to their level of studies: "primary school", "middle school" and "university studies or higher". That is, adults who had only attained primary, secondary or higher education.

Materials

All materials used were prepared *ad hoc* with Microsoft Office PowerPoint 2007. A total of 24 stimuli were designed, and then formed into four classes. Each class was made up of three elements. Element A was defined as "Painter" and represented by the artist's photograph or name. Element B was defined as the "Painter's nationality" and represented by the country's flag or name. Element C was defined as the "Painter's work" and was symbolized by an image of the painting or its title. These stimuli are shown in Tables 1 and 2 according to their format.

Table 1. *All stimuli in word format.*

	A	**B**	**C**
Class 1	Mauricio Rugendas	Germany	*El malón*
Class 2	Andrés Masson	France	*Back to the execution*
Class 3	Víctor Brauner	Rumania	*Adam and Eve*
Class 4	Miguel Condé	Mexico	*Dispute of the Oracles*

Table 2. *All stimuli in image format.*

	A	B	C
Class 1			
Class 2			
Class 3			
Class 4			

Scorecards were prepared to collect the data, one for each type of discrimination, and one for each type of test, so that one side shows the number of the test and the position of the correct element, while the other shows a blank box that subjects had to fill in with the position they selected (see Appendix I).

To measure the independent variable, "level of study", a brief survey with open questions was elaborated to gather information on participants' educational level. All information regarding official studies was collected through this questionnaire, which consisted of specific questions about the participants' education (see Appendix II).

An Informed Consent Model was also composed in which each participant agreed to collaborate with the present research and gave permission for the results obtained on their performance to be used in the scientific study proposed (see Appendix III).

Design

Three independent variables were analysed: "type of discrimination", "type of stimulus" and "level of studies". The first had two values – "conditional discrimination with pairing" *vs.* "chained conditional discrimination"– and examined the type of discrimination used for the learning task (Arntzen, 2004; Holcombe et al., 1993). The second variable analysed the "type of stimulus" used during the

learning task. It also had two values: "image" and "word". The third independent variable, "level of studies", was codified to determine the possible influence of participants' educational level on task performance. It had three values: "primary school", "middle school" and "university studies or higher". Five participants representing each one of the values of this variable were assigned to each experimental condition. The training is done by truncating multiphase trials, therefore, although with the same phases as in the aforementioned studies, a different configuration is given.

Thus, this study had a 2 x 2 x 3 multivariate factorial design. Table 3 shows the different study conditions.

Table 3. *Experimental conditions as a function of the independent variables.*

	Discrimination with pairing			**Chained discrimination**		
Image	Primary school	Middle school	University studies	Primary school	Middle school	University studies
Word	Primary school	Middle school	University studies	Primary school	Middle school	University studies

In order to analyse whether participants acquired the learning of the relations during the task, the "Discriminatory training measure" was considered as a dependent variable, expressed by the trial number. The criterion of correct responses was 20 consecutive correct trials. Only at that point were the relations trained deemed to have been acquired.

For those subjects who had acquired discriminatory learning, the "derivation of the response of equivalence between stimuli" was recorded as a second dependent variable. Two measures were taken: first, the percentage of correct responses for each property of equivalence (Reflexivity, Symmetry, Transitivity and Equivalence) on a total of 4 trials for each property, except Symmetry, which was measured in two relations and, therefore, required 8 trials. A property was considered to have been obtained when a participant achieved 75% of correct responses. Second, a global measure of Derivation was used: we considered that subjects had successfully derived when the percentage of correct responses for all properties was equal to or greater than 75%.

Procedure

All trials were conducted in a room furnished with a table and two chairs, one for the experimenter, the other for the participant. Subjects were given a headset to help them concentrate and to ensure that they listened to the auditory stimulation that the program presented. All experimentation was performed using an HP ProBook with Windows 7 to display the materials in the different phases of the study.

After signing the consent agreement, subjects were asked to fill out a brief survey to collect basic sociodemographic information (see Appendix II), then they were assigned to one of the conditions according to their educational level until the groups for each condition were formed.

Figure 2 shows the phases of the study. The first phase involved a test to discern whether or not the participant had already acquired the relations between the stimuli that were going to be trained. If they passed this test, then they proceeded to the second phase, which consisted in a learning task based on conditional discriminations. In this phase, subjects received feedback on their performance. Once the response criterion was satisfied, the third phase took place to verify whether the training had allowed the participant to derive relations between stimuli that had not been trained before. Subjects did not receive feedback in either one of these two testing phases, which were of a longitudinal character.

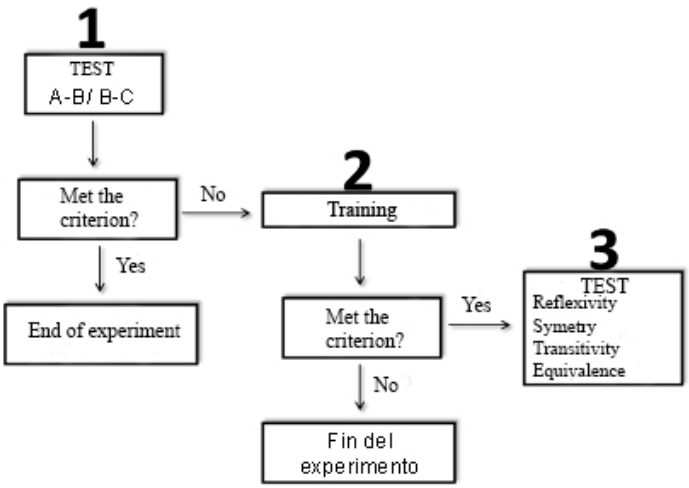

Figure 2. Phases of research.

Phase 1: Pre-training tests

Two pre-training tests were designed. The first probed the relation between element A, "Painter", and element B, "Painter's country" (see Figure 3). The second measured the relation between B, "Painter's country", and between, C "Painter's work" (see Figure 4). Subjects performed a total of 8 trials on both tests. To consider that the relations had been acquired, subjects' performance had to surpass 80% of correct responses. It should be emphasised that the instructions given are only the continuation of the procedure, in the event that the subject meets the requirements.

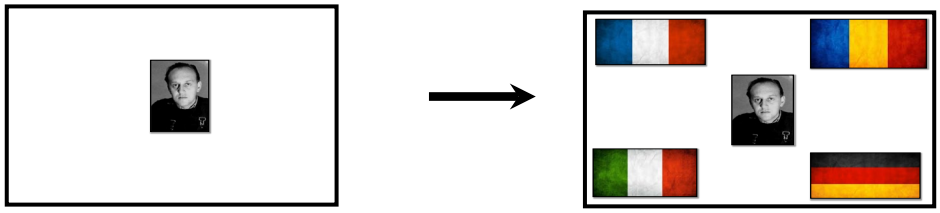

Figure 3. Relation A-B example (image).

