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The influence of the parents' educational level and participants' age in the derivation of equivalence-equivalence

Andrés García García[1], Álvaro Viúdez González[1] and Jaclyn Gayle Lefkowitz[2]
[1] Universidad de Sevilla and [2] Cornell University

Abstract

Background: The objective of this work was the study of analogical reasoning from the perspective of the equivalence-equivalence phenomenon. **Method:** The variables studied consisted of the age of the participants and the educational level of the parents, in relation to performance on a reasoning task. The task utilized a sample size of 64 participants and an instrument based on conditional discriminations using the matching-to-sample procedure. **Results:** The results showed a significant difference in the performance on the task between the children of parents with college degrees, and those of parents without college degrees. However, there were no conclusive results as to age. **Conclusions:** The results are analyzed from the perspective of the derivation of the relationship of equivalence-equivalence via multiple exemplar training.

Keywords: *equivalence-equivalence, analogical reasoning, multiple exemplar training, children.*

Resumen

Influencia del nivel educativo de los progenitores y la edad en la derivación de equivalencia-equivalencia. **Antecedentes:** el objetivo de este trabajo fue el estudio del razonamiento analógico desde el fenómeno de equivalencia-equivalencia. **Método:** las variables estudiadas fueron la edad de los participantes y el nivel educativo de los padres, en relación a la ejecución de la tarea de razonamiento. Para ello se utilizó una muestra de 64 participantes. Se diseñó un instrumento basado en discriminaciones condicionales utilizando el procedimiento de igualación simbólica a la muestra. **Resultados:** los resultados mostraron una diferencia significativa en la ejecución de la tarea entre los niños con padres universitarios y los niños con padres no universitarios. Sin embargo, en relación a la edad no se obtuvieron resultados concluyentes. **Conclusiones:** se analizan estos resultados desde la perspectiva de la derivación de la relación de equivalencia-equivalencia a través de entrenamiento en múltiples ejemplares como origen de la derivación del fenómeno.

Palabras clave: *equivalencia-equivalencia, razonamiento analógico, múltiples ejemplares, niños.*

Numerous studies have addressed the cause behind the derivation of behavior that has not been explicitly trained (Valero & Luciano, 1992). This phenomenon has been studied on many occasions within the Experimental Analysis of Behavior, beginning with Sidman's discoveries in 1971 (see García & Benjumea, 2001) and continuing with those of other authors within the framework of equivalence classes. Simple and conditional discriminations are fundamental concepts to understand the logic of equivalence classes.

Simple discriminations consist of a discrimination containing three elements (discriminative stimulus, response and consequent stimulus), the basic pillar of operant conditioning. However, conditional discriminations include a fourth element. In addition to the discriminative stimulus, response, and consequence, a conditional stimulus is added, which changes the function of the discriminative stimulus to positive or negative. The conditional relations between stimuli are studied via matching-to-sample procedures (Pérez-González, 1994), which consist of choosing between various comparison stimuli (discriminative stimuli) in response to a sample stimulus (conditional stimulus). Of the two comparison stimuli that are typically used in the procedure, only one is the correct choice. In other words, the principal characteristic of conditional discriminations is the control the conditional stimuli have over the relation between the discriminative stimulus, the response, and the reinforcer (Pérez, 2007).

Working with conditional discriminations, Sidman (1971) was the pioneer in the experimental study of equivalence classes. Sidman's work was the beginning of a line of research that he describes and analyzes in his 1994 publication, and gave way to an enormous quantity of studies (García & Benjumea, 2002, 2006; Pérez, García, & Gómez, 2011).

Equivalence classes refer to a set of stimuli that are functionally equal for the individual, despite having completely different physical properties. The necessary tests to determine this relationship are derived from the mathematical definition of equivalence relations (Sidman & Tailby, 1982), which specifies three properties: reflexivity, symmetry, and transitivity. The display of these relations is considered indicative of equivalence between stimuli. Thus, we have Class 1 made up of A1, B1 and C1, Class 2 (A2, B2 and C2), Class 3 (A3, B3 and C3), etc.

