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Empirical Analysis of Derived Hierarchical Responding

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Abstract

In hierarchical responding, classes of stimuli (e.g., granite or marble) are grouped into broader classes (e.g., rocks), and these broader classes can be further grouped into even broader classes (e.g., minerals). Relational Frame Theory (RFT) conceptualizes a hierarchical network as a derived relational response in which specific stimuli (is part of, belongs to, ...) called relational cues are learned through multiple examples with non-arbitrary functions among stimuli, which are subsequently applied to relate stimuli arbitrarily. This experiment analyzes the circumstances under which derived hierarchical responses might be brought under experimental control. A total of 9 adults took part in the experiment. Participants were familiarized with the tasks and experimental procedure in the first phase. In the second phase, four relational cues were trained: Sameness (Sa), Distinction (Di), Inclusion-Sameness (IncSa), and Inclusion-Distinction (IncDi). In the third phase, four arbitrary networks were trained using the four cues, one per cue, respectively, and functions were assigned to different stimuli of the four networks. Finally, derived relations and functions were tested for each network. Six out of nine participants correctly responded to all tests, two partially, and one failed. The study extends the previous research regarding derived hierarchical responding in terms of the complexity of the derived patterns shown in the networks. Implications and limitations are discussed.
Key words: Relational Frame Theory, Hierarchical Responding, Derived Relational Responding.

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Novelty and Significance

What is already known about the topic?

- Several empirical studies have been conducted to train hierarchical relational cues and then use these cues to train and analyze function derivation in hierarchical networks.
- Despite progress, several questions remain regarding the characteristics of training relational cues and the pattern of derived responses in these networks.

What this paper adds?

- This paper extends the knowledge of relational cue training by exploring which features enable its training.
- This article shows the training of an analogue of a hierarchical response, replicating features previously explored in other studies and revealing previously unexplored features.

Hierarchical responding is a response in which a class or category of stimuli, such as “minerals,” includes subclasses or subcategories of stimuli, such as “metals” or “rocks,” with each of these subclasses possibly integrating additional levels (Zentall, Galizio, & Critchfied, 2002). It has been pointed out that hierarchical responding plays a central role in different areas of human behavior, such as concept learning (Tenenbaum, Kemp, Griffiths, & Goodman, 2011), reasoning (Eckstein, Starr, & Bunge, 2019; Hadjichristidis, Sloman, & Over, 2014), social psychology (Blasco Delgado, Llobera Cascalló, Ruiz Sánchez, & Villarroel Carrasco, 2019; Bodenhausen, Kang, & Peery, 2012), psychopathological phenomena and human language (Foody, Barnes-Holmes, Barnes-Holmes, Rai, & Luciano, 2015; Luciano, Törneke, & Ruiz, 2021; Luciano, Ruiz, Gil Luciano, & Villarroel 2023).

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Relational Frame Theory (RFT; Hayes, Barnes-Holmes, & Roche, 2001) is a functional-analytic theory aiming to understand complex behaviors such as those previously mentioned. According to RFT, arbitrarily applicable relational responding, or relational framing, is an operant that consists of relating through the previously established functions of relational cues. The relational cues (Crels) that define natural language are the following: coordination ("same as"), distinction ("different from"), comparison (e.g., "more than," "less than"), opposition ("is the opposite to"), temporal ("after," "before"), deictic (I-Now-Here; You-Then-There, and combinations), hierarchical ("includes," "belongs to," "members of"), spatial ("here-there", inside-outside"), and casual ("if..., then").

The main characteristic of relational framing is the derivation of stimulus relations and the transformation of stimulus functions. For instance, when we are told that Luis is better than María at the piano and that Juan is worse than María, we might derive that Juan is the worst and Luis is the best of the three at the piano. Note that in this example, the Crels are of comparison (i.e., "better than," "worse than") and that the transformation of functions occurs when the appropriate functional context is present. For example, if we are interested in listening to good piano music, we might invite Luis to play it. However, let's say that Adams, one of us, is a fantastic pianist who is unwilling to invite someone who might be better than him. In such a case, Adams should recommend inviting Juan to play piano. These contexts that determine the transformation of function are called functional context (Cfunc) in RFT. According to RFT, we learn to derive relations because of the social interactions we experienced in childhood involving multiple exemplars of relating, for instance, through comparison (e.g., "more than") in which deriving coherent relations and functions was explicitly reinforced. The multiple exemplars of applying relational responding established a functional context of coherence with high-reinforcing properties.

RFT suggests that the main properties of relational framing are mutual entailment, combinatorial entailment, and transformation of functions. These properties were in place in the example of the pianists. For instance, mutual entailment involves the bidirectionality of stimulus relations. In our example, once we were told that "Luis is better than María at the piano," we could derive that "María is worse than Luis at the piano." Likewise, after being told that "Juan is worse than María at the piano," we could derive that "María is better than Juan at the piano." As well, combinatorial entailment is derived as: "Luis is better than Juan" or "Juan is worse than Luis." Then, a network is built that relates María, Luis, and Juan in the context of comparison when the Cfunc (e.g., piano listening) is present. However, deriving very basic networks, as in the example, is not the whole history of derived relational responding. We also learn to derive relations between networks, as when we do analogies, metaphors, or very complex categories. The example of hierarchical responding, given in the introduction, is one of these complex ways of relating different networks. A more detailed analysis of these characteristics can be found in the original book (Hayes *et alii*, 2001) and more recent publications (e.g., Barnes-Holmes, Barnes-Holmes, Hussey, & Luciano, 2016; Barnes-Holmes & Hughes, 2016; Fryling, Rehfeldt, Tarbox, & Hayes, 2020; Luciano, Valdivia Salas, Berens, Rodríguez Valverde, Mañas, & Ruiz, 2009). This paper will focus on the most flexible relational operant, identified as hierarchical responding.

Following the introductory example, let us think that Tom is learning the minerals category. As Figure 1 shows, Tom learns that Iron serves the steel industry, Gold is used for jewelry, Granite is typical in construction, and Marble is often used in art for making sculptures. Later, the teacher tells Tom that all these four stimuli, despite their differences, can be grouped into two broader categories: Iron and Gold belong to the Metals category because they share the property of electrical conductivity, and Granite and Marble to the Rocks category because they share the function of showing compression resistance and durability. Similarly, the teacher says that these categories, with their distinctive functions, can also be grouped on a broader one, with Metals and Rock being members of, or belonging to, the minerals category. This way, the minerals category comprises many properties from its members (e.g., durability, conductivity, etc.), and all the category members, despite having distinctive features, are firstly organized by sharing one or more general/inclusive functions that define the entire network: geological processes develop all minerals.

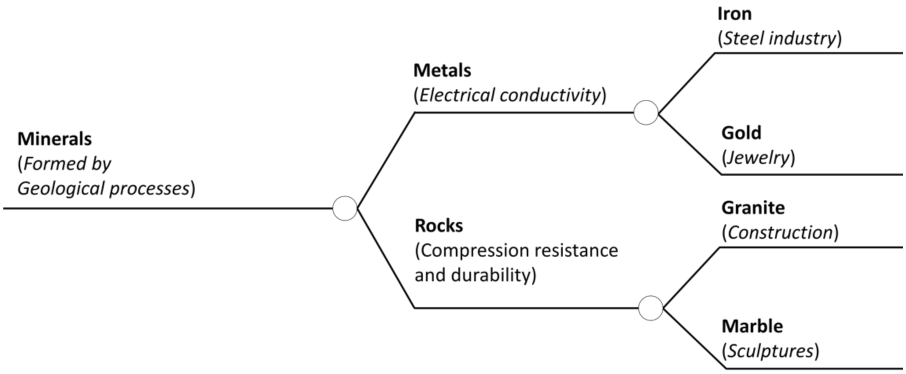


Figure 1. Hierarchical network example where the Mineral represented the highest level, as the middle level, and the respective branches, as the lower level.

We typically learn such categories with ease. However, two questions emerged. One concerns the precise conditions under which we learn the Crel of inclusion/integration (e.g., belongs to, is part of…) so that, as in our example Tom understands or formulates new relations among different groups of elements and keep all of them together under the control of specific functions. This question concerned our developmental interactions with the verbal community. The second question concerns the conditions under which hierarchical responding might be brought under experimental control. A recent systematic review by Budziszewska, Villarroel, and Gil (2022) has shown a high variability regarding the conceptualizations of a derived hierarchical response and the procedures implemented to train it. First, some studies aimed to test and train the classic Piagetian class-inclusion response task, which consists of answering questions such as “Are there more dogs or animals?” when presented with an array of stimuli consisting of four dogs and three cats (Ming, Mulhern, Stewart, Moran, & Bynum, 2018; Zagrabska-Swiatkowska, Mulhern, Ming, Stewart, & McElwee, 2020). Second, other studies trained classification repertoires based on non-arbitrary properties (e.g., training to classify triangles of different angles) and then tested the generalization of this response to novel triangles (Griffe & Dougher, 2002; Slattery, Stewart, & O’Hora, 2011). Third, some studies aimed at training and testing arbitrary networks using natural language relational cues such as “contains” or “is a type of” mix with non-arbitrary functions (Mulhern, Stewart, & McElwee, 2017; Mulhern, Stewart, Ming, Zagrabska-Swiatkowska, & McElwee, 2018). Lastly, other studies have focused on training relational cues using non-arbitrary multiple-exemplar training, which is then used to relate stimuli arbitrarily to build networks of different levels, and then to test for derived responses (Gil, Luciano, Ruiz, & Valdivia Salas, 2012, 2014; Slattery & Stewart, 2014).

Gil *et alii* (2014) trained four abstract figures as the relational cues for “includes,” “belongs to,” “same,” and “different” through a multiple-exemplar training that included several sets of stimuli, non-arbitrarily related, through “inside/outside” relations, such as a picture of a circle containing a clock and a chair, and a dog outside the circle. Additionally, several sets comprise stimuli with culturally established inclusion relations (e.g., religions and different types of religions, the alphabet, and different letters, etc.). Then, three equivalence classes were established using the "same" cue, and then, the "includes" relational cue was used to train two arbitrary networks, one with two branches (see Figure 2, left part) and the other with one, as control. The relevant network involves "X includes X1 and X2; X1 includes the equivalence class A1-B1-C1-D1, and X2 includes the equivalence class A2-B2-C2-D2." Afterwards, functions were assigned to some stimuli of the networks (X1 and D2 were, respectively, established as cold and heavy). Lastly, participants were tested for derived responses.

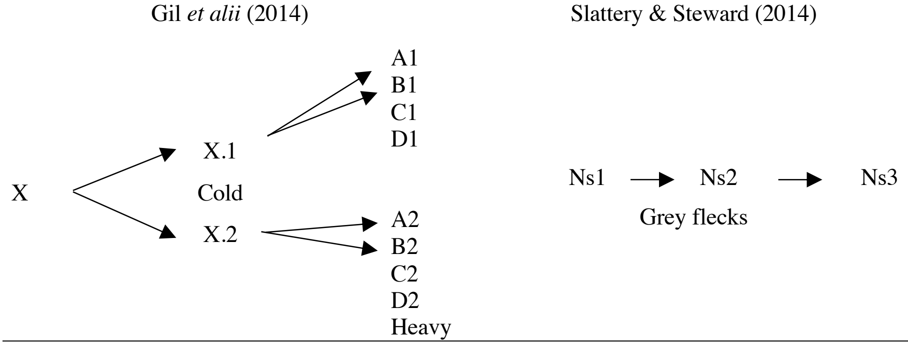


Figure 2. Networks trained using "includes" cues by Gil *et alii* (2014) and by Slattery and Stewart (2014).
Notes: Cold= Function assigned to X.1; Heavy= Function assigned to D2; Grey flecks= Function assigned to Ns2; Ns= nonsense syllable.

The results showed that the stimuli at the top of the hierarchy (X) integrated the functions of the lower levels, e.g., participants identified X as "heavy and cold," that is, including the functions of the subordinate branches X.1 (heavy) and D2 (cold). This was referred to as an Up pattern of ToF (in the present manuscript, it will be called bottom-up). In addition, the stimuli of the lower level of the hierarchy acquired the functions of the higher level, e.g., C1 was identified as "cold" because it belonged to X.1. This was referred to as a top-down pattern of ToF. Finally, the distinction between the different branches of the hierarchy was shown since the stimuli belonging to branch X.2 were not considered "cold," and the stimuli belonging to branch X.1 were not considered "heavy."

