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A Preliminary Demonstration of Transformation of Functions through Hierarchical Relations

Enrique Gil[*]
Carmen Luciano[*]
Francisco J. Ruiz
Universidad de Almería, España
Sonsoles Valdivia-Salas
Universidad de Zaragoza, España

ABSTRACT

The current study focuses on the experimental analysis of hierarchical responding, and aims at analyzing some of the transformation of functions that take place at different levels of hierarchical categories. Ten university students participated. During Phase 1, four arbitrary stimuli were established as INCLUDES, BELONGS TO, SAME, and DIFFERENT relational cues, respectively. During Phase 2, three four-member equivalence classes were trained and tested (A1-B1-C1-D1; A2-B2-C2-D2; A3-B3-C3-D3). These equivalence classes constituted the bottom level of two hierarchical categories. The middle and top levels of the hierarchical categories were formed during Phase 3. The middle level was established by training hierarchical relations (INCLUDES and BELONGS TO) between novel stimuli X.1 and A1/B1; X. 2 and A2/B2; and Y and A3/B3. The top level was established by training hierarchical relations between X and X.1/X.2, and between Y and Y.1. During Phase 4, X.1 was established as always cold, D2 as always heavy and C3 as always sweet. During Phase 5 (Critical Test), six stimuli from both hierarchical categories (Y, X, C1, X.2, D3, C2) and a non-related stimulus (M) were tested for the transformation of functions. Nine of the ten participants responded correctly to the test. The implications and limitations of these findings, as well as lines for future research, are discussed.
Key words: hierarchical responding, transformation of functions, derived relations, relational frame theory, problem solving.

Establishing categories is broadly considered to be at the core of complex human behavior (e.g., Barsalou, 2005; Medin & Rips, 2005). A category is a class of elements that bear some physical similarity among them (e.g., the category "white chairs" or "race cars") or shares some functional property (e.g., the category of "things my mother hates," such as being late to dates, ants, or loud music) (Zentall, Galizio, & Critchfield, 2002).

[*] Correspondence concerning this article should be addressed to the first or second authors at: Facultad de Psicología, Edificio A, Universidad de Almería, 04120 Almería, España. Email: enrgil2@yahoo.es mluciano@ual.es. This study was conducted in partial fulfillment of the requirements for the Ph.D. degree granted to the first author under the supervision of the second and the third authors. This research was partially supported with I+D+i funds from Ministerio de Educación y Ciencia, Spain (SEJ05845) and Junta de Andalucía, Spain (research Group HUM-1093). Portions of the study were presented at the Annual Convention of the Association for Behavior Analysis, Phoenix, AZ, in May of 2009.

Categories themselves can be hierarchically ordered. For example "Granny Smith" belongs to the category of "apples," and "apples" in turn belong to the category of "fruit." Most of the research on hierarchical classification has been conducted under the umbrella of mainstream cognitive research by using class-inclusion logic problems similar to those of Inhelder and Piaget (1964). For instance, when children under 5 years old are given twelve apples and three oranges and they are asked whether there are more apples or more fruit, they often say that there are more apples. However, older children respond correctly by including oranges and apples as part of the concept "fruit" (e.g., Halford, 2005). Hierarchical categorization is highly relevant in the understanding of this kind of problem solving. However, the information available from this perspective is mostly descriptive, and thus does not specify the contextual variables that can be manipulated to influence this complex behavior. This, in turn, hinders the designing of protocols to train hierarchical categorization when it is absent.

As Slattery, Stewart and O'Hora (2011) have recently pointed out, research on hierarchical classification in the field of behavior analysis is lacking, with only a couple of studies addressing this topic. The first one was conducted by Griffe and Dougher (2002) and used a combination of contextually controlled conditional discrimination training, stimulus generalization and stimulus equivalence in order to simulate the emergence of hierarchical categorization in natural settings. As predicted, participants showed the naming of new stimuli based on contextually controlled common physical dimensions of the stimuli involved. According to Slattery *et al*. (2011), this experiment showed a formal feature of hierarchical categorization, namely, transitive class containment, that is, the relations between the members of a category are transitive. For instance, if C is a member of B and B is a member of A, then C is a member of A (e.g., all Siamese are cats, and all cats are animals; therefore, all Siamese are animals). Griffe and Dougher (2002), however, did not explicitly test whether participants' responses were consistent with the feature of transitive class containment. This feature was tested by Slattery *et al*. (2011) by using stimuli that were physically different from the training stimuli.

Besides transitive class containment, there are features of hierarchical categorization that have not been experimentally analyzed. One of these features relates to the asymmetrical relations among members of the same category. For instance, if class A contains class B, then class B does not contain class A (e.g., "animals" contains "dogs," but "dogs" does not contain "animals") (Murphy, 2002). Also, while the properties of the class at the top of the hierarchy are shared with the classes and members at the bottom of the hierarchy (e.g., if animals have blood, and mammals and aves are animals, then they and all the members of these classes such as dogs, cats, crows, etc., also have blood); the characteristics of the members of a specific class at the bottom of the hierarchy are not necessarily shared with the members of another class at the same level of the hierarchy (e.g., dogs bark but cats do not; birds have wings but mice do not). In this last case, different classes at different levels of the hierarchy have different properties (e.g., dogs, cats, aves, mammals, etc.) but they all are part of the same hierarchy (e.g., animals).

These additional features of hierarchical categories may be modelled in the laboratory by following the functional contextual approach to human language and cognition outlined by Relational Frame Theory (Hayes, Barnes-Holmes, & Roche, 2001;

Hayes, Fox, Gifford, Wilson, Barnes-Holmes, & Healy, 2001; Luciano, Valdivia-Salas, Berens, Rodríguez, Mañas, & Ruiz, 2009; Slattery *et al*., 2011). From this perspective, hierarchical categorization would have its origins in the multiple-exemplar training of contextually controlled patterns of relational responding based on non-arbitrary relations of inclusion (or containing) and belonging to (or members of). For instance, a child soon learns to tact his body and his body parts (e.g., eyes, ears, mouth) as elements of his body; and to play with toys or in places that contain other pieces and objects (e.g., the car contains wheels, an engine, doors, etc.; his room contains a bed, wardrobe, dolls, etc.). Through multiple interactions like these, the repertoire of classifying objects comes under contextual control of the words that are used as hierarchical relational cues for containing (e.g., "includes" or "contains", like in "the car contains the wheels, etc.") and belonging (e.g., "belongs to," "is a member of" or "is in", like in "the bed and the wardrobe are in my bedroom"). Later, these relational hierarchical cues will be brought to bear in arbitrary and complex ways. For instance, María tells her friend Juan that her family is visiting soon. One part of her family is from Santander and is very intelligent, while the other part of her family is from Sevilla and is very funny. Next, Juan meets María's cousin from Sevilla (Ana) and her uncle from Santander (Luis). Juan automatically assumes that Ana will be funny and Luis will be intelligent. In sum, if Juan is asked about María's family, he will respond that her family is funny and intelligent or, more precisely, that one part is funny and the other part is intelligent. This example shows that the functions given to different parts of the hierarchy (i.e., the functions "intelligent" and "funny" given, respectively, to the Santander and Sevilla parts of María's family) alter the function of the members of the subordinate class (e.g., because Ana is from Sevilla, she is funny; because Luis is from Santander, he is intelligent). Also, these functions are derived to the superordinate class (e.g., because relatives from Sevilla are funny and relatives from Santander are intelligent, María's family is partly funny and partly intelligent).

