



# Learning Symmetrical Relations Facilitates Emergence of Intraverbals after Reading a Text: Effects on Reading Comprehension

Luis Antonio Pérez-González<sup>1</sup>  · Javier Oltra<sup>1</sup>

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## Abstract

We studied the effect of prior learning of symmetrical intraverbals on the emergence of complex intraverbals after reading a text. In Experiment 1, eighteen 7- and 8-year-old children read a text with sentences in which A and B stimuli and B and C stimuli were related (e.g., “The Alps” to “Mont Blanc,” and to “Falcon”). Thereafter, all ABC intraverbals (e.g., C–A—“Name the mountain range of the falcon”) were probed without reinforcement with written stimuli and written responses. In Condition 1, six children learned before intraverbals that relate the categories to the exemplars that served as stimuli in the text (e.g., “Name a mountain”—“Mont Blanc”—*Exemplars*) and learned intraverbals that relate the exemplars to the categories (e.g., “What is the Mont Blanc?”—“A mountain”—*Categories*.) In Conditions 2 and 3, 12 children did not learn Categories or neither Exemplars and Categories. All children in Condition 1 demonstrated the emergence of all ABC intraverbals, but not all children in Conditions 2–3 demonstrated emergence. Experiment 2 controlled that text presentations and teaching trials did not affect the results and replicated the effect. Therefore, learning simple discriminations symmetrical to one another facilitates further emergence with more complex discriminations—intraverbals—which evidence reading comprehension.

**Keywords** Verbal behavior · Intraverbals · Emergence · Symmetry · Stimulus relations · Reading · Reading comprehension

Symmetry in selection-based conditional discriminations was defined by Sidman and Tailby (1982): after learning to match sample A1 to comparison B1 (instead of the alternative comparison B2) and to match sample A2 to B2 (instead of B1), the symmetrical conditional discrimination consists of matching B1 or B2, functioning as samples, to comparison A1 and A2, respectively. Symmetry BA typically emerges after learning the AB conditional discrimination, when probed with no prompts or reinforcement.

The acquisition of symmetrical relations appears to affect the acquisition of more complex skills such as labeling related events, classifying, and reasoning, as indicated by the findings that symmetry facilitates three types of emergence:

First, Pérez-González (1994) studied a type of emergence with arbitrary relations that are more complex than equivalence. At first, he taught a conditional discrimination AB, with three samples and three comparisons. Thereafter, he taught a conditional discrimination in which an A stimulus (e.g., A1) and a B stimulus (e.g., B1) were presented as a two-stimulus sample and two novel stimuli X1 and X2 were the comparisons; he arranged contingencies in such a way that if the two stimuli presented in the sample were two stimuli related to one another in AB as a sample-correct comparison (e.g., when A1 and B1 were presented), comparison X1 was correct. When the two stimuli in the sample were two stimuli related to one another in AB as a sample-incorrect comparison (e.g., when A1 and B2 were presented), comparison X2 was correct. Thus, it was intended that participants selected X1 when any two stimuli in the sample had a sample-correct comparison relation and that they selected X2 when the two stimuli in the sample had a sample-incorrect comparison relation. To verify whether the participants had learned that type of generalized responding, he taught a novel conditional discrimination PQ and probed the emergence of the PQX discrimination, in which one stimulus P and other stimulus Q formed the sample and

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✉ Luis Antonio Pérez-González  
laperez@uniovi.es

<sup>1</sup> Department of Psychology, University of Oviedo, Plaza Feijóo s/n. Despacho 217, 33003 Oviedo, Spain

X1 and X2 were the comparisons. Correct selections (e.g., selections of X1 in the presence of P1 and Q1 and selections of X2 in the presence of P1 and Q2) would demonstrate that participants had learned to select X1 or X2 based on the relations previously acquired between the two stimuli in the sample. Of interest for the present research is that only two of four adult participants demonstrated the emergence of PQX after learning just AB, ABX, and PQ, but four other participants demonstrated that emergence after receiving *symmetry probes* of AB (i.e., BA probes) and of PQ (i.e., QP probes). These results indicated that probing the symmetry of the single-sample stimuli conditional discriminations (and/or the resulting emergence) facilitated this type of relational responding with X1 and X2 as comparisons. Most or all replications of this generalized responding by demonstrating the emergence of the conditional discrimination of the PQ-X type did so after probing the symmetrical relations BA and QP (Carpentier et al., 2000, 2002a, 2002b; Junior & Costa, 2003; Junior et al., 2001; Pérez-González, 2008).

Second, Horne and Lowe (1996; also Lowe & Horne, 1996) defined naming as an overarching operant that encompasses two related operants: the tact of an object or event and the selection of that object or event after listening to its name, such as saying “apple” in the presence of an apple and selecting an apple presented with other objects upon the request of picking the apple. They theorized that the acquisition of naming would be a foundation for acquiring more complex learning skills. In a series of empirical studies, they demonstrated that children who tacted the objects after learning to select them upon hearing the adults request to do so performed much better in further more-complex tasks, such as sorting the objects with the same name or transfer functions acquired by a nonverbal stimulus to another nonverbal stimulus with the same name (Horne & Lowe, 1996, 1997; Horne et al., 2006; Horne et al., 2004; Kobari-Wright & Miguel, 2014; Lowe et al., 2005; Lowe et al., 2002). From the analytical point of view used in the present article, naming involves two discriminations in which the stimulus in the tact (i.e., the object) is the correct comparison in the selection-based conditional discrimination and the response in the tact (i.e., the object’s name) is the sample in the selection-based conditional discrimination. Thus, the tact and the selection can be considered two symmetrical relations. Therefore, the empirical evidence of the studies on naming indicates that the acquisition of these two symmetrical skills facilitates the emergence of more complex verbal skills.

Third, in a study to explore the emergence of intraverbals (as defined by Skinner, 1957), Pérez-González et al. (2008) taught AB intraverbals in which 5 to 6-year-old children learned to say the name of a city in a country (e.g., “Name a city of Argentina”—“Buenos Aires”), and the BC intraverbals, in which they learned to name of a park in that city (e.g., “Name a park of Buenos Aires”—“El Botanico”).

Thereafter, they probed the emergence of the BA, CB, AC, and CA intraverbals (e.g., one CA intraverbal was, “Name the country of El Botanico”—“Argentina”). In an initial study, only one child out of five demonstrated the emergence of all intraverbals. Thereafter, the experimenters designed two types of symmetrically related intraverbals, denominated *Exemplars* and *Categories*. In the Exemplars, the children participants learned to say the experimental exemplars corresponding to the three categories involved (countries, cities, and parks; e.g., “Name a country”—“Argentina”; “Name another country”—“Uruguay”). In the Categories, they learned to say the categories corresponding to the six experimental exemplars (e.g., “What is Argentina?”—“A country”). In a second experiment, four novel children learned the Exemplars and the Categories before learning the AB and BC intraverbals. All four children demonstrated the emergence of all intraverbals. A series of studies devoted to studying the impact of teaching both Exemplars and Categories in the emergence of the novel ABC intraverbals (Belloso-Díaz & Pérez-González, 2015a; Carp & Petursdottir, 2012; Pérez-González et al., 2008; Pérez-González et al., 2014; Pérez-González & Oltra, 2022). The data of 12 studies included in these five articles indicated that almost every child older than 6 demonstrates the emergence of these intraverbals when both Exemplars and Categories are taught, whereas learning Exemplars alone or Categories alone does not have as strong an impact. In summary, data indicated again that learning the symmetrically related Exemplar and Category intraverbals has a great effect on the emergence of more complex conditional discriminations in the form of intraverbals.

The effect of learning Exemplar and Category intraverbals demonstrated in these studies was also observed in a recent study (Pérez-González & Oltra, 2022) with intraverbals in which the stimuli were written questions and the responses were written, conducted with children aged between 6 years 11 months and 8 years 0 months (see also Skinner, 1957, for the characterization of these operants as intraverbals). All children read texts with sentences with the stimuli to be related; for example, they read, “A city of Argentina is Buenos Aires. In Buenos Aires there is a park called el Botanico.” The purpose was to teach to relate A (“Argentina”) to B (“Buenos Aires”) and B to C (“El Botanico”).<sup>1</sup> All children who read texts and received probes with Exemplars and Categories demonstrated the emergence of all ABC intraverbals (AB, BC,

<sup>1</sup> Presenting a text with stimuli to be related seems to be a procedure similar to presenting two stimuli in succession, which has been demonstrated to produce emergence in selection-based conditional discriminations (e.g., Leader & Barnes-Holmes, 2001; Leader et al., 1996) and topography-based verbal operants (e.g., Carnerero & Pérez-González, 2014, 2015).

BA, CB, AC, and CA). In contrast, some children who did not receive the texts and the probes with Exemplars and Categories failed to demonstrate the emergence of all ABC intraverbals. In that study, however, the effect of learning just Exemplars or Categories was not analyzed.