Other studies, such as Slattery and Stewart (2014), have used a different strategy to train hierarchical relational cues and have trained simpler networks, as shown in Figure 2 (right part). More specifically, firstly, stimuli that share functions were used to develop the "belongs to" and "includes" relational cues (e.g., squares or circles of different colors or abstract shapes that share dots or lines). Then, both relational cues were used to train one of two arbitrary networks. For instance, Ns1 (nonsense syllable) includes Ns2; and Ns2 includes Ns3. Subsequently, a function was assigned to the stimuli in the middle (e.g., Ns2 was set as "grey flecks"), and finally, participants were tested for derived relational responses. Different from Gil et alii (2024) results, the former studies only show a top-down pattern of ToF; that is, Ns3, which belongs to Ns2, was considered to have grey flecks, but Ns1, which included Ns2, was not regarded as grey flecks. Perhaps the difference has to do with the kind of networks established in this experiment: two networks of three stimuli each using, respectively, the cues "belongs to" and "includes." Given the absence of more than one stimulus that belongs to, or is included in another one, it is unclear what kind of networks were formed by the participants.

Finally, recent unpublished studies have explicitly trained complex networks with different stimuli and different functions aimed to analyze experimental analogs of hierarchical categorization. On the one hand, Budziszewska (2023) used inclusion/

belonging sets of stimuli that shared features (e.g., different stimuli but with a common function, such as motion) and exemplars of culturally established categories during relational cue training, with results that replicate those of Gil et alii (2014). Conversely, the unpublished study by Callejón (2020) used sets of different stimuli that shared features as well as inside/outside non-arbitrary functions to establish the relational cue. The results obtained extended previous studies in testing the top-down, bottom-up, and differentiation between branches while all stimuli share a joint/inclusive function. However, the results should be taken cautiously because the procedure explicitly trained some of these responses.

The present study further explores the complexity of derived responses through hierarchical networks. On the one hand, the studies by Gil et alii (2012, 2014) -and other unpublished studies- have shown the bottom-up and top-down transformation of functions and differentiation between branches, while other studies only have shown the top-down transformation of functions. Furthermore, the most inclusive function has not been incorporated or has not been experimentally isolated, so we cannot assume that an analog of the complex hierarchical categorization has been experimentally established. In addition, the networks established in the different studies have been different, which must be considered as sources of variations. To sum up, the hierarchical pattern of transformation of functions needs to be precisely explored. The present experiment aims to advance in this track by training a hierarchical network where (a) different branches or networks should be related in increasingly inclusive functions, where (b) different functions should be given to different stimuli in the whole network to test for derived top-down and bottom-up, and where (c) the most inclusive function should be identified in the network.

Method

Participants

Nine undergraduate psychology students (6 females) participated in the experiment. Their ages ranged between 19 and 22 (*M*= 19.66, *SD*= 1.11 years). They were recruited through an email announcement that informed the opportunity to receive course credits for participating in the experiment. None of the participants had prior experience with RFT experiments and did not know the purpose of the experiment.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Apparatus, Settings, and Stimuli

The experiment was conducted in a 3x3 meter room equipped with a table, a chair, a laptop (HP Pavilion x360 convertible laptop with a 14-inch monitor), and a one-way mirror that allowed the experimenter to observe the computer screen from an adjacent room. The experimental tasks were designed and executed using Microsoft PowerPoint™ software, which enabled the display of visual stimuli (labels, drawings, symbols, effects, instructions, etc.) and to record the participant's responses. Participants completed the tasks within the PowerPoint software and, when required, using sheets and pens.

Figure 3 shows examples of the stimuli used throughout the experiment. In the initial phase, 105 stimuli were presented on slides or sheets of paper. These stimuli included figures and labels such as words, letter pairs, nonsense syllables, numbers, and symbols. These stimuli were combined to form culturally known (e.g., F: Spanish movies { G: El Verdugo, H: Viridiana) or unknown networks (F: 253{ G: 186, H: 54.)

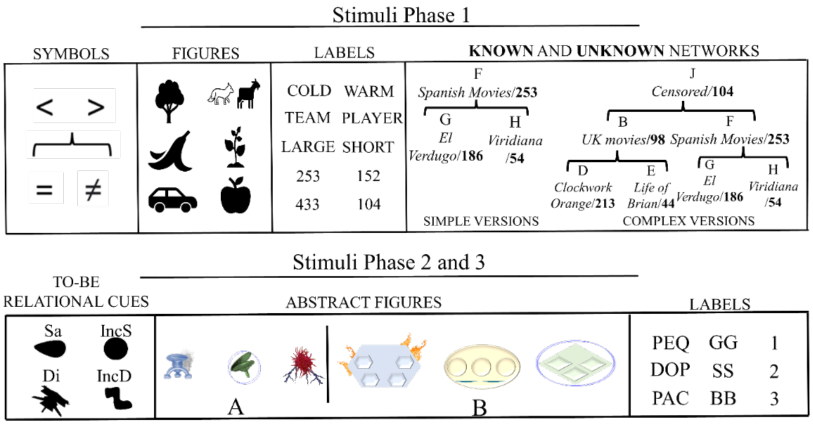


Figure 3. Examples of stimuli used in the different phases of the experiment.
Notes: Known networks= Comprise culturally known words (e.g., "F: Spanish movies { G: El Verdugo, H: Viridiana"); Unknown networks= Comprise numbers (e.g., "F: 253{ G: 186, H: 54"); Simple versions= three stimuli networks; Complex versions= more than three stimuli networ.

with simple (consisting of three stimuli) or complex (consisting of more than three stimuli) network versions.

The second phase employed 168 labels, including nonsense syllables, words, and numbers. Additionally, abstract figures were created using 26 shapes extracted from a stimuli database (NOUN; Horst & Hout, 2015) and Microsoft Power Point, five colors, and seven GIFs. The figures were divided into two groups: A larger and B smaller. Appendix 1 shows the shapes, colors, and gifs that combine to form the abstract figures.

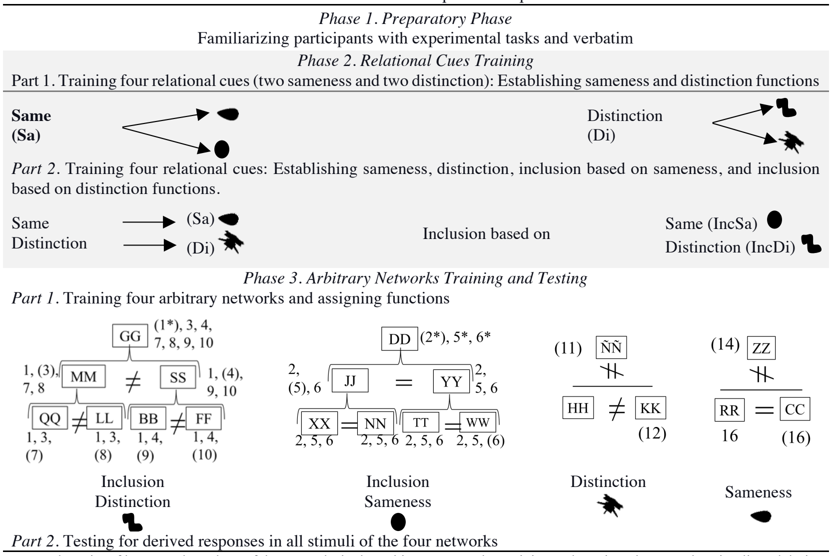
Finally, in the third phase of the experiment, 52 labels were used, including 35 letter pairs and 17 number pairs. These stimuli were presented in various sizes, ranging from 0.5 to 12 cm wide and 1 to 6.5 cm high.

Design

The primary purpose of this experiment was to develop a training protocol to establish a hierarchical network analog to the one described in the introductory example in which (a) the transformation of functions occurs both top-down and bottom-up, in which (b) different branches include different stimuli, and in which (c) there was a function more inclusive than the rest. An intra-subject design was applied with one training protocol with four different Multiple-Exemplar training (MET) aiming at training four arbitrary networks, one analog to a hierarchical network and three with variations of the analog one. As shown in Table 1 (lower part), the Inclusion based on the distinction network was analogous to the hierarchical network; the Inclusion based on sameness was similar but without distinction among branches, and the remaining two comprise fewer stimuli, and there was no inclusion. One was based on Sameness, and the other on Distinction.

As indicated in Table 1, the experiment comprised three phases: (1) the *Preparatory Phase*, (2) the *Relational Cues Training Phase*, and (3) the *Arbitrary Networks Training and Testing Phase*. The Preparatory Phase aimed to familiarize participants with the verbatim and trial formats utilized throughout the experiment. The Relational Cues Training Phase involved four METs aimed at establishing four abstract figures as relational cues: Sameness relational cue (Sa), Distinction (Di), Inclusion sameness (IncSa), and Inclusion Distinction (IncDi). The Arbitrary Networks Training and Testing Phase focused on training the four networks using each of the trained relational cues, assigning functions to some network stimuli, and testing for derived relations in each network.

Table 1. Schema of the Experimental phases.



Notes. The pairs of letters and numbers of the networks in the Arbitrary Networks Training and Testing Phase are the stimuli used during this phase. Participants were informed that the numbers did not have a numerical sense and were just codes to refer to unknown features of the stimuli.

Procedure

The experimental procedure was applied individually. After each participant signed a consent form, they were instructed to begin the experimental task. The whole procedure is described following the phases indicated in Table 1.

Phase 1. Preparatory Phase. This phase was designed to familiarize participants with the terminology and trial formats of the tasks by responding to culturally established relational cues (=, ≠, {, and < >). There were two blocks of trials. The first block comprised a total of 20 trials, including five different types of trials: 1) Selecting the relational cue, 2) Selecting the stimuli, 3) Selecting the inclusion function, 4) Selecting the network, and 5) Selecting the stimulus functions of the networks (see Figure 4).
In type-1 trials (i.e., Selecting the relational cue), participants chose symbols (e.g., { or <) to establish a relation between two stimuli (e.g., "soccer team" and "player"; correct response: {). Type-2 trials (i.e., Selecting the stimuli) involved choosing between stimuli (e.g., drawings of plants or animals) to complete an incomplete relation (e.g., "plants {___"; correct response= drawings of plants). Type-3 trials (i.e., Selecting the inclusive function) assessed the inclusivity of features in a network, with participants determining whether one feature was more inclusive than the rest (e.g., A: green things= B: green phone= C: green shirt= D: green car; correct response= green). Type-4 trials (i.e., Selecting the network) required selecting a network (e.g., D {F and J, or J {D and F) that best represented the relations between stimuli (e.g., F: Aspid viper, J: black widow spider, D: poisonous animals; correct response= J {D and F). Type-5 trials (i.e., Selecting the stimulus functions of the networks) consisted of describing a stimulus (e.g., B) from a network (e.g., A: Acid=B=C) using labels from an array (e.g., acid, salad, sweet, bitter, I don't know, none).
Each relational cue (sameness "=," distinction "≠," comparison "><," and inclusion "{") had five trials (one for each type), resulting in a total of 20 trials. The presentation order was as follows: first, the four type-1 trials; second, the type-2 trials; third, the type-3 trials; fourth, the type-4 trials; and finally, the type-5 trials. A green tick and