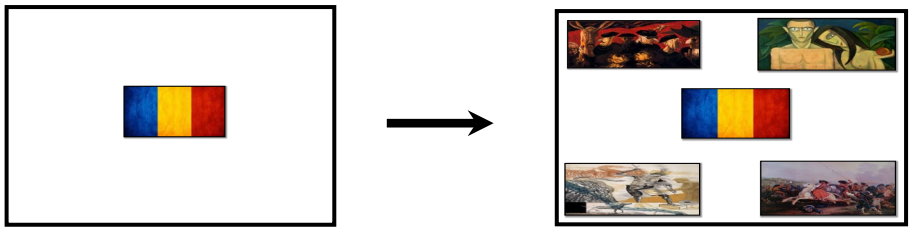

Figure 4. Relation B-C example (image).

For this phase, participants received the following instruction, which varied only in the type of stimulus used:

Next, an image will appear in the middle of the screen. You must click on it. Once you click, four other pictures will appear, one in each corner of the screen. You must select only one; the one that you believe corresponds to the image in the middle of the screen.

If the participant satisfied the response criterion, the trial ended; if not, she/he moved on to phase 2 of the experiment (see Figure 2).

Phase 2: Training

A total of 80 tests for each condition were designed. The position of each element was randomized in each trial (see Appendix IV). When a new test was presented, a sample with four comparisons appeared. The exact nature of the test performed depended on the condition or group to which the participants had been assigned.

First, the work was with *conditional discrimination with pairing*. In this condition, participants received the instructions shown below. The only variation was in the type of stimulus used:

Next, an image will appear in the middle of the screen. You must click on it. Once you click, four other pictures will appear, one in each corner of the screen. You must select only one; the one that you believe corresponds to the image in the middle of the screen. You will notice that the program tells you if your choice is correct or not. If the program indicates that you chose the correct option, do not do anything; wait until the next word appears in the middle of the screen and then repeat the same procedure.

During the presentation of the sample (Element A), and after the observation response, four comparisons appeared (Element B), of which only one was correct. If the correct comparison was not selected, a 2-second time-out occurred, after which the same test was shown again. Once the correct comparison was chosen, element C appeared for 5 seconds together with a sound (applause for getting it right, as a likely reinforcer). This was followed by a 2-second interval between tests. The training ended after 20 consecutive correct trials. Then, a new test requiring the same procedure appeared. An example of this can be seen in Figure 5.

Secondly, the work was done with *chained conditional discrimination*. The instructions presented to participants in this condition are shown below. The only element that varied was the type of stimulus used:

Next, an image will appear in the middle of the screen. You must click on it. Once you have, four other pictures will appear, one in each corner of the screen. You must select only one, the one that you believe corresponds to the image in the middle of the screen. You will notice that the program will tell you if your choice is correct or not.

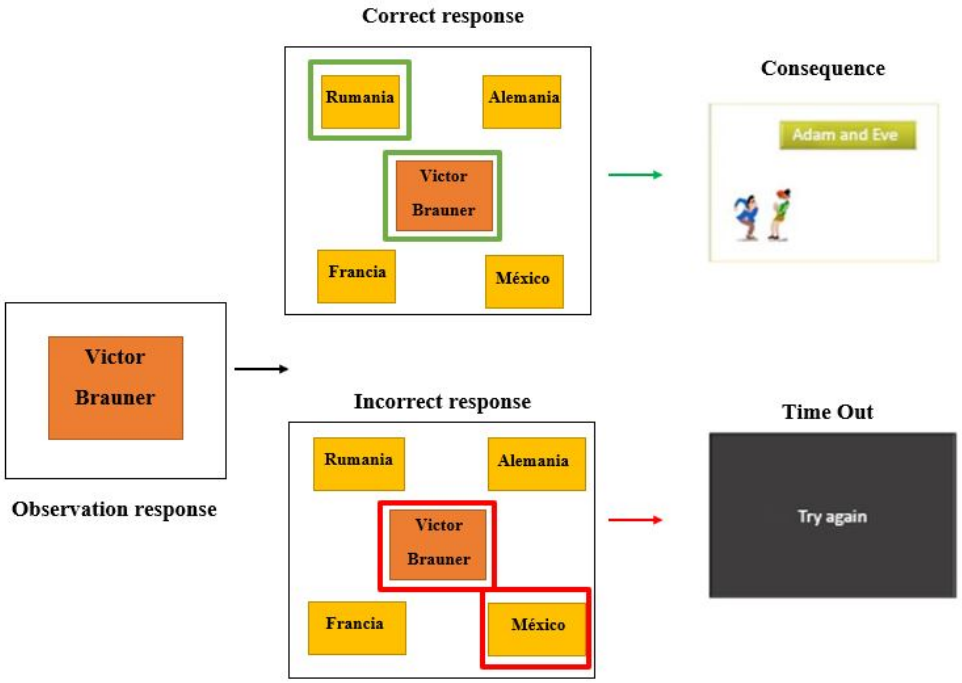

Figure 5. Test for the condition "Discrimination with pairing".

The beginning of this test is the same as in the previous case, only that when the correct comparison was selected, a new one appeared. This is where the difference with the previous discrimination lies. Element B moved in the PowerPoint presentation without the subject making any response to the central position. Hence, element B changed from being a comparison to serving as a sample of the second discrimination. Next, four new elements appeared (Element C) as comparisons, only one of which was correct. The consequences applied to both correct and incorrect responses were the same as in the previous conditions. An example of this procedure is shown in Figure 6.

Phase 3: Post-training test

Once the criterion of response –*i.e.*, 20 consecutive correct trials– was achieved, a post-training test was presented to check the derivation of the properties of equivalence. To this end, a test was designed for each class of element, so that there were 4 tests for each property to be evaluated (Reflexive, Transitive and Equivalence), except for symmetry, which was evaluated in two relations (B-A and C-B) and, therefore, required 8 tests. Participants thus performed a total of 20 tests. The criterion of response was a score above 75% for each property. Note that the criterion applied for the training phase differed from the one used in the testing phase. This is because the number of trials in the testing phase for each property was only 4, which means that a score above 75% (3 correct responses out of a total of 4) comes out to 100% since it impedes the score of 80% that was considered in the earlier phase.