In summary, the findings obtained in Pérez-González (1994) and follow-up studies, in the cited studies on naming, and Pérez-González et al. (2008) and follow-up studies are related to one another in that some type of symmetrical relation was demonstrated to have a strong effect on the emergence of more complex relations. In that context, the present study aimed to explore further the effect of learning symmetrical relations on emergence. In contrast to Beloso-Díaz and Pérez-González's (2015a) study, in which the experimenters taught and probed intraverbals with spoken stimuli and responses, in the present study we used a procedure similar to that used by Pérez-González and Oltra (2022), in which children read texts with the stimuli paired for learning the Exemplars, the Categories, and the AB and BC relations (i.e., they did not learn intraverbals) and the responses were written. In that context, the main goal of the present study was to find out if the effect of learning Exemplars and Categories on the emergence of more complex relations would expand (1) to learning with stimuli with a written topography; (2) to learning with stimuli that were paired by being presented simultaneously; and (3) when the probed intraverbals had textual stimuli and responses of the written topography. If that effect were found, it would expand the previous findings, which would demonstrate that the processes in these different circumstances would be similar or identical. Therefore, that would bring about important theoretical derivations because a few learning principles would be involved in a variety of performances. Moreover, it would bring practical derivations because the format of reading a text (in which verbal stimuli are presented simultaneously) and answering written questions is often used in teaching.

Studies cited above demonstrated that the Exemplars had a much greater effect than the Categories on emergence. For example, a study conducted with adults (Pérez-González et al., 2014) showed that all adults demonstrated the emergence of all ABC intraverbals if the Exemplars are taught, but one third of adults did not demonstrate emergence when Exemplars were not taught. For that reason, we assumed that learning Exemplars is necessary for most children to demonstrate the emergence of all the ABC intraverbals. Moreover, in that study, two adults did not demonstrate the emergence of all ABC intraverbals when they learned the Categories. As a result, in the present study we sought to compare the effects of teaching both Exemplars and Categories with that of teaching just Exemplars, and with that of not teaching Exemplars nor Categories, i.e., we did not seek to compare the effect of teaching both Exemplars and Categories with that of teaching Categories but no Exemplars.

The general purpose of the present study was experimental. The stimuli used, however, were common names and relations. The reason for this use was that pilot studies with auditory stimuli and vocal responses with arbitrary stimuli were hard for the participants to learn (especially for children) and the emergence was less likely. Recent studies indicated that the nature of stimuli can affect emergence, for example, Beloso-Díaz and Pérez-González (2015b, 2016) found that the emergence of symmetrical BA intraverbals after learning AB intraverbals was very likely to occur with 5- to 7-year-old children when they learned tacts with B as responses and the stimuli were common. In contrast, Petursdottir et al. (2015) found that these relations did not emerge with arbitrary stimuli in 3.5- to 5.5-year-old children. These findings are coherent with this assumption in that the type of stimulus (and/or age-related variables) could have been a variable that affected emergence. Thus, we used common names and relations. To control that the participants had not acquired the experimental intraverbals before the intervention, we conducted a preintervention probe.

## Experiment 1

The goal of Experiment 1 was to compare intraverbal emergence after learning both Exemplars and Categories, Exemplars, or nothing prior to reading the text. Thus, all children participants received the text and the emergence probe with the targeted intraverbals but they differed in the previous experience with simpler intraverbals.

## Method

### Participants

Eighteen children who attended second grade in a public primary school in Oviedo, Spain, participated, with an age range from 7 years and 3 months to 8 years and 1 month (mean: 7 years 10 months). They were randomly selected among the children of two school classrooms whose parents signed informed consent. No child had received any diagnosis by the psychologist of the school; thus, it was assumed that all of them were typically developing and it was assumed that all children had the typical reading skills of second-grade Spanish children. No child participated in previous research on intraverbal emergence.

### Stimuli, Relations, and Materials

The stimuli were components of targeted intraverbals and texts related to them. We used three types of intraverbals: ABC intraverbals, Exemplars, and Categories. The intraverbals were presented in written form. Therefore, the questions were

**Table 1** The ABC Intraverbals Used and Translation into English in Italics

Type of Intraverbal	Antecedent Stimuli	Response
<i>Alps set</i>		
A–B direct—Range–Mountain	Nombra una montaña de los Alpes <i>Name a mountain of the Alps</i>	Mont Blanc <i>Mont Blanc</i>
B–C direct—Mountain–Bird	Nombra un ave del Mont Blanc <i>Name a bird of Mont Blanc</i>	Halcón <i>Falcon</i>
B–A symmetry—Mountain–Range	Nombra la cordillera del Mont Blanc <i>Name the mountain range of the Mont Blanc</i>	Los Alpes <i>The Alps</i>
C–B symmetry—Bird–Mountain	Nombra la montaña del Halcón <i>Name the mountain of the falcon</i>	Mont Blanc <i>Mont Blanc</i>
A–C transitive—Range–Bird	Nombra un ave de los Alpes <i>Name a bird of the Alps</i>	Halcón <i>Falcon</i>
C–A equivalence—Bird–Range	Nombra la cordillera del Halcón <i>Name the mountain range of the falcon</i>	Los Alpes <i>The Alps</i>
<i>Andes set</i>		
AB direct—Range–Mountain	Nombra una montaña de los Andes <i>Name a mountain of the Andes</i>	Aconcagua <i>Aconcagua</i>
B–C direct—Mountain–Bird	Nombra un ave del Aconcagua <i>Name a bird of Aconcagua</i>	Cóndor <i>Condor</i>
B–A symmetry—Mountain–Range	Nombra la cordillera del Aconcagua <i>Name the mountain range of the Aconcagua</i>	Los Andes <i>The Andes</i>
C–B symmetry—Bird–Mountain	Nombra la montaña del cóndor <i>Name the mountain of the condor</i>	Aconcagua <i>Aconcagua</i>
A–C transitive—Range–Bird	Nombra un ave de los Andes <i>Name a bird of the Andes</i>	Cóndor <i>Condor</i>
C–A equivalence—Bird–Range	Nombra la cordillera del cóndor <i>Name the mountain range of the condor</i>	Los Andes <i>The Andes</i>

written on a paper sheet that was covered by two cardboards that left the question plus a space below for the child to write the answer. In addition, we used texts for teaching the AB and BC relations, Exemplars, and Categories. All texts were written on 21.0 cm x 29.7 cm paper sheets, with 16-point Verdana font. All the stimuli were in Spanish and all the procedures were conducted in Spanish, with the Spanish usage (such as using the article every time with “Alps” and “Andes”).

**ABC Intraverbals** We used six intraverbals that relate a mountain range (A), to a mountain (B), and to a bird (C) that lives in the corresponding mountain range (e.g., Alps, Mont Blanc, falcon, and Andes, Aconcagua, condor; see Table 1). The resulting intraverbals were denominated the A–B Range–Mountain direct, the B–C Mountain–Bird direct, the B–A Mountain–Range symmetric, the C–B Bird–Mountain symmetric, the A–C Range–Bird transitive, and the C–A Bird–Range equivalence intraverbals.

**Exemplars** The Exemplars were intraverbals in which the antecedent stimuli were, “Name a mountain range,” “Name a mountain,” or “Name a bird” (see those with the Alps set in Table 2; the Exemplars with the Andes were analogous). The

responses defined as correct were the exemplars of the categories mentioned (e.g. “Alps,” “Mont Blanc,” and “Falcon”). They were labeled as Exemplars because their correct response consisted of writing the exemplar of the exposed category.

**Categories** The Categories were intraverbals in which the antecedent stimuli were, “What is . . . ?” followed by the name of a mountain range, a mountain, or a bird (see Table 2). The responses defined as correct were the categories these stimuli belong to (i.e., “mountain range,” “mountain,” or “bird”). They were labeled as Categories because their correct response consisted of writing the category of the exposed exemplar.

**Texts for Teaching Exemplars** The texts consisted of six sentences that related a category to an exemplar of the set (e.g., A, B, and C corresponding to the Alps), such as, “A mountain range is the Alps” (see Table 3).

**Texts for Teaching Categories** They were analogous to the texts used for teaching Exemplars. The texts consisted of six sentences that related an exemplar to a category of the set (e.g., A, B, and C corresponding to the Alps), such as, “The Alps are a mountain range” (see Table 3).

**Table 2** The Intraverbals of the Type of Exemplars and Categories Corresponding to the Alps Set and the English Translation (in italics)

Antecedent stimuli	Response
<i>Exemplars</i>	
Nombra una cordillera ( <i>Name a mountain range</i> )	Los Alpes ( <i>The Alps</i> )
Nombra una montaña ( <i>Name a mountain</i> )	Mont Blanc ( <i>Mont blanc</i> )
Nombra un ave ( <i>Name a bird</i> )	Halcón ( <i>Falcon</i> )
<i>Categories</i>	
¿Qué son los Alpes? ( <i>What is the Alps?</i> )	Una cordillera ( <i>A mountain range</i> )
¿Qué es el Mont Blanc? ( <i>What is the Mont Blanc?</i> )	Una montaña ( <i>A mountain</i> )
¿Qué es un halcón? ( <i>What is a Falcon?</i> )	Un ave ( <i>A bird</i> )

**Table 3** Texts Used for Teaching the Exemplars and Categories

Text used	English Translation
<i>Alps—Exemplars</i>	
Una cordillera son los Alpes	<i>A mountain range is the Alps</i>
Una montaña es el Mont Blanc	<i>A mountain is the Mont Blanc</i>
Un ave es el halcón	<i>A bird is the falcon</i>
<i>Alps—Categories</i>	
Los Alpes son una cordillera	<i>The Alps is a mountain range</i>
El Mont Blanc es una montaña	<i>The Mont Blanc is a mountain</i>
El halcón es un ave	<i>The falcon is a bird</i>
<i>Andes—Exemplars</i>	
Una cordillera son los Andes	<i>A mountain range is the Andes</i>
Una montaña es el Aconcagua	<i>A mountain is the Aconcagua</i>
Un ave es el cóndor	<i>A bird is the condor</i>
<i>Andes—Categories</i>	
Los Andes son una cordillera	<i>The Andes is a mountain range</i>
El Aconcagua es una montaña	<i>The Aconcagua is a mountain</i>
El cóndor es un ave	<i>The condor is a bird</i>

**Table 4** Texts Used for Inducing the ABC Intraverbals and the English Translation (in italics)

<i>The Alps</i>	
Una montaña de los Alpes es el Mont Blanc. En el Mont Blanc hay un ave que se llama halcón.	<i>A mountain of the Alps is the Mont Blanc. In the Mont Blanc there is a bird called falcon.</i>
<i>The Andes</i>	
Una montaña de los Andes es el Aconcagua. En el Aconcagua hay un ave que se llama cóndor.	<i>A mountain of the Andes is the Aconcagua. In the Aconcagua there is a bird called condor.</i>

**Texts for Teaching the AB–BC Relations** We designed one text for each mountain range (see Table 4). Each text consisted of two sentences, the first one related the A and B stimuli in that order (e.g., “A mountain in the Alps is the Mont Blanc”) and the second one related the B and C stimuli in that order (e.g., “In the Mont Blanc there is a bird called falcon”).

