Title of the paper (Times New Roman 16 Bold)

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ABSTRACT (Times New Roman 12 bold)

This paper reports on a small-scale exploratory case study that aims at highlighting preschoolers' ability to categorize, grasp criteria for categorizing and use categories for attributing properties to target entities. Conducting individual, semi-structured interviews with 10 preschoolers (age 4-5) of a public kindergarten in the broader area of Patras, we attempted to trace their ability to (a) form categories by appealing to coherent criteria, (b) recognize the criteria that were used in the formation of given categories, and (c) infer the properties of target entities from the category they belong.

KEYWORDS (Times New Roman 12 bold)

Preschoolers and categories, preschoolers and categorization criteria, preschoolers and category-based reasoning

RÉSUMÉ (Times New Roman 12 bold)

Cet article rend compte d' une étude de cas exploratoire à petite échelle qui vise à elucider la capacité des enfants d'âge préscolaire à classer, comprendre les critères de catégorisation et utiliser des catégories pour attribuer des propriétés aux entités cibles. En menant des interviews individuels et semi-structurés avec 10 enfants d'âge préscolaire (4-5 ans) d'une école maternelle publique de la region de Patras, nous avons essayé de retrouver leur capacité à (a) former des catégories en faisant appel à des critères cohérents, (b) reconnaître les critères qui ont été utilisés pour la formation des catégories specifiques, et (c) inférer des propriétés des entités cibles à partir de la catégorie à laquelle ils appartiennent.

MOTS-CLÉS (Times New Roman 12 bold)

Enfants d'âge préscolaire et catégories, enfants d'âge préscolaire et critères de catégorisation, enfants d'âge préscolaire et raisonnement à partir de la catégorie.

THEORETICAL FRAMEWORK (FIRST TITLE = Times New Roman 12 bold)

Categorizing lies at the rock bottom of scientific thinking. We need to form some kind of categories in order to have theories about the world. Yet, in order to form categories we need to have some kind of coherent criteria about what it is to be a member of each category. Categorizing can then help us attribute properties, use deductive and inductive reasoning, etc. In this paper, we explore preschoolers' ability to categorize, grasp criteria for categorizing and/or use categories to attribute properties.

The theoretical probleme (Second title = Times New Roman 12 bold+ italic)

The most crucial element of scientific thinking (or even rigorous thinking in general) is the ability to distinguish between theory and evidence and then co-ordinate the two, climbing the ladder up and down (Kuhn & Pearsall, 2000; Kuhn, 2010). Evidence is supposed to verify and/or falsify a theory (investigative thinking) and a theory is constructed by interpreting evidence (inferential thinking). What counts as *theory* then? According to Kuhn & Pearsall (2000), there are four types of theory, T1 to T4, from the least to the most demanding.

T1 is what Kuhn & Pearsall call a *category claim* ("plants are living things"), while T2 is what they call an *event claim* ("this plant died"). Referring to T3, Kuhn & Pearsall mean a *causal or explanatory claim* ("the plant died because of inadequate sunlight"), while an *explanatory system claim* is what they have in mind when they refer to T4 ("a multivariable process of photosynthesis maintains plant life"). One can gather supporting and/or disconfirming evidence for each type of theory.

Different aspects of….. (Third title = Times New Roman 12 italic)

Many believe that categories are constructed in the light of ones' theory (Carey, 1985, 2004, 2009; Keil, 1992; Gopnik & Meltzoff, 1997). We will not take issue with this thesis here. Our only claim is that in order to have a theory one needs to have a theory about *something*, that something being a universal or a member of a universal category. *Universals* are supposedly the referents of general terms, such as *furniture*, *cat*, *human*, etc. In contrast, *particulars* are the referents of singular terms, an extreme version of which is *ostensives*, such as "this" or "that thing" (which I am showing you now). You cannot have a theory about a particular or about an ostensive. In order to have a theory, you must at least hypothesize or imply that this particular x belongs to that universal category Y.