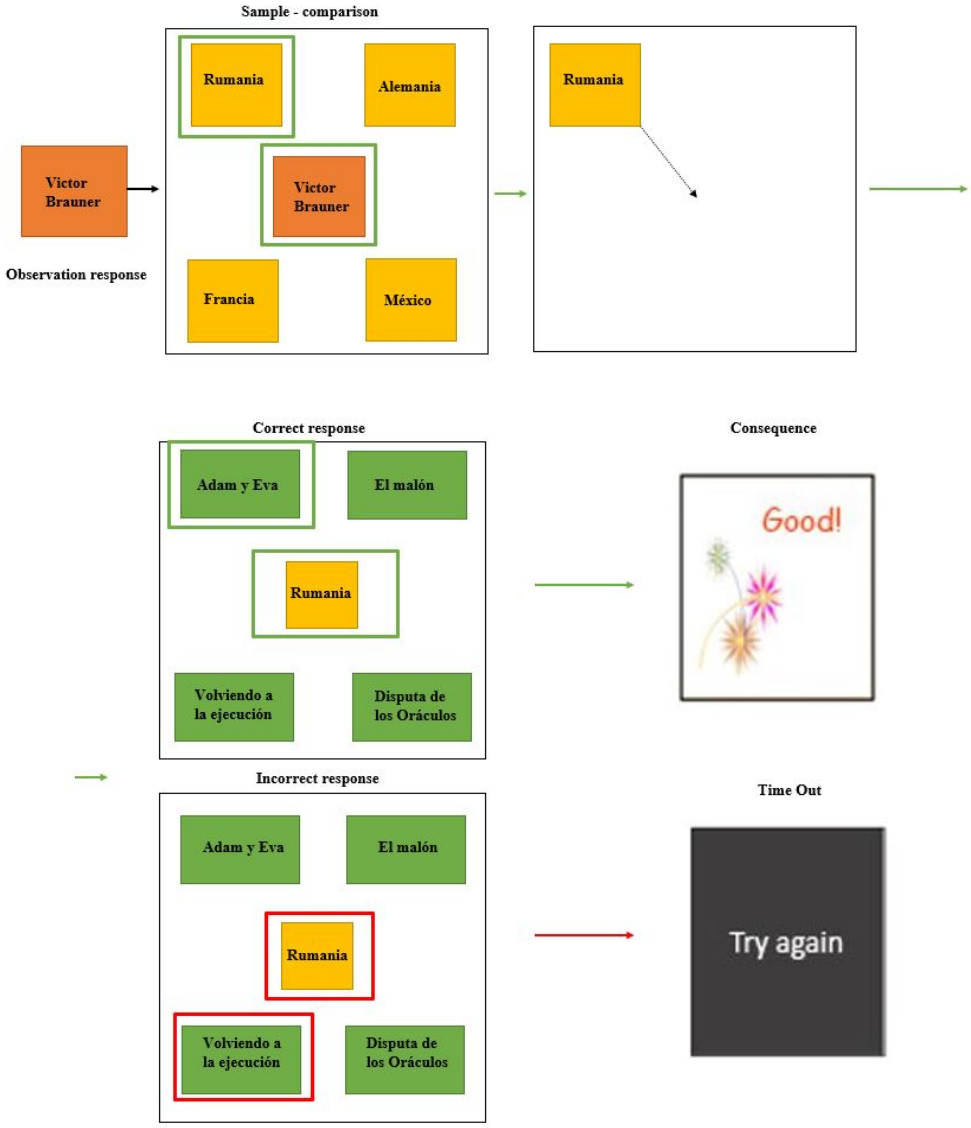

Figure 6. Test for the "Chained discrimination" condition.

Data analysis

SPSS Windows (Version 20) was used for all statistical analyses. To analyse whether there were differences with respect to the variables "type of stimulus", "type of discrimination" and "level of studies" during the learning of the task, a univariate ANOVA was performed. A *post hoc DHS Tukey* test was applied to measure if the differences between the conditions of the variables were significant or not.

To determine whether "type of stimulus", "type of discrimination" and "level of studies" had effects on the derivation of each one of the properties of equivalence, another univariate ANOVA was carried out, also verified by a *post hoc DHS Tukey* test.

In addition, these three variables were tested in the "Global derivation" by applying a Chi-squared test, which was also performed by layers in an analysis designed to determine whether the variable "level of study" influenced the relation between "type of discrimination" and "Global derivation".

For the interactions between variables that turned out to be significant in the inter-subject tests, a one-factor ANOVA was done to determine in which conditions those differences were significant.

Results

Phase 1: pre-training test

None of the participants in this study satisfied the criterion of response in the first phase of testing; therefore, they moved on to phase 2 of training.

Phase 2: training

During the training phase, the university-level subjects needed the fewest trials to learn the relations, followed by the middle school group. The subjects in the primary school group needed the most trials. The specific condition for which those participants required more trials was "Conditional discrimination with pairing" with the image format.

The analysis of variance showed that the effect of "type of stimulus" was not significant, $F(1,48)=.55$,$p=.459$, $R^2=.011$. The effect of "type of discrimination" was not significant either, $F(1,48)=2.13$,$p=.150$, $R^2=.043$. In contrast, there were significative differences for the variable "level of studies", $F(2,48)=90.09$, $p=.000$, $R^2=.79$. These differences are shown in Figure 7. No between-variables interactions were significant.

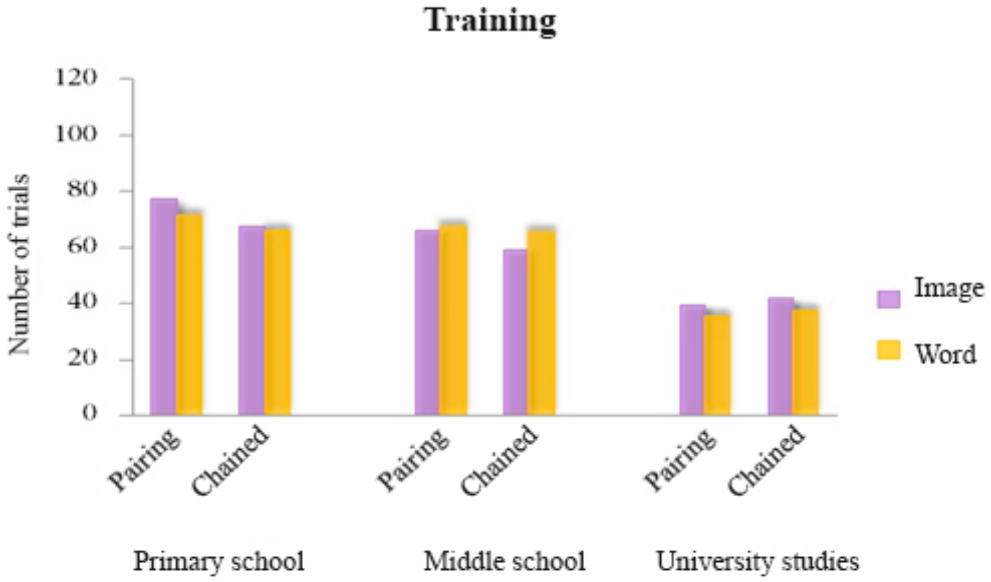

Figure 7. Average number of trials required to achieve the criterion.

The *post hoc DHS Tukey* tests for comparison of multiple samples show that the differences are significant for all three conditions of the variable "level of studies", as follows: between Primary school (M=70.50) and Middle school (M=64.10) (p=.037), between Primary school and University studies (M=38.60) (p=.000), and finally, between Middle school and University studies (p=.000).