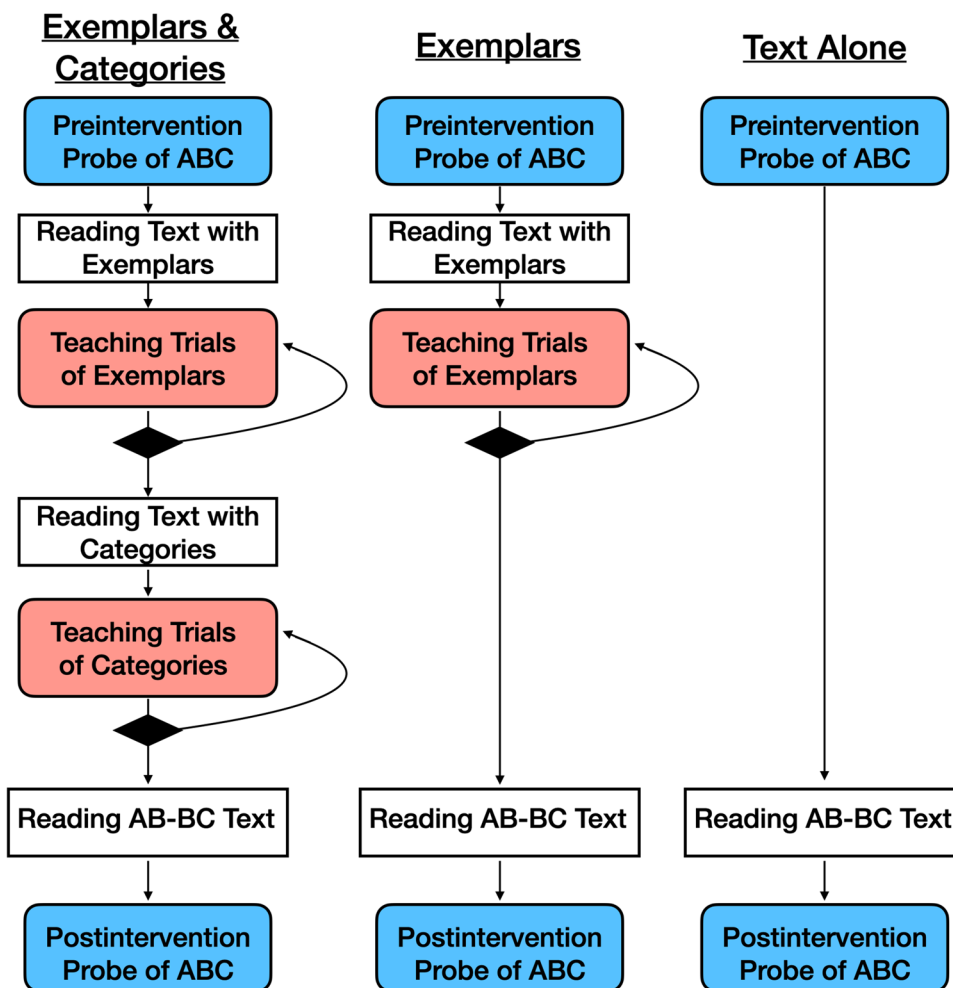
**Procedures**

The children were randomly assigned to one of three conditions: *Exemplars and Categories*, *Exemplars*, or *Text Alone*. A flow chart of the three procedures appears in Fig. 1. In the *Exemplars and Categories Condition*, six children (1)

received a preintervention probe of the ABC intraverbals, Exemplars, and Categories; (2) read the text with the Exemplars and received teaching trials of the Exemplar intraverbals with the first mountain range; (3) read the text with the Categories and received teaching trials of the Categories with the first mountain range; (4) read the text for teaching the AB and BC relations and received the probes of the ABC intraverbals with the first mountain range. Then steps (2) through (4) were repeated with the second mountain range. The criterion for a child to participate in the experiment was to demonstrate no more than one correct response in the preintervention probe of the ABC intraverbals and no more than two correct responses in the probes with Exemplars and



**Fig. 1** Flowchart of Experiment 1 *Note.* Blue boxes indicate the probes of the ABC intraverbals. White boxes indicate that the child read a text. Red boxes indicate that the child received teaching trials regarding the text just read (either Exemplars or Categories) until reaching a criterion (see text for details). Notice that no child received teaching trials of the ABC intraverbals



Categories; all children met this criterion. Three children received the procedures with the Alps first; the other three children received the procedures with the Andes first. If a child made all correct responses in the probe of the ABC intraverbals of a mountain range (in step [4])—, the procedure with that mountain range was not presented anymore; if the child made one or more errors, steps (2) through (4) were repeated with that mountain range or ranges (in the same order), i.e., they were reviewed. We defined a *cycle* as a part of the procedure in which steps (2) through (4) were repeated. Each child received a maximum of three cycles.

The six children in the *Exemplars Condition* received the same procedures as the *Exemplar and Categories Condition*, except that the Categories were not taught, i.e., step (2) was omitted. The six children in the *Text Alone Condition* received the same procedures as the *Exemplars and Categories Condition*, except that the Exemplars and the Categories were not taught, i.e., steps (2) and (3) were omitted.

**Variables and Design** The dependent variables were correct responses and errors (i.e., incorrect responses) in each type

of the ABC intraverbals (direct AB and BC, symmetric BA and CB, transitive AC, and equivalence CA) as well as cycles to criterion. The main independent variable was the effect of reading the Exemplar text and learning the Exemplars and reading the Category text and learning the Categories. Thus, this variable was analyzed by comparing the results across conditions. The independent variable within each participant was the effect of reading the text or texts (after the first reading) and the effect of repeating reading–probing cycles. Thus, the design included two AB designs, one related to the effect of reading the text the first time (a pre- and postdesign) and the other one related to repeating reading–probing cycles. Moreover, the effects were analyzed twice, one with each mountain range. The main goal of the present study, however, consisted of comparing the effects on the dependent variables of the procedures received across conditions.

**Setting** Sessions were conducted in a quiet classroom at the school. The children were told that they/they were to read a text and answer some written questions related to that text by writing the answer and that after a little while they were

to return to the class. Each session could have one or more cycles; it was about half hour long. Each child received one or two sessions in the same week.

**Probe of the ABC Intraverbals** Six trials of the ABC intraverbals were presented in the following order: AB, BC, BA, CB, AC, and CA. The child was told that he/she were about to answer questions by writing the answers, and that the experimenter was not to tell him/her whether the answers were correct or not. In the postintervention probe, the experimenter also told the child that the questions were related to the text or texts just read. The child wrote the answers with a pencil and could use an eraser if they chose to (i.e., a self-correction with no intervention from the experimenter), but just once. The time for starting to write the answer was 10 s; after that time, if the child did not start to write, the experimenter showed the next question. No differential consequences for responding correctly or incorrectly were administered. After writing the answer or not responding, the next question was uncovered, and an identical procedure was conducted until all questions were presented. The child was never allowed to go back to a previous question.

**Probes of the Exemplars and Categories** The three Exemplar intraverbals were presented in a random sequence, thereafter, the three Category intraverbals were presented also in a random sequence. In both probes, the procedures were analogous to those used in the probe of the ABC intraverbals.

**Teaching of Exemplars** The text of the Exemplars was presented for 20 s. That time was enough for all children to read the text, as determined in pilot probes. If the child read the text silently, the experimenter asked the child after 20 s if they had finished. The children answered “Yes” on all occasions. Then, the experimenter removed the text. Thereafter, trials of Exemplar intraverbals were presented in a sheet with the three questions written twice, grouped three by three, which made up six questions per page. These questions were initially covered by two pieces of cardboard. In each trial, the experimenter uncovered just one question (i.e., previous and subsequent questions remained covered). The experimenter allocated 10 s for the child to start to write. If a child had not started to write within 10 s, the experimenter would dictate the correct response to the child. Correct responses were followed by an expression such as “Very good!,” “Nice!,” or “Perfect!” These expressions functioned as reinforcers in previous studies and in the context of this research because they served for teaching the targeted skills. Incorrect written responses were followed by “No” and the dictation of the correct response (a correction). No answers or incorrect written responses were considered incorrect responses. After writing the answer or not responding, an

identical procedure was conducted until all questions were presented. Trials were presented until the child made six consecutive correct responses.