In a series of experiments (e.g., Gil, Luciano, & Ruiz 2010, 2011; Gil, Luciano, Ruiz, & Sánchez, 2009), different forms of hierarchical categorization were for the first time established by using an analogue of the multiple-exemplar training procedures that are assumed to underlie the emergence of this repertoire from a contextual viewpoint. Following the aforementioned analysis: (a) arbitrary stimuli were first established as hierarchical relational cues; (b) these cues were then used to establish arbitrary hierarchical relations among abstract nonsense stimuli; and (c) after assigning functions to some of the stimuli, the derivation of these functions to other members of the hierarchies was tested.

The first experiment of this series is presented here. Participants were first presented with errorless multiple-exemplar training (MET) procedures to establish four arbitrary shapes as the relational cues INCLUDES, BELONGS TO, SAME, and DIFFERENT. Subsequently, two hierarchical categories were formed: hierarchy X included two different branches and hierarchy Y included only one branch and served for within-subject control purposes. Three different functions were then assigned to three members of the hierarchical categories. Finally, participants were tested for the transformation of functions of some of the stimuli in the different levels of the hierarchies.

METHOD

Participants

Ten graduate and undergraduate students (6 males; age range= 18-33) from diverse disciplines (e.g., psychology, teaching, history) volunteered to participate in the experiment. None of them had previous experience with the procedures employed in the present study. All participants were recruited through bulletin board announcements and personal contacts. They did not receive any compensation for their participation. Upon completion of the tasks, the participants were fully debriefed.

Setting, Apparatus, and Stimuli

The experiment was conducted in a quiet room equipped with a table, a chair and a laptop computer. A computer program designed in Visual Basic 6.0© served to present visual stimuli and record participants' responses.

All stimuli were presented in black-and-white. Arbitrary symbols in the upper portion of Figure 1 were used as the to-be relational cues INCLUDES, BELONGS TO, SAME, and DIFFERENT. Thirteen sets of visual stimuli (including drawings and

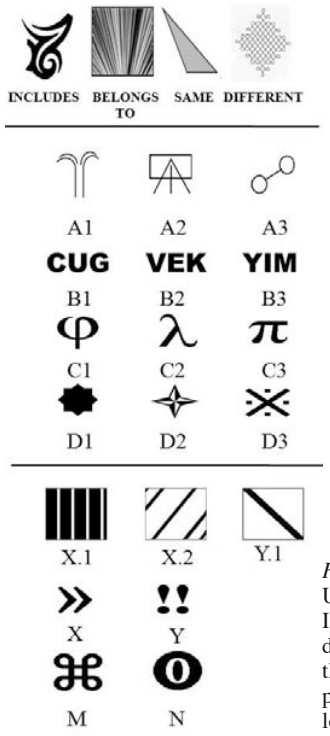

Figure 1. Arbitrary stimuli used during the procedure. Upper panel: Stimuli used as the to-be relational cues INCLUDES, BELONGS TO, SAME, and DIFFERENT during Phase 1. Middle panel: stimuli employed to train three 4-member stimulus classes during Phase 2. Bottom panel: stimuli employed to complete the middle and top level of hierarchies X and Y during Phase 3.

pictures of known objects) served to train the relational cues (see Table 1). Figure 1 (middle and bottom parts) shows the abstract figures and nonsense syllables used to form the hierarchical categories.

Procedure

Upon agreeing to participate in the experiment, participants were escorted to the experimental room and sat in front of the computer. The experimenter asked participants to follow the instructions on the screen in order to complete the tasks and left the room.

The whole experiment included five phases (see Figure 2) and two brief breaks (about the end of Phases 2 and 3). During Phase 1, four arbitrary stimuli were established as the relational cues: INCLUDES, BELONGS TO, SAME, and DIFFERENT. During Phase 2, three 4-member equivalence classes were trained and tested using abstract shapes and nonsense syllables (Class 1: A1-B1-C1-D1; Class 2: A2-B2-C2-D2; Class 3: A3-B3-C3-D3). These equivalence classes constituted the bottom level of two hierarchical categories. During Phase 3, the middle and top level of the hierarchies were trained using the INCLUDES and BELONGS TO relational cues (see Figure 1). The middle level was first trained by relating two members of each of the three bottom level equivalence classes with three new stimuli, namely, X.1, X.2 and Y.1. The top level was trained by relating X.1 and X.2 to X, and Y.1 to Y. In Phase 4, X.1 was established as always cold, D2 as always heavy and C3 as always sweet by means of a stimulus-pairing procedure. The transformation of functions of other members of the hierarchies was tested during Phase 5.

Table 1. Sets of stimuli used during Phase 1.

Set 1. Circle that includes a clock. A chair and a dog.
Set 2. Rhombus that includes a pencil and an umbrella. A radio, a trumpet and a rose.
Set 3. Circle that includes a lamp and an envelope. Rectangle that includes a stair and a boot. A ball of wool, a car, a doll and a chef hat.
Set 4. Two arbitrary geometric shapes. Shape 1 includes letter "A". Shape 2 includes letter "R". Letters "P" and "Z".
Set 5. Glass that includes a heart and a dartboard. Octagon that includes a snowman and an apple. A racket, a table and a sun.
Set 6. Three arbitrary geometric shapes. Shape 1 includes a briefcase and a hairdryer. Shape 2 includes a pair of ladies shoes. Shape 3 includes a toy and a boat. A bulb, a tent, a leaf and a barber's chair.
Set 7. Circle that includes the moon, the letter "x", a pentagon and a triangle. In turn, the pentagon includes a computer and a crown, and the triangle includes a calculator. Cross includes a glasses and a planet. A pack of cards and the numbers "7" and "5".
Set 8 (Set Body). Drawings of a human body, a robot, a human head, a crocodile head, a nose, an elephant's trunk, a brain, a nut, an eye and a marble.
Set 9 (Set Continents). Drawings of the following continents, countries and cities: Europe, Asia, Spain, France, Spain, Santiago, Almeria, Mexico City, Madrid and Buenos Aires.
Set 10 (Set Alphabet). The following words: alphabet, numbers, vowels, consonants. The letters: A, F, E, K, U, R.
Set 11 (Set Religions). The following words: Religions, Islam, Christianity, Catholic church, Priest.
Set 12 (Set Vegetables). The following words: Flower shop. Drawings of a rose and a carrot.
Set 13 (Set Universe). Drawings of the Universe, the planets Saturn and Earth, a comet and a rocket