Received: July 9, 2013 • Accepted: January 24, 2014
Corresponding author: Andrés García García
Facultad de Psicología
Universidad de Sevilla
41018 Sevilla (Spain)
e-mail: andresgarcia@us.es

The equivalence-equivalence phenomenon represents one step closer to a better understanding of complex behavior (Barnes-Holmes, Hegarty, & Smeets, 1997). Due to the nature of the tests assessing the equivalence-equivalence phenomenon, its measurement requires compound stimuli in both the sample and comparison stimuli. Specifically, the sample can be two stimuli of the same equivalence class or two stimuli of distinct classes. In the first case, the participants should choose the comparison stimulus composed of two stimuli of the same equivalence class. In the second case, they should choose the comparison stimulus made up of two stimuli of distinct classes. The participants should choose the pair of stimuli that maintain the same relation with one another as the pair of stimuli in the sample (belonging or not belonging to the same equivalence class). Therefore, the equivalence-equivalence phenomenon refers to both types of relations: those of equivalence-equivalence and those of nonequivalence-nonequivalence (Carpentier, Smeets, & Barnes-Holmes, 2003; Stewart, Barnes-Holmes, Roche, & Smeets, 2002).

If we train four equivalence classes consisting of four members each, such as A1-B1-C1-D1, A2-B2-C2-D2, A3-B3-C3-D3 and A4-B4-C4-D4, the compound stimulus A1B1 maintains an equivalence-equivalence relation with B2C2 because both compounds contain elements belonging to the same class. In the same manner, the compound A2C3 maintains a nonequivalence-nonequivalence relation with A3C4. Figure 1 shows a diagram of the equivalence-equivalence phenomenon utilizing the format of the matching-to-sample procedure.

Different explicative hypotheses have addressed why these relations between stimuli that have not been trained in the individual's ontogenesis are derived. One of the most influential ideas in this sense was proposed by Hayes (1989) and Boelens (1994), and is known as Exemplar Theory. These authors proposed that during verbal development, human beings are trained in a large number of conditional discriminations and their symmetric counterparts. The double training as a listener and speaker allows one to learn the discriminative control relation that is established between the pronunciation of a word and the appearance of an object, as well as that which is established between the presentation of an object and the pronunciation of a word. According to the authors, the derivation of symmetry among humans can be explained by assuming that multiple exemplar training occurred in an individual's natural history. Exemplar training, therefore, is based on training both A1-B1 and B1-A1, A2-B2 and its symmetrical counterpart, and so on until An-Bn and Bn-An. At a certain point, we can conduct a test training Ax-Bx and testing Bx-Ax (Gómez, 2008).

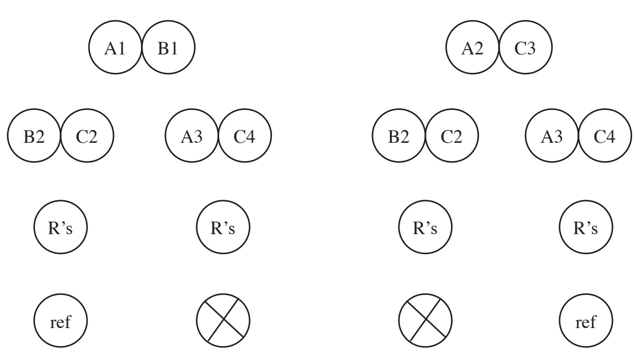

Figure 1. *Diagram of the equivalence-equivalence phenomenon. The stimuli A1 and B1 belong to the same equivalence class. Therefore, the reinforced choice is the stimuli pair B2C2, which maintains an equivalence relation. The stimuli A2 and C3 belong to different equivalence classes. The reinforced choice in this occasion is the pair A3C4, which is formed by stimuli belonging to different equivalence classes*

When Boelens (1994) formulated the Exemplar Theory, he also extended the idea to the rest of the equivalence properties (reflexivity, transitivity, and equivalence), proposing that human beings in their natural environments generalize a series of properties: generalized identity, generalized symmetry, generalized transitivity, and generalized equivalence. As a result, an individual's behavior remains subject to a property of the stimulus—the correct relation between the sample and the comparison. The individual can respond using the generalized property, such as the symmetrical relation, when faced with new stimuli (Luciano, Becerra, & Valverde, 2007).