**Teaching of Categories** The procedure for teaching the Categories was analogous to the procedure of teaching Exemplars, with the text of the Categories and the Category intraverbals taught.

**Presentation of the Text for Teaching the AB and BC Relations** The text of a mountain range was presented on the table and the experimenter asked the child to read it silently or aloud as they chose. If the child read the text silently, the experimenter asked the child after 20 s if he had finished, they answered “Yes” on all occasions, and the experimenter removed the text. The time allocated for reading was determined in pilot probes and prior experiments. This time was enough for reading the text once but insufficient for reading it twice. The text was removed 2 s after the child ended up reading it.

**Definition of Correct Responses** Responses considered correct were those that accomplished the grammar rules established by the Spanish *Real Academia de la Lengua*, with the following exceptions, adapted to 7-year-old children: (1) lack of hyphen or incorrect addition of hyphen (e.g., “Halcon” instead of “Halcón”); (2) lower-case letters instead of upper case letters (e.g., writing “mont blanc” was considered correct); (3) joint two contiguous words (e.g., “montblanc” instead of “Mont Blanc”); (4) the omission of a consonant sound of a syllable following by a syllable that starts with a consonant (e.g., “Aconagua” instead of “Aconcagua”); (5) the omission of a silent grapheme (e.g., “Alcón” instead of “Halcón”); (6) the translation of a word or words to Spanish (e.g., “Monte Blanco” instead of “Mont Blac”); (7) the inclusion or absence of an article before the response (e.g., “El halcón” instead of “Halcón”).

**Interobserver Agreement** All texts written by the children were scored as correct or incorrect by the experimenter and an undergraduate student specifically taught for this task. The experimenter and the second scorer analyzed 1,204 responses of all 18 children. Both scorers agreed on 1,200 responses, which result in 99.6% agreement. They agreed on 100% of the responses of 14 children and disagreed on one response of 4 children. Agreement across children ranged from 98.5% to 100%.

## Results

### Preintervention Probes

In the *ABC intraverbals*, all children scored with a maximum of one correct response out of six. In *Exemplars* and

**Table 5** Correct Responses and Trials in Preintervention Probes and Teaching Phases of Exemplars and Categories in the Exemplars and Categories Condition of Experiment 1

Stimulus set	Participant					
	Cora	Gina	Paulo	Iberia	Elmo	Sora
<i>The Alps—Exemplars</i>						
Probe	0/3	0/3	0/3	0/3	0/3	0/3
Teaching	7/11	8/9	11/14	7/9	6/7	6/6
Review	-	6/6	-	-	-	-
<i>The Alps—Categories</i>						
Probe	1/3	2/3	0/3	0/3	1/3	0/3
Teaching	7/8	6/6	7/8	6/6	6/6	6/6
Review	-	6/6	-	-	-	-
<i>The Andes—Exemplars</i>						
Probe	0/3	0/3	0/3	0/3	0/3	0/3
Teaching	10/14	8/12	16/30	7/12	7/11	7/9
Review	14/17	-	-	6/8	-	-
<i>The Andes—Categories</i>						
Probe	0/3	0/3	0/3	0/3	0/3	0/3
Teaching	6/6	6/6	6/6	6/6	6/6	6/6
Review	6/6	-	-	6/6	-	-

**Table 6** Correct Responses and Trials in Preintervention Probes and Teaching Phases of Exemplars and Categories in the Exemplars Condition of Experiment 1

Stimulus set	Participant					
	Marta	Leo	Polo	Hado	Rica	Paca
<i>The Alps—Exemplars</i>						
Probe	0/3	0/3	0/3	0/3	0/3	0/3
Teaching	9/14	6/9	7/9	11/12	7/9	6/9
Review	-	-	-	6/7	6/6	12/14
<i>The Alps—Categories</i>						
Probe	0/3	1/3	1/3	0/3	0/3	0/3
<i>The Andes—Exemplars</i>						
Probe	0/3	0/3	0/3	0/3	0/3	0/3
Teaching	7/15	6/8	9/12	6/8	8/12	6/12
Review	6/6	-	-	7/9	12/12	12/13
<i>The Andes—Categories</i>						
Probe	0/3	0/3	0/3	0/3	0/3	0/3

*Categories*, all children made 0 to 2 correct responses out of 12 (see Tables 5, 6 and 7). Three children made two out of three correct responses in the probes of the *Categories* of a stimulus set, but they did not respond correctly to any of the three *Categories* of the other set or to the *Exemplars*. Therefore, all children continued in the experiment.

### Learning of Exemplars and Categories

The six children of the *Exemplars and Categories Condition* acquired the Exemplar and Category intraverbals within 14 or fewer trials and five or fewer errors with each stimulus set, except Paulo, who did so within 30

trials with the *Exemplars* of the *Andes* (see Table 5). All children learned with all correct responses the *Categories* of the *Andes*. The six children of the *Exemplars Condition* acquired the Exemplar intraverbals within 15 or fewer trials (see Table 6). The *Exemplars* of the *Andes* produced most errors in the children of the two conditions.

### Emergence of the ABC Intraverbals

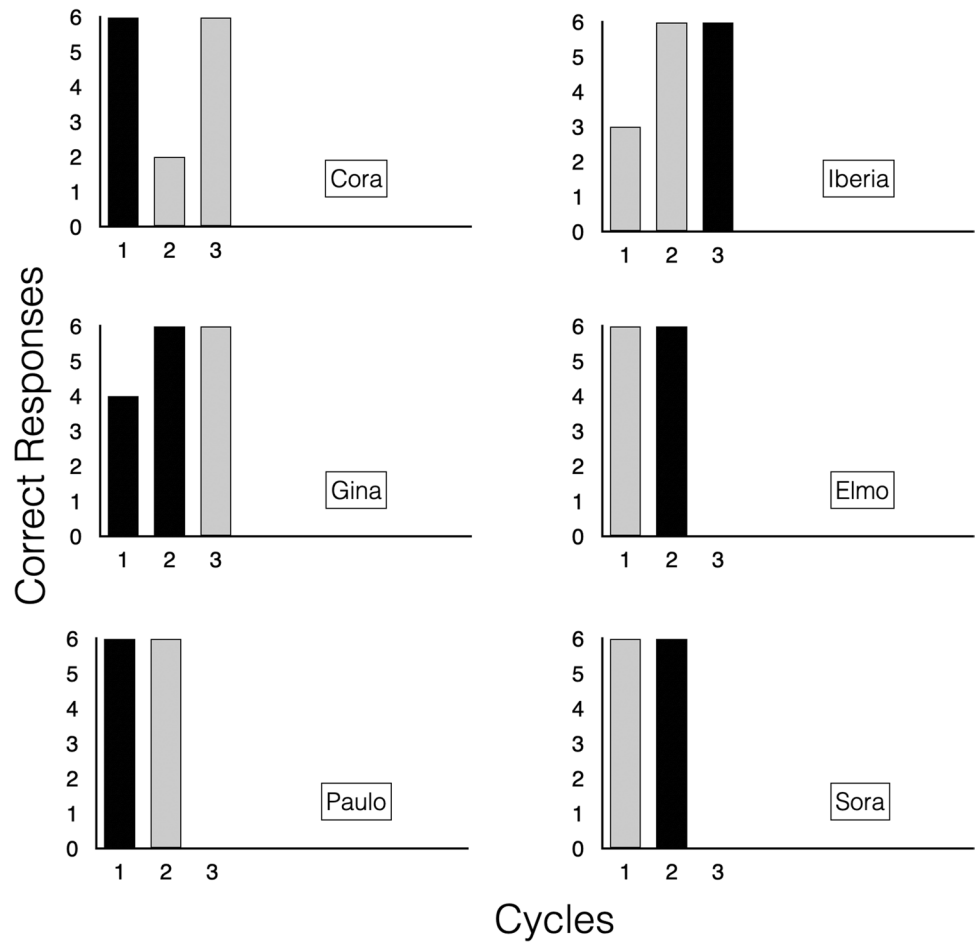
Emergence across conditions is described first. The results appear in Figs. 2, 3 and 4 and detailed results appear in Appendices A, B, and C. All six children of the *Exemplars and Categories Condition* (Fig. 2) demonstrated the



**Table 7** Correct Responses and Trials in Preintervention Probes of Exemplars and Categories in the Text Alone Condition of Experiment 1

Stimulus set	Participant					
	Domo	Carma	Mario	Nerea	Concha	Jano
<i>The Alps—Exemplars</i>						
Probe	0/3	0/3	0/3	0/3	0/3	0/3
<i>The Alps—Categories</i>						
Probe	1/3	2/3	1/3	2/3	0/3	1/3
<i>The Andes—Exemplars</i>						
Probe	1/3	0/3	0/3	0/3	0/3	0/3
<i>The Andes—Categories</i>						
Probe	0/3	0/3	1/3	0/3	0/3	0/3

