Designing an interview protocol for identifying young children reasoning about variation within populations

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ABSTRACT
This paper reports on the design of an interview protocol that aims at identifying young children's reasoning about the idea of variation within animal populations. More specifically, the protocol is meant to provide us with the opportunity to explore (a) whether 5-6 years-old children consider the members of a population as not identical to each other but possibly different in their external body traits, and (b) whether they can mobilize this idea of variation in the context of a problem-situation. We will discuss the design of the protocol, as well as some preliminary results of its small-scale implementation.

KEYWORDS
Variation-with-populations, population thinking, preschool, interview protocol

RÉSUMÉ
La communication présente l'élaboration d'un protocole d'entretien individuel qui vise à identifier, chez des enfants de 5-6 ans, leurs conceptions et raisonnements sur l'idée de variation au sein des populations animales. Nous cherchons à explorer (a) comment les élèves peuvent envisager la part d'individualité des organismes appartenant à une même espèce à travers la reconnaissance ou non de variations portant sur des caractéristiques phénotypiques visibles et (b) comment ils peuvent mobiliser cette idée de variation dans le cadre d'une situation-problème. Nous détaillerons les étapes de l'entretien individuel et présenterons les premiers résultats obtenus après une mise en œuvre à petite échelle.

MOTS-CLÉS
Variation, pensée populationnelle, enfants d'âge préscolaire, protocole d'entretien

THEORETICAL FRAMEWORK

Historically, the recognition of the importance of variation within populations of living species has made it possible for Darwin to formulate the principle of natural selection. Variation within populations is what allows for the differential survival and reproduction of living species (Emmons, Smith & Kelemen, 2016). In biology education, recognizing this variation is a prerequisite for understanding adaptation as a population-based selection process (Gobert, 2014; Jégou-Mairone, 2012). But thinking patterns like essentialism, teleology or intentional causality, which seem to be frequent among young children, are actually incompatible with recognizing the variation within populations and developing evolutionary thinking (Emmons et al., 2016; Pobiner, 2016). This paper reports on a starting research about the early evolutionary thinking of young children at preschool. To approach such concept, the proposition is made to focus on population thinking with young children. In other words, the research presented in this paper concerns children's ability to express ideas of variation within animal populations.

Population thinking: epistemological contributions

'Population thinking' lies at the heart of the evolutionary paradigm and is generally opposed to 'typological thinking' (Mayr, 1959). It is not the place here to detail the ongoing debate about population versus typological thinking, or the link made between typological thinking and essentialism. However, for the context of science education, it is interesting to get some idea on how population and typological thinking lead to radically different ways of interpreting biological phenomena. Typological thinking seeks to highlight 'types' or 'essences' behind the diversity of individuals of the same species. This way of thinking neglects the diversity and uniqueness of individuals and focuses on the search for similarities between them. In contrast, population thinking is directed towards the analysis and comparison of individual differences (phenotypic variations, for example) and focuses on the diversity and uniqueness of living things in a historical perspective. In this research we focus on the idea that a first introduction to populational thinking is possible for young children and could help them start understanding that living things can evolve.

Young children and population thinking

Studies show that resistance to evolutionary thinking by older students and adults in cognitive terms, may often be linked to cognitive biases present in childhood. When the intuitive ideas of young children are not disputed, they can become deep-rooted (Kelemen, 2012) and function as obstacles for the teaching and learning of scientific concepts (Astolfi & Peterfalvi, 1993). Over time, these ideas can generate common-sense ideas that contribute to the incorrect beliefs of high-school students and adults regarding adaptation as a goal-oriented process in an individual's lifetime (Coley, Arenson, Xu & Tanner, 2017; Emmons et al., 2016). Three categories of common-sense ideas are incompatible with evolutionary explanations: essentialist, teleological and ideas of intentional causality (Pobiner, 2016). In this paper, we focus our attention on essentialist ideas, common among young children. Essentialist ideas are opposed to population thinking in the sense that they prevent the recognition of individual differences within a species or a population. Furthermore, they promote the idea that species or populations are invariant. Studying the essentialist bias with preschool children, Shtulman and Schulz (2008) point out that the non-recognition of intraspecific variation is an obstacle to understanding adaptation by natural selection. These authors show the importance of drawing students' attention to intraspecific variation. According to Emmons & Kelemen (2015), certain contexts may facilitate

children to get familiar with variational thought, which is essential to the development of evolutionary thought. However, with young children, we think it is important to articulate population thinking with typological thinking. Starting a pre-evolutionary education at an early age could possibly reduce the misunderstandings we trace at late childhood, adolescence and even adult life about the evolution of living things.