Since the 70's then, empirical studies are concerned with finding our primary categorization cues. Examining how categories may be formed in early childhood, as well as whether young children can use them as reasoning tools seems to be of key importance. So, even more cues are being examined now, for example, whether the medium (object *vs* picture) or the mother tongue affects categorization (Long et al., 2012; Saalbach, Imai & Schalk, 2012; Ware, Gelman & Kleinberg, 2013).

METHODOLOGICAL FRAMEWORK

The overview of the study

This paper reports on a small-scale exploratory case study, which investigates how young children may categorize entities or use categories in order to attribute their properties to new target entities. The informants of the study were 10 preschoolers (6 boys / 4 girls, age 4-5), attending a public kindergarten in the broader area of Patras during the academic year 2013-2014. The school was situated in Kato Alissos, a semi-urban area of medium socio-economic status and it was selected because the teacher volunteered to facilitate our study. The children were familiar with educational interactions, since they had already been kindergarten pupils for several months. Moreover, they were never engaged in formal learning activities about categorization up to that moment.

Tracing children's reasoning was carried out through individual, semi-structured interviews of approximately 20 minutes. The interviews were conducted and tape-recorded by the third author in a quiet place of the school. The interviewer had already got familiar with the informants and gained their own assent for taking part in the study. Parents' informed consent was also asked.

The interview protocol

The interview protocol was organized in two parts. The first part had to do with (a) forming categories freely, and (b) recognizing how *given* categories have been formed. More specifically:

(a) Children were provided with objects that were different regarding their material (soft and plastic), color (black & white, others colors), size (small, medium, large), use (money-saving, playing) and representation (different kind of animals, plants and balls). The objects were the following: a big black & white soft ball, a medium black & white ball-shaped money-box, a medium black & white cow-shaped money-box, a small red plastic ball, a yellow tennis ball, two big soft vividly-colored flowers, two small green plastic trees, two small pots with a colored plastic and a colored soft flower respectively, big soft animals of different colors (parrot, cow, dog) and small plastic animals of different colors (elephants, tiger, lion, rhino, zebra, dog, fish). Then, they were required to put them in groups and justify why they did so: *"You see all these things here? Can you make groups with them? Why did you make these groups? What do the things in this group have in common?"*.

(b) Children were told that some other kid had formed three groups with their objects. They were just shown these groups (animals, plants, ball-shaped objects) and were asked if they could understand why he or she sorted the objects like that.

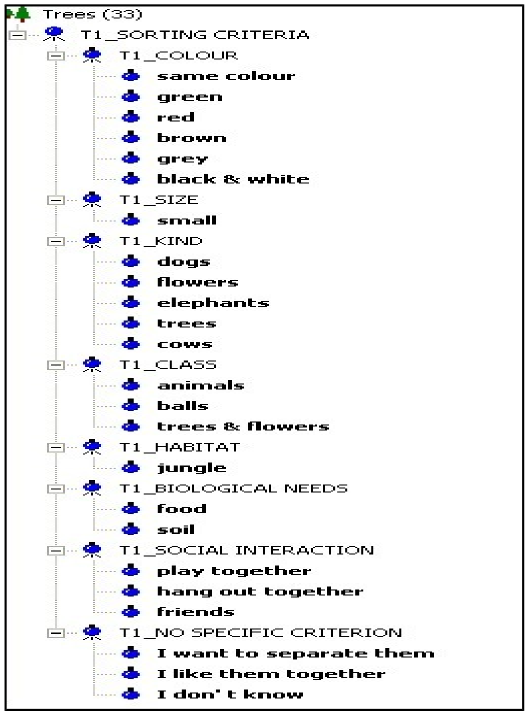
The second part of the protocol had to do with children's ability for category-based reasoning. Drawing upon the tasks suggested by Gelman & Markman (1986), we developed the following probe:

(c) Children were shown a drawn dragon and were told that its heart was star-shaped and a drawn dinosaur and were told that its heart was ball-shaped. Then they were shown a drawn animal that looked like a dragon and were asked to predict the shape of its heart. Afterwards, they were provided with the information that the dragon-looking animal was actually a dinosaur and they were asked to predict the shape of its heart once more.