Phase 3: post-training test of each equivalence class

To analyse the derivation of the relations, the influence of the three independent variables on the percentage of individual correct responses for each property was also examined statistically.

-Reflexivity

On the test of Reflexivity, all subjects obtained an average of M=100, DT=.000; thus satisfying the criterion. There were no differences for any of the independent variables: "type of stimulus", $F(1,48)$= 1.00, p=.322, R^2=.020, "type of discrimination", $F(1,48)$= 1.00,p=.322, R^2=.020, or "level of studies", $F(2,48)$= 1.00,p=.375, R^2=.040. No interactions proved to be significant.

- B-A symmetry

For the B-A Symmetry relation, all subjects derived this relation with an average of M=100, DT=.000, except those who belonged to the "Discrimination with pairing" sub-group of Primary school participants with the image type of stimulus, who obtained an average of M=95, DT=11.18.

The analysis of variance found that no significant effects existed for any of the independent variables, as shown in Figure 8: "type of stimulus", $F(1,48)$= 1.00, p=.322, R^2=.02, "type of discrimination", $F(1,48)$= 1.00,p=.322, R^2=.02, and "level of studies", $F(2,48)$= 1.00,p=.375, R^2=.04. The interactions were not significant either.

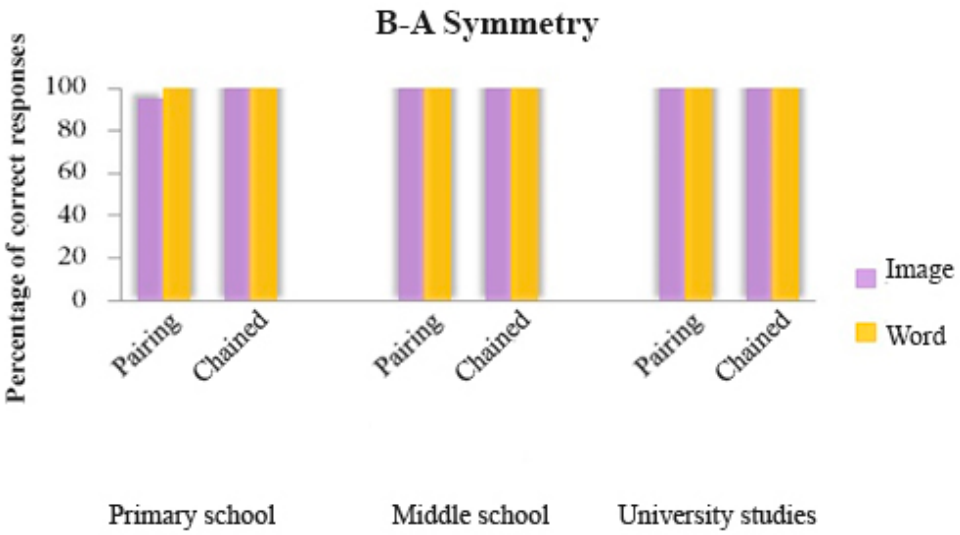

Figure 8. Average number of correct responses for B-A Symmetry.

- C-B symmetry

For the test of C-B Symmetry, as Figure 9 shows, the percentage of correct responses for the Primary school participants was lower than for the other subjects in the "Discrimination with pairing" condition; however, they obtained 100% in the "Chained conditional discrimination" condition. Similar results were achieved by the Middle school participants, who obtained a lower percentage of correct responses for "Conditional discrimination with pairing" but approached 100% for "Chained Discrimination". The University-level subjects obtained 100% on both types of discrimination.

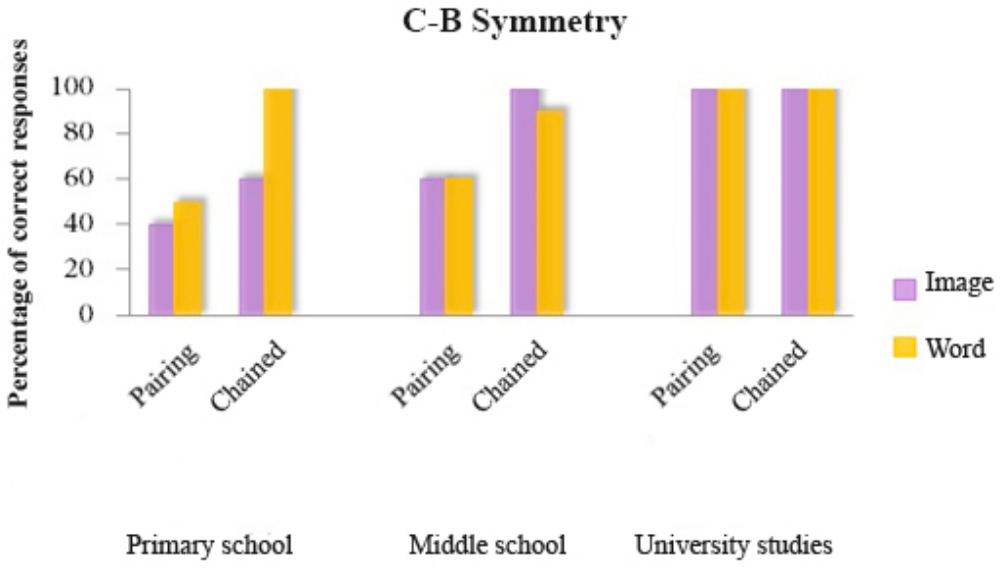

Figure 9. Average number of correct responses for C-B Symmetry.

Here, the analysis of variance showed that the difference due to "type of stimulus" was not significant, F (1,48)=.00, p=1.00, R^2=00. In contrast, this same analysis revealed that "level of study" had a significant effect on the C-B Symmetry test, F (2,48)= 6.48, p=.003, R^2=02. Moreover, the type of discrimination also had a significant effect, F(1,48)= 20.40,p=.000, R^2=.29, and the interaction "level of studies x type of discrimination" also proved to be significant, F(2,48)= 5.85,p=.005, R^2=.19. This result will be analysed below.

A confirmation test was run using *post hoc* tests for the variable "level of study" with a *DHS Tukey* test. This analysis showed that the difference in the means between "Primary school" (M=72,5) and "Middle school" (M=77,5) was significant (p=.813), as was the difference between the means for the "Primary school" and "University studies or higher" groups (M=100) (p=.004). The difference in the means between the University studies and Middle school subjects (p=.813) also proved to be just as significant (p=.021).

-Interaction of "level of studies × type of discrimination" in C-B Symmetry

A one-factor ANOVA was performed for each level of the variable "level of study". The only significant difference found between the types of discrimination occurred among the Primary school participants, $F(1,19)= 18,45$, $p=.000$, who obtained an average of $M=45$, $DT=40,48$ for "Conditional discrimination with pairing". For the "Chained conditional discrimination", they obtained an average of $M=100$ for correct responses $DT=.00$, as shown in Figure 9.