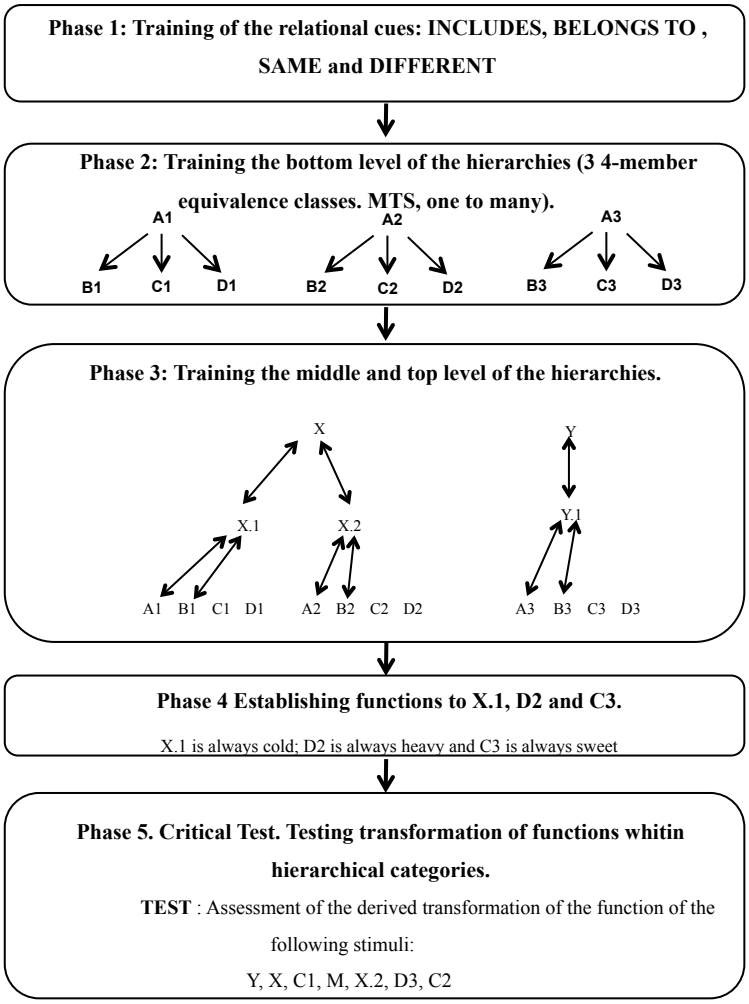

Figure 2. Schematic overview of the procedure.

All phases were conducted in one experimental session that lasted between 60 and 105 minutes. Participants were run through the tasks individually. All the instructions were presented on the screen.

Phase 1. Training of the relational cues INCLUDES, BELONGS TO, SAME, and DIFFERENT. The purpose of this phase was to establish four arbitrary stimuli as the relational cues INCLUDES, BELONGS TO, SAME, and DIFFERENT. By means of an errorless multiple-exemplar training (MET), INCLUDES and BELONGS TO were first established with Sets 1 to 7. Subsequently, SAME and DIFFERENT relational

cues were established with Sets 8 to 10 (sets Body, Continents and Alphabet). Sets 8 to 10 also served to include additional training trials of INCLUDES and BELONGS TO relational cues. Three new sets were used to test all four relational cues (Sets 11-13: Religions, Vegetables and the Universe).

The MET had the following characteristics: (a) there were two types of trials: select-the-stimulus and select-the-cue. In any given select-the-stimulus trial, a sample stimulus appeared at the top of the screen, followed by a stimulus in the middle (the to-be relational cue) and three or four comparisons at the bottom (positions were randomized across trials). In any select-the-cue trial, a sample stimulus appeared at the top of the screen, followed by one stimulus in the middle and four stimuli (the to-be relational cues) at the bottom (positions were also randomized across trials). (b) Each relational cue was trained across multiple trials and across multiple sets of stimuli. (c) The order of trial presentation was prefixed and kept constant across participants. Also, participants had to respond correctly to any trial for the next trial to be presented. An incorrect response in any part of the sequence was followed by the repetition of the same trial. Consequently, the mastery criterion was achieved when participants responded correctly to the last trial of the sequence. And (d) novel sets were introduced to test for the four relational functions trained during this phase

Phase 1 consisted of five stages. Each of these stages is described below. The sets of stimuli, examples of trials, and the specific content and sequence of trials can be traced in Table 1, Figure 3 and Appendix A.

Stage 1. Establishing an arbitrary stimulus as the INCLUDES relational cue. Participants read the following instructions on the computer screen (only the select-the-stimulus type of trial was used):

> "First you will see several drawings centered in the middle of the computer screen. They will then be move to the top right of the screen. One of the drawings will also appear at the top left of the screen, followed by other drawings at the bottom, and a symbol in the middle. With the mouse, select the drawing at the bottom that best goes with the drawing at the top depending on the symbol in the middle. The computer will inform you with a written message on the screen whether your choice is correct or not. Errors are normal at the beginning. Do your best to accumulate as many correct responses as possible."

In a typical select-the-stimulus trial type (see upper portion of Figure 3), a particular set of stimuli (e.g., a rhombus containing a pencil and an umbrella; a radio, a trumpet and a rose) appeared at the top right-half of the computer screen. After 1.5 s, a sample stimulus (e.g., rhombus) appeared at the top left of the screen, followed 1 s later by three comparison stimuli at the bottom left of the screen (e.g., pencil, trumpet, rose), and 0.5 s later one of the to-be relational cues (in this case, INCLUDES) was placed between the sample and the comparisons. Participants selected one of the comparisons by clicking on it with the mouse. Selecting one comparison (e.g., pencil) cleared the screen and the written message "Correct" or "Wrong" was displayed during 1 s. After a 1.3 s inter-trial interval (ITI), a new trial commenced. Training included 13 trials distributed as follows: Set 1 (2 trials), Set 2 (6 trials), Set 3 (5 trials) (see Appendix A for the specific trials and blocks).

Stage 2. Establishing an arbitrary stimulus as the BELONGS relational cue. The training had the same characteristics as in Stage 1, and included 12 trials distributed as follows: Set 4 (4 trials), Set 5 (4 trials), Set 6 (4 trials) (see Appendix A). For

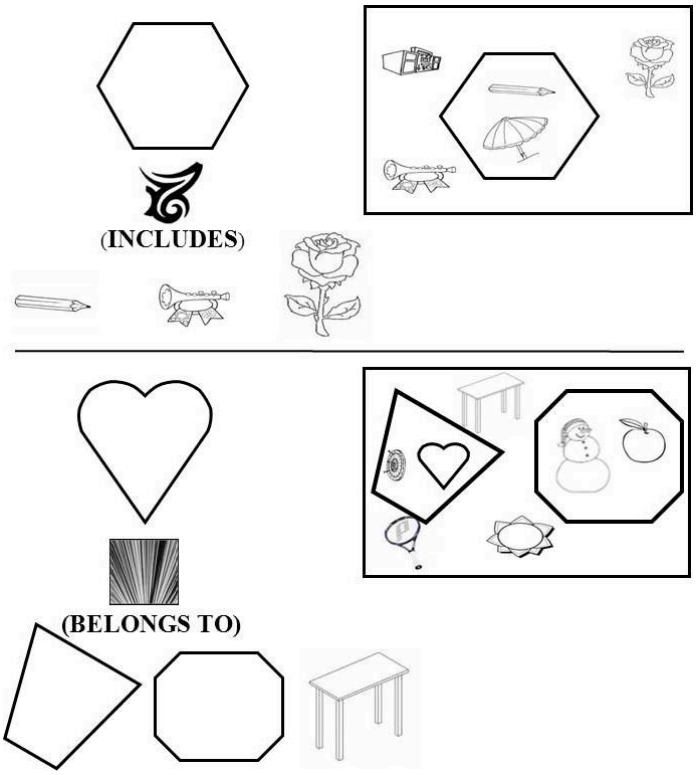

Figure 3. Examples of trials used during Phase 1 for INCLUDES and BELONGS TO relational cues: The upper panel shows a trial for the training of the INCLUDES relation. The bottom panel shows a trial for the training of the BELONGS TO relation. The words Includes and Belongs to were not visible to participants.

example, in Set 5 the 18th trial consisted of the following: at the top right of the computer screen (see bottom portion of Figure 3) participants saw a glass containing a heart and a dartboard; an octagon containing a snowman and an apple; a racket, a table and a sun. In addition, a picture of a heart appeared in the upper left portion of the screen, the stimulus for BELONGS TO appeared in the middle of the screen, and three figures at the bottom of the screen (the correct response is italized): *a glass*, an octagon and a table.