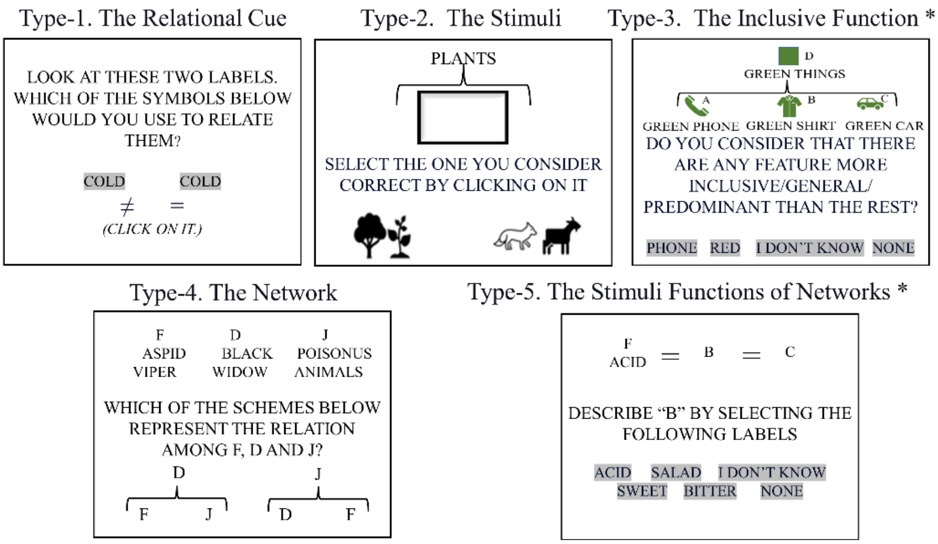


Figure 4. Trial types used during the preparatory phase. *Notes*: Participants only saw what is displayed inside the squares; *= trial types without feedback.

the word "Correct" followed correct responses, while a red cross, the word "Error," and the trial repetition followed incorrect responses. No feedback was given for the Type-3 and Type-5 trials to prevent explicit training of the response associated with the transformation of functions and inclusivity. After completing the 20 trials, participants were presented with a slide that asked the following question: "Briefly explain the meaning of each of these symbols, considering what you have learned up to this point (=, ≠, < >, and {)." Below the question on the slide were the five symbols, and below each symbol were five text boxes where participants could write their answers. Correct answers involved describing each symbol by its cultural relational meaning. Specifically, state that "=" means *equal*, "≠" means *different*, "<,>" *means less than* and *more than*, respectively, and "{" means *includes*. Synonyms of these words were considered correct. Participants who responded correctly to the meaning of each cue proceeded to the second block, while those who did not were required to repeat the entire block.

The second block evaluated derived functions in more complex networks (comprising more stimuli) than those used in the previous block. Throughout the block, different networks with different levels of complexity were presented multiple times (Figure 3, upper part, right), and questions were asked about the characteristics of the stimuli within each network and the inclusivity of one function over the rest. For this purpose, 57 trials were used: 8 type-3 trials (assess the inclusivity) and 49 type-5 trials (describe stimuli in networks). These trials were distributed across two sets: the Culturally known set, which was presented first and comprised 40 trials with "culturally known networks" (Figure 3, upper part, right), and the Culturally unknown set, which comprised 17 trials using "culturally unknown networks" (Figure 3, upper part, right), three per cue, except for the hierarchical cues, which comprised eight trials.

Throughout the block, no feedback was given to participants to avoid explicit training on correct responses. However, Alternative trials were presented if participants did not exhibit a bottom-up transformation of functions in the Culturally unknown set, meaning that the functions of the lower-level stimuli do not derive in the upper stimulus when presented with hierarchical networks. In so doing, the experimenter entered the room and instructed the participant to pause.

The Alternative trials involved comparing two different networks presented on paper.

Each network comprised one stimulus containing two stimuli. In one network, a stimulus contained an unpleasant experience. In contrast, in the other, a stimulus contained a pleasant one. Network 1 was: "A {B: Shock and C: __"; whereas Network 2 was: "D {E: Money and F: __." The participant was asked the following: "If you could get one of the two stimuli, which would you choose, A or D?" Afterward, the participant was asked to explain their decision. A correct answer was to select A or D and to clarify that this was chosen because the stimulus contained an "aversive" or "pleasant" stimulus. If the participant responded correctly, they repeated the Culturally unknown set while considering what they had learned until that moment. The specific trial sequence and networks used are available upon request from the corresponding author.

Phase 2. Relational Cues Training. Four MET protocols were used to train the following four relational cues: Sa, Di, IncSa, and IncDi. Table 2 summarizes the training protocols applied during this phase.

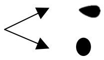
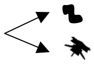
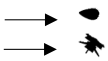
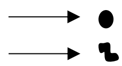
Part 1. Establishing sameness and distinction functions. This part aimed to train Sameness functions to Sa and IncSa cues and Distinction functions to Di and IncDi cues. As described below, six trial types were used, three for training and three for testing.

In the "Identifying the cue trials" (as depicted in Figure 5), a pair of stimuli (e.g., A1-A1) was displayed at the top of the screen, and three stimuli (including two to be the relational cues and one figure with the shape of a cloud, CS) at the bottom. A correct response consisted of selecting the Sa and Inc-Sa cues when presented with identical pairs (e.g., A1-A1), selecting the Di and IncDi cues when presented with entirely different pairs (e.g., A1-A2), and selecting CS when presented with not completely identical or different pairs. A green tick followed correct responses, while incorrect responses led to a red cross and repetition of the trial until a correct response was obtained.

In the "Identifying the stimuli" trial, one of the relational cues (Sa, IncSa, Di, or IncDi) was displayed in the middle of the screen, one stimulus (e.g., A1) at the top, and an array of stimuli (e.g., A1-A2-A3-A4-CS) at the bottom. A correct response consisted of selecting from the array the stimulus identical to the one at the top (e.g., A1) when the Sa or IncSa cues were present, one completely different (e.g., A2) when the Di or IncDi cues were present, and the CS stimulus when the cue was not presented, or there was not a correct choice among the array stimuli. Correct responses were followed by a green tick, while incorrect by a red cross and the repetition of the trial till the correct response. This trial type was also presented in an alternative format where the top stimulus was omitted. In this case, participants were required to compare and select identical or different stimuli from the array based on the provided cue.

In the "figuring out" trial, a message appeared informing that nonsense syllables have replaced the figures along with one nonsense syllable at the top of the screen ("CUG"), one of the cues in the middle, and four none-sense syllables at the bottom ("PLU," "TRO," and "TAW"). Simultaneously, an arrow pointed to the correct option

Table 2. Summary of the four protocols used during the Relational Cues Training Phase.

Relational Cues Training Phase	
Part 1. Establishing sameness and distinction functions to four cues	
Same 	Distinction 
To Select the physically *Identical* stimuli	To select the physically *Different* stimuli.
Part 2. Establishing inclusion functions to two of the four cues.	
Same / Distinction 	Inclusion based on: Same / Distinction 
Select the physically *Identical* or D*ifferent* stimuli	Select the *Identical* or *Different* stimuli *Contained* in a physically larger stimulus. These identical or different stimuli *shared their acquired property* because they were included in the larger stimulus.

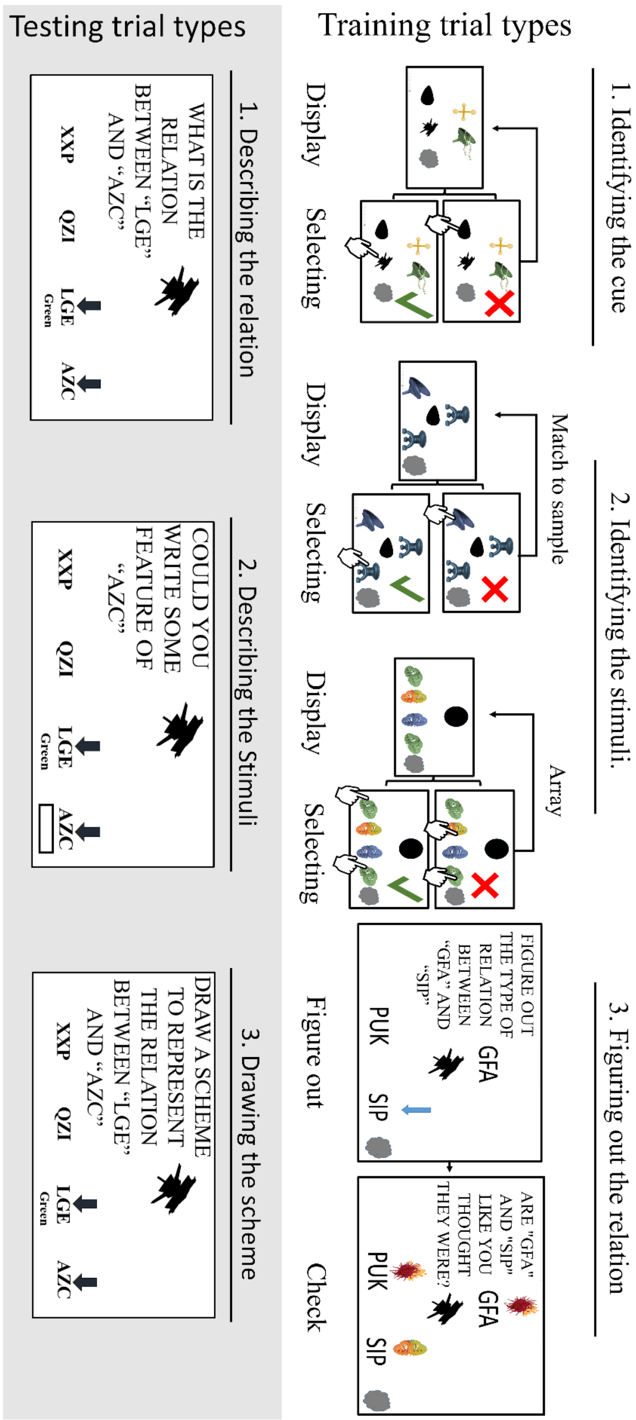


Figure 5. Sameness and distinction functions trial types.

(e.g., "PLU") at the bottom of the screen. Participants were asked to figure out the relation between the correct option and the top stimulus based on the presented cue. The participant was then presented with the replaced figures and asked whether their relation matched the one they had imagined.

These three trial types were distributed across three training blocks (see Table 3). The first block focused on training the Sa and Di cues and consisted of 28 trials. This block concluded when the participant achieved correct responses in 5 out of the final six trials (a set without feedback). If this criterion was not met, participants had to repeat the 28 trials. The second block was equivalent in quantity, types of trials, and performance criteria but aimed to train the IncDi and IncSa cues. Finally, the third block mixed the four cues along 22 trials.

Table 3. Summary of the trials in the Relational Cues Training Phase.

Part 1. Training Sameness and Distinction functions			
Blocks	Type of trial	Trials per cue	Total *n* of trials
Training Sameness and Distinction functions for Sa and Di cues.	Identify the stimuli: 20. Identify the cue: 6. Figure out trial: 2.	Sa: 8, Di: 8, NC:4. Sa-Di: 6 Sa:1, Di: 1.	28
Training Sameness and Distinction functions for IncSa and IncDi cues.	Identify the stimuli: 20. Identify the cue: 6. Figure out trial: 2.	IncSa: 8, IncDi: 8, NC:4. IncSa-IncDi: 6 IncSa:1, IncDi: 1.	28
Training Sameness and Distinction functions for Sa, Di, IncSa, and IncDi cues.	Identify the stimuli: 16. Identify the cue: 6.	Sa: 3, Di: 3, IncSa: 3, IncDi: 3, NC: 4 Di-IncSa: 1, IncDi-Sa: 1, Di-Sa: 2, IncSa-IncDi:2	22
Testing the four relational cues.	Describing the relation: 4 Describing the stimuli: 4 Drawing the scheme: 4	Sa: 1, Di: 1, IncSa: 1, IncDi: 1 Sa: 1, Di: 1, IncSa: 1, IncDi: 1 Sa: 1, Di: 1, IncSa: 1, IncDi: 1	12
Part 2. Training Inclusive Functions			
Blocks	Type of trial	Per cue	Total
Familiarized participants with describing stimuli	Comparing Describing		7 7
Training the Inclusion relational cues: IncSa and IncDi.	Identify the stimuli. Identify the cue	Sa: 3, IncSa: 4, Di: 3, IncDi: 4 IncDi-Di: 4, IncSa-Sa: 4	14 8
Drawing relations and describing functions in the context of each cue.	Draw the scheme. Describe the stimuli	Sa: 1, IncSa: 1, Di: 1, IncDi: 1 Sa: 1, IncSa: 1, Di: 1, IncDi: 1	4 4
Part 3. Stimuli substitution			
Substituting the figures per non-sense syllables	Stimuli substitution	Si: 2, IncSa: 2, Di: 2, IncDi: 2	8

Notes: Sa= Sameness cue; DI= Distinction cue; IncSa= Inclusion-Sameness cue; IncDi= Inclusion-Distinction cue; NC= No cue.