-Transitivity

The University or higher participants obtained an average of 100% of correct responses, except for those who were assigned to the "Chained conditional discrimination" condition with image format, whose score was 90%. The participants who obtained the lowest percentage of correct responses were from the Primary school group assigned to the "discrimination with pairing" task (20% and 35% of correct responses). The percentage of correct responses increased in the "Chained Discrimination" condition in both the Primary school and Middle school groups.

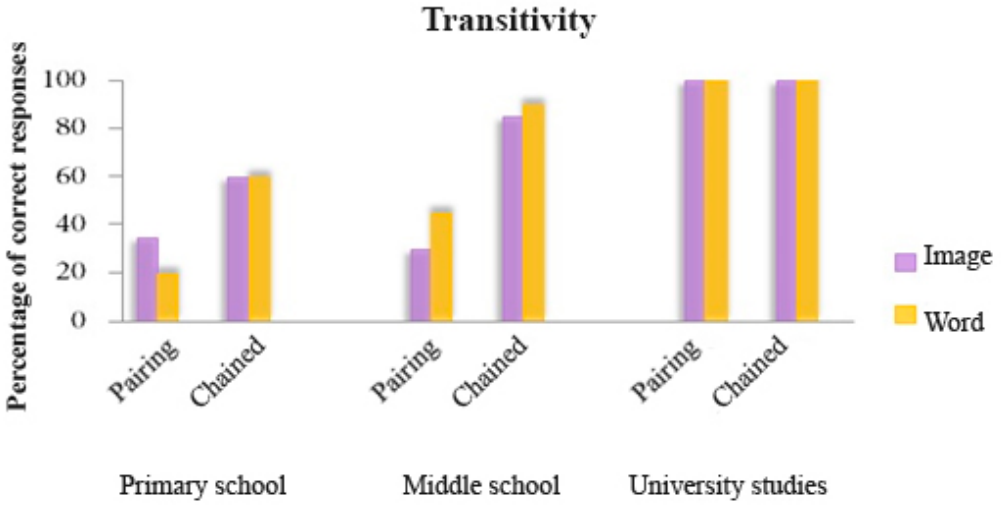

Figure 10. Average number of correct responses for Transitivity.

Figure 10 presents the results for the test of Transitivity. The analysis of variance showed that the influence of "type of stimulus" was not significant, $F(1,48)= 0.84$, $p=.773$, $R^2=.00$, but that the variables "type of discrimination", $F(1,48)= 8.98$, $p=.004$ $R^2=.15$, and "level of studies", $F(2,48)= 13.35$, $p=.000$ $R^2=.35$, did have an effect on the test of Transitivity. Interaction did not prove to be significant.

The *post hoc* test and, specifically, the *DHS Tukey* test, showed that the difference in the percentages of correct responses between the Primary school ($M=43,75$) and Middle school participants ($M=62,50$) was not significant ($p=.188$). The difference between Primary school and University studies subjects, in contrast, did prove to be significant ($M=97,50$), ($p=.000$). The difference in the means between the Middle school and University studies groups also turned out to be significant ($p=.005$).

-Equivalence

On the test of Equivalency, the mean percentage of correct responses by the University-level students was 100%, except for those assigned to the "Chained conditional discrimination" condition with image format. Once again, the Primary school subjects obtained the lowest percentage of correct responses, and both the Middle school and Primary school participants obtained higher percentages of correct responses for the "Chained discrimination" condition than on the "Discrimination with pairing" condition. No such difference appeared in the University-level group.

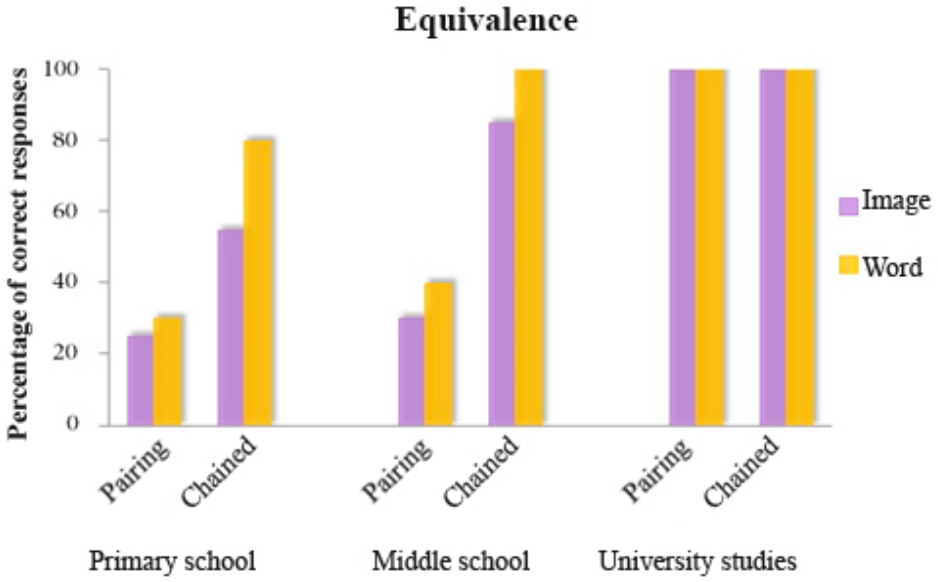

Figure 11. Average number of correct responses on Equivalence.

The between-conditions differences can be seen in Figure 11. The analysis of variance showed that there were no significant differences for the effect of "type of stimulus", $F(1,48)= 1.99$, $p=.165$, $R^2=.40$, but differences for the variable "type of discrimination" were found, $F(1,48)= 13.15$, $p=.001$ $R^2=.40$. Also significant was the effect of "level of studies" on the Transitive property, $F(2,48)= 12.01$, $p=.000$, $R^2=.33$. There were no significant effects between interactions.

The *post hoc* tests showed that the differences between the Primary school ($M=47,50$) and Middle school ($M=63,75$) subjects were not significant ($p=.254$), but that those between the Primary school and University studies or higher groups were significant ($M=96,25$), ($p=.000$), as was the difference between the Middle school and University studies participants ($p=.007$).

Phase 3: global post-training test

When the percentage of correct responses surpassed 75% for each property of equivalence (Reflexivity, Symmetry, Transitivity, Equivalence), a Global derivation was considered to have been obtained. To analyse the influence of each independent variable on the Global derivation, a Chi-squared test was applied. First, the effect of "type of stimulus" was measured, but no significant effect was found, χ^2 (1) =.287, $p=.592$, $R^2=.06$. However, the effect of "type of discrimination" did prove to be significant, χ^2 (1) = 4.593, $p=.032$, $R^2=.27$, as did the effect of "level of studies" on the derivation of relations χ^2 (1) = 13.923, p =.001, $R^2=.46$.