Stage 3. Combining INCLUDES and BELONGS TO trials. Training included eight trials with Set 7.

Stage 4. Establishing arbitrary stimuli as the SAME and DIFFERENT cues and additional training of INCLUDES and BELONGS TO cues. Training included 6 blocks of trials for a total of 72 trials. Training proceeded as follows (see Appendix A):

Block 1. Set Body (stimuli depicting parts of the human body, see Table 1) was used for the training of INCLUDES and BELONGS TO (8 trials). For example, in trial 34th (see Appendix A), a picture of a nose

appeared in the upper place of the screen, the stimulus for BELONGS TO appeared in the middle, and three figures at the bottom of the screen (e.g., *a head*, a trunk, and a nose).

Block 2. Set Body was used for the training of SAME and DIFFERENT relational cues (14 trials). For example, in trial 50th, a brain appeared in the upper place, the stimulus for DIFFERENT relation appeared in the middle and three figures at the bottom (*a walnut*, a head and a brain; Figure 4).

Block 3. A new set (Continents, see Table 1) was used for mixing the training of the four relational cues (13 trials). For example, in trial 56th the name "Madrid" appeared in the upper part of the screen, the stimuli for the contextual cue SAME in the middle part and three comparisons at the bottom (names of *Madrid*, Buenos Aires, Spain, see Figure 4).

Block 4. A new set (Alphabet, see Table 1) was used with identical characteristics to the previous block.

Block 5. Set Body, Alphabet and Continents were used (12 new trials, four trials for each set) for mixing training trials of the four relational cues.

Block 6. All sets were mixed using the select-the-cue format (12 trials) For example, in trial 94th (see Appendix A), a picture of Spain appeared both at the top and in the middle of the screen, and the four stimuli

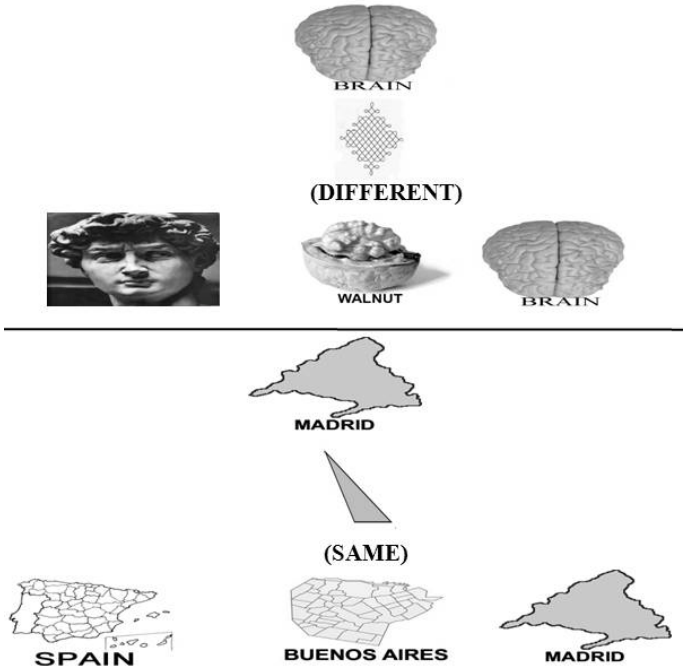

Figure 4. Examples of trials for DIFFERENT and SAME relational cues. The upper panel shows a trial for the training of the DIFFERENT relation. The bottom panel shows a trial for the training of the SAME relation. The words Different and Same were not visible to participants.

for *SAME*, DIFFERENT, INCLUDES and BELONGS TO appeared at the bottom of the screen. Participants had to click in one of these four options. When participants responded correctly to the six blocks of this phase, testing with new sets followed as indicated in the next stage.

Stage 5. Testing the SAME, DIFFERENT, INCLUDES and BELONGS TO cues. The relational functions of the arbitrary stimuli established as cues were tested with sets 11, 12, and 13 (Religion, Vegetables, and Universe) by using select-the-cue type of trials. In a typical trial, the words "Religions" and "Christianity" appeared, respectively, at the top and the middle of the screen, and the stimuli for SAME, DIFFERENT, INCLUDES and BELONGS TO appeared at the bottom (see Appendix A for details). Participants were informed that no feedback would be provided from this moment. As an exception, the order of presentation of each trial block was randomized across participants. The mastery criterion was established at 100% correct responses in one 9-trial block. Incorrect responses were immediately followed by a 4-trial retraining block including trials from previous stages. The test was resumed when participants produced 100% correct responses within one block. Participants who did not achieve the testing criterion within five testing-retraining cycles were dismissed from further participation.

Phase 2. Training and testing of three 4-member equivalence classes (bottom level of the hierarchies). Three 4-member equivalence classes were trained using one-to-many matching-to-sample (MTS) procedures (Class 1: A1-B1, A1-C1, A1-D1; Class 2: A2-B2, A2-C2, A2-D2; Class 3: A3-B3, A3-C3, and A3-D3) (see the 12 stimuli used in the middle portion of Figure 1). Training included select-the-stimulus type of trials only, where A stimuli served as samples; either B, C, or D stimuli served as comparisons; and the SAME cue served as the relational stimulus.

The training sequence was as follows. Each new relation (e.g., A1-B1) was trained until participants produced two consecutive correct responses. This was followed by the training of the same relations in Class 2 (A2-B2) and Class 3 (A3-B3) until two consecutive correct responses per relation were produced. Subsequently, the three relations (A1-B1, A2-B2, A3-B3) were presented at random in blocks of six trials (two per relation), until participants produced one block with 100% correct responses. The remaining new relations were trained in the same manner, except for the order of training (in A-C training: first A2-C2, then A3-C3 and, finally, A1-C1; in A-D training: first A3-D3, then A2-D2 and, finally, A1-D1). Training blocks containing all relations followed (three 6-trial blocks with A-B, A-C, and A-D relations) until 100% correct responses were produced. A written message then appeared on the screen informing participants that no feedback would be provided after responding during the subsequent trials. This message was followed by a 9-trial block (A1-B1, A2-B2, A3-B3, A1-C1, A2-C2, A3-C3, A1-D1, A2-D2, A3-D3). If participants produced 100% correct responses in one block, the stimulus equivalence test commenced; otherwise, they were presented with an additional 9-trial block with feedback.

Stimulus equivalence testing started without providing any additional instruction to the participants. It consisted of one 9-trial block (three trials per B-C, B-D, and C-D relations). If participants responded correctly to all trials, they were allowed to take a 5 to 15 minute break before proceeding to the next phase. Otherwise, symmetrical testing followed with one trial per relation. Combinatorial testing was resumed after producing 100% correct responses. Participants who did not meet testing criterion after five cycles were dropped from further participation. During the break, participants stayed alone in an adjacent room and were offered a drink.

After the break, relational cues and conditional discriminations were re-trained. First, 4-trial blocks for the retraining of each of the four relational cues with sets 8 to 10 (Continents, Body and Alphabet) were presented until participants produced 100% correct responding in one block. Then, 9-trial blocks for the retraining of each of the A-B, A-C, and A-D relations were presented until participants produced 100% correct responses within one block. Finally, 9-trial blocks for retesting each of the B-C, C-D, and B-D combinatorial relations were presented until participants produced 100% correct responses within a block. The mastery criteria were the same as in Phase 2.