The test block consisted of 12 trials to evaluate if the participants arbitrarily relate stimuli in the context of the four relational cues according to sameness and distinction relations. Figure 5 (lower part) shows three types of trials: To "describing the relation," "describing the stimuli," and "drawing the scheme." The three types of trials followed the same structure. Before each trial, a message informed participants that "nonsense syllables have replaced the figures." Then, a relational cue was displayed at the top of the screen (e.g., IncDi), while four nonsense syllables were presented at the bottom (e.g., XVO, ÑSE, QRI, IYR). The stimuli were accompanied by arrows pointing to the correct option. Participants then encountered different questions depending on the type of trial, as described in the following paragraphs. In the "To describing the relation" trial (see Figure 5, lower part, left), the participant was asked to describe the relation between the correct options based on the presented cue. A correct response involved writing that the stimuli related under the context of the Sa and IncSa cues were identical. In contrast, those related under the context of the Di and IncDi cues were different. In the "to describing the stimuli" trial (see Figure 5, lower part, center), the participant was asked to describe one of the correct stimuli based on the features of the other and the presented cue. A correct response consisted of writing the same feature as the corresponding stimuli in the presence of the IncSa and Sa cues and writing a different feature or "I do not know" in the presence of the Di and IncDi cues. In the "to drawing the scheme" trial (see Figure 5, lower part, right), the participant was asked

to draw a scheme representing the stimuli's relation. A correct response consisted of drawing schemes with symbols expressing sameness (e.g., =) in the presence of the Sa and IncSa cues, whereas drawing schemes with symbols expressing distinction in the presence of the Di and IncDi cues.
To proceed to Part 2, participants had to respond correctly to all test trials. Participants who did not complete this criterion were re-exposed to the entire block and retested again. The details and order of the trials are available upon request to the corresponding author.

Part 2. Training inclusive functions. This part aimed to train the inclusive functions for two relational cues, IncSa and IncDi. As depicted in Table 2, this part comprised three blocks:

> *Block 1. Comparing and describing stimuli*. This block aimed to prepare participants to describe stimuli. For this purpose, two types of trials were used: "Comparing and Describing stimuli." In both types of trials, two stimuli were displayed on the screen that could be identical, completely different, or have only one feature in common. Then, in the Comparing trials, the participant was asked: "Look at the two figures. Do they have the SAME features, and/or do they share some features?" Below the question was a text box where they could write their answers. In the Describing trials, there was also a textbox below the figures where participants wrote the answer to the following question: "Which of the following options would you use to describe each of these stimuli? (try to be precise and use as many as you need)" Below the question, there were several labels as options for describing the stimuli, such as "spinning arrow," "red," "green," "shadow," etc. There were 14 trials, seven of each type. No criteria were required to proceed to the second block.
>
> *Block 2. Training the inclusion relational cues*. This block trained the inclusive functions for the IncSa and IncDi cues and maintained the sameness and distinction functions for the Sa and Di cues, respectively. As described below, two trial types were used: "Identifying the stimuli" and "Identifying the cue trial types."
> A typical identifying the stimuli trial started with the presentation of a relational cue in the middle, followed by a B stimulus (e.g., B1) at the top of the screen, and an array of As stimuli at the bottom (e.g., A1-A1-A1-A2) (see figure 6, upper part, step 1). A correct response was to choose the identical stimuli in the presence of the

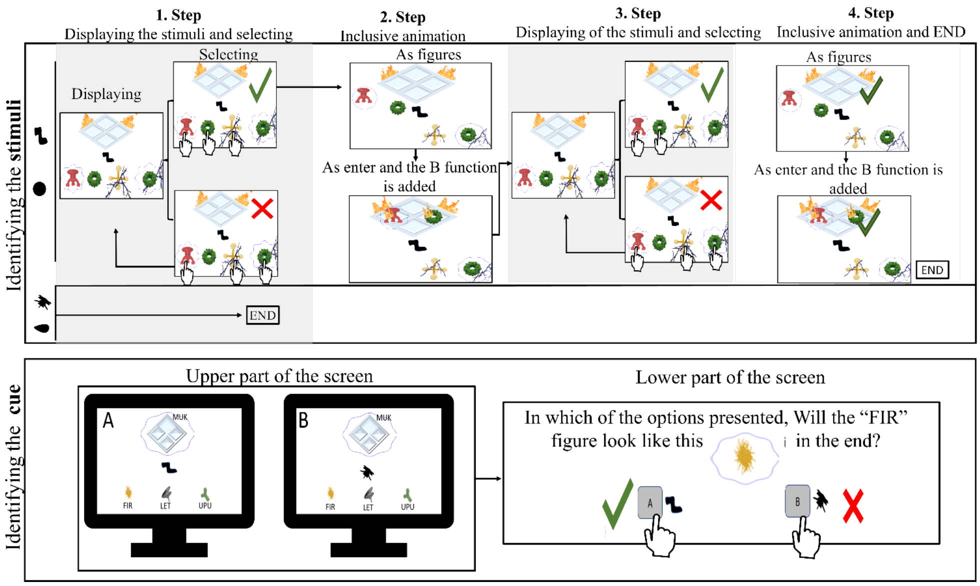


Figure 6. Training inclusion relational cues trial types.

Sa and IncSa cue (e.g., A1-A1-A1) and the different ones in the presence of the Di and IncDi cue (e.g., A1-A2-A3). If the participant failed, a red cross appeared, and the same trial was repeated until a correct response. If participants made the correct selection, subsequent steps differed depending on the cue type presented. In both cases, a message appeared inviting participants "to observe what would happen next":

- In the presence of the Sa and Di cues (Figure 6, upper part), a green tick followed correct responses, and the trial ended.
- However, in the presence of the IncSa and IncDi, an "inclusion animation" was displayed (Figure 6, upper part, step 2). In this animation, some of the selected As stimuli (e.g., A1-A1 in the presence of the SI or A1-A2 in the presence of the IncDi) moved and entered the stimulus "B," and the function of the B stimulus was added to the A ones while this maintains their initial function. Any other stimuli remain unchanged. Afterward (step 3), all the stimuli were displayed again on the screen with the same configuration as at the start of this trial, and the participant was asked to select the correct stimuli again based on the previous experience. A correct response was to select the identical (IncSa cue) or different (IncDi cue) stimuli that acquire the B stimulus feature after being grouped into it. Correct responses were followed by a green tick and the repetition of the animation (step 4). Incorrect responses were followed by a red cross and the repetition of steps 2 and 3 till the correct response.

Some of these trials also introduce questions to explore and facilitate participant discrimination of the inclusion functions. For example, in Step 1 (Figure 6, upper part) ("Will something happen to the selected figures? Think about it and then press the 'Next' button") or after Step 4 ("Did something happen to the selected figures from the beginning to the end? Think about it and then press the 'Next' button"), no feedback was given for these questions.

A typical identifying the cue trial (see Figure 6, lower) began with presenting a pair of screens at the top of the screen (see Figure 6, lower, left). Both screens showed the same array of stimuli, the only difference being the relational cue in the middle. This was followed by a question about which relational cues allowed the As stimuli to acquire the function of the B stimulus and which did not, and two response options corresponding to two relational cues (see Figure 6, lower, right). A correct response was to select the inclusive cue (e.g., IncDi) when the stimulus had the additional function and the non-inclusive cue (e.g., Di) when the stimulus did not have the additional function. Correct responses were followed by a green tick, incorrect responses by a red cross, and the trial was repeated until a correct response was obtained.

These three trial types were distributed across the set by presenting six identifying the stimuli identification trials, eight identifying the cue identification trials, and eight identifying the stimuli without feedback. The participant proceeded to the second set of trials when they achieved the mastery criteria of six correct responses out of the final eight trials.

Block 3. Drawing relations and Describing stimuli. This block consisted of two sets of trials, each corresponding with a specific trial type: "Drawing schemes" and "Describing stimuli", as described below.

In the first set, four drawing scheme trials were presented. In these trials, the participant had to make a scheme representing a relation among stimuli. The stimuli were displayed on the screen with a nonsense syllable for each stimulus (Figure 7, upper left). For example, "FLO" at the top of the screen together with the B stimulus, the IncDi relational cue in the middle, and "PEK-RUP-BRI-EGR" at the bottom together with a particular A stimulus. Additionally, two arrows point to two nonsense syllables at the bottom (e.g., PEK and RUP) along with the following message: "The arrows point to the correct ones. Try to imagine what will happen to them precisely." Then, participants were asked to "Draw a scheme representing the relation that FLO, PEK, and RUP will have at the end of the trial. You can use the symbols you saw at the beginning of the experiment (=, ≠, {, ><)" (Figure 7, upper right). Once participants completed their drawings and pressed "continue," the "inclusive animation" was displayed in the presence of the IncSa and IncDi, and the trial ended. However, in the presence of the Sa and Di cues, the trial ended without displaying the inclusive animation.

Correct responses depended on the type of symbols used in the scheme for representing the relations; specifically, correct responses consisted of using the symbols "≠" and "=" for Sa and Di cues, respectively, and additionally to using the symbol "{" for IncDi and IncSa cues. No feedback was provided for correct responses. Failure on

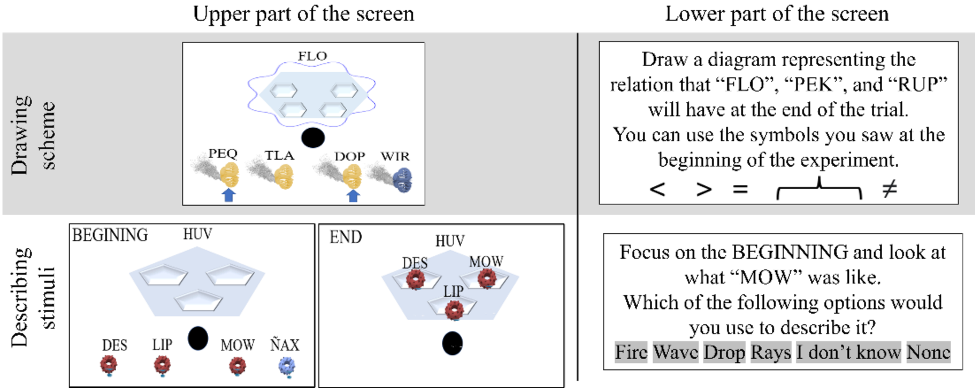


Figure 7. Draw relations and describe stimuli trial types.

any trial resulted in repeating the whole set without indicating which trial failed. During the repetition of the set, participants were instructed to verbally describe the stimulus relations before drawing the scheme. To proceed to the next set, participants must respond correctly to all four trials.

The second set comprised four describing stimuli trials. These trials consisted of responding to six questions to describe stimuli on the screen. The trial began and ended similarly to the Identifying the Stimuli trial described in Figure 6. However, after completing the trial (Figure 6, upper part, step 4), two screens appeared at the top of the screen (see Figure 7, lower left). The left screen displayed the stimuli disposition at the trial at the beginning, and the right screen showed the disposition at the end.

Below the two screens, six subsequent questions were presented as indicated below (figure 7, lower right):

1. "Look, on the left are the figures as they look at the beginning, and on the right, they look like at the end. Think about whether you notice any changes."
2. "Focus on the BEGINING and see what "MOW" looks like. Which of the options below would you use to describe MOW?" Participants were instructed to click the labels below (e.g., *Lightings, Wet, Waves, Spin, I do not know, None*) to describe the MOW.
3. Question number 2 regarding the right screen.
4. Question number 2 regarding the HUV stimuli.
5. Question number 2 regarding the HUV stimuli on the right screen.
6. Finally, a question about the entire array focused on the end of the trial. "Do you see any feature as more inclusive, general, or predominant than the rest?" Participants were then required to click one of the labels at the bottom of the screen (e.g., *Lightings, Wet, Waves, Spin, I do not know, None*) to indicate their response.