The "Chained conditional discrimination" condition produced a higher percentage of correct responses than "Conditional discrimination with pairing" in both the Primary school and Middle school groups. In fact, the "Conditional discrimination with pairing" condition in both of these groups generated a higher percentage of FAILED derivations than VALID ones. The participants with University studies obtained a much higher percentage than all other subjects for both discriminations.

To establish whether "level of studies" influenced the relation between "type of discrimination" and the Global derivation, a layered Chi-squared test was performed. The variable "type of stimulus" was eliminated because it failed to reach the level of significance in the previous analysis. This analysis showed that there was no significant effect on the Primary school subjects (χ^2 (1) = 3.333 p =.068, R^2=.40) of either variable, despite the large magnitude of the difference. This may have been due to the dispersion of the data. There was a significant effect on the Middle school subjects, χ^2 (1) = 5.051, p =.025, R^2=.50, but no significant effect on the University studies group, χ^2 (1) = 1.053, p =.305, R^2=.22.

Discussion

The first goal of this study was to test the efficacy of two new procedures. By the end of the training phase, all subjects had achieved the response criterion, regardless of the discrimination condition in which they were trained. The procedures designed for this research performed the two potential relations in the same test (A-B; B-C). Results show that both are valid for teaching relations between stimuli and, therefore, reduce the amount of training time require, thus accelerating the process of learning relations. Therefore, the structure of the procedure used for training does not significantly affect the derivation of the relationships (Fiorentini, Arismendi and Yorio, 2012).

This result fulfils our first research objective and confirms the first hypothesis proposed, which entailed designing two new teaching tools. Moreover, using these strategies makes it possible to control the conditions in which learning is produced: if the conditions in which learning arises could be understood, then it would be easier to determine the causes of its absence.

The variable "type of stimulus" had no effect on the task. This finding confirms another hypothesis, and encourages the use of any kind of stimulus to increase the generality of these procedures. This will make it possible to adapt the strategy to all types of content and to base education on valid experimental designs.

Differences in the speed of acquisition at the different educational levels were found, as the University participants learned the task faster than the others. The subjects who required the largest number of trials were those in the Primary school group. This proves that, while both discriminations proved to be effective procedures, faster or slower learning processes will be generated according to the abilities of each individual. This leads to the question: what type of abilities foster generating a faster learning process? But this opens up a whole new field for research on human learning. In this regard, Díaz, García, Gutierrez and Martínez (1994) have already published evidence that educational level determines the number of trials required to discover a rule.

The second objective was to determine whether or not these procedures allowed the derivation of relations. In this case, our results varied according to the type of property involved. For the Reflexivity and B-A Symmetry tests, all subjects acquired the criterion with no differences and, moreover, could invert the relation that was trained in that phase. However, this did not occur on the other tests. For C-B

Symmetry, Transitivity and Equivalence, only the University participants derived the relations correctly and, therefore, were able to form the class of equivalence between stimuli using both discriminations. The participants in the Middle school and Primary school groups achieved results similar to those of the University-level subjects in the "Chained discrimination" condition, but these results were not replicated in the "Conditional discrimination with pairing" condition. On the latter, the percentage of correct responses decreased, and most subjects were unable to derive any of the properties. These findings confirm that "Chained discrimination" facilitates the process of deriving relations among Primary school and Middle school subjects, *but does not* support the hypothesis proposed, since we predicted that the derivation of relations between the independent variables would be accomplished without differences.

This difference between the discriminations may be due to the fact that in the "Chained discrimination" procedure explicit training took place on the relations between elements B-C, thus facilitating their discrimination. However, in the "Discrimination with pairing" condition, element C appeared contiguous to the consequence. In view of our results, it seems clear that only the participants with a higher level of study were able to relate this element directly to the previous ones, so the simultaneity between displaying Element C and the consequence was insufficient to permit the formation of classes of equivalence among our Primary and Middle school participants. Perhaps this issue could be resolved by asking subjects for an observation response while the consequence and Element C are present, as this would allow us to make sure that participants understand that element.

Gómez (2009) pointed out that –as both "naming" theory and relational-frame theory argue– verbal stimuli are transformed into "symbols" through a process that abstracts their properties. This seems to be an ability that appears more frequently in people with higher levels of education. Here, different educational levels would provide greater or lesser experiences of learning that would generate a higher ability to discriminate the relations among those "symbols".

The Global derivation analysis conducted herein confirms the results described above. All the university participants derived successfully in both discriminations, but this was not the case for our Middle school or Primary school subjects. This indicates that deriving relations depends strongly on the level of study, while the type of discrimination was significant for the Middle school and Primary school groups, because the "Chained conditional discrimination" condition increased the probability of generating the correct derivation.

Finally, although both procedures are equally valid at the time of learning relations, it seems that only one ensures that the derivation of relations will be accomplished successfully by participants with, and without, higher levels of study. It is important to emphasise that these results *do not* show that "Conditional discrimination with pairing" is invalid, only that it requires a higher level of abilities. Since the goal of our research is to design new teaching methods, this data encourages us to modify this procedure so that it facilitates establishing relations without previous training.

Conclusions

— The two procedures designed are effective for learning relations between stimuli.

— The higher participants' levels of study, the higher the speed with which the task is acquired.

— There is a higher probability that the properties of equivalence will be derived as educational level increases.

— "Chained conditional discrimination" makes deriving relations more likely than "Conditional discrimination with pairing".

— The type of stimulus does not influence the acquisition or derivation of the properties of equivalence.

Conflicts of interest

The authors have no conflicts of interest to declare that are relevant to the content of this article. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript. The authors have no financial or proprietary interests in any material discussed in this article.

References

Arntzen, E (2004). Probability of Equivalence Formation: Familiar Stimuli and Training Sequence. *Psychological Record 54*, 275–291 (2004). https://doi.org/ 10.1007/BF03395474

Arntzen, E., Nartey, R. K., & Fields, L. (2018). Reorganization of equivalence classes: effects of preliminary training and meaningful stimuli. Journal of the Experimental Analysis of Behavior, 109(3), 564–586. doi:10.1002/jeab.329

Brodsky, J. & Fienup, D. (2018). Sidman Goes to College: A Meta-Analysis of Equivalence-Based Instruction in Higher Education. *Perspectives on Behavior Science. 41*. 95-119. 10.1007/s40614-018-0150-0.

Devany, J., Hayes, S. & Nelson, R. (1986). Equivalence class formation in language-able and language-disabled children. Journal of the experimental analysis of behavior. 46. 243-57. 10.1901/jeab.1986.46-243.

Díaz, A. García A., Gutiérrez, J.M. & Martínez, V. (1994). Uso de contrastes ortogonales en diseños mixtos. *Un caso concreto: El efecto del entrenamiento y el nivel educativo en el descubrimiento de reglas*. Conferencia llevada a cabo en la V jornada de fomento de la Investigación en Psicología. Universidad de Sevilla, España.