In the present work, we approached the equivalence-equivalence phenomenon from this point of view (Ruiz & Luciano, 2012), seeking to experimentally investigate the effect of multiple exemplar training on the derivation of equivalence-equivalence responding. Additionally, we explore the relevance of variables that could influence the derivation of this phenomenon: the participants' age and the educational level of the family.

With reference to the variable age, a study conducted by Carpentier, Smeets, and Barnes-Holmes (2002) and subsequent replications showed that children younger than 9 years old do not show generalized equivalence-equivalence relations. Interpreting these results from the perspective of the Exemplar Theory, these children did not reach the success criterion in the tests of equivalence-equivalence because they had not received sufficient exemplar training. Additionally, these studies found positive results in children older than 9 years old, as well as in adults (Pérez, García, Gómez, Bohórquez, & Gutiérrez, 2004). In our study, we chose to work with children ages 8-9 and 14-15, considering that the former is a critical period for analogical reasoning and the latter corresponds to a period in which previous research indicates positive results (García, Pérez, Martín, Gutiérrez, Gómez, & Pérez, 2011).

With respect to the second variable, the educational level of the families, there have been no studies measuring the equivalence-equivalence phenomenon. However, interest in other psychological phenomena has been varied. Palacios and González (1998) found important differences between families as to how their interactions determine the tools involved in the child's intellectual development. One of the most significant differences is related to the parents' educational level, which, in turn, is related to the family socioeconomic level. Similarly, Arranz, Bellido, Mazano, Martín and Olabarrieta (2004) indicate that parents with higher educational levels use verbal strategies of interaction more frequently. Among them are decontextualized strategies, which consist of helping the child to evoke events, people and situations beyond the current spatio-temporal context. For example, parents with higher educational levels produce nonspecific questions and suggestions, which serve as richer and more stimulating forms of relations. Such strategies are not necessarily the most elaborate and complex, but rather the best adjusted to the child's interactive situation and level.

This implies that a family with a higher educational level helps to promote the development of complex behavior. Therefore, it is relevant to investigate the influence of the parents' educational level on the genesis of phenomena that are part of analogical reasoning, such as equivalence-equivalence relations. Keeping in mind previous discoveries found within psychology, we hypothesize that there will be differences in equivalence-equivalence responding between children of parents with college degrees and children whose parents do not have such degrees.

Consequently, in the present work, we will address two independent variables: age, utilizing the two above-mentioned conditions, and parents' educational level, distinguishing between parents without college degrees and parents with college degrees. The dependent variable will be performance on the reasoning task.

Therefore, the goals of this work are to verify whether:

- The children of parents with college degrees (at least one of the parents has a completed college degree) will perform better on the reasoning task than the children of parents without college degrees.
- The children of ages 14-15 years will perform better on the reasoning task than the children of ages 8-9.
- There will be an interaction effect between both variables, so that older children of parents with college degrees will obtain the best results.

Method

Participants

The participants consisted of 64 children (between 8 and 15 years old) from distinct areas of Seville. They were assigned to 4 experimental groups according to the independent variables: 16 children who were 8-9 years old and had parents with college degrees, 16 children who were 8-9 years old and had parents without college degrees, 16 children who were 14-15 years old and had parents with college degrees and 16 children who were 14-15 years old and had parents without college degrees. Sex was controlled in all groups to avoid its possible influence.

Materials

In order to evaluate equivalence-equivalence responding, we used an experimental procedure of simultaneous symbolic matching-to-sample. This procedure consists of presenting a sample stimulus and two comparison stimuli at the same time. In order to answer correctly in a trial, participants must choose the comparison stimulus that maintains a particular relation with the sample stimulus. The relation can be equivalence-equivalence or nonequivalence-nonequivalence. If participants selected the correct comparison stimulus in a training trial, they would hear the sound of applause. If they made an incorrect selection, they would hear the sound of a horn. The same instruments were used during the test phase, however, feedback about performance was not offered throughout the trials.

Both the sample and comparison were compound stimuli containing two stimuli each (images or photographs). The elements within the compound stimuli could maintain an equivalence or nonequivalence relation. If the sample compound stimulus contained two elements of the same equivalence class, the children should choose the comparison stimulus containing two elements that also belonged to the same class. However, if the sample stimulus was composed of elements that did not belong to the same class, the comparison stimulus containing nonequivalent elements was the correct choice.