The overview of the analytic procedure

The tape-recorded interviews of the children were transcribed and prepared for coding within the qualitative analysis software *NVivo*. The tape-recorded interviews of the children were transcribed and prepared for coding within the qualitative analysis software NVivo. The tape-recorded interviews of the children were transcribed and prepared for coding within the qualitative analysis software NVivo. The tape-recorded interviews of the children were transcribed and prepared for coding within the qualitative analysis software NVivo. Coding the prepared interviews resulted in a series of *categories* for each of the three tasks, which were organized to a *coding scheme*. Part of it is shown in Figure 1.

FIGURE 1



Part of the coding scheme (task 1)

RESULTS

The analysis of our data with regard to the *1st research question* about children's ability to categorize with coherent criteria showed the following: When engaged in creating groups with the provided objects that depicted different living and non-living entities, most of our informants did not seem to activate a unique, coherent criterion throughout the task. If for example they activated the color-criterion coherently, they would end up with a variety of color-groups, so that all the available objects would belong to one of them. Contrariwise, children seemed to activate different criteria for making different groups in the same sorting task. So, most of them came up with several groups, each of which was formed with a different criterion: a color-group next to a size-group, next to a class-group etc. As shown in Table 1, children's criteria were the objects' *color*, *kind* (e.g. elephants), *class* (e.g. animals), *social interaction, biological needs, habitat* and *size*. Nevertheless, there were also children that for some or even all of their groups did not use a specific criterion.

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TABLE 1

Children's sorting criteria in task 1

Sorting criteria	Number of children	Number of groups formed upon the criterion / total number of groups, per child (C)
color	5	C04 → 6/6 C05 → 2/6 C06 → 1/3 C07 → 1/11 C08 → 1/10
kind	4	C01 → 4/11 C05 → 1/6 C07 → 2/11 C08 → 1/10
class	3	C01 → 2/11 C06 → 1/3 C08 → 5/10
social interaction	4	C06 → 1/3 C07 → 4/11 C08 → 1/10 C10 → 2/4
biological needs	2	C05 → 1/6 C08 → 1/10
habitat	1	C01 → 2/11
size	1	C05 → 1/6
I don't know	4	C01 → 3/11 C05 → 1/6 C07 → 3/11 C08 → 1/10
I like them together	4	C03 → 1/2 C07 → 1/11 C09 → 1/1 C10 → 2/4
I want to separate them from the rest	2	C02 → 3/3 C03 → 1/2

More specifically, the *color* of the objects was used by 5/10 children for the formation of at least one of their groups. In children's own words: *"I put together a flower with red roses and a parrot with red feathers and a small ball with black and red… I thought to do it this way because they are red"*. It is worth noticing that *one* of these five children *did* use *color* as a coherent criterion for *all* the six groups he made.

The second most frequent criterion was the *kind* of the entities, which were represented by the objects. 4/10 children used *kind* for at least one of their groups, while one child among these four used it for making 4 out of his 11 groups. In children's own words: *"I put them together because they are dogs"; "They go together because they are all cows", "… because they are elephants"*, *"…because they are both flowers"*.

Moving to the third criterion, we should notice that 3/10 children appealed to the *class* of the entities for at least one of their groups, while there was *one* child among these three, who used class for making all three of her groups (balls, plants, animals) with one exception: the animal group also had a ball "*so that the dog could play with it*". Another child also used *class* for 5 out of her 10 groups. In children's own words: *"I did it this way over there because all of them are animals"; "These go together because they are trees and flowers"* (the child is not using the word "plants", but this is probably due to the fact that children of this age are not familiar with this term).