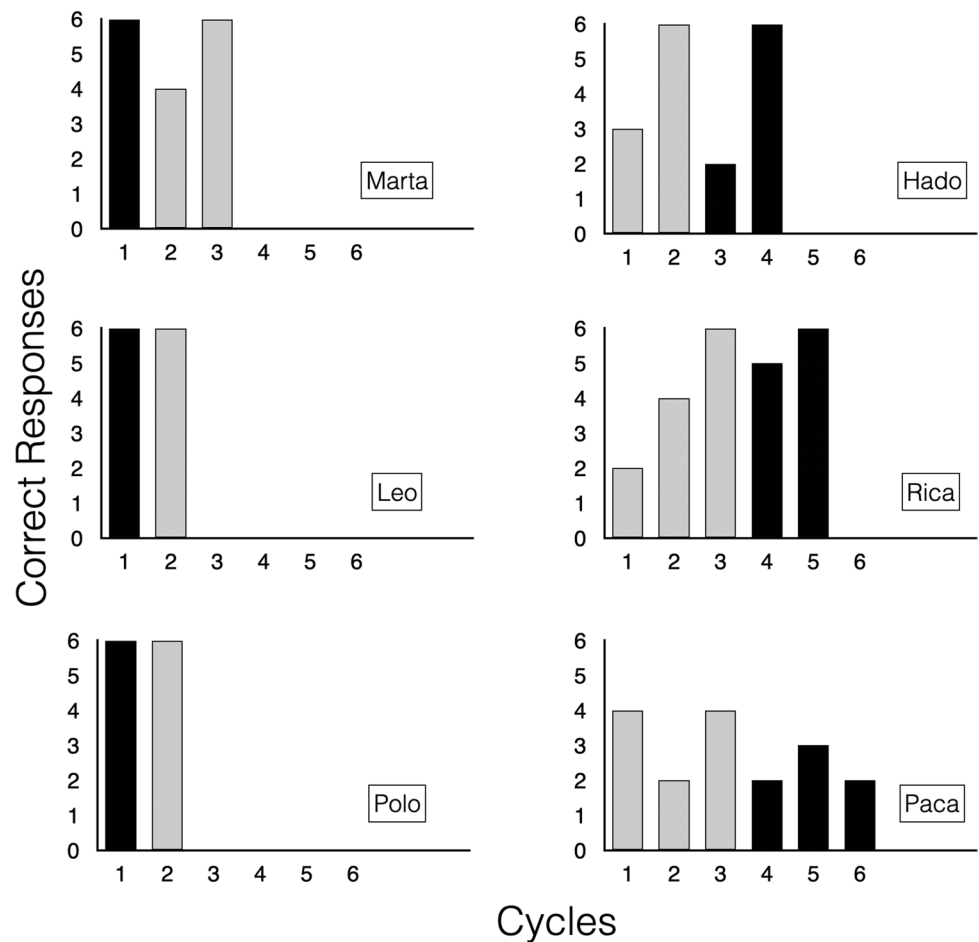
**Fig. 2** Intraverbal Emergence after Learning Exemplars and Categories and Reading the Text in Experiment 1. *Note.* Black bars depict the results in the Alps; grey bars depict results in the Andes



emergence of all relations with the two stimulus sets in one cycle (three children) or one cycle in a set and two cycles with the second (the remaining three children). They made only nine errors: one child made four errors and other child made three errors in the Alps, and one child made two errors in the Andes. In contrast, four children of the *Exemplars Condition* (Fig. 3) demonstrated the emergence of all relations with the two stimulus sets within the two first cycles. One child demonstrated emergence in the third cycle, but

the remaining child (Paca) did not demonstrate emergence. The six children made 35 errors in the probes, in one to three cycles. Moreover, only one of the six children of the *Text Alone Condition* (Fig. 4) demonstrated the emergence of all relations with the two stimulus sets within the two first cycles. No child demonstrated the emergence of all relations in the second or the third cycle; thus, the remaining five children did not demonstrate emergence. The six children made 86 errors in the probes, in one to three cycles.

**Fig. 3** Intraverbal Emergence after Learning Exemplars and Reading the Text in Experiment 1. *Note.* Black bars depict the results in the Alps; grey bars depict results in the Andes



**Emergence across Intraverbals** The AB and BC Direct Intraverbals emerged with the two stimulus sets in 16 out of the 18 children (two children from the *Text Alone Condition* failed with one of the two stimulus sets in the AB direct). The CA Equivalence intraverbals produced the fewest correct responses in the *Exemplars Condition* and in the *Text Alone Condition*. The BA Symmetry, the CB Symmetry, and the AC Transitivity intraverbals produced intermediate correct responses in the *Exemplars Condition* and in the *Text Alone Condition*. The children in the *Exemplars and Categories Condition* responded with very few errors; thus, no clear differences could have been observed across intraverbals.

## Discussion

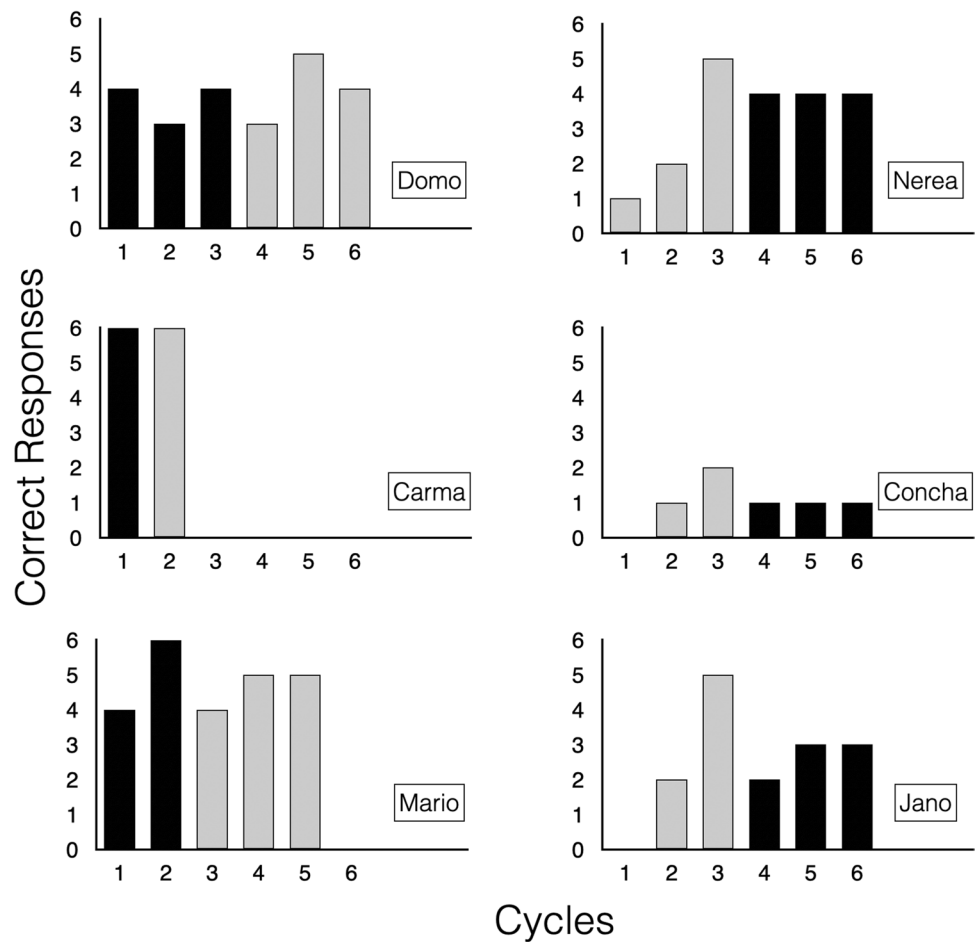
All children who learned Exemplars and Categories demonstrated emergence, but one child who learned just Exemplars did not. Most children who learned Exemplars and Categories demonstrated emergence within fewer cycles than those who learned just Exemplars. Moreover, the children who learned Exemplars and Categories needed fewer probe trials of the ABC intraverbals to demonstrate emergence and did so with fewer than one third of errors on

average than children who learned just Exemplars. Therefore, acquiring both Exemplars and Categories before reading the text with the AB and BC relations seems to produce a significant effect on the emergence of the ABC intraverbals. There exists, however, a slight probability that learning with more trials either of Exemplars and Categories or of just Exemplars could facilitate learning. In such a possibility, then the children of the *Exemplars and Categories Condition* could have demonstrated more emergence than those of the *Exemplars Condition* because they received more teaching trials of Exemplars and Categories than those of the *Exemplars Condition* received with the Categories. Even though that fact did not affect the experiences with the text with the AB and BC relations nor the ABC intraverbals, this possibility was explored in Experiment 2

## Experiment 2

The goal of Experiment 2 was to rule out the possibility that more instances of intraverbal emergence occur among the children of the *Exemplars and Categories Condition*

**Fig. 4** Intraverbal emergence after reading the text in Experiment 1. *Note.* Black bars depict the results in the Alps; grey bars depict results in the Andes. Cycles with no bars indicate zero correct responses



than in those of the *Exemplars Condition* due to the fact that these children received on average more teaching trials of Exemplars and Categories. Therefore, we replicated these conditions of Experiment 1 with a design that assured that children in the *Exemplars Condition* received as many or more trials in those of the *Exemplars and Categories Condition*.

**Method**

**Participants**

Eight children who attended second grade in a public primary school (the same school as in Experiment 1) in Oviedo, Spain, participated, with an age range from 7 years and 1 month to 7 years and 10 months (mean: 7 years 5 months). They were selected with the same criterion and they have the same characteristics as those in Experiment 1.