We worked with stimuli from natural categories that were most likely formed previously in the everyday experience of the participants (without pre-testing), given their ages. The categories were organized in ten blocks (from 1 to 10), with each block containing three categories. The assignment of the categories to sets and the order of their presentation were randomized (see Table 1).

Each block was made up of 20 trials, in which one half corresponded to equivalence-equivalence and the other half to nonequivalence-nonequivalence. The order in which the two types of trials were presented and the position of the correct comparison stimuli were counterbalanced. The proportion of elements from each class and the position of the elements within the stimuli were also controlled (see Table 2). We employed the same structure for all blocks.

Procedure

In order to evaluate equivalence-equivalence responding, we designed a procedure made up of two types of trials-testing and training. To pass each phase, the participants needed to answer correctly in 80% of the equivalence-equivalence trials as well as in those of nonequivalence-nonequivalence (i.e., correctly answering a minimum of eight out of ten for each type of trial).

In order to finish the experiment, one of the following cases had to occur:

- The participant does not pass the criterion in any of the 5 trainings within a block.
- The participant passes the criterion for any test.
- The participant does not pass the test phase in the last block of stimuli.

The test and training phases were presented as follows:

Test Phase 1: We began evaluating the objective phenomenon of our study utilizing the first block without offering feedback to the participants. The participant completed the study if he/she passed the above-mentioned criteria. If the child demonstrated a lower level performance (< 80%), the training phase began.

Training Phase 1: The same set of stimuli as in the previous phase was presented for up to a maximum of five repetitions that now included feedback. If the participant did not perform correctly in any of the repetitions, the experiment was completed. If the child demonstrated a performance above 80% in any of the presentations, he/she proceeded to the next phase.

Test Phase 2: Implied completing a test phase with the second block of trials. The criteria were identical to those employed in the first phase.

Training Phase 2: Consisted of completing the same steps as in the first training phase.

This logic continued throughout the experiment until the participant reached one of the above-mentioned conditions.

The experiment took place in an authorized research laboratory, with only two experimenters and the participant present. One of the experimenters sat to the left of the child and recorded the

Table 1
Categories and stimuli used in each block

Number of block			Stimulus A	Stimulus B	Stimulus C
Block 1	Class 1	Appliances	Washing machine	Microwave	Refrigerator
	Class 2	Jungle gym	Beam	Seesaw	Slide
	Class 3	Professions	Police	Fireman	Butcher
Block 2	Class 1	Board games	Parcheesi	Chess	Dominoes
	Class 2	Numbers	Five	Eight	Three
	Class 3	Vegetables	Lettuce	Carrot	Tomato
Block 3	Class 1	Cartoons	SpongeBob	Mickey	The Simpsons
	Class 2	Jewels	Earrings	Necklace	Ring
	Class 3	Vehicles	Motorcycle	Car	Bus
Block 4	Class 1	Animals	Dog	Cat	Horse
	Class 2	Drinks	Coffee	Coke	Milk shake
	Class 3	Footwear	Rain Boots	Sneakers	High-Heels
Block 5	Class 1	Clothes	Pants	T-shirt	Skirt
	Class 2	Christmas	Christmas Tree	Three wise men	Santa Claus
	Class 3	Buildings	Sky-scraper	House	Old building
Block 6	Class 1	Fast Food	Hamburger	Hot dog	Pizza
	Class 2	Planets	Earth	Saturn	Mars
	Class 3	Letters	B	C	M
Block 7	Class 1	Cutlery	Fork	Spoon	Knife
	Class 2	Landscapes	Mountain	Caribbean	Dusk
	Class 3	Human body	Hand	Ear	Nose
Block 8	Class 1	Fruits	Apple	Banana	Orange
	Class 2	Sports	Basketball	Soccer goal	Tennis racket
	Class 3	Tools	Hammer	Screwdriver	Wrench
Block 9	Class 1	Furniture	Sofa	Armchair	Chair
	Class 2	Insects	Butterfly	Fly	Wasp
	Class 3	Red objects	Flower	Umbrella	Pepper
Block 10	Class 1	Geometric figures	Circle	Triangle	Square
	Class 2	School	Blackboard	Desk	Chalk
	Class 3	People	Baby	Adult	Elderly man