Phase 3. Training the middle and top level of the hierarchies. During this phase, we used A and B stimuli, and the five novel stimuli shown at the bottom of Figure 1. Stimuli labeled as M and N served as negative response options during MTS procedures (i.e., they were not related with any other stimulus). Participants saw the following written message on the computer screen: "Remember everything you have learned before the break because it will help you during this part of the experiment." First, the middle level of the hierarchies was established, followed by the training of the top level of the hierarchies. Lastly, all trained hierarchical relations were presented in two blocks.

Stage 1. Training the middle level of the hierarchies (X.1, X.2 and Y.1). The following relations were trained: X.1 includes A1, X.1 includes B1, A1 belongs to X.1, and B1 belongs to X.1 (for branch X.1 of hierarchy X); X.2 includes A2, X.2 includes B2, A2 belongs to X.2, and B2 belongs to X.2 (for branch X.2 of hierarchy X); Y.1 includes A3, Y.1 includes B3, A3 belongs to Y.1, and B3 belongs to Y.1 (for hierarchy Y). A total of 37 trials were presented (see Table 2). The order of presentation of the trials was predetermined and kept constant across participants. Responding correctly to all trials was followed by two 6-trial blocks (one trial per relation) in which the order of presentation was randomized across participants. The mastery criterion was set at 100% correct responses in both blocks.

Stage 2. Training the top level of the hierarchies (X and Y, see Table 3). Four relations were trained for the first hierarchy: X includes X.1, X includes X.2, X.1 belongs to X, X.2 belongs to X. Two relations were trained for the second hierarchy: Y includes Y.1, and Y.1 belongs to Y. A total of 24 trials were presented in a predetermined sequence that was kept constant across participants. Responding correctly to all trials was followed by two 6-trial blocks (one trial per relation). The order of presentation was randomized across participants and the mastery criterion was set at 100% correct responses in both blocks (see Table 3).

Stage 3. Combining the middle and top levels of the hierarchies. Two 6-trial blocks were presented that contained trials from both levels of the hierarchy. Participants had to produce 100% correct responses in each block to proceed to the next 5-min break.

After the break, participants were presented with five blocks of trials for additional training of all the relations learned up to this point in the procedure (two blocks for the relations established in phases 1 and 3, and one block for the relations established in Phase 2).

Phase 4. Establishing X.1, D2 and C3 as cold, heavy and sweet, respectively. Stimulus-pairing and MTS procedures were used as follows. Firstly, two consecutive stimulus-pairing trials were presented for each stimulus for a total of six trials. On each trial, a stimulus, for example X.1, appeared centered on the left half of the screen; 0.5 s later the expression "is always cold" appeared centered on the right half of the screen.

Table 2. Sequence of trials for the training of the middle level of both hierarchical categories.

TRAINING X.1
A1/C1 [**SAM**-BEL] (2)
A1/X.1 [SAM-**BEL**] (2)
A1/B1 [**SAM**-BEL] (1)
B1/X.1 [SAM-DIF-**BEL**] (1)
X.1/B1 [SAM-DIF-**INC**] (1)
X.1/B1 [SAM-DIF-**INC**-BEL] (1)
A1/D1 [**SAM**-DIF-INC-BEL] (1)
A1/BEL[**X.1**-X.2-Y.1] (1)
B1/BEL[**X.1**-X.2-Y.1] (1)
X.1/INC [**A1**-A2-A3] (1)
X.1/INC [**B1**-B2-B3] (1)
TRAINING X.2
A2/C2 [**SAM**-BEL] (1)
A2/X.2 [SAM-**BEL**] (2)
A2/B2 [**SAM**-BEL] (1)
B2/X.2 [SAM-DIF-**BEL**] (1)
X.2/B2 [SAM-DIF-**INC**] (1)
X.2/B2 [SAM-DIF-**INC**-BEL] (1)
A2/D2 [**SAM**-DIF-INC-BEL] (1)
A2/BEL[X.1-**X.2**-Y.1] (1)
B2/BEL[X.1-**X.2**-Y.1] (1)
X.2/INC [A1-**A2**-A3] (1)
X.2/INC [B1-**B2**-B3] (1)
TRAINING Y.1
A3/C3 [**SAM**-BEL] (1)
A3/Y.1 [SAM-**BEL**] (2)
A3/B3 [**SAM**-BEL] (1)
B3/Y.1 [SAM-DIF-**BEL**] (1)
Y.1/B3 [SAM-DIF-**INC**] (1)
Y.1/B3 [SAM-DIF-**INC**-BEL] (1)
A3/D3 [**SAM**-DIF-INC-BEL] (1)
A3/BEL[X.1-X.2-**Y.1**] (1)
B3/BEL[X.1-X.2-**Y.1**] (1)
Y.1/INC [A1-A2-**A3**] (1)
Y.1/INC [B1-B2-**B3**] (1)
Two 6-TRIAL BLOCKS
BLOCK 1: RANDOM (6)
X.1/INC [**A1**-A2-A3]
X.2/INC [B1-**B2**-B3]
Y.1/INC [B1-B2-**B3**]
B1/BEL[**X.1**-X.2-Y.1]
B2/BEL[X.1-**X.2**-Y.1]
A3/BEL[X.1-X.2-**Y.1**]
BLOCK 2: RANDOM (6)
X.1/B1 [SAM-DIF-**INC**-BEL]
X.2/A2 [SAM-DIF-**INC**-BEL]
Y.1/B3 [SAM-DIF-**INC**-BEL]
B1/X.1 [SAM-DIF-INC-**BEL**]
B2/X.2 [SAM-DIF-INC-**BEL**]
A3/Y.1 [SAM-DIF-INC-**BEL**]

Notes: Correct answers appear in bold. Figures in parenthesis indicate the number of correct trials (1 or 2) necessary to proceed to the next trial. SAM= Same relational cue; DIF= Different relational cue; INC= Includes relational cue; BEL= Belongs to relational cue.

Table 3. Sequence of trials for the training of the top level of both hierarchical categories.

TRAINING X & Y
X.1/X [**SAM**-BEL] (2)
X/X.1 [SAM-DIF-**INC**-BEL] (2)
X.2/X [SAM-**BEL**] (2)
X/X.2 [SAM-DIF-**INC**-BEL] (2)
Y.1/Y [SAM-**BEL**] (2)
Y/Y.1 [SAM-DIF-**INC**-BEL] (2)
X.1/BEL [**X**-M-Y] (2)
X/INC [**X.1**-Y.1-N] (2)
X.2/BEL [**X**-M-Y] (2c.)
X/INC [**X.2**-Y.1-N] (2)
Y.1/BEL [X-M-**Y**] (2)
Y/INC [X.1-X.2-**Y.1**] (2)
Two 6-TRIAL BLOCKS
BLOCK 1: RANDOM (6)
X.1/BEL [**X**-M-Y]
X/INC [**X.1**-Y.1-N]
X.2/BEL [**X**-M-Y]
X/INC [**X.2**-Y.1-N]
Y.1/BEL [X-M-**Y**]
Y/INC [X.1-X.2-**Y.1**]
BLOCK 2: RANDOM (6)
X.1/X [SAM-DIF-INC-**BEL**]
X/X.1 [SAM-DIF-**INC**-BEL]
X.2/X [SAM-DIF-INC-**BEL**]
X/X.2 [SAM-DIF-**INC**-BEL]
Y.1/Y [SAM-DIF-INC-**BEL**]
Y/Y.1 [SAM-DIF-**INC**-BEL]

Notes: Correct answers appear in bold. Figures in parenthesis indicate the number of correct trials (1 or 2) necessary to proceed to the next trial. SAM= Same relational cue; DIF= Different relational cue; INC= Includes relational cue; BEL= Belongs to relational cue.