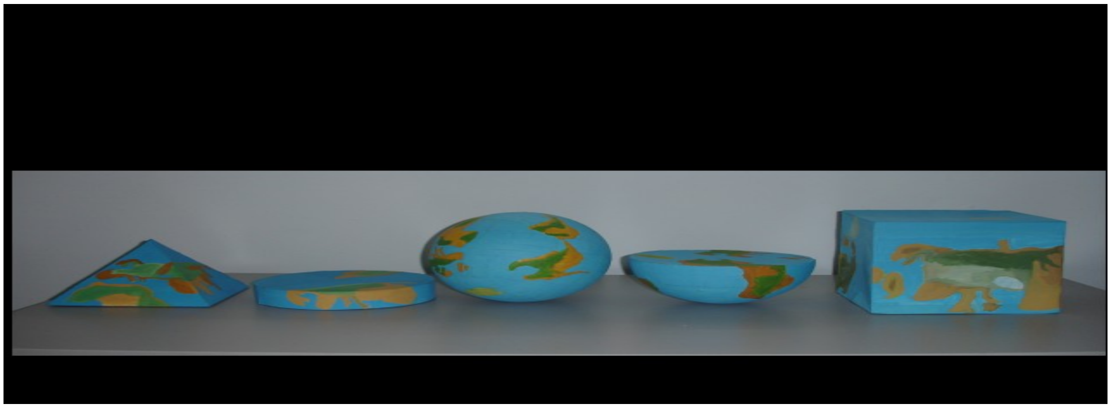
Social interaction was also used by 4/10 children as a criterion for at least one of their groups. This interaction had to do with friendship or need for companionship. In children's own words: *"The cow with the rhino because they are fiends", "I put the zebra with the parrot because they need to hang out together", "The dog goes with the ball to play with it"*.

Biological needs was used as a sorting criterion by 2/10 children just once. It had to do with food relationships or common dependence upon environmental factors like soil: *"I put the flower with the cow because the cow can eat the flower", "The tree and the flower go together because they are planted in the soil"*.

Finally, *size* was used as a criterion by 1/10 children for one of her groups: *"I put the little dog and the little fish together, because they are little".* Two out of the 11 groups of another child were created by appealing to a common *habitat*: *"The lion and tiger go together in one group because they live in the jungle"*.

Moving on to our findings with regard to the 2nd *research question* about whether preschoolers can grasp how given categories have been structured, we note that most of the children were able to understand how the given groups (animals, plants, ball-shaped objects) were formed. In other words, they did not encounter significant difficulties in recognizing *class-representation* as the grouping-criterion of the categories in question (Figure 2).

FIGURE 2



3-D objects with geophysical surface

It is worth-noticing that the child, who had previously used *color* as a coherent criterion for his groups, could not recognize how the ball shape-group was formed. In fact, he thought that it was wrong to form such a group. In his own words: *"These do not match. This one is red. And…the other is yellow. The others are black & white"*. Moreover, there was one child that was not able to locate the criterion for the plant-group and two children that had the same problem with the animal-group. For the latter group, criteria like *friendship* and *habitat* were used by one and two children respectively, as shown in Table 2.

Finally, regarding our findings about children's ability for category-based reasoning (3rd research question) we note the following. When presented with the drawings of two different entities - a dragon and a dinosaur - that were supposed to have a star-shaped and a ball-shaped heart respectively, 9/10 children predicted that the heart of a third, dragon-looking entity would be star-shaped. In other words, 9/10 children developed their reasoning by drawing upon appearance: they inferred that the third, dragon-looking entity would have the same shape of heart as the dragon (Table 2).