Table 2
Distribution of tests in each block

Trial number	Type of trial	Sample	Left comparison stimulus	Right comparison stimulus
1	N-N	B2A1	**C1A2**	B3C3
2	E-E	A2B2	**C3B3**	B2B1
3	E-E	B1C1	C3A1	**B2C2**
4	N-N	B3C1	**A1 B2**	B2A2
5	N-N	B1C2	A3B3	**C3A1**
6	E-E	C2A2	A3C1	**A1C1**
7	E-E	C1A1	B2B3	**A2C2**
8	N-N	A1C2	C3A3	**B3A2**
9	N-N	A1C3	**C3B2**	A2C2
10	E-E	B3A3	**B1C1**	C2A1
11	N-N	C1A2	**B1C2**	C3B3
12	E-E	C3B3	A2A1	**B2C2**
13	E-E	A3B3	**C1B1**	A1B2
14	E-E	B2C2	**C3A3**	A3B1
15	N-N	B1A3	B2C2	**B3C2**
16	N-N	C3B2	A1B1	**C2B1**
17	E-E	A2C2	A3C1	**A1B1**
18	E-E	A3C3	**C2A2**	B2B1
19	N-N	B1A1	**A3C1**	A3B3
20	N-N	A1 C3	C2A2	**A3B2**

E-E: equivalence-equivalence relation. N-N: nonequivalence-nonequivalence relation. The numbers correspond to the equivalence class to which the stimulus belongs, while the letter corresponds to the particular stimulus of the said class. The correct option of each test appears in bold

answers. This experimenter evaluated whether the child passed the established criterion upon finishing each of the sessions. The other investigator sat to the right of the child, gave feedback related to the answer (when necessary) and ran the subsequent trial. The instructions were as follows:

We introduce ourselves and tell the participant:

– *We designed a computer game in which a couple of images appear in the upper part of the screen. You will have to look at this pair and choose one of the two pairs on the bottom, the one that you believe goes with the one above. Only one pair from below will be correct, but we will not tell you if you are winning. Do you have any questions? Are you ready?*

We then continue to test phase 1. If the participant passes, we tell him/her the following:

– *Thank you for your collaboration. You have been a great help. We have finished.*

If the child does not pass the test phase we say:

– *Now we are going to continue on to a similar task. The same images are going to appear, but now when you choose* *one of the pairs, the computer is going to emit a sound. If the sound is applause, you chose correctly, but if the sound is a bullhorn (we present the sound on the computer), you chose incorrectly.*

If the participant passes to the new block of stimuli (the following test phases) we say:

– *Very good, now we are going to test with new images and, like in the beginning, there will be no sounds that indicate whether you are choosing correctly.*

When the participant completes the experiment in one of the previously mentioned situations, we say:

– *Thank you for your collaboration. You have been a great help. We have finished.*

As previously indicated, the session began with test phase 1 and continued according to the above sequence, with new instructions offered when necessary.

Data analysis

The data was analyzed using the statistical program SPSS.19. The analysis included an intergroup comparison using the binomial test.

Results

Of the participants, 62.5% passed at least one equivalence-equivalence test, whereas the remaining 37.5% did not pass any.

In accordance with the first goal, we analyzed the relationship between the parents' educational level and the performance on the reasoning task. Of the children of parents without college degrees, 37% passed one equivalence-equivalence test, whereas in the case of the children of parents with college degrees, the percentage increased to 87%. Utilizing the binomial test, we found a significant difference in task performance between children of parents with college degrees and children of parents without college degrees ($p = .039$). In the first group (parents with college degrees), there was a greater proportion of children who passed the test.

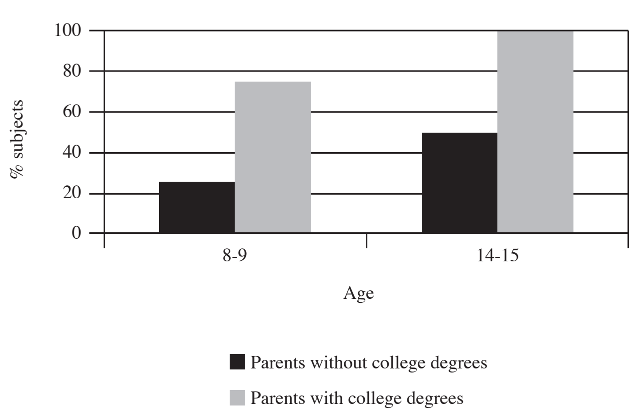

Figure 2. *Percentage of participants that reached the criterion in the equivalence-equivalence tests based on the educational level of the parents*

For the second goal, we analyzed the relationship between the variable age and the performance on the reasoning task. We found a tendency that points to older children performing better on the task (75 vs. 50%), but this tendency was not significant ($p = .302$).