Correct responses depended on the cue presented. When presented with Sa and Di cues, the correct response was to provide identical descriptions for the As stimuli (e.g., fire for questions 2 and 3) and the B stimulus (e.g., light for questions 4 and 5) at the beginning and end of the trials (both screens), which indicated that the stimuli had not changed from the beginning to the end of the trial. Moreover, they should not identify one feature as more inclusive than the rest (question 6). However, when presented with IncSa and IncDi cues, the correct response was to provide different descriptions for the As stimuli (e.g., fire for question 2 and fire and lighting for question 3) and the B stimulus (e.g., lighting for question 4 and fire, waves, and lighting for question 5) at the beginning and end of the trials (both screens), which indicated that the As figures had acquired the features of the B figure and vice versa. Finally, the B feature (e.g., waves) was to be identified as more inclusive than the rest. No feedback was given for correct answers. If a trial failed, the experimenter intervened after the sentence, as described below:

- Failure to answer questions 2-3 resulted in two consecutive trials. In each trial, the participant was presented with a stimulus relation. For example, using the IncDi cue in the middle, the "TOG: Painful" stimulus at the top was related to "MUG and PIZ" stimuli at the bottom. Participants were then asked to "touch or not touch" MUG or PIZ and to "explain their choice." The correct answers depended on the cue; with the IncSa and IncDi cues, the correct answer was to explain that "MUG and PIZ are part of TOG and therefore, I do not want to touch them." With the Sa and Di cues, it was to explain that "it does not matter because MUG and PIZ are not part of any stimuli." The other trial was the same but with an appetitive function (e.g., TOG pleasant). Correct responses to both trials led to the repetition of the set.

- Failure to answer questions 4 and 5 resulted in two consecutive trials like the ones described above. However, in this case, the aversive or appetitive stimuli were displayed at the bottom (e.g., MUG: painful), and the participant was asked whether to "touch" or "not touch" the upper one while explaining. The correct answers depended on the cue; with the IncSa and IncDi cues, the correct answer was to explain that "TOG includes the stimulus (MUG) and therefore, I would like to TOUCH or NOT TOUCH." With the Sa and Di cues, it was to explain that "it does not matter because JUP does not include any stimuli." The consequences for correct and incorrect responses were the same as in the previous trial.
- Failure question number 6 resulted in the following trial. The experimenter provided a known relation for asses inclusivity. For instance, the experimenter might say, "Considering you are from Almeria, and I am from Valladolid, and you likely have friends from cities like Madrid or Barcelona, do you believe there are certain features that we all share across these places despite the differences?" Correct responses involved identifying inclusive features such as "we all share the language, some customs, or festivities, etc." The consequences for correct and incorrect responses were the same as in the previous trial.

After completing this block, participants were asked to respond to the following question: "Briefly describe what happens when these figures (the four relational cues) are present, considering what you have learned up to this point about them". The criterion to complete the block was responding correctly to each cue's meaning. The correct response involved describing the IncDi and IncSa cues in which the presence had to select the different or identical stimuli (As), respectively, and then acquire the feature of a larger stimulus (B) after entering it. In contrast, the Sa and Di cues were cues in which the presence had to choose between identical and different stimuli (As). Participants were re-exposed to the entire block if the cues were incorrectly described.

Part 3. Substituting figures per nonsense syllables. In this block, the participants were asked to apply the relational cues to relate nonsense syllables (arbitrary stimuli). The "Stimuli substitution" trial types were like the describe the stimuli trials of the previous phase but with some modifications. First, the participant was informed that "in this case, you will not see the figures themselves, but names that represent figures." Then, the participant was presented with a screen showing three nonsense syllables related in the context of a cue (Figure 8, left). Some nonsense syllables were associated with functions, while others were not. For example, "VIV: Waves" at the top, the IncSa cue in the middle, and "JAX: FOG and FLU: ___" at the bottom. Five subsequent questions were asked about the derivation of the functions within the relations (Figure 8, right):

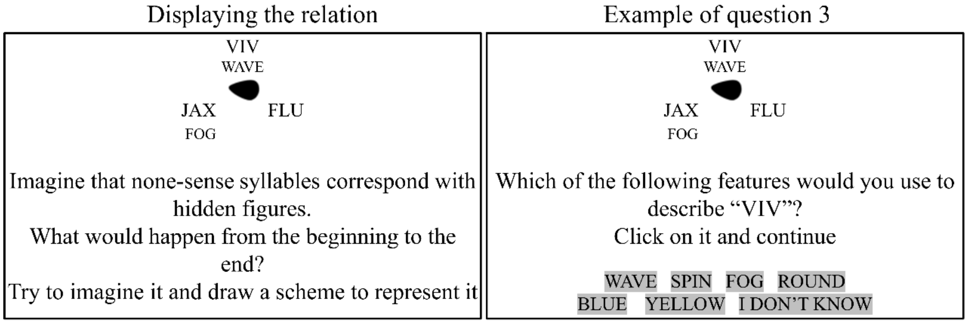


Figure 8. Stimuli substitution trial type.

1. "Imagine that nonsense syllables correspond with hidden figures. What would happen from the beginning to the end? Try to imagine it and draw a scheme to represent it."
2. "Of the options below, which would you use to describe FLU?" The participant was instructed to click the labels below (e.g., FOG, FIRE, WET, WAVES, SPIN, I DO NOT KNOW, NONE).
3. Question 2 applied to JAX.
4. Question 3 applied to VIV.
5. "Do you see any feature as more inclusive, general, or predominant than the rest?" The participant was instructed to click one of the labels at the bottom of the screen (e.g., LIGHTINGS, FIRE, WET, WAVES, SPIN, I DO NOT KNOW, NONE) to indicate their response.

Correct responses depended on the cue presented. In the presence of the Di and Sa cues, correct responses were (1) to describe the two stimuli in the lower part of the relational cue (Questions 2 and 3) as having different (Di cue) or identical (Sa cue) functions,(2) to describe the upper stimulus (Question 4) as independent of the others, and (3) to indicate that there was no inclusive function in the whole (Question 5). In the presence of the IncDi and IncSa cues, correct responses were (1) to describe the stimuli in the lower part of the relational cue (Questions 2 and 3) as having different (IncDi) or identical (IncSa) functions and in both cases, sharing the function of the upper stimuli, (2) to describe the upper stimulus (Question 4) as containing the functions of the lower stimuli, and (3) to identify the inclusive function (Question 5) as the one associated with the upper stimulus. When the participant answered the questions, the figures appeared on the side of each nonsense syllable, and in the presence of the IncSa and IncDi cues the inclusive animation was displayed. Participants were then instructed to review their responses and to change what they considered necessary.

There were eight stimuli substitution trials in total, two per cue. Participants had to correctly respond to the final four trials to complete the set. These trials followed the same format but without feedback. Participants did not look at the figures after answering the questions. In the event of a trial error, the experimenter intervened after the set, as described in the describing the stimuli set of the previous part but using different stimuli, and participants repeated the four final trials.

Phase 3. Arbitrary Networks Training and Testing. This phase was divided into two parts; "Training and testing the inclusive networks" and "Training and testing the non-inclusive networks."

Part 1. Training and testing the inclusive networks. This part was divided into two sets, the "Upper levels" and the "Lower levels", as described below.

Training and Testing Upper Levels. Figure 9 illustrates the types of trials used for upper-level training, namely "Training the relations", and "Training the functions" trial types. The first trial type presented was training the relations (Figure 9, upper left), during which a stimulus (such as GG) appeared in the center of the screen. A relational cue (such as IncDi) appeared below the stimulus, and four stimuli (JJ, YY, SS, and MM) appeared below the relational cue, along with two arrows pointing to two of them. In addition, a message appeared at the top of the screen informing participants that "the arrows point to the correct ones" and instructing participants to write the information provided on paper. There was one trial per cue. Therefore, the "GG {MM ≠ SS" relations were trained in a single trial with the "GG" presented at the top of the screen, the "IncDi" cue in the middle, and the "SS; MM" stimuli indicated as correct at the bottom of the screen. Similarly, the "DD {JJ = YY" relations were trained in a separate trial with the "DD" stimulus at the top of the screen, the "IncSa" cue in the middle, and the "JJ" and "YY" stimuli indicated as correct at the bottom of the screen.

Subsequently, the participants were presented with the training the functions trials. During these trials, a message appeared at the top of the screen ("Now you will know more about:"), a stimulus in the center (e.g., GG) accompanied by a number (e.g., 1), and another message at the bottom, "Imagine that the number is a feature. Write it on the paper and then continue". In this way, functions (numbers) were assigned to

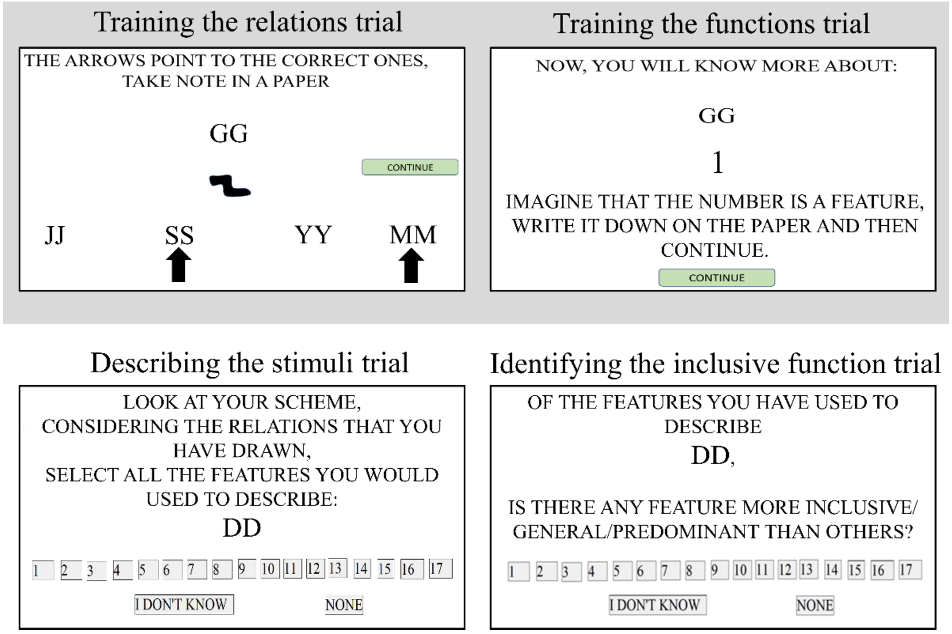


Figure 9. Training and testing relations trial types. *Note*: Participants only saw what is displayed inside the squares.

some of the stimuli, namely GG: 1, DD: 2, MM: 3, SS: 4, and JJ: 5. One slide was presented per stimulus, each with its corresponding number.

Once the trials for training the relations and functions were presented, participants proceeded to the testing. First, participants were asked to represent the learned relations in schemes. A slide was shown with the following instructions: "This is a crucial moment. Look at what you have written down and draw the relations schematically. Remember what these figures mean (image of IncDi cue and IncSa cue)". Then, the derived functions were tested by presenting two trial types per stimulus, "Describing the stimuli" and "Identifying the inclusive function."

For each stimulus of the networks, the describing the stimuli trial was presented first. As shown in Figure 9 (lower part, left), during this trial, a message appeared at the top of the screen saying, "Think about the relations among this stimulus and the rest. Select ALL the features you would use to describe it," and below the message were several options (1, 2, 3... 17, None, I do not know) to choose from. After participants had described a given stimulus, the identifying the inclusive function trial was presented. As shown in Figure 9 (lower part right) this trial consisted of the following question: "Of the features you chose to describe the stimulus, do you think there is one that is more general/predominant or inclusive than the rest?" Participants could choose from options (1, 2, 3... 17, None, I do not know). The derived functions in each network were tested from top to bottom. Participants were first asked to describe the top stimuli of the network (e.g., DD) and then the bottom stimuli (e.g., SS and MM). The order of testing was first the IncSa network and then the IncDi network.

Training the lower levels and testing the whole network. The training of relations and functions was the same as in the previous part. Specifically, the following relations were trained: 1. MM {QQ ≠ LL (IncDi cue), 2) YY {TT= WW (IncSa cue), 3) SS {BB≠ FF (Inc-Di cue), and 4) "JJ{XX= NN (Inc-Sa cue) and functions: TT: 6, QQ: 7, LL: 8, BB: 9, and FF: 10.