**Stimuli, Relations, and Procedures**

The stimuli and relations were identical to those of Experiment 1. The procedures were identical except for the following:

First, the eight children were grouped in four pairs in which the two members were of a similar academic level and similar age. Second, one child of each pair was randomly selected to receive the procedure of the *Exemplars and Categories Condition*, which was identical to that procedure of Experiment 1. This child received all experimental sessions first. Third, the other child of the pair received a procedure identical to that of the *Exemplars Condition* of Experiment 1 with the following exceptions: (1) The number of text presentations and trials in each teaching phase of Exemplars and Categories of each cycle with each stimulus set of the paired peer in the *Exemplars and Categories Condition* was recorded. Then the child in the *Exemplars Condition* received at least as many text presentations and teaching trials of Exemplars, in the same sequence as the

**Table 8** Correct Responses and Trials in Preintervention Probes, Teaching, and Review Phases of Exemplars and Categories (E+C) and in the Exemplars (E) Conditions, Plus Number of Times the Texts were Presented in Experiment 2

Stimulus set	Participant & Condition							
	Magno E+C	Mayo E	Cintia E+C	Melba E	Ania E+C	Mendo E	Enzo E+C	Alicia E
<i>The Alps—Exemplars</i>								
Probe	0/3	0/3	0/3	0/3	0/3	0/3	1/3	0/3
Teaching	6/6	8/12	9/12	14/23	10/12	8/12	13/18	17/18
Review 1	-	6/6	9/11	6/6	11/12	8/8	-	6/6
Review 2	-	6/7	-	11/11	-	12/12	-	6/6
Review 3	-	8/9	-	6/6	-	6/6	-	-
Review 4	-	-	-	-	-	6/8	-	-
<i>The Alps—Categories</i>								
Probe	1/3	0/3	0/3	0/3	1/3	1/3	1/3	0/3
Teaching	6/6	-	6/6	-	7/8	-	6/6	-
Review	-	-	6/6	-	6/6	-	-	-
<i>Text Presentations</i>	2	4	4	4	4	5	2	3
<i>The Andes—Exemplars</i>								
Probe	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3
Teaching	7/12	12/19	6/10	20/36	9/19	14/19	7/15	14/21
Review 1	-	15/17	11/16	6/6	9/12	11/11	13/16	10/10
Review 2	-	7/8	-	16/16	8/9	12/12	-	16/16
Review 3	-	7/9	-	7/7	-	7/7	-	6/6
Review 4	-	-	-	-	-	9/9	-	6/6
Review 5	-	-	-	-	-	6/6	-	-
Review 6	-	-	-	-	-	6/6	-	-
<i>The Andes—Categories</i>								
Probe	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3
Teaching	6/6	-	6/6	-	9/11	-	8/10	-
Review 1	-	-	6/7	-	6/12	-	6/6	-
Review 2	-	-	-	-	6/6	-	-	-
<i>Text Presentations</i>	2	4	4	4	6	7	4	5

Children in the E Condition received equal number or more trials than the child in the E+C Condition, as shown in the column left to each one

yoked child, in the first cycle. For example, Cintia, from the *Exemplars and Categories Condition*, acquired the Exemplars in 12 trials and the Categories in 6 trials with the Alps set and received a second cycle with 11 trials of the Exemplars and 6 trials of the Categories, each one preceded by the text presentation. Then, her paired peer in the *Exemplars Condition* (Melba) received at least four text presentations followed by blocks of at least 12, 6, 10, and 6 trials of the Exemplars in the first cycle. In each trial block, the child received additional trials if they did not meet criterion, because a requirement was reaching criterion in Exemplars teaching and review. This procedure assured that all children in the *Exemplars Condition* received the same number or more trials than his/her yoked peer in the *Exemplars and Categories Condition*.

**Interobserver Agreement** All texts written by the children were scored as correct or incorrect by the experimenter and a

graduate student specifically taught for this task. The experimenter and the second scorer analyzed all 1,099 responses of all eight children. Both scorers agreed on 1,095 responses, which result in 99.6% agreement. They agreed on 100% of the responses of six children and disagreed on four responses of two children. Agreement across children ranged from 98.6% to 100%.

## Results

### Preintervention Probes

In the *ABC intraverbals*, seven children made all responses incorrectly. In the *Exemplars and Categories*, all children made zero or one correct response out of 12 (see Table 8). In the probes of the Exemplars, one child made one correct response in one stimulus set. In the probes of the

Categories, four children made one correct response in one stimulus set. Therefore, all children continued in the experiment.

### Learning of Exemplars and Categories

The results in learning and review appear in Table 8. The four children of the *Exemplars and Categories Condition* acquired the Exemplar and Category intraverbals within 6–19 trials and 12 or fewer errors in each stimulus set (see Teaching rows in Table 8). They received from 30 (participant Magno) to 102 (participant Ania) trials of Exemplars and Categories with the two sets—Magno did not need any review trial but Ania needed 52 review trials. The four children of the *Exemplars Condition* received between 12 and 36 trials of the Exemplar intraverbals with each stimulus set. They received from 87 (Mayo) to 130 (Melba) trials of Exemplars with the two sets.

### Reading the Text

The four children of the *Exemplars and Categories Condition* received from two to five cycles with the two sets; therefore, they read the two texts a total from two to five times. The four children of the *Exemplars Condition* received from four to six cycles with the two sets; therefore, they read the two texts from four to six times (see Fig. 5).

### Emergence of the ABC Intraverbals

Emergence *across conditions* is described first. The results appear in Fig. 5 and detailed results appear in Appendices D and E. Three of the four children of the *Exemplars and Categories Condition* demonstrated the emergence of all relations with the two stimulus sets. The remaining child (Ania) demonstrated emergence with one stimulus set (the Alps set); this child responded correctly to all ABC intraverbals except the trial of the CA intraverbal in the three session probes with the Andes set. One child demonstrated emergence in the first cycle with the two stimulus sets, two other children did so in the first or second cycle, and the fourth child (Ania) demonstrated emergence with the Alps set in the second cycle. Three of the four children made 3 or fewer errors in each set; the fourth child (Ania) made 7 errors with the Andes set and 2 errors with the Alps set).

These children made a total of 16 errors. In contrast, two children of the *Exemplars Condition* demonstrated the emergence of all relations with the two stimulus sets, one child did so with one stimulus set, and one child did not demonstrate the emergence with all relations with any stimulus set. The two children who demonstrated emergence of all

relations did so in the second cycle and the child who demonstrated emergence in one set did so in the third cycle. These children made a total of 49 errors.

**Emergence across Intraverbals** The AB and BC Direct Intraverbals emerged with the two stimuli in the four children of the *Exemplars and Categories Condition* and three children of the *Exemplars Condition*. One child of the *Exemplars Condition* (Mayo) responded correctly in the AC trial of the first stimulus set in the second cycle but he responded incorrectly to that trial in the third cycle.

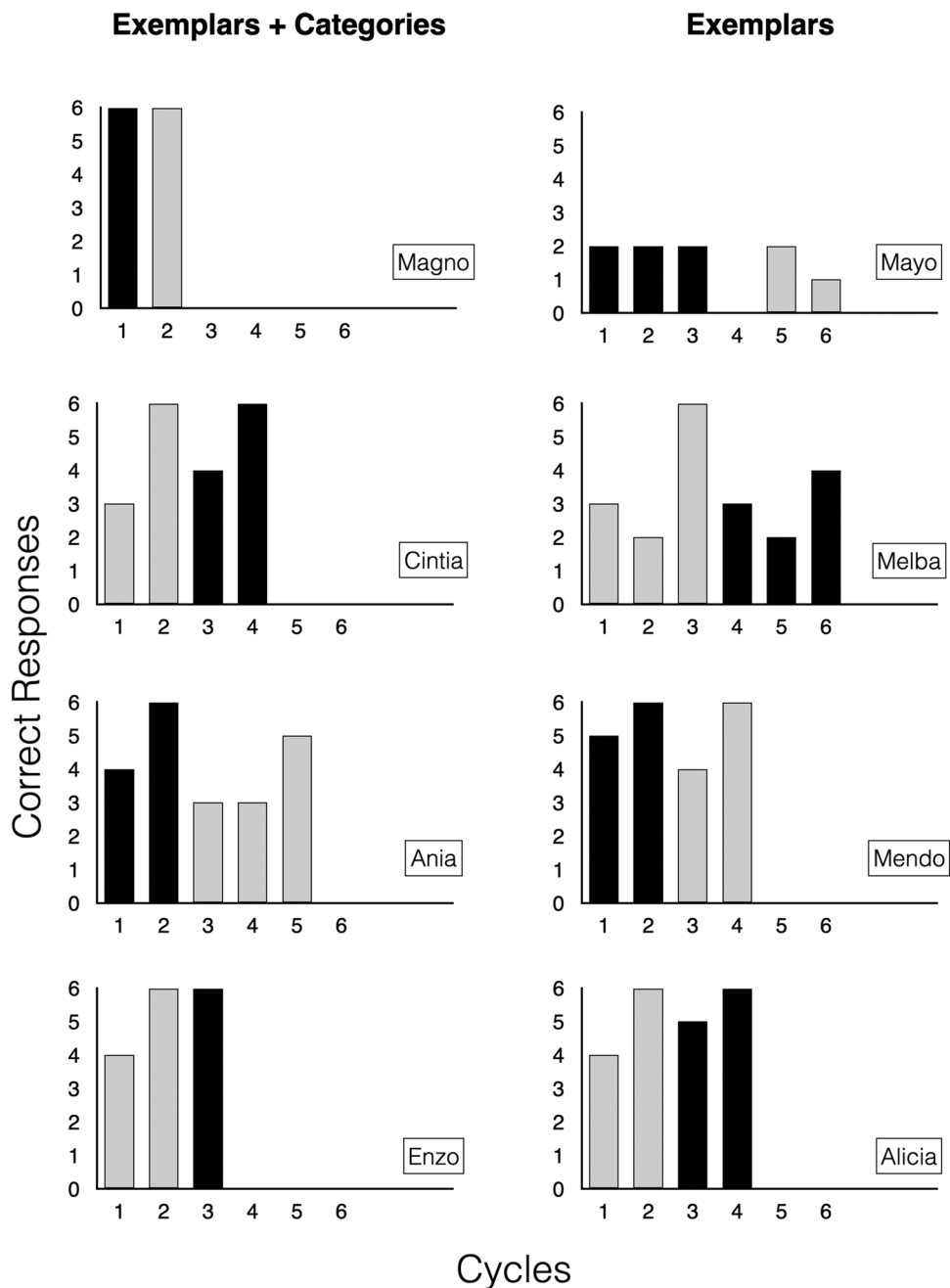
The children in the *Exemplars and Categories Condition* responded with more correct responses than the children in the *Exemplars Condition* in each of the BA Symmetry, CB Symmetry, AC Transitivity, and CA Equivalence intraverbals. The greater difference between the two conditions was in the CB symmetry: The children in the *Exemplars and Categories Condition* responded correctly in 12 of the 14 trials (86%) whereas the children in the *Exemplars Condition* responded correctly in 7 of the 20 trials (34%). No clear differences were found among the remaining probed intraverbals of both conditions.