Dickins, T. E., & Dickins, D. W. (2001). Symbols, stimulus equivalence and the origins of language. *Behaviour and Philosophy*, *29*(1), 221-244. https://www.jstor.org/ stable/27759429?seq=1

Fernández, A. & Ferro, R. (2006). Psicoterapia Analítico-Funcional: Una aproximación contextual funcional al tratamiento psicológico. *EduPsykhé: Revista de psicología y psicopedagogía*, *5*(2), 203-230. https://dialnet.unirioja.es/servlet/ articulo?codigo=2147834

Ferro, R. Valero, L. & López,,M.A. (2009). La conceptualización de casos clínicos desde la psicología analítica funcional. *Papeles del psicólogo*, *30*(3), 255-264. https://dialnet.unirioja.es/servlet/articulo?codigo=3066287

Fiorentini, L., Arismendi, M., & Yorio, A.A. (2012). Una revisión de las aplicaciones del paradigma de equivalencia de estímulos. *International Journal of Psychology and Psychological Therapy*, *12*(2),261-275. https://www.ijpsy.com/ volumen12/num2/330/una-revisin-de-las-aplicaciones-del-paradigma-ES.pdf

Fiorentini, L.; Vernis, S.; Arismendi, M.; Primero, G.; Argibay, J.; Sánchez, F.; Tabullo, A.; Segura , E. & Yorio, A. (2013). Relaciones de equivalencia de estímulos y relaciones de equivalencia-equivalencia: efectos de la estructura de entrenamiento. *International Journal of Psychological Therapy, 13*(2), 233-242. https://www.ijpsy.com/volumen13/num2/358/relaciones-de-equivalencia-de-estmulos-ES.pdf

García, A. & Benjumea, S. (2002). Orígenes, ampliación y aplicaciones de la equivalencia de estímulos. *Apuntes de Psicología, 20* (2), 171-186. https://idus.us.es/handle/11441/67091

García, A. (2012) *Aprendizaje Complejo*. Sevilla, España. Ediciones San Bernardo.

Gómez, J. (2009). *La simetría como operante generalizada. Propiedades de las clases de equivalencia y teoría de los ejemplares.* [Tesis de doctorado, UNED]. Dialnet. https://dialnet.unirioja.es/servlet/tesis?codigo=43340

Gómez, J., García, A., Pérez, V., Gutiérrez, M. T. & Bohórquez, C. (2004). Aportaciones del análisis conductual al estudio de la conducta emergente: algunos fenómenos experimentales. *Revista Internacional de Psicología y Terapia Psicológic*a, *4*(1), 161-191. https://dialnet.unirioja.es/ servlet/articulo?codigo=890829

Green, G. & Saunders. R. (1998). A discrimination analysis of training-structure effects on stimulus equivalence outcomes. *Journal of the experimental analysis of behaviour, 72*(1), 117,137. https://doi.org/10.1901/jeab.1999.72-117

Gutiérrez, M.T. & Benjumea, S. (2003). Formación de clases funcionales utilizando, un entrenamiento de condicionamiento clásico. *Revista Latinoamericana de Psicología*, *35*(2), 65-174. https://www.redalyc.org/pdf/805/80535204.pdf

Hayes, S. C. (1986). Behavioral philosophy in the late 1980's. *Theoretical and Philosophical Psychology, 6,* 39-43. https://doi.org/10.1037/h0091405

Holcombe, A., Wolery, M., Werts, M.G. et al. (1993). Effects of instructive feedback on future learning. *Journal of Behavioral Education 3*, 259–285. https://doi.org/10.1007/BF00961555

Leader, G., Barnes, D. & Smeets, P.M. (1996). Establishing Equivalence Relations Using a Respondent-Type Training *Procedure. Psychol Rec 46*, 685–706. https://doi.org/10.1007/BF03395192

Mackay, H.A. & Sidman, M. (1984). Teaching new behavior via equivalence relations. En P.H. Brooks, R. Sperber y C. McCauley (Eds.), *Learning and cognition in the mentally retarded*, 493-513. Hillsdale, NJ: Lawrence Erlbaum Associates.

Pérez-González, L. (2001) Proceso de aprendizaje de discriminaciones condicionales. *Psicothema, 13*(4), 650-658. http://www.psicothema.com/psicothema.asp? id=493

Randell, T., & Remington, B. (1999). Equivalence relations between visual stimuli: The functional role of naming. Journal of the Experimental Analysis of Behavior, 71(3), 395–415. https://doi.org/10.1901/jeab.1999.71-395

Roche, B. & Barnes, D. (1997). A transformation of respondently conditioned stimulus function in accordance with arbitrarily applicable relations. *Journal of the Experimental Analysis of Behavior, 67(1)*, 275-300. https://doi.org/ 10.1901/jeab.1997.67-275

Sidman, M. & Tailby, W. (1982). Conditional discrimination vs. matching to sample. An expansion of the testing paradigm. *Journal of the experimental analysis of behaviour, 37*(2), 5-22. https://onlinelibrary.wiley.com/doi/abs/10.1901/ jeab.1982.37-5

Sidman, M. (1971). Reading and auditory-visual equivalences. *Journal of Speech & Hearing Research*, *14*(1), 5-13. https://pubs.asha.org/doi/10.1044/jshr.1401.05

Sidman, M. (1994). *Equivalence relations and behavior: A research story*. Authors Cooperative.

Smeets, P.M., Barnes, D. & Luciano, M.C. (1995). Total reversal of emergence simple discrimination in children: A component analysis. *Journal of Experimental Child Psychology*, *60 (1)*, 327-343. https://doi.org/10.1006/jecp.1995.1044

Tonneau, F., & González, C. (2004). Function transfer in human operant experiments: The role of stimulus pairings. Journal of the Experimental. *Analysis of Behavior, 81*, 239-255

Valero, L. & Luciano, M.C. (1992) Relaciones de equivalencia: Una síntesis teórica y los datos empíricos a nivel básico y aplicado. *Psicothema*, *4*(2), 413-428. http://www.psicothema.com/psicothema.asp?id=842

Virues, J. Descalzo, A. & Vencesla, J. (2003). Aspectos funcionales de la psicoterapia analítico funcional. *Revista asociación española Neuropsiquiatría, 88(3),* 49-69. https://doi.org/10.4321/s0211-57352003000400005

Appendix I

Scorecard: "Discrimination with pairing"

Subject Image/Word Total number of trials

Trial	Correct position	Marked position
1	2	
2	1	
3	4	
4	1	
5	2	
6	2	
7	1	
8	2	
9	4	
10	4	
11	2	
12	2	
13	1	
14	2	
15	2	
16	4	
17	1	
18	2	
19	2	
20	4	
21	1	
22	4	
23	2	
24	1	
25	2	
26	1	
27	2	
28	4	
29	2	
30	4	
31	1	
32	2	
33	2	
34	1	
35	2	
36	2	
37	4	
38	4	
39	2	
40	4	