Finally, the whole networks were tested. First, participants were asked to extend the schemas they had drawn to include these new relations. Then, the derived functions of the networks were tested using the same trial types described for testing the upper levels. The order was from top to bottom. The first participant was asked to describe the stimuli of the Inclusion based on Sameness network in the following order: DD, JJ, MM, XX, NN, TT, and WW. Then, the Inclusion based on distinction network will be GG, SS, MM, QQ, LL, BB, and FF.

Part 2. Training and testing the non-inclusive networks. The relations and functions were trained as in the previous part to maintain the trial format. That is, one stimulus at the top of the screen, the relational cue in the middle, and several stimuli at the bottom, two of which were indicated as correct by an arrow pointing to them. Specifically, the following relations were trained: 1) “ÑÑ does not include HH≠ KK” with ÑÑ presented at the top of the screen, the Di cue in the middle, and the HH and KK stimuli marked as correct at the bottom of the screen, 2) “ZZ does not include RR= CC” *with the ZZ stimulus presented at the top of the screen*, *the Sa cue in the middle,* and the RR and CC stimuli marked as correct at the bottom of the screen—the functions ÑÑ: 11, HH: 12, CC: 13, and ZZ: 14.
Finally, the test consisted of drawing the schemes and asking for derived responses using the describing the stimuli and identifying the inclusive function trial types. First, the Distinction network was tested first in the following order: ÑÑ, HH, and KK. and then was tested the Sameness network followed the same order with the respective stimuli: ZZ, RR, and CC.
At the end, participants were again asked about the inclusivity of the features for each network. Specifically, the following question was asked: “You will have four schemes, each organized based on the symbols you see below (the image of the IncSa, IncDi, Sa and Di cues.) Look at the stimuli of your schemes and their characteristics. Do you consider that there is any feature that is more general/predominant or inclusive than the rest?” Additionally, the meaning of the relational cues trained was asked again: “Briefly describe the meaning of these figures (the image of the IncSa, IncDi, Sa and Di cues.) considering what you have learned to this point.”

Results

Table 4 shows the results of the preparatory phase and relational cues training phase. All participants met the mastery criterion of the preparatory phase in this phase. However, three participants (P1, P5, and P9) required the Alternative trials and then a re-exposure to the final trials of the phase. The individual data are available upon request from the corresponding author.

Relational Cues Training Phase. Regarding the relational cues training phase, all participants completed the three parts (see Table 4). All participants completed the first part (see second column). Specifically, eight out of nine completed the three blocks of

Table 4. Results in the Preparatory Phase and in the Relational Cues Training Phase.

	Preparatory Phase	*Relational Cues Training Phase*		
	(Trials) %	Part 1. Sameness and Distinction functions.	Part 2. Inclusion functions	Part 3. Stimuli Substitution
P1	(99) 76.7* ✓	(143) 80.9* ✓	(62) 83.8*. ✓	(14) 71.4* ✓
P2	(82) 89 ✓	(98) 91.8 ✓	(57) 87,7.7* ✓	(8) 75 ✓
P3	(78) 96.1 ✓	(115) 78.2 ✓	(58) 81* ✓	(8) 100 ✓
P4	(78) 84.6 ✓	(96) 93.7 ✓	(53) 88.6* ✓	(8) 100 ✓
P5	(78) 89.7 ✓	(97) 90.7 ✓	(56) 87.5* ✓	(8) 100 ✓
P6	(99) 86.5* ✓	(106) 84.9 ✓	(57) 89.4* ✓	(14) 69* ✓
P7	(78) 100 ✓	(98) 91.8 ✓	(47) 93.6 ✓	(8) 100 ✓
P8	(78) 89.7 ✓	(99) 90.9 ✓	(56) 85.7* ✓	(14) 71.4* ✓
P9	(99) 83.5* ✓	(104) 85.5 ✓	(46) 95.6 ✓	(8) 100 ✓

Notes: *= Re-exposure block; ✓= Correct responding; P1 to P9= participants.

the part on the first exposure (range 96-115 trials), while P1 needed a second exposure (indicated with "*") to the first block of the part and, therefore, more trials (143). All participants complete the second part (see third column). Two (P7 and P9) completed it in the first exposure, while the rest required a second exposure to Block 3. Specifically, two participants (P2 and P1) required a second exposure to the two sets of the block, four participants (P5, P3, P6, and P8) to Describe the stimuli set, and one (P4) to Draw the relation set. Finally, all participants completed the stimuli substitution trials. Six out of nine participants (P2, P3, P4, P5, P7, and P9) in their first exposure, and the remaining three (P1, P6, and P8) required a second exposure. The individual data are available upon request from the corresponding author.

The arbitrary networks training and testing phase results include the drawings made by the participants to represent the relations between the stimuli, the results of the trials that assess the derived functions and the inclusivity of one function over the rest in the networks, and the meaning of the relational cues. The following paragraphs provide a summary of the response pattern of each participant. The individual data are available upon request from the corresponding author.

Figure 10 shows the networks that participants had to derive. Each network included the stimuli (e.g., GG), symbols representing the relations among the stimuli (e.g. {), the trained ("(1)"), the derived (e.g. (3, 4, 7, etc.), and the inclusive (*) function. As described in Phase 3, participants were informed that the numbers had no numerical meaning and were used as labels to denote features they did not know.

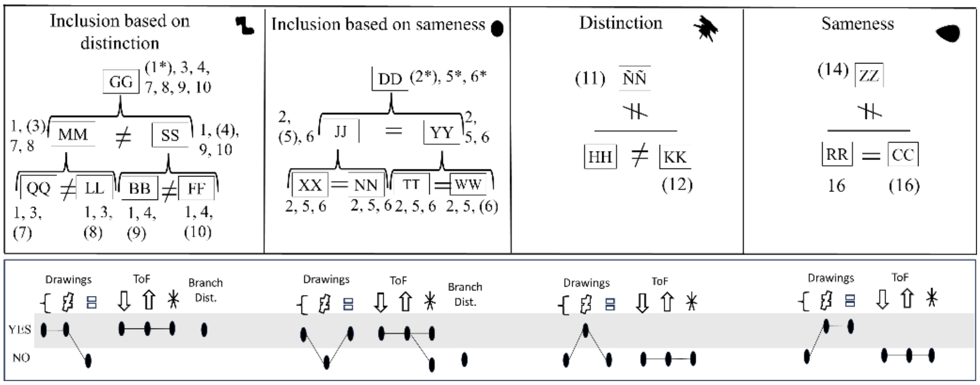


Figure 10. Networks to be Derived. *Notes*: Numbers in ()= Functions trained; Numbers= Functions derived; Symbols drawn, {= Inclusion Crel; ≠= Distinction Crel; == Sameness Crel, ToF= Functions derived: ⇩= Top-Down; ⇧= Bottom-Up; ✱= Inclusivity; Branch Dist.= Distinction among branches; ●= correct responses.

The left part of Figure 10 shows the Inclusion based on distinction network, which participants must represent using the inclusive symbol (e.g. {) to show relations among the different levels and the distinction symbol (e.g. ≠) to show relations between different branches. For the transformation of functions (ToF), all functions provided in different branches of the hierarchy should converge to "GG," the top stimulus showing a bottom-up (arrow up) pattern of transformation of functions. The function provided to "GG" should be transferred to all stimuli in both branches of the hierarchy, showing a top-down (arrow down) pattern of transformation of functions. The functions provided in both branches, "MM" and "SS," should derived from it to the top stimulus and to the lower stimuli of each branch but not from and to the other branch, showing the distinction (Bch. Dist.) between branches. Regarding Inclusivity (asterisk), the function identified as more inclusive or general should be the function provided to the top stimulus (1*). Two types of trials assess the inclusivity: one type that asks for the inclusivity of the functions of the ones used for describing each stimulus, and one type that asks for the inclusivity of one function over the rest in the whole network at the end of the test. In case of discrepancy between both, the data taken as the final one is extracted from the trials that asked about the whole network (this applies to the four networks).

The left-middle part of Figure 10 shows the Inclusion based on sameness network that must be represented using the inclusion symbol ({) to show the relations among the levels; however, in this case, the sameness one (=) should be chosen to represent the relations among the branches. Regarding the ToF, in this case, all functions provided in the different branches and levels of the hierarchy should be derived from and to all network stimuli. Participants should also identify the function provided in the top stimulus as the most inclusive or none of them. The middle-right of Figure 10 shows the Distinction network, which must be represented using the distinction symbol (≠) to show the relation between HH and KK stimuli, and additionally, using the distinction symbol (≠) to indicate that these two stimuli are not included in the ÑÑ stimulus. Regarding the ToF, the function provided in the KK must not be derived from it to the other two stimuli since KK does not include it (no Top-Down). The function provided to ÑÑ must not be derived to KK since it is not included (No Bottom-Up) and must not be derived to HH since it is different. Additionally, no functions must be identified as more inclusive than the rest. The right part of Figure 10 shows the Sameness network, which must be represented using the sameness symbol (=) to show the relations between RR and CC and the distinction symbol (≠) to show the relation of these two stimuli with the ZZ stimulus since they are not included in this stimulus. Regarding the ToF, the function provided to the ZZ stimulus should not be derived to the remaining two stimuli since it does not include them (no top-down). The function of CC must be derived to the RR stimulus since they are equal but not derived from ZZ since they are not included in it (no bottom-up). Figure 10 shows the response pattern of each participant in a row of YES or NO according to the previously mentioned response patterns for each network. In addition, the last column of Figure 10 indicates whether the participants described each relational cue correctly.

As shown in Figure 11, most participants follow the same differential response pattern according to each network. Regarding the drawings, In the case of the IncDi network, six participants (P2, P3, P4, P5, P7, and P9) represented the whole network using the inclusive symbol ({) to represent the relations among the different levels of the network and the distinction (≠) symbol to represent the relations among the branches and the stimuli within each branch. In the case of the IncSa network, the same eight participants responded accordingly but used the sameness (=) symbol to represent the relations between the branches. The remaining three participants (P1, P6, and P8) followed the same pattern as the others in their use of symbols but made separated parts of the networks and did not unify the parts to make the whole network. In the case of the Di network, all participants used the distinction symbol to represent the relations between all stimuli (ÑÑ ≠ HH ≠ KK). Regarding the Sa network, eight out of nine participants used the sameness symbol to represent the relation between RR and CC (RR=CC) and the distinction one to represent the relation of these two stimuli with ZZ. The remaining one (P1) used the distinction symbol to represent all relations (Appendix 2 shows examples of the drawings).