### Discussion

Three of the four children who learned Exemplars and Categories demonstrated emergence with the two stimulus sets and the other child responded correctly to all probed ABC intraverbals except for one trial of one set. In contrast, two children who learned just Exemplars demonstrated the emergence of all ABC intraverbals in the two sets and one more did so in one set; the fourth child did not demonstrate emergence with all the ABC intraverbals in any set. The children who learned Exemplars and Categories demonstrated emergence within fewer cycles and produced fewer errors on average than those who learned just Exemplars. Therefore, the results of Experiment 2 replicated those of Experiment 1 regarding that acquiring both Exemplars and Categories before reading the text with the AB and BC relations appears to have a significant effect on the emergence of the ABC intraverbals.

The children who learned Exemplars and Categories received fewer text presentations and fewer trials of the Exemplars and Categories. Still, they demonstrated more instances of intraverbal emergence than the children who learned just Exemplars. These facts indicate that the number of text presentations or learning trials is not a variable that determines intraverbal emergence. Instead, what appears as the critical factor for the emergence of the intraverbals is learning the Categories in addition to learning the Exemplars.

**Fig. 5** Intraverbal Emergence after Reading the Text in Experiment 2. *Note.* Black bars depict the results in the Alps; grey bars depict results in the Andes. Cycles with no bars indicate zero correct responses



**Joint Analysis of the Results of Experiments 1 and 2**

A summary of the results in the *Exemplars* and the *Exemplars and Categories Conditions* appear in Table 9. We selected four variables: overall errors in the ABC probes as an indicator of how difficult is to reach emergence, because it includes errors in all repetitions of the probes; errors in the CA probes because that probe has been observed the last and less likely to emerge in previous and the present study (it includes symmetry and transitivity); cycles because it is an indicator of how long the emergence occurs; and correct

responses in the first CA probe as the better indicator of immediate emergence. The differences in the four variables were similar in Experiments 1 and 2.

The procedures that received the children of the *Exemplars and Categories Condition* of the two experiments were identical; the procedures that received the children of the *Exemplars Condition* of the two experiments were also identical except for that the children of Experiment 2 received extra trials of the Exemplars and more text presentations. For that reason, the data of all 20 participants of Experiments 1 and 2 can be combined for descriptive and statistical analyses. We used the *t*-student even though we did not assume



**Table 9** Mean Results of Experiments 1 and 2, and of Both Experiments

Condition	Errors in the ABC probes			Errors in CA probes			Cycles			Proportion Correct in first CA probe		
	Exp1	Exp2	Both	Exp1	Exp2	Both	Exp1	Exp2	Both	Exp1	Exp 2	Both
T+E	2,92	5,33	4,15	0,92	1,38	1,10	1,83	2,50	2,10	0,42	0,38	0,40
T+E+C	0,75	1,78	1,25	0,17	0,63	0,35	1,25	1,75	1,45	0,83	0,63	0,75
Proportion	3,89	3,00	3,32	5,50	2,20	3,14	1,47	1,43	1,45	0,50	0,60	0,53

T+E stands for Text+Exemplars. T+E+C stand for Text+Exemplars+Categories. The proportion row depicts the result of dividing the figure in Text+Exemplars by the figure in Text+Exemplars+Categories

a normal distribution based on data from previous similar studies showed no such a distribution; that was because the *t*-test appears robust to show effect sizes and significance with small samples even when the distribution differs from normal (de Winter, 2013). The effect size of the differences between the *Exemplars Condition and the Exemplars and Categories Condition* was strong in total errors in the probes of the ABC intraverbals (Cohen's  $d = 0.81$ ), strong in errors in the CA probes (Cohen's  $d = 0.74$ ), strong in cycles (Cohen's  $d = 0.96$ ) and strong in correct responses in the first CA probe (Cohen's  $d = 0.926$ ). These differences were significant at the 5% level in total errors in the probes of the ABC intraverbals (Student  $t = 2,57$ ;  $p = .007$ ), errors in the CA probes (Student  $t = 2.36$ ;  $p = .011$ ), cycles (Student  $t = 2,92.5$ ;  $p = .002$ ), and correct responses in the first CA probe (Student  $t = 2.33$ ;  $p = .012$ ).

## General Discussion

The main goal of the present study was to isolate the effect of learning either Exemplars and Categories or Exemplars alone or none of these intraverbals on the emergence of the ABC intraverbals. That effect would have been demonstrated if children who learned first Exemplars and Categories demonstrated more instances of emergence or demonstrated it before the children who did not learn Categories. All children who learned Exemplars and Categories demonstrated emergence with the exception of one child in just one trial in one stimulus set, but three children who learned just Exemplars did not. Most children who learned Exemplars and Categories demonstrated emergence within fewer cycles than those who learned just Exemplars. Moreover, the children who learned Exemplars and Categories needed fewer trials to demonstrate emergence and did so with an average of fewer than one third the errors of children who learned just Exemplars. Therefore, acquiring both Exemplars and Categories before reading the text with the AB and BC relations appears to have a significant effect on the emergence of the ABC intraverbals.

The results of the present study replicated and extended the main effect found in a previous study (Pérez-González & Oltra, 2022) in that Exemplars and Categories have a great effect on the emergence of the ABC intraverbals. These results responded to the experimental question of whether Exemplars alone would suffice to promote the emergence analyzed in that study by indicating that learning Categories as well as Exemplars produce more instances of emergence of the ABC intraverbals than learning just Exemplars. The findings of the present study and the Pérez-González and Oltra (2022) study also extend those obtained with children with intraverbals composed of auditory stimuli and vocal responses (Belloso-Díaz & Pérez-González, 2015a; Pérez-González et al., 2014). All findings indicate that learning Exemplars and Categories first has a stronger effect than learning just Exemplars. In that vein, the acquisition of previous operants with the responses of the intraverbals probed for emergence had been demonstrated to have a strong effect (see also Grow & Kodak, 2010; Pérez-González, 2019, 2020). That would partially explain why learning Exemplars alone facilitates emergence, but that factor does not explain the incremental facilitating effect of learning Categories. In other words, learning Categories has an impact beyond the primary effect of learning intraverbals with the same response (see more below). The findings related to the joint effect of learning Exemplars and Categories—symmetrical (or bidirectional) to one another—also provide additional evidence to the effect found with selection-based conditional discrimination and arbitrary stimuli (e.g., Pérez-González, 1994, and replications) in which probes for symmetry appear to increase the probability of matching related stimuli (e.g., previously taught A1 and B1) to a specific comparison (no related to any other stimulus) and matching unrelated stimuli (e.g., A1 and B2) to another specific comparison.

The effect of Exemplars and Categories on intraverbal emergence also adds evidence of the effects of naming on classification conducted after the seminal study of Horne and Lowe (1996) because naming is a symmetric (i.e., bidirectional) relation. Therefore, both Exemplar and Categories and naming relations (symmetric relations) play an

important role in intraverbal emergence and categorization skills (more complex skills than the symmetrical ones).

Another effect that has also been replicated and extended is that after learning AB and BC intraverbals or after reading sentences with AB and BC relations, the CA intraverbals emerge last. Regarding the order of emergence of the BA Symmetric, CB Symmetric, and AC Transitive intraverbals, no clear order effect was found in the present study. These findings of the present study replicated and extended those from a previous study with intraverbals in writing form after reading a text (Pérez-González & Oltra, 2022). Moreover, this effect is different from that observed after learning AB and BC intraverbals with auditory stimuli and vocal responses, in which more differences across intraverbals are found (i.e., the baseline AB and BC relations are maintained in the probes, symmetrical relation CB emerge first, symmetric BA and transitivity relations AC emerge thereafter, and equivalence relations CA emerge last, e.g., Belloso-Díaz & Pérez-González, 2015a; Pérez-González et al., 2008).