41	1	
42	2	
43	2	
44	2	
45	2	
46	4	
47	1	
48	4	
49	2	
50	4	
51	2	
52	2	
53	2	
54	4	
55	2	
56	2	
57	1	
58	1	
59	2	
60	1	
61	2	
62	2	
63	2	
64	1	
65	2	
66	4	
67	2	
68	2	
69	2	
70	4	
71	2	
72	2	
73	2	
74	4	
75	2	
76	2	
77	2	
78	5	
79	1	
80	1	

Scorecard: "Chained discrimination"

Subject Image/Word Total number of trials

Trial	Correct position	Marked position	Trial	Correct position	Marked position
1	2		1	1	
2	1		2	2	
3	4		3	1	
4	1		4	2	
5	2		5	2	
6	2		6	4	
7	1		7	4	
8	2		8	2	
9	4		9	2	
10	4		10	2	
11	2		11	1	
12	2		12	1	
13	1		13	2	
14	2		14	3	
15	2		15	3	
16	4		16	4	
17	1		17	2	
18	2		18	1	
19	2		19	1	
20	4		20	2	
21	1		21	3	
22	4		22	2	
23	2		23	1	
24	1		24	2	
25	2		25	3	
26	1		26	3	

27	2		27	4	
28	4		28	4	
29	2		29	3	
30	4		30	2	
31	1		31	2	
32	2		32	1	
33	2		33	3	
34	1		34	3	
35	2		35	4	
36	2		36	4	
37	4		37	2	
38	4		38	2	
39	2		39	1	
40	4		40	2	
41	1		41	3	
42	2		42	4	
43	2		43	2	
44	2		44	2	
45	2		45	1	
46	4		46	1	
47	1		47	4	
48	4		48	3	
49	2		49	1	
50	4		50	1	
51	2		51	4	
52	2		52	2	
53	2		53	2	
54	4		54	4	
55	2		55	4	
56	2		56	2	
57	1		57	2	
58	1		58	1	

59	2		59	1	
60	1		60	2	
61	3		61	3	
62	2		62	4	
63	2		63	3	
64	1		64	3	
65	3		65	2	
66	4		66	1	
67	2		67	2	
68	2		68	4	
69	3		69	4	
70	4		70	3	
71	2		71	4	
72	3		72	3	
73	4		73	2	
74	3		74	1	
75	4		75	1	
76	2		76	2	
77	3		77	1	
78	4		78	2	
79	1		79	2	
80	1		80	3	

Appendix II

INITIAL SURVEY

Age:

Sex:

Level of studies:

Indicate below if you study or work (or both), and specify the sector or area and the number of hours devoted to that activity.

Father´s level of studies

Father´s employment

Mother´s level of studies

Mother´s employment

Specify below at least three hobbies or pastimes to which you devote your time; that is, what do you enjoy doing on your free time?

Do you read? If yes, specify below how many hours a day, or a week, you spend reading.

Appendix III

INFORMED CONSENT

1. This is to inform you that you are about to participate in a research project on human learning in the area of Basic Psychology.

2. The information collected during the tasks you will perform is completely anonymous and will be used exclusively for research and teaching purposes.

Your personal information will be codified in such a way that you cannot be identified.

3. You may abandon the study at any time with no repercussions whatsoever.

I, Mr./Mrs/Ms. , being over the age of majority, have read the Informed Consent statement presented to me, understand the explanations it contains, and have had all my questions in this regard answered to my satisfaction. I also understand that I may, at any time and with no need to give an explanation, withdraw the consent offered. I have further been informed that my personal information will be protected and used only for the training and research of the students who carry out the study. Taking all the foregoing into consideration and under the stated conditions, I hereby CONSTENT to participate in the research on Human Learning and to have the data derived from my participation utilised to fulfil the objectives specified in the document.

In on the 2015.

Signature

Appendix IV

Stimulus position

Trial Nº	Sample	Position 1	Position 2	Position 3	Position 4	Response	Sample	Position 1	Position 2
1	A2	B1	B2	B4	B3		B2	C2	C1
2	A4	B4	B1	B2	B3		B4	C1	C4
3	A4	B2	B1	B3	B4		B4	C4	C3
4	A3	B3	B1	B2	B4		B3	C1	C3
5	A1	B3	B4	B1	B2		B1	C4	C2
6	A4	B2	B4	B3	B1		B4	C2	C1
7	A3	B3	B1	B2	B4		B3	C4	C1
8	A4	B3	B2	B4	B1		B4	C3	C2
9	A3	B2	B1	B4	B3		B3	C1	C4
10	A3	B2	B1	B4	B3		B3	C1	C4
11	A3	B4	B2	B3	B1		B3	C3	C2
12	A4	B1	B4	B3	B2		B4	C4	C3
13	A1	B1	B2	B3	B4		B1	C3	C1
14	A1	B4	B1	B3	B2		B1	C4	C2
15	A2	B1	B3	B2	B4		B2	C1	C3
16	A2	B3	B4	B1	B2		B2	C3	C4
17	A2	B2	B3	B4	B1		B2	C3	C1
18	A2	B4	B1	B2	B3		B2	C2	C3
19	A1	B3	B1	B2	B4		B1	C1	C2
20	A1	B3	B4	B2	B1		B1	C3	C1
21	A1	B1	B2	B4	B3		B1	C3	C4
22	A1	B2	B4	B3	B1		B1	C2	C1
23	A2	B3	B1	B2	B4		B2	C2	C4
24	A3	B3	B4	B2	B1		B3	C4	C3
25	A1	B4	B1	B3	B2		B1	C2	C3
26	A3	B3	B4	B2	B1		B3	C1	C2
27	A2	B1	B2	B4	B3		B2	C1	C4
28	A3	B2	B4	B1	B3		B3	C2	C1
29	A1	B4	B2	B1	B3		B1	C4	C3
30	A4	B3	B1	B2	B4		B4	C3	C4
31	A2	B2	B3	B4	B1		B2	C4	C2
32	A3	B1	B3	B4	B2		B3	C3	C1
33	A2	B4	B2	B1	B3		B2	C4	C3
34	A4	B4	B2	B3	B1		B4	C1	C2
35	A4	B2	B4	B1	B3		B4	C2	C1
36	A1	B2	B3	B1	B4		B1	C4	C2
37	A4	B3	B1	B2	B4		B4	C1	C3
38	A2	B3	B1	B4	B2		B2	C1	C2
39	A4	B1	B2	B4	B3		B4	C4	C3
40	A3	B2	B4	B1	B3		B3	C4	C3
41	A4	B4	B1	B2	B3		B4	C3	C2
42	A4	B2	B4	B1	B3		B4	C1	C2
43	A1	B3	B4	B1	B2		B1	C3	C4
44	A2	B3	B1	B2	B3		B2	C4	C2
45	A1	B4	B1	B3	B2		B1	C1	C3