With respect to the third goal, there were no significant results as to the interaction effect between the parents' educational level and the age of the participants on the reasoning task performance. The first significance index (Figure 2) showed that there were no differences in performance on the reasoning task between older and younger children of parents with college degrees (50 vs. 25%, $p = .465$). Similarly, the second significance index showed that there were no significant differences between older and younger children of parents without college degrees (100 vs. 75%, $p = .285$).

Discussion

Regarding the parents' educational level, we found that the children of parents with college degrees performed better on the reasoning task than the children of parents without college degrees. This finding emphasizes the importance of the educational interaction as a key factor in the acquisition of complex behavior.

Based on this finding, the influence of this element needs to be further explored. The variable parental educational level could have provided more information if we had refined it by introducing relevant criteria. For example, we considered the variable of the parents' educational level as a dichotomy: parents with college degrees and parents without college degrees. In future studies, each condition can be broken down into several categories. Therefore, we could work with parents who have college degrees in social or technical fields. We could also differentiate the parents without college degrees, separating them according to primary education, secondary education, vocational training, etc.

Because the socioeconomic level has also proven influential in intellectual development, this variable can also be redefined by keeping the familial socioeconomic level in mind along with the parents' educational level (Bradley & Corwyn, 2002). This association is based on the fact that economic and social resources increase the possibility of obtaining the educational and formative resources that produce greater stimulation. This stimulation facilitates the child's intellectual development, and consequently leads to better performance on reasoning tasks.

Parents' involvement in the interaction with their children could be another interesting variable. The work of Razza, Martin and Brooks-Gunn (2010) confirms that the presence of two highly involved parents is associated with a more advanced psychological level than when only one or neither of the parents is involved. Whereas this study dealt with toddlers, it could be potentially significant for the age groups with which we worked.

Similarly, it would be interesting to study the importance of other educational sources (school, classmates, grandparents, etc.).

Ultimately, it would be beneficial to choose a more complex and specific variable that better delimits the stimulation that parents and children can contribute.

Although we did not find differences in performance on the reasoning task between the children ages 8-9 and those ages 14-15, there was a tendency. As indicated in the works of Carpentier et al. (2002, 2003), an individual's ontogenetic experiences, rather than age, are the most relevant variable for the development of equivalence-equivalence responding.

One line of work that is relevant to the study of equivalence-equivalence is the study of response criteria that can enter into competition with relational criteria. There mey be competition between equivalence-equivalence criterion and criteria of other procedures resembling similarity or equivalence (criteria both in the same or different comparisons, presented simultaneously or sequentially). This competition can occur with natural as well as with arbitrary categories (García, Gutiérrez, Bohórquez, Gómez, & Pérez, 2002; García, Bohórquez, Gómez, Gutiérrez, & Pérez, 2001; García, Gómez, Pérez, Bohórquez, & Gutiérrez, 2003; Bohórquez, García, Gutiérrez, Gómez, & Pérez, 2002; García, Bohórquez, Pérez, Gutiérrez, & Gómez, 2008). These studies examining competition were conducted with individuals (adults) who had already acquired the relational response evaluated by analogical reasoning tasks. Therefore, it would be of special interest to see how these distractor elements affect children while they are acquiring this ability.

This study cannot clarify the influence of multiple exemplar training on the derivation of equivalence-equivalence responding. In our study, we had two types of participants: those who already utilized analogical reasoning due to training in a sufficient number of exemplars in their sociocultural environment, and those who did not. Because the number of trainings was limited (5 maximum), it was not sufficiently extensive to facilitate the derivation of equivalence-equivalence in the individuals who did not yet utilize analogical reasoning. However, the design did reveal the competence of the participants who had already acquired this type of reasoning. In just a few tests (4 maximum), these participants were able to pass the discrimination.

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