MTS trials were then presented in 15-trial blocks containing five trials per stimulus until participants produced 100% correct responses within a block. In a given trial, one of the stimuli appeared centered at the top of the screen, followed 0.5 s later by the expression "is always" centered in the middle of the screen, and 1 s later by four comparisons: "cold," "heavy," "sweet," and "none of the options is correct" at the bottom. The position of the comparisons was balanced across trials. Feedback (i.e., CORRECT or WRONG) followed participants' responses.

Phase 5. Critical Test. Testing transformation of functions within hierarchical categories. This phase started immediately after Phase 4. Participants read the following instructions: "The arrangement of the stimuli on the screen will now be different. Please, respond according to what you have learned throughout the procedure. Pay close attention to the response options across trials and select the MOST CORRECT one. Sometimes

the computer will tell you whether your choice is correct or not." Feedback was never provided during test trials.

Transformation of functions was tested with two stimuli from the top of the hierarchies (i.e., X and Y), one stimulus from the middle level of the two-branch hierarchy (i.e., X.2), three stimuli from the lower level of both hierarchies (i.e., C1, C2 and D3), and one negative comparison stimulus (i.e., M). The latter was used for experimental control purposes. Test trials were presented in MTS format in the following order across participants: Y, X, C1, M, X.2, D3, and C2. The stimulus to be tested served as the sample, and six response options served as comparisons. As in the previous phase, the expression "is always" appeared in the middle of the screen between the sample and the comparisons. Comparisons for stimulus Y were (the correct response is in italics): heavy; *sweet*; heavy and sweet; cold and heavy; heavy; none of the options is correct. Comparisons for stimulus X were: cold; heavy; *cold and heavy*; heavy and sweet; cold and sweet; none of the options is correct. Comparisons for stimulus C1 were: *cold*; heavy; cold and sweet; heavy and sweet; sweet; none of the options is correct. Comparisons for stimulus M were: cold; heavy; cold and sweet; heavy and sweet; sweet; *none of the options is correct*. Comparisons for stimulus X.2 were: *heavy*; sweet; heavy and sweet; cold and sweet; cold and heavy; none of the options is correct. Comparisons for stimulus D3 were: heavy; *sweet*; cold and sweet; heavy and sweet; cold; none of the options is correct. And comparisons for C2 were: *heavy*; sweet; cold and heavy; heavy and sweet; cold; none of the options is correct.

The criterion for passing the test was established at six correct responses out of the seven stimuli tested on the condition that the responses to the X and Y stimuli were among them. Both the selection of the stimuli to be tested and their order of presentation were based on the assumption that when a member of a hierarchy acquires a function, how this function transfers will depend on the specific relations established among the members of the hierarchy. In the present experiment, two hierarchies (with X and Y at the top) were established in a highly structured way: one (X) with two branches (X.1 and X.2) and the other one (Y) with only one branch (Y.1). Accordingly, the following effects were expected. First, the function acquired by X.1 (i.e., "is always cold") should transfer down to A1, B1, C1, and D1 stimuli and up to X. Second, the function acquired by C3 (i.e., "is always sweet") should transfer not only to the other members of Class 3 (i.e., A3, B3, and D3) but up to Y.1 (since Y.1 includes C3) and to Y (that includes Y.1 and all the members of Class 3). And third, the function acquired by D2 (i.e., "is always heavy") should transfer in the same way as for C3. Given that X.1 was established as cold, and X.2 acquired heavy functions by derived means, both cold and heavy functions should transfer to X. One would expect that both functions then transfer back down to X.1 that would now also be heavy, and X.2 that would now also be cold. However, the derived relations of distinction between X.1 and X.2, and between Class 1 and Class 2 members, would stop this top-down transfer (i.e., the *cold* function of X.1 should not transfer to X.2, A2, B2, C2 or D2; and the *heavy* function of D2 should not transfer to X.1, A1, B1, C1 or D1).

Participants who did not meet the testing criterion were presented with two 6-trial blocks for the retraining of the hierarchical relations, followed by a 6-trial block for the retraining of X.1, D2, and C3 functions (2 trials per stimulus). The test was then resumed. Participants were fully debriefed after completing the test.

RESULTS

Training and testing the relational cues INCLUDES, BELONGS TO, SAME, and DIFFERENT (Phase 1). All 10 participants met the testing criterion on the first attempt. The number of trials necessary to reach the criterion varied from 105 (P1) to 121 (P7) (see Table 4, Phase 1) and the percentage of correct responses varied from 86.8% (P7) to 100% (P1).

Training of the Equivalence classes (the bottom level of the hierarchies). All participants showed the formation of the three 4-member equivalence classes. The range of trials needed to complete the training and percentage of correct responses were, respectively, from 68 (P1) to 94 (P3) and from 88.1% (P8 and P9) to 92.8% (P7) (see Table 4, Phase 2). All but three participants passed the test on the first attempt (P4 on the third, P9 on the second and P10 on the fourth attempt). Equivalence classes were retested twice, at the end of phases 2 and 3. All participants met the test criterion on the first attempt except for P6 who needed four attempts to complete the first retest.

Training of the middle and top levels of the hierarchies and establishment of functions. All 10 participants met the training criterion (see Table 4, Phase 3). The number of trials needed to reach the criterion ranged from 97 (P2 and P5) to 126 (P6) with correct responses ranging from 86.4% (P10) to 100% (P2 and P5). Also, all participants met the criterion for the establishment of functions to X.1, D2 and C3 within the first block of trials.

Critical Test: Test for transformation of functions. In order to pass the test, participants had to respond correctly to stimulus X (i.e., "X is always cold and heavy") and stimulus Y (i.e., "Y is always sweet"), and to four of the remaining five stimuli at least. Nine of the 10 participants eventually passed the test. As shown in Figure 5, five participants (P1, P4, P6, P8, and P9) met the test criterion on their first attempt

Table 4. Number of trials to meet the training criterion (and percentage of correct responses) during phases 1 to 3. Number of correct responses to the function transformation test during Phase 5.

	Phase 1 Hierarchical cues		Phase 2 Bottom level		Phase 3 Middle and top level	Phase 5 Critical Test	
	Training	Test	Training	Test	Training	1st attempt	2nd attempt
P1	105 (100%)	OK	68 (92.6%)	OK	116 (93.9%)	7/7*	
P2	111 (94.6%)	OK	75 (90.7%)	OK	97 (100%)	6/7	7/7*
P3	118 (88.9%)	OK	94 (89.4%)	OK	119 (90.7%)	6/7	6/7
P4	120 (89.2%)	OK	77 (89.6%)	OK	110 (97.3%)	7/7*	
P5	115 (91.3%)	OK	72 (88.9%)	OK	97 (100%)	6/7	7/7*
P6	116 (90.5%)	OK	70 (90%)	OK	126 (92.1%)	7/7*	
P7	121 (86.8%)	OK	84 (92.8%)	OK	99 (97.9%)	5/7	6/7*
P8	110 (95.4%)	OK	76 (88.1%)	OK	113 (94.7%)	6/7*	
P9	113 (92.9%)	OK	84 (88.1%)	OK	106 (96.2%)	7/7*	
P10	117 (89.7%)	OK	84 (91.6%)	OK	118 (86.4%)	5/7	7/7*

*= Participants who met the Critical Test criterion.