The results of the present study also suggest that learning Exemplars alone (i.e., without learning Categories) increases emergence: more children of the *Exemplars Condition* in Experiment 1 demonstrated emergence than the children in the *Text Alone Condition* (five children instead of one) and they had fewer errors (35 instead of 86). This effect also replicated the effect found with children regarding the emergence of ABC intraverbals after learning the AB and BC intraverbals (e.g., Belloso-Díaz & Pérez-González, 2015a) and also with adults, because these studies revealed that learning Exemplars first is necessary for a portion of adults to demonstrate emergence (Pérez-González et al., 2014).

The present study encourages conceptual analysis regarding the effects of basic learning processes on types of processes that are considered of a different order, even cognitive, namely, reading. In other words, the present study shows that basic processes found with arbitrary stimuli and precise and definite discriminations occur also when people read and demonstrate complex skills derived from that reading, such as demonstrating untaught relations—a type of *inference*. That derivation has been conceptualized here as the emergence of novel intraverbals; at the same time, it is conceptualized as a type of *reading comprehension* in the literature of reading and cognitive skills.

The processes shown in the present research are involved in reading comprehension. From our point of view, “reading” is a pre-scientific word that involves precise behavioral processes plus scholarly theories and intuitive knowledge. Behavior analysts have defined specific types of skills that are related to the everyday definitions of reading and comprehension. For example, a type of reading is textual behavior, as defined by Skinner (1957). A definition of reading comprehension was provided by Sidman (e.g., Sidman,

1994; Sidman & Cresson, 1973) as the emergence of matching-to-sample relations between pictures (or objects) and written words after learning to match spoken words to pictures and spoken words to written words. The type of reading comprehension shown in the present study has a different nature. It involves relations among words. It is very likely that other processes are involved in what is denominated “comprehension” in everyday life. Regardless of the meaning of this word, what Sidman’s studies and the present one demonstrate are complex behavioral processes necessary for emitting and responding to verbal behavior.

Some methodological considerations have surged in the present study. First, the found effect cannot be due to the fact that the children in the *Exemplars and Categories Condition* had more learning experiences: In fact, the children of Experiment 1 in the *Exemplars and Categories Condition* met criteria with fewer text reads and fewer probe trials than the children in the two other conditions. The children in the *Exemplars and Categories Condition* received more trials than the children in the *Exemplars Condition*, but they received on average fewer cycles (which bring the need of reading—thus, they occasion reading episodes) than the children in the *Exemplars Condition*; thus, they learned faster. Moreover, the children of Experiment 2 in the *Exemplars and Categories Condition* met criteria with fewer text reads, fewer learning and review trials of Exemplars and Categories, and fewer probe trials than the children in the *Exemplars Condition*. Therefore, the differences should occur because of the specific experiences received: reading the text with the Exemplars and the Categories and receiving teaching trials of these types of intraverbals facilitates the emergence of the untaught ABC intraverbals.

Second, the effect of reading just the text or receiving teaching trials was not isolated in the present study. Regarding the text alone of the Exemplars (i.e., without subsequent teaching trials), probably does not suffice to demonstrate the emergence of the ABC intraverbals, as suggested by the fact that most children made errors in the trials with the Exemplars. Regarding the text alone of the Categories, however, probably suffices to facilitate the emergence of the ABC intraverbals, as suggested by the fact that most children responded correctly in virtually all trials with the Categories, which were taught after the Exemplars. In fact, Categories can emerge from Exemplars (Pérez-González et al., 2018). In that line, it is possible that probing the Categories (instead of teaching them with differential reinforcement) would suffice for the emergence of the ABC intraverbals, or even would produce a greater effect than teaching them. They were not probed because they do not easily emerge in the first probe; in fact, only nine of twenty-six 5- to 6-year-old children in the study by Pérez-González et al. (2018) demonstrated emergence in the first probe.

Third, it is likely that a group design for evaluating the effect of teaching the Categories works better than a multiple baseline design in which all children received first probes of the ABC intraverbals just after learning Exemplars to which Categories are then added. This design was used by Bellos-Díaz and Pérez-González (2015a) and it was not useful for observing the effect of the Categories because only one in five children demonstrated emergence, very likely due to using long baselines in which the ABC intraverbals were probed before teaching the Categories.

Four, we did not analyze the effect of just teaching Categories on intraverbal emergence. We did so because previous studies had shown the little effect of teaching them when Exemplars are not taught; hence, we hypothesized that that effect is small. Despite this supposition, further research is necessary to confirm that hypothesis.

The effects of learning both Exemplars and Categories can be related to the acquisition of the emergence from one another. The capacity of emergence of the symmetry with selection-based discriminations is acquired by children around the second year of life (e.g., Lipkens et al., 1993). With Exemplars and Categories, however, the capacity of demonstrating emergence from one another does not happen in most children at least before 6 years (e.g., Pérez-González et al., 2018). In contrast, adults are likely to demonstrate the emergence of the Categories after learning the Exemplars. Moreover, they do not need learning Categories for demonstrating that emergence of the ABC intraverbals (Pérez-González et al., 2014). Therefore, the acquisition of the capacity of demonstrating emergence from Exemplars to Categories and vice versa seems correlated with the fact that both Exemplars and Categories are necessary for the emergence of the ABC intraverbals. For that reason, the acquisition of that capacity may be necessary for the latter. More research on this topic is necessary to verify that hypotheses.

An interesting question is the effect of the symmetrical relations on facilitating emergence of more complex relations, namely, the BA and QP symmetries in the PQX emergence, naming on classification tasks, and the effect of Categories and Exemplars on the emergence of the probed ABC intraverbals, described above. In our opinion, this effect cannot be explained by discriminative process, as it is related to bidirectional relations established between correlated stimuli. Yet, the correlations that appear necessary for stimulus equivalence do not suffice. In these studies, it was found that the stimulus correlation needs to be bidirectional, as evidenced by either learning the two bidirectional relations (e.g., Exemplars and Categories) or by presenting and demonstrating emergence in probes of the symmetrical relations (e.g., demonstrating the emergence of BA after learning AB). We do not find other basic principles on which this effect could be based. Therefore, because this process related to bidirectional relations does not admit an explanation in

terms of simpler learning principles, it should be better conceptualized as a basic process (see also discussions on this topic in Pérez-González, 2019, 2020).

An ancillary finding of the present study was that the number of text presentations and teaching trials did not affect emergence as confirmed by analyses of differences between the *Exemplars Condition* of Experiment 1 and the *Exemplars Condition* of Experiment 2—no differences were found in total errors, errors in the CA probes, and correct responses in the first CA probe, and the differences found in cycles were likely due to the fact that more errors were obtained when *more reading experiences and teaching trials* were presented. This likely effect is also coherent with the lower cases of emergence found by Bellos-Díaz and Pérez-González (2015a) when repeated cycles of teaching and probing were repeated.

One limitation of the present study is that the intraverbals of the two stimulus sets were not intermixed. This has been explored by Pérez-González and Oltra (2022), Experiment 4, who found that all children that learned Exemplars and Categories before the first probe maintained emergence when the ABC intraverbals of two sets were intermixed. A second one can be that texts may appear to be too short—as in a typical text, like a child story, there are much more sentences. In any case, what the present study, together with the previous one, suggests is that a proportion of typically developed 7-year-old children cannot respond correctly to some questions (especially the CA intraverbals) after reading a short text if some even shorter and simpler texts are not presented before and, it may be, if some questions are not presented before. Finally, the effect of teaching the Categories alone was not targeted as a goal in the present study, because it was of no clear effect in the related studies conducted with intraverbals with oral stimuli and spoken responses. The effect of learning Categories but not Exemplars with written stimuli and responses, however, needs empirical analysis, which should be addressed in further studies. The use of verbal stimuli could be seen as a limitation; these types of studies, however, are difficult to conduct with arbitrary stimuli and the difficulties of the participants for learning the basic relations raise ethical concerns. Yet, strong control on the access to information by the participants should be made. Finally, another factor that could be controlled in further studies is the fact of letting the children read the text silently; although no effects were found in the present study, either reading aloud or silently should be chosen based on the reading skills of the participants.

The present study demonstrates once more the close relatedness between the processes studied with arbitrary stimuli and those commonly used in everyday life. This does not come as a surprise given that behavior analysts have assumed, and often demonstrated, that the learning processes are identical. Thus, the research with arbitrary stimuli

found, in a great measure, the research with another type of stimulus (see also, for example, Fields, 2016).

The present study together with those related to it, indicates that children can respond to all questions if the teaching materials and procedures are similar to those used here, with Exemplars and Categories before presenting the target text. In particular, this finding suggests that learning before the category–exemplar and the exemplar–category of the words used in the text improves comprehension. For example, before reading a text about the relations between elements of a castle and the defense in the case of a siege, the child should learn that towers and battlements are parts of a castle (Categories) and that a castle has towers and battlements (Exemplars). The counterexample is that teaching the meaning of new words (such as “battlement”) at the time of teaching a battle in a castle would make the task difficult for the child and not lead to full comprehension. For these and related facts, this finding can have an enormous potential for designing textbooks and other teaching materials.

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**Data Availability** The data and materials for all experiments are available.

## Declarations

**Conflict of Interest** The authors declare that they have no conflict of interest.

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

**Ethical Standards** This article does not contain any studies with animals performed by any of the authors.

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