METHODOLOGICAL FRAMEWORK

The overview of the study

This paper reports on part of a larger research about familiarizing young children with population thinking and more specifically with the idea of variation within animal populations (in short, the 'V-within-pops'-notion). The research includes several case studies with young children in both France and Greece, so that the teaching-learning sequence we designed can be implemented, evaluated and elaborated further. Our focus here is on the evaluation process and particularly on an interview protocol that could be used to trace children's understanding about the 'V-within-pops'-notion. More specifically, the question we address is whether it would be feasible to design an interview protocol for identifying young children's reasoning about the idea of variation within populations and evaluating the effectiveness of our teaching-learning sequence. Given children's young age, this question becomes even more important than usually. The type, content and phrasing of the protocol tasks need to be chosen very carefully, so that our young participants can really be supported in expressing their intuitive understanding about the variety or not of the body traits of individual animals within a population. In the subsection that follows we provide an overview of the interview protocol and the rationale that guided its design, in order to then proceed to the feedback we got from part of its pilot use ('Results') and finally close with how we could use this feedback for its further elaboration ('Conclusions').

The interview protocol

The interview protocol includes three tasks that address the 'V-within-pops'-notion in a qualitative manner. We present here a first piloting of the protocol with four children (age 5-5.5) in 10-15 minute, semi-structured interviews conducted by one of the authors. These children were participating in an out-of-school festival with lots of educational activities at the University of Patras in Greece and their selection was performed conveniently: their teacher wished to facilitate the piloting of our protocol and suggested four children that she considered as talkative, in the sense that they would not be shy to engage in the interview. In fact, the children were rather enthusiastic and freely volunteered after the teacher introduced us and asked whether any of them would like to answer our questions about several animals**.**

The piloted protocol includes three tasks: (a) a drawing task, (b) a forced-choice task, and (c) a problem-exploring task summarized in Table 1. The first aims at tracing whether young children seem aware of the 'V-within-pops'-notion when reasoning about the appearance of real animals in a natural population. The second task aims at tracing whether they seem to prefer the 'V-within-pops'-notion when given the opportunity to choose this or its alternative, in order to predict the appearance of supposedly 'newly discovered animals' they really don't know. And finally, the third task aims at tracing whether they can *mobilize* the 'V-within-pops'-notion themselves when reasoning once more about real animals in a natural population, but this time in the context of an open, problem-exploring scenario. In sum, the protocol attempts to engage children in reasoning about the 'V-within-pops'-notion in different ways (freely or with forced-

choice) and different kind of contexts (real/predictive, imaginary/predictive and real/problem-exploring).

TABLE 1

The tasks of the interview protocol

	Type	**Context**	**Requirement**
Task 1	Drawing task	Real/predictive: a natural population to be drawn next to a photo of one of its members (a blue guppy)	Choose between 2 boxes of markers (blue vs. multicolored) and draw the blue guppy's companions
Task 2	Forced-choice task	Imaginary/predictive: the discovery of fictional, but realistic, individual animals (drawings of fish, reptile, bird, mammal) is followed by the discovery of populations of theirs (drawings of populations)	Choose between 2 populations each time (one composed of identical members, one presenting a variation in a specific trait)
Task 3	Problem-exploring task	Real/problem-exploring: a natural population in its environment (photo of deers) facing a problematic situation (photo of a tunnel)	Engage in a discussion about a problematic situation in which the members of a deer population have to go through a tunnel to find food

Task 1: 'The blue guppy's companions'

Children are familiar with performing drawing activities in preschool and it can be easier for them to express their ideas on the basis of their drawings (Delserieys, Impedovo, Fragkiadaki & Kampeza, 2017). So, task 1 is a drawing task, in which children (a) are shown a photo of a blue fish on a sheet of paper, (b) are told that this fish is a 'guppy' and it lives always with other guppies in lakes, (c) are asked whether they would like to draw on the sheet of paper these other guppies that live with the blue one in a lake, and (d) are asked to first choose either a box with blue markers or a box of multicolored ones. When they are done with their drawing, the interviewer starts with making sure that all the fish they drew are supposed to be guppies and not other fish. If this is not true, the interviewer focuses children's attention only on those fish of the drawing which are supposed to be guppies. Children are then asked similar questions which are, however, adapted to whether they used the blue or the multicoloured markers and thus drew the 'companions of the blue guppy' in blue or in several colours (see (i) and (ii), respectively). More specifically, they are asked (a) why they did so, and (b) whether they think that all the guppies that live with the blue one may have some differences (i) despite their same colour, or (ii) except from their different colour. Finally, the interviewer sets children's attention to the real world by explicitly asking them (i) whether they think that all guppies *in nature* are blue or that it may be possible to find a yellow guppy living with the blue one in a real lake and why, or (ii) whether they think that guppies *in nature* may have several colours and thus it may be possible to find a yellow or a red or a green guppy living with the blue one in a real lake and why.

Task 2: 'The members of a newly discovered kind of animals'

This is a modified version of a forced-choice task introduced by Emmons & Kelemen (2015). It includes four questions that concern four different kinds of animals. These 'fictional, but realistic, drawn animals' are supposed to be recently discovered by some scientists (Ibid, p151). Each of the four kinds of animals (a) belongs to a different vertebrate class (fish, reptiles, birds, and mammals), (b) has a peculiar name that means nothing in the interview language (e.g. MUP), and (c) has a body trait with two discrete versions (e.g. white dots *vs* black dots). Unlike Emmons & Kelemen (2015), (a) we avoided behavioural traits or internal body traits for keeping the task less complicated for children, and (b) we avoided attributing beneficial functions to any version of our external body traits for not encouraging children to use teleological thinking that would probably lead them to the non-variation option.