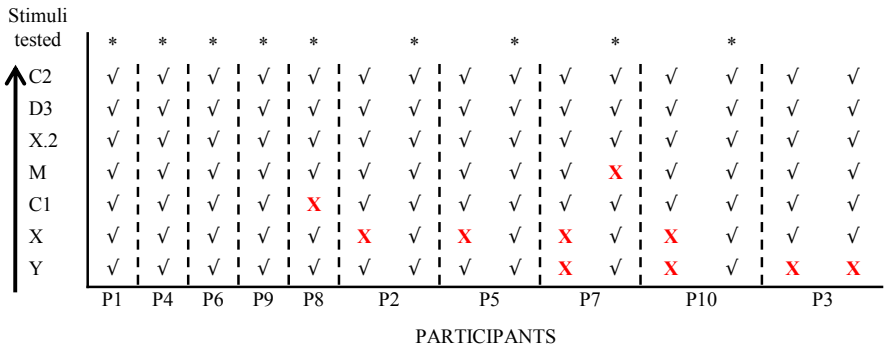

Figure 5. Participants' responses to the Critical Test of transformation of functions according to hierarchical relations. Stimuli that were tested appear on the ordinate axis. The symbol √ indicates a correct answer. The symbol X indicates a wrong answer. The symbol * indicates that the Participant passed the test.

(four of them by responding correctly to all trials: P1, P4, P6, and P9). Three of the remaining 5 participants responded correctly to 6 out of 7 trials but failed to respond correctly to X or Y. After retraining, all five participants except one (P3) passed the test, as Figure 5 shows.

DISCUSSION

The current study is the first of a series of experiments (Gil *et al*., 2009, 2010, 2011) focused on the experimental analysis of hierarchical categorization and hierarchical responding. Specifically, the aim of the current study was to analyze some of the transformation of functions that take place among the members of hierarchical categories. First, through MET, four stimuli were trained as the relational cues INCLUDES, BELONGS TO, SAME, and DIFFERENT. Subsequently, two 3-level hierarchical categories were trained by using the relational cues previously trained. Three different functions were then provided to three different stimuli of the hierarchical categories (i.e., X.1. is always cold, D2 is always heavy, and C3 is always sweet). Finally, transformation of functions was tested with the two stimuli at the top of the hierarchies (i.e., X and Y), one stimulus at the middle level of the two-branch hierarchy (i.e., X.2.), three stimuli in the lower level of both hierarchies (i.e., C1, C2, and D3), and a negative comparison stimulus (i.e., M).

Nine of the ten participants responded according to what was expected, that is, according to the arbitrary relations established among the stimuli. More specifically, they responded that D3 was always sweet by virtue of its combinatorial (or equivalence) relation with C3 that was directly established as always sweet. They also responded correctly that X.2 was always heavy by virtue of its derived hierarchical relation with D2 that was directly established as always heavy. Finally, they responded correctly

that category X was always cold and heavy, by virtue of the hierarchical relations with X.1 (directly established as always cold) and X.2, the latter in a derived hierarchical relation with heavy D2.

To our knowledge, the current study is the first in which: (a) arbitrary stimuli are established as hierarchical relational cues (i.e., "includes" or "contains" and "belongs to" or "is a member of"), (b) hierarchical categories are formed using these hierarchical relational cues, and (c) the transformation of functions in accordance with hierarchical relations is tested. Despite this, the present study has some limitations that need to be overcome in future experimental preparations. The main limitation relates to the fact that the context "is always" was included both during the establishment of the functions cold, heavy and sweet, and during the Critical Test as part of the item format. This may have hindered the accurate downward transformation of functions within the X hierarchy. That is, "X has a cold part and a heavy part" might be a better descriptor for the transformed function of stimuli X, instead of the general response "is always cold and heavy." According to the information provided by the participants at the end of the experiment, both forms ("is always cold and heavy" and "has a cold part and a heavy part") would have the same colloquial meaning, and although saying, for instance, "part of my family is intelligent and another part is funny" is technically more accurate, the option "my family is intelligent and funny" is more colloquial. This is because, in some contexts, the expression "is" can be functionally equivalent to "has a part," and it is used to express hierarchical relations. Nonetheless, future studies might implement procedures to allow participants to discriminate between both types of relations (equivalence vs. hierarchical) more precisely.

Another limitation of the present experiment is that hierarchical relations were trained in both directions (e.g., X includes X.1, and X.1 belongs to X). Thus, it might be argued that the transfer of functions from X.1 to X is not based on derived relations. Further research should consider training hierarchical relations in only one direction, in our case, either X includes X.1, or X.1 belongs to X, but not both.

Finally, participants in this study were adults with preexisting repertoires of hierarchical categorization, as in previous studies (i.e., Griffe & Dougher, 2002; Slattery *et al*., 2011). Unlike to those studies, our study was directly aimed to establish the hierarchical relational cues, which may be useful to use with children lacking this repertoire.

Going back to the example presented in the introduction, our participants' performance during the Critical Test may be functionally equivalent to Juan's reaction. In the same way as Juan, after hearing María saying that her family from Sevilla are funny, he automatically derived that Ana, María's cousin from Sevilla must be funny too; our participants automatically derived that C1 was cold because it belonged to X.1, directly established as cold. This shows how functions transfer down to subordinate stimuli. Another example is how Juan derived that María's family is funny and intelligent in the same way that our participants derived that X was cold on X.1 side, and heavy on X.2 side (or both cold and heavy). This shows how functions transfer up from subordinate to superordinate stimuli. Further research might analyze how the transformation of functions occurs when functions are provided to the top of the hierarchy. For instance,

if María told Juan that her whole family is very generous, this function would transfer top-down to all family members, regardless of their birthplace, although her family from Sevilla would still be funny (but not intelligent) and her family from Santander would still be intelligent (but not funny).

The present experiment is only a preliminary step towards the experimental analysis of the complex relations defining hierarchical categorization. Future research is needed to refine the procedures and isolate the different transformation of functions that may occur within a hierarchy.

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Appendix A

Sequence of trials for the training of relational cues INCLUDES, BELONGS TO, SAME and DIFFERENT. Correct answers appear in italics. Figures in parenthesis indicate the number of correct trials (1 or 2) necessary to proceed to the next trial. SAM= SAME relational cue; DIF= DIFFERENT relational cue; INC= INCLUDES relational cue; BEL= BELONGS TO relational cue.

STAGE 1. TRAINING INCLUDES RELATIONAL CUE

SET 1

1-CIRCLE/INC [*clock*, chair, dog] (2)

SET 2

3-RHOMBUS/INC [*pencil*, trumpet, rose] (1)
4-RHOMBUS/INC [*umbrella*, rose, radio] (1)
5-RHOMBUS/INC [*pencil and umbrella*, trumpet, rose] (1)
6-RHOMBUS/INC [*pencil and "another thing*," trumpet and "another thing," rose] (1)
7-RHOMBUS/INC [*none is correct*, rose and "another thing," trumpet] (1)
8-RHOMBUS/INC [*pencil*, none is correct, radio and "another thing"] (1)

SET 3

9-CIRCLE/INC [*envelope*, boot, car] (1)
10-RECTANGLE/INC [*stair*, ball of wool, car] (1)
11-CIRCLE/INC [*envelope and lamp*, envelope and stair, stair and "another thing"] (1)
12-CIRCLE/INC [*none is correct*, envelope and boot, ball of wool and envelope] (1)
13-RECTANGLE/INC [*boot and "another thing",* lamp, none is correct] (1)