Regarding the ToF, in the case of the Inclusion based on Distinction network, six out of nine participants (P2, P3, P4, P5, P7, and P9) identified all the functions provided in the different levels and branches of the network in the top stimulus (bottom-up) and the function provided in the top stimulus was identified as the most inclusive one and derived to all stimuli of the network (top-down). In the case of the Inclusion based on Sameness network, these six participants showed the same pattern with the functions provided in the lower levels (e.g., WW: 6) deriving from it to the top ones (DD) and vice versa. Two participants (P6 and P8) exhibited a similar pattern in both networks

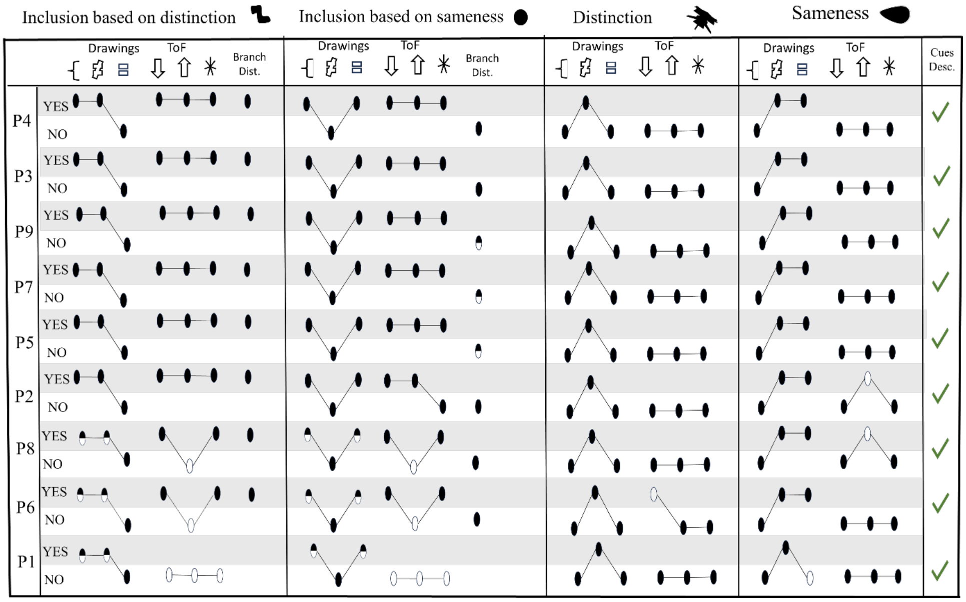


Figure 11. Participant's response patterns in the four networks. *Notes*: = Correct; = Incorrect; = Partially correct; Cues Desc.= Meaning of the cues; ✓= Correct meaning of the cues; Participants are organized from the one who showed the best response pattern (P4, top) to the one who showed the worst (P1, bottom).

except for not showing a bottom-up ToF. The remaining one, P1, failed the test. In the case of the Distinction network, eight participants described each stimulus as being different from the rest, and the remaining one (P6) identified the function of ÑÑ in the other two stimuli. None of them identify one function as more inclusive than the rest. In contrast, in the Sameness network, six out of nine participants (P1, P3, P4, P5, P7, P8) described two stimuli with the same function (RR and CC), while the other (ZZ) was described differently with their trained function. The remaining two (P2 and P9) described the three stimuli with the same functions. None of them identified one function as more inclusive than the rest.

Regarding the distinction among the branches, in the case of the Inclusion based on Distinction network, eight out of nine participants (P2, P3, P4, P5, P6, P7, and P8) described all stimuli at different levels of the network with different functions. Therefore, the distinction was shown among branches at different levels of the network. For example, participants described the "MM" branch (2, 3, 7, and 8) using functions different from those used to describe the "SS" branch (1, 4, 9, and 10). Similarly, the stimuli included in each of these branches were described differently. For example, the stimuli included in the MM branch were described as "1, 3, and 7" for QQ and "1, 3, and 8" for LL. In the case of the Inclusion based on Sameness network, these eight participants showed no differentiation between the branches. Specifically, five participants (P2, P3, P4, P6, and P8) showed complete sameness between the branches in the different levels. The functions used to describe the JJ branch (2, 5, and 6) were the same as those used to describe the YY branch (2, 5, and 6), and the stimuli contained in each branch were the same. Three participants (P5, P7, and P9) showed partial sameness between the branches, with the function provided in the middle level of the branch (JJ:5) deriving to the other (YY), but the function provided in the lower level of the branch (WW:6) not deriving the other. The remaining participant (P1) failed the test in both networks.

Regarding the descriptions of the cues (Figure 11, right), all participants described each cue differently according to the functions trained through the MET. Specifically, the description of the IncDi relational cue must indicate that different figures are grouped in a larger one and, therefore, acquire the features of the larger one. The same pattern of responses should be produced in the presence of the IncSa relational cue, except that the grouped figures should be identical. In the case of the Di relational cue, participants must indicate that different figures are not grouped. Similarly, participants must indicate that identical figures are not grouped in the presence of the *Sa relational cues*. For example, P8 described the IncDi cue as “All figures differ from each other. The tiny figures enter the larger figure, which changes the characteristics of these figures” and in the presence of the IncSa cue as “All figures are equal. Tiny figures enter the larger figure, which changes their characteristics”. However, P8 described what happened in the presence of the non-inclusive cues according to sameness and distinction functions, not inclusive ones. Specifically, P8 described what happened in the presence of the Di cue as “All figures are different and will not move” and in the presence of the Sa cue as “All figures are equal and will not move.”

Discussion

The present study aimed to advance the experimental analysis of hierarchical responding by showing all its features together in an experimental preparation. Specifically, the ToF in hierarchical responding involves the following four features. First, the top-down ToF, in which the functions of a stimulus from a higher level are derived to the stimuli at lower levels (e.g., if we say that geological processes form minerals, then all members of minerals will do so, including iron, gold, granite, etc.). Second, the bottom-up ToF, in which the functions of a stimulus from a lower level are contextually transferred to stimuli at higher levels (e.g., if gold and iron are minerals and have electrical conductivity, at least some minerals have electrical conductivity). Third, the distinction among branches of the hierarchy impedes the ToF from one branch to others (e.g., if we say rocks have compression resistance and durability, this does not imply that other minerals, such as metals, necessarily have them). Lastly, the fourth feature is that at least one function of the hierarchical network is more inclusive or definitory than the rest (e.g., the feature of being the result of a geological process is the most inclusive function of the network because all minerals are also the result of a geological process). Even more, if one additional function is added to Minerals, all the elements belonging should acquire such an additional function.

In so doing, the experiment comprised one training protocol with four different METs, one aimed to establish an analog network with the features of hierarchical responding (inclusion based on a distinction network), while three others aimed to establish networks with characteristics other than the previous one (that is, inclusion based on sameness, sameness, and distinction networks). The experimental protocol comprised, first, The Relational Cues Training phase and then, the Arbitrary Networks Training and Testing Phase. In the Relational Cues Training Phase, participants underwent four METs to establish abstract figures as relational cues: Sameness (Sa), where participants matched identical stimuli; Distinction (Di), where participants matched different stimuli; Inclusion Sameness (IncSa), where participants matched identical stimuli that acquired more features after being grouped into a larger one; and Inclusion Distinction (IncDi), where participants matched different stimuli that acquired more features after being grouped into a larger one. The Arbitrary Networks Training and Testing Phase focused on training the four networks using the previously trained relational cues, assigning functions to some network stimuli, and testing the ToF in each network.

The Inclusion based on distinction network comprised two levels and two different branches. The test consisted of asking the participants to make drawings to represent the relations and describe the stimuli according to the functions provided in the network. To complete the test correctly, participants needed to represent the network using the inclusive symbol (i.e., {) to identify relations among levels and the distinction symbol (e.g. ≠) to identify relations between different branches (see Figure 10, left). For the ToF, the criteria were as follows: a) all functions provided in different branches of the hierarchy should converge to "GG," the top stimulus (bottom-up ToF); b) the function provided to "GG" should derive to all stimuli in both branches of the hierarchy (top-down ToF); c) the functions provided to each branch (i.e., "MM" and "SS") should not be transferred to the other branch (that is, distinction between branches); and d) the function identified as more inclusive is the one provided to the top stimulus (GG). Eight out of nine participants responded accordingly (two of them failed the bottom-up), and one failed the test.

The Inclusion based on the sameness network was like the previous one, except that the relation between the branches was of sameness instead of distinction. The network also had two levels with three different functions assigned to the stimulus at the top (DD), the one in the middle (JJ), and the one at the bottom (TT). To complete the test correctly, participants had to represent the network using the inclusive symbol (i.e., {) as well as to identify relations among levels using the sameness symbol (e.g., =). That should permit to assume that both branches were equal (see Figure 10, left-middle). The ToF criteria were identical to the Inclusion based on distinction network (bottom-up ToF, top-down ToF, and inclusivity of the function provided to the stimulus at the top), except for the differentiation between branches. In this case, the functions of one branch (JJ or YY) should be derived to the other as the same. Eight out of nine participants responded accordingly (two of them failed the bottom-up), and one failed the test.

The Distinction and Sameness networks served as controls for the inclusive ones. The Distinction network comprised three stimuli, and two functions were assigned to two of them. To complete the test correctly (see Figure 10, middle-right), the network must be represented as different stimuli (≠). Regarding the ToF, the criteria were not showing bottom-up, not top-down, and not inclusivity of any function over the rest. Eight out of nine participants achieved such criteria. The sameness network comprised three stimuli, and functions were assigned to two stimuli. To complete the test correctly (see Figure 10, middle-left), the network must be represented as two stimuli being identical by using the sameness symbol (=) and another stimulus not including these identical stimuli by using, for example, the distinction symbol (e.g., ≠). Regarding the ToF, the criteria were not shown top-down, not bottom-up, and there was no inclusivity of any function over the rest. Seven out of nine showed the criteria.

The results showed that all participants demonstrated that the relational cues acquired the expected relational functions. Also, the four different networks were successfully trained in eight of the nine participants. Of these eight participants, six showed a pattern of ToF that demonstrated the four features of hierarchical responding (i.e., bottom-up, top-down, branch differentiation, and inclusivity) with the analog network (i.e., inclusion based on distinction network) and not with the three networks as controls.

As indicated in the introduction, the experimental analysis of hierarchical responding has provided diverse procedures to establish relational cues and to bring this complex response under experimental control. For example, Slattery and Stewart (2014) trained a network with three stimuli under the "includes" or "belongs to" cues, where only a function was assigned to one of the stimuli, the one which was considered as the middle one (see Figure 2, right). Functions were derived from the middle to the lower stimuli but did not to the stimuli at the upper level according to the relations established in the experiment. Following this rationale, participants derived showing a top-down ToF. However, the experiment network contained only three stimuli and one function, which, in the absence of additional results from the participants, might prevent the assumption that the participants responded to the stimuli as a category with different branches and respectively derived functions. Alternatively, the previous studies by Gil *et alii* (2012, 2014) explored hierarchical networks by training a network with different levels and branches (see Figure 2, left). In those networks, the functions were provided in the middle stimulus of one branch and at the lower level of the other branch. Then, the test showed derived contextually controlled bottom-up and top-down, but distinct functions were maintained between the two branches. Still, the experimental analogs have not provided information regarding how functions corresponding to different networks can be organized through their integration in the context of an inclusive function. The present study extends the exploration of hierarchical networks in adult participants who have acquired hierarchical responses. As mentioned, the present study aims to bring hierarchical categorization under experimental control and test for the bottom-up and top-down ToF, the differences between branches, and the inclusivity of one function over others.

Regarding the protocols for training the relational cues, previous research has used different METs to train hierarchical categorization. For example, Griffe and Dougher (2002), Slattery and Stewart (2014) used METs to teach relational responses based on common functions. Other studies, such as Mulhern *et alii* (2017), used inside-outside relations to train hierarchical cues, while Gil *et alii* (2012, 2014) mixed "inside-outside" relations with culturally established hierarchical categorization. More recent unpublished studies, such as Callejón (2020), have combined "inside-outside" relations with sharing common functions to train hierarchical responses.

The present study extends the previous findings by designing the MET for training the hierarchical relational cue (IncDi) through sets of different stimuli that kept their distinct functions and acquired common functions by being grouped within a larger stimulus. Furthermore, the present study trained three METs of Inclusion based on Sameness (IncSa), Sameness (Sa), and Distinction (Di) so that the same participants served as their controls and resulted in different types of derived functions that allow an account of the hierarchical categorization indicated in the introduction. For example, the MET that established the IncSa cue used the "inside-outside" relations that were in the MET of the IncDi, but the relation between branches was of sameness. Despite this relevant differentiation between the MET for training both inclusive relational cues (IncDi and IncSa), one question to discuss is why participants in the arbitrary network trained with the IncSa cue identify one feature as more inclusive than the rest, even though all stimuli share all features. We should need to trace how the IncSa relational cue was trained to give an account of this result in the sameness-based inclusion network. As described earlier, the inclusion functions of the METs in both inclusion relational cues (IncSa and IncDi) maintain the combination of stimuli that are grouped into a larger stimulus and thus acquire its additional function. Perhaps this factor allowed participants to derive that although all stimuli had the same functions in the IncSa, not all the functions had the same "weight" because of the inclusion function given during the training.

The experimental procedure presents some limitations that must be considered. On the one hand, the procedure was too long and demanding according to the information provided by some of the participants at the debriefing, especially those with more errors during the process. Perhaps, more breaks during the process could have been effective in this regard. On the other hand, as the participants had their pre-experimental history about anything, in this case, about the words and structure task during training, the present study included a phase to familiarize participants with the verbatim and experimental task. However, this phase could be improved for a better coordination of the procedures and the particularities of each participant which might consequently to have avoided errors and the corresponding additional trials to achieve the criteria.