TABLE 2

Percentage of prospective teachers' responses regarding what a teacher should do in case a student has difficulties in understanding a mathematics or science concept

In case a student has difficulties in understanding a concept a teacher should:	**Mathematics**		**Science**	
	Primary School teachers	**Kindergarten Teachers**	**Primary school teachers**	**Kindergarten teachers**
Repeat the unit	3,8	2,2	21,5	14,3
Proceed to the next unit	1,2			
Try other activities in the same unit	75	66,6	63,3	78
Encourage student to experiment on his/her own	2,5	9,7	29,1	33
Encourage student to cooperate with other children	17,5	20,4	25,3	30,8
Other		1,1		

Nevertheless, when children were provided with new information about the class of the target entity *("Let me reveal something to you: this may look like a dragon, but in fact it is a dinosaur")*, they reconsidered their prediction about the shape of its heart. In fact, all nine children who had previously made a prediction about a star-shaped heart by drawing upon the similarity of the target entity with the dragon changed their minds and argued for a ball-shaped heart by drawing upon the shared class of the target entity with the dinosaur (Table 3). In their own words: *"Ah, Ah! Like a ball because you said he is a dinosaur and the heart of the dinosaur is like a ball", "Heart like a ball. If you say that he is a dinosaur, then he will have a heart like a ball", "He is a dinosaur? Like a ball, because he is a dinosaur"*.

It is probably worth-noticing that the child (C10) who wasn't able to justify his predictions in both cases (namely, without or with class info about the target entity) didn't go so well in the other tasks, too. In task 1, he created 4 groups using the criterion of *social interaction* for two of them *('because they are friends')* and the criterion of *I like them together* for the other two. Finally, in task 2 he *did* recognize *class* as the underlying criterion of the given category of *balled-shaped objects*, but he didn't come up with any conclusion about the criteria underlying the given categories of *animals* and *plants*

DISCUSSION

As already shown, the informants of the study activated a series of criteria in order to make groups with the objects they had at hand. Most of these criteria were perceptual. In fact, objects' *color* was the most frequent criterion, which is in line with the relevant bibliography (Gelman & Markman, 1986; Tversky, 1985; Markman, 1989). Another perceptual criterion was *size*. Nevertheless, non-perceptual criteria were also traced. Representation of *kind* (e.g. two elephants), *class* (e.g. animals that differ in size, color, material etc.), *social interaction*, *biological needs* and *habitat*, which were also employed by the children, seem to be more conceptual than perceptual.

Perceptual criteria then, were not the only ones participants spontaneously activated. Children were much more creative than we expected; they came up with criteria, such as *social interaction.* It is in fact a code we had to invent in order to account for the stories children made up to justify their groups; it is a conceptual criterion, but it is probably given *ad hoc*. One possibility is that children appealing to *social interaction* did not actually employ a criterion for grouping the objects; perhaps they made random groupings and then tried to justify them by telling a story.

Another possibility though, is that children categorize in different ways than adults do. This leaves us with a question about the sorting tasks we develop. It could be that tasks adult researchers develop are biased into producing the categories we use in adult reasoning. May be this is why the task we used, which was very open and included a vast variety of objects that differed in many ways, produced anything but clear-cut categories. It seems more possible for children to use a coherent criterion of either perceptual or conceptual nature when given the task to sort, for instance, an open red umbrella with either a closed umbrella or a red umbrella-shaped mushroom than to make groups out of long series of different objects.

Besides the methodological implications of our findings, it would be purposeful to summarize the educational ones, which seem to be rather promising. Children were not just perceptually bound when forming categories. They also activated conceptual criteria, some which were rather advanced and can be used in science teaching. Appealing to the *class* of the represented entities, to their *habitat* or their *biological needs*, shows children's potential to reason about the biological world in a rational way. Moreover the fact that in some cases one could detect a coherent criterion for all or most categories participants formed, also pinpoints to this potential. It is important then, that we support children to fully develop this potential. Categorizing lies at the heart of scientific reasoning. It saves time, energy and memory-load, it facilitates inductive and deductive reasoning and thus can help children learn, understand and schematize new pieces of information about nature.

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