STAGE 2. TRAINING BELONGS TO RELATIONAL CUE

SET 4

14-A/BEL [*shape 1*, shape 2, Z] (2)
16-R/BEL [*shape 2*, shape 1, P] (2)

SET 5

18-HEART/BEL [*glass*, octagon, table] (1)
19-APPLE/BEL [*octagon*, glass, racket] (1)
20-TABLE/BEL [*none is correct*, glass, octagon] (1)
21-HEART/BEL [*glass*, octagon, none is correct] (1)

SET 6

22-SHOES/BEL [*shape 2*, shape 1, shape 3] (1)
23-SHOES/BEL [*none is correct*, shape 1, shape 3] (1)
24-BOAT and TOY/BEL [*shape 3*, shape 1, none is correct] (1)
25-TOY and HAIRDRYER/BEL [*none is correct*, shape 2, shape 3] (1)

STAGE 3. COMBINING INCLUDES AND BELONGS TO TRIALS

SET 7

26-PENTAGON/INC [*computer and crown*, calculator, planet] (1)
27-MOON/BEL [*circle*, triangle, cross] (1)
28-PENTAGON/BEL [*circle*, triangle, cross] (1)
29-CIRCLE/INC [*moon and crown*, moon, none is correct] (1)
30-COMPUTER AND MOON/BEL [*circle*, cross, none is correct] (1)
31-CIRCLE/INC [*none is correct*, 7 and cards, glasses and "another thing"] (1)
32-GLASSES AND PLANET/BEL [*cross*, circle, none is correct] (1)
33-CROSS/INC [*planet and "another thing",* planet, computer and crown, none is correct] (1)

STAGE 4. TRAINING SAME, DIFFERENT, INCLUDES AND BELONGS TO

BLOCK 1

SET 8 (SET BODY)

34-NOSE/BEL [*head*, trunk, nose] (2)
36-HEAD/INC [*nose*, crocodile head, head] (2)
38-BRAIN/BEL [*head*, walnut, brain] (1)
39-HEAD/INC [*brain*, crocodile head, head] (1)
40-EYE/BEL [*head*, marble, eye] (1)
41-HEAD/INC [*eye*, crocodile head, head] (1)

BLOCK 2

42-NOSE/SAME [*nose*, trunk, head] (2)
44-BRAIN/SAME [*brain*, walnut, head] (2)
46-EYE/SAME [*eye*, marble, head] (1)
47-NOSE/DIF [*trunk*, head, nose] (2)
49-NOSE/SAME [*nose*, trunk, head) (1)
50-BRAIN/DIF [*walnut*, head, brain] (2)
52-BRAIN/SAME [*brain*, walnut, head] (1)
53-EYE/DIF [*marble*, head, eye] (2)
55-EYE/SAME [*eye*, marble, head] (1)

BLOCK 3

SET 9 (SET CONTINENTS)

56-MADRID/SAME [*Madrid*, Buenos Aires, Spain] (1)
57-MADRID/BEL [*Spain*, Buenos Aires, Madrid] (1)
58-SPAIN/INC [*Madrid*, France, Spain] (1)
59-MADRID/DIF [*Buenos Aires*, Spain, Madrid] (2)
61-ALMERIA/DIF [*Mexico City*, Spain, Almeria] (1)
62-ALMERIA/SAME [*Almeria*, Mexico City, Spain] (1)
63-ALMERIA/BEL [*Spain*, Mexico City, Almeria] (1)
64-SPAIN/INC [*Almeria*, France, Spain] (1)
65-CADIZ/BEL [*Spain*, Santiago de Chile, Cadiz] (1)
66-CADIZ/SAME [*Cadiz*, Santiago de Chile, Spain] (1)
67-CADIZ/DIF [*Santiago de Chile*, Spain, Cadiz] (1)
68-SPAIN/INC [*Cadiz*, France, Spain] (1)

BLOCK 4

SET 10 (SET ALPHABET)

69-A/SAME [*a*, f, vowels] (1)
70-A/BELONG [*vowels*, f, a] (1)
71-A/DIF [*f*, vowels, a] (1)
72-VOWELS/INC [*a*, consonants, vowels] (1)
73-E/BEL [*vowels*, k, e] (1)
74-E/SAME [*e*, k, vowels] (1)
75-VOWELS/INC [*e*, consonants, vowels] (1)
76-E/DIF [*k*, e, vowels] (2)
78-VOWELS/INC [*u*, consonants, vowels] (1)
79-U/DIF [*r*, vowels, u] (1)
80-U/SAME [*u*, r, vowels] (1)
81-U/BEL [*vowels*, r, u] (1)

BLOCK 5

SET 8 (SET BODY)

82-HEAD/BEL [*human body*, crocodile head, head] (1)
83-HEAD/SAME [*head*, crocodile head, human body] (1)
84-HEAD/DIF [*head crocodile*, human body, head] (1)
85-HUMAN BODY/INC [*head*, robot, human body] (1)

SET 10 (SET ALPHABET)

86-ALPHABET/INC [*vowels*, numbers, alphabet] (1)
87-VOWELS/SAME [*vowels*, consonants, alphabet] (1)
88-VOWELS/DIF [*consonants*, alphabet, vowels] (1)
89-VOWELS/BEL [*alphabet*, consonants, vowels] (1)

SET 9 (SET CONTINENTS)

90-SPAIN/BEL [*Europe*, France, Spain] (1)
91-SPAIN/SAME [*Spain*, Asia, Europe] (1)
92-EUROPE/INC [*Spain*, Asia, Europe] (1)
93-SPAIN/DIF [*France*, Europe, Spain] (1)

BLOCK 6

94-SPAIN/SPAIN [*SAM*-DIF-INC-BEL] (1)
95-HEAD/BRAIN [SAM-DIF-*INC*-BEL] (1)
96-BRAIN/HEAD [SAM-DIF-INC-*BEL*] (1)
97-EUROPE/ASIA [SAM-*DIF*-INC-BEL] (1)
98-HUMAN BODY/EYE [SAM-DIF-*INC*-BEL] (1)
99-U/U [*SAM*-DIF-INC-BEL] (1)
100-ALPHABET/NUMBERS [SAM-*DIF*-INC-BEL] (1)
101-CADIZ/SPAIN [SAM-DIF-INC-*BEL*] (1)
102-BRAIN/HUMAN BODY [SAM-DIF-INC-*BEL*] (1)
103-A/F [SAM-*DIF*-INC-BEL] (1)
104-SPAIN/ALMERIA [SAM-DIF-*INC*-BEL] (1)
105-ALMERIA/SPAIN [SAM-DIF-INC-*BEL*] (1)

STAGE 5. TESTING SAME, DIFFERENT, INCLUDES AND BELONGS TO.

SET 11 (SET RELIGIONS)

RELIGIONS/CHRISTIANITY [SAM-DIF-*INC*-BEL]
PRIEST/CATHOLIC CHURC [SAM-DIF-INC-*BEL*]
ISLAM/RELIGIONS [SAM-DIF-INC-BEL]

SET 12 (SET VEGETABLES)

CARROT/CARROT [*SAM*-DIF-INC-BEL]
ROSE/CARROT [SAM-*DIF*-INC-BEL]
FLOWER SHOP/ROSE [SAM-DIF-*INC*-BEL]

SET 13 (SET UNIVERSE)

UNIVERSE/SATURN [SAM-DIF-*INC*-BEL]
EARTH/UNIVERSE [SAM-DIF-INC-*BEL*]
COMET/ROCKET [SAM-*DIF*-INC-BEL]