In the piloting that concerns us here, we only used the mammal-question. So, according to the scenario, some scientists have discovered only *one* brown, four-legged, mammal-like individual with white dots called MUP (children were shown a picture of it). These scientists are also looking for a whole group of MUPs and they wonder whether these would be (a) identical to the first one regarding the colour of its dots, or (b) different from it. So, children have to make a justified choice between (a) the non variation-option: children are shown pictures of six individuals within a plastic circle, all having white dots as the first one, and (b) the variation-option: children are shown pictures of three individuals with white dots and three individuals with black dots, all within a plastic circle once more (Figure 1).

FIGURE 1

The interview set-up of task 2

Task 3: 'The deer-tunnel problem'

This is a problem-exploring task (Fabre, 1999), in which young children need to draw upon the 'V-within-pops'-notion in order to solve a problem of a group of deer. According to the scenario of the task, there is a group of adult deer (children are shown a picture of it), which have very hard (and thus impossible to bend) antlers and live near a tunnel (children are shown a picture of the tunnel). On the other side of the tunnel there is plenty of food for them, so they just have to cross the tunnel in order to get it. However, children are told that scientists have been observing the group of deer one day and they saw one deer, and then a second and a third, to try to go through the tunnel but fail because of the antlers. So, children are asked whether they believe (and why) that there may be some deer in this group that can actually go through the tunnel and get food. . If the children claim that no deer of the group can cross the tunnel, they are told that scientists finally saw some deer crossing it and are asked to explain how this might have happened.

RESULTS

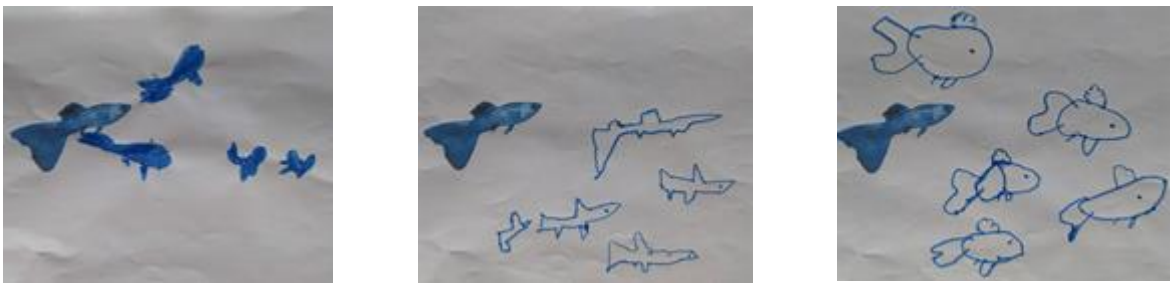
Feedback about Task 1

Problem 1: children's drawings vs children's reality

Children may consider a drawing as a creation that does not necessarily have to represent reality the way they understand it. So, their drawings may reveal a poor understanding about the 'V-within-pops'-notion which is not necessarily the real one. For instance, child 4 suggested a rather rich variation in the colour of guppies within a lake by providing several examples in the discussion *('In the lake we can find a yellow guppy, and also a blue guppy with black on it, and a black guppy, and…'),* whereas a few minutes before she had created a drawing according to which all the companions of the blue guppy were blue as well (Figure 2a). And even more interestingly, when the interviewer pointed out the inconsistency between her drawing and her oral response and asked why she did not use the multicoloured markers if she was so sure that there are guppies of many different colours in nature, she answered that she just preferred to use the blue markers and not the multicolored ones.

Similarly, child 2 drew all the companions of the blue guppy in blue as well (Figure 2b), whereas when the interviewer tried to shift his attention from the drawing to nature itself, he suggested that *'the guppies that live with the blue guppy in nature are not identical with it'*. On the other hand, however, when the interviewer tried to keep the focus on nature by asking him about the possible differences between the guppies, child 2 pointed one of the guppies in his drawing and said that *'this one looks like a bird and the blue guppy doesn't'.* So, although he didn't feel the need to make a drawing that would represent what he thought that was really happening with the guppies in nature, in a given moment he *did* appeal to the drawing in order to justify his claim about the natural guppies and their possible differences. Finally, after having his attention shifted from his drawing to nature, child 2 managed to come up with some differences, but these were related with age or illness *('some guppies will be old and some will be babies and old guppies and baby guppies are different', or 'some may be ill and their colour will be different because they are ill').*

FIGURE 2



(a) (b) (c)

Drawings produced by child 4 (a), child 2 (b) and child 3 (c)

Problem 2:'V-within-pops'-notion vs 'family resemblance'-notion

Children's own experience about individuals who live together has to do with families. And they do know that family resemblance is in place (Ergazaki, Alexaki, Papadopoulou