Overall, this experiment extends the previous research by bringing the training of a hierarchical network under experimental control as an analog of the complex but typical hierarchical categorization illustrated in the introduction. This study has experimentally shown, for the first time, the core features of this categorization as a network built of different branches and the derived functions across the different levels of the whole network as well as the identification of the most inclusive function that keeps the elements integrated. This was done innovatively by introducing the training of four networks to the same participants so that the functions derived in each network was observed. Moreover, to achieve the training of the four arbitrary networks, this study implemented four kinds of experimental protocols to actualize in adults the meaning of four relational cues, mainly the two most complex ones, the inclusion based on distinction and the inclusion based on sameness. Future research might further explore the nature of the non-arbitrary functions that lead to establishing hierarchical relational cues that, subsequently, might be applied to form such a complex pattern of hierarchical derived responses. In other words, future research could explore the role of preparations in establishing different functions and relational cues. For instance, inside or outside, contains, is part of, belonging to, sharing functional features, identical or different groups of stimuli, etcetera. In this track, it might be necessary to be aware of the conditions under which these types of relational cues are developed in the natural context to establish such complex networks. Perhaps this should be a useful context to design training procedures in the lab that might reproduce the natural process with adults as well as to apply it to children who still have not learned these complex repertoires.

References

Barnes-Holmes D, Barnes-Holmes Y, Hussey I, & Luciano C (2016). Relational frame theory: Finding Its Historical and Intellectualt Roots and reflecting upon Its Future Development. In RD Zettle, SC Hayes, D Barnes-Holmes, & A Biglan (Eds), *The Wiley Handbook of Contextual Behavioral Science*, (pp. 117-128). New York: John Wiley & Sons, Ltd.

Barnes-Holmes D & Hughes S (2016). Relational frame theory: The basic account. In RD Zettle, SC Hayes, D Barnes-Holmes, & A Biglan (Eds), *The Wiley Handbook of Contextual Behavioral Science*, (pp. 129-178). New York: John Wiley & Sons, Ltd.

Blasco-Delgado E, Llobera-Cascalló A, Ruiz-Sánchez LJ, & Villarroel-Carrasco J (2019). Measuring the attitudes from Spanish and Catalan people toward Spanish and Catalan Identity with the Implicit Relational Assessment Procedure. *International Journal of Psychology & Psychological Therapy*, *19*, 191-202.

Bodenhausen G, Kang S, & Peery D (2012). Social categorization and the perception of social groups. In G. R. Semin & E. R. Smith (Eds.), *The SAGE Handbook of Social Cognition* (pp. 311-329). SAGE Publications Ltd.

Budziszewska L, Villarroel Carrasco J, & Gil E, (2022). Hierarchical Classification from Relational Frame Theory: A Review. *International Journal of Psychology & Psychological Therapy, 22*, 2, 143-162.

Budziszewska L (2023). *Análisis del comportamiento relacional jerárquico y transformación de funciones*. Doctoral Dissertation. Universidad de Almería.

Callejón Z (2020). *Entrenando la respuesta jerárquica*. Doctoral Dissertation. Universidad de Almería.

Eckstein, MK, Starr A, & Bunge SA, (2019). How the inference of hierarchical rules unfolds over time. *Cognition, 185*, 151-162. Doi: 10.1016/j.cognition.2019.01.009

Foody M, Barnes-Holmes Y, Barnes-Holmes D, Rai L, & Luciano C (2015). An Empirical Investigation of the Role of Self, Hierarchy, and Distinction in a Common Act Exercise. *Psychological Record, 65*, 231-243. Doi: 10.1007/s40732-014-0103-2.

Fryling MJ, Rehfeldt RA, Tarbox J, & Hayes LJ (2020). *Applied behavior analysis of language and cognition: Core concepts and principles for practitioners*. Oakland, CA: Context Press.

Gil E, Luciano C, Ruiz FJ, & Valdivia-Salas S (2012). A preliminary demonstration of transformation of functions through hierarchical relations. *International Journal of Psychology and Psychological Therapy, 12*, 1-19.

Gil E, Luciano C, Ruiz FJ, & Valdivia-Salas S (2014). A further experimental step in the analysis of hierarchical responding. *International Journal of Psychology and Psychological Therapy, 14*, 137-153.

Griffee K & Dougher MJ (2002). Contextual Control of Stimulus Generalization and Stimulus Equivalence in Hierarchical Categorization. *Journal of the Experimental Analysis of Behavior, 78*, 433-447. Doi: 10.1901/jeab.2002.78-433

Hadjichristidis C, Sloman SA, & Over DE (2014). Categorical induction from uncertain premises: Jeffrey's doesn't completely rule. *Thinking and Reasoning, 20(4)*, 405.-431. Doi: 10.1080/13546783.2014.884510.

Hayes SC, Barnes-Holmes D, & Roche B (2001). Relational frame theory: A post-skinnerian account of human language and cognition. In HW Reese & R Kail (Eds.), *Advances in child development and behavior* (pp. 101-138). New Orleans: Academic Press.

Horst JS & Hout MC (2015). The Novel Object and Unusual Name (NOUN) Database: A collection of novel images for use in experimental research. *Behavior Research Methods, 48*, 1393-1409. Doi: 10.3758/s13428-015-0647-3.

Luciano C, Valdivia-Salas S, Berens NM, Rodríguez-Valverde M, Mañas I, & Ruiz FJ (2009). Acquiring the earliest relational operants. Coordination, difference, opposition, comparison, and hierarchy. In RA Rehfeldt & Y Barnes-Holmes (Eds.), *Derived relational responding: Applications for learners with autism and other developmental disabilities* (pp. 149-170). Oakland, CA: New Harbinger.

Luciano C, Törneke N, & Ruiz F, (2021). Clinical Behavior Analysis and RFT: Conceptualizing Psychopathology and Its Treatment. In MP. Twohig, ME Levin and JM Petersen (Eds.) *The Oxford Handbook of Acceptance and Commitment Therapy.* (pp. 109-142). Oxford University Press.

Luciano C, Ruiz F, Gil-Luciano B, & Villarroel J (2023). La perspectiva contextual en el abordaje de los trastornos de la personalidad. In MA Vallejo & L Vallejo-Slocker (Eds.), *Manual de Terapia de Conducta. Tomo II.* (pp. 597-676). Madrid: Dykinson.

Ming S, Mulhern T, Stewart I, Moran L, & Bynum K (2018). Training class inclusion responding in typically developing children and individuals with autism. *Journal of Applied Behavior Analysis, 51*, 53-60. Doi: 10.1002/jaba.429.

Mulhern T, Stewart I, & McElwee JM (2017). Investigating relational framing of categorization in young children. *The Psychological Record*, *67*, 519-536. Doi: 10.1007/s40732-017-0255-y

Mulhern T, Stewart I, Ming S, Zagrabska-Swiatkowska P, & McElwee J (2018). Facilitating Relational Framing of Classification in Young Children. *Journal of Contextual Behavioral Science, 8,* 55-68. Doi: 10.1016/j.jcbs.2018.04.001.

Slattery B, Stewart I, & O'Hora D (2011). Testing for transitive class containment as a feature of hierarchical classification. *Journal of the Experimental Analysis of Behavior, 96*, 243-260. Doi: 10.1901/jeab.2011.96-243.

Slattery B & Stewart I (2014). Hierarchical classification as relational framing. *Journal of the Experimental Analysis of Behavior, 101*, 61-75. Doi: 10.1002/jeab.63.

Tenenbaum JB, Kemp C, Griffiths TL, & Goodman ND (2011). How to grow a mind: Statistics, structure, and abstraction. *Science, 331*, 6022, 1279-1285. Doi: 10.1126/science.119278

Zagrabska-Swiatkowska P, Mulhern T, Ming S, Stewart I, & McElwee J (2020). Training class inclusion responding in individuals with autism: Further investigation. *Journal of Applied Behavior Analysis, 53*, 2067-2080. Doi: 10.1002/jaba.712.

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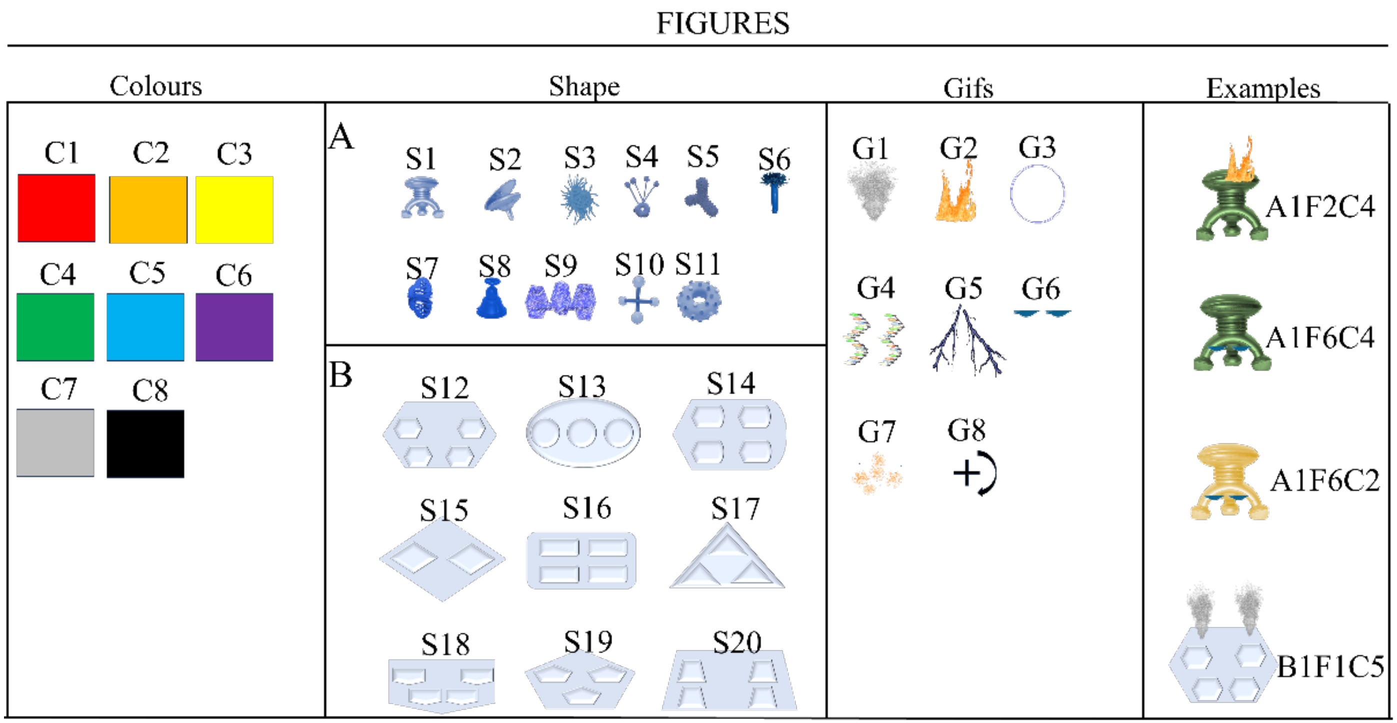
Appendix 1

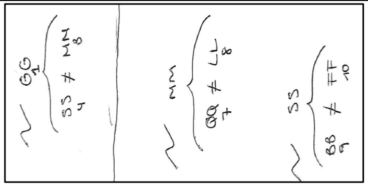
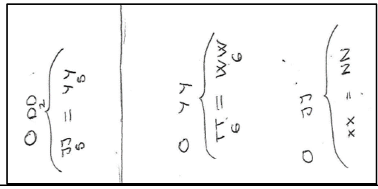
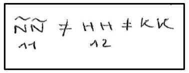
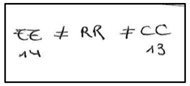
Stimuli used in the second and third phases of the experiment.
Figures and nonsense syllables.
Notes: C= Colour; S= Shape; G= Gifs.



APPENDIX 2

Examples of participant's drawings for representing the four networks.

Note: P1 is an example of incomplete (IncDi and IncSa) or wrong networks (Sa), and P4 is an example of complete right networks.

	IncDi	IncSa	Di	Sa
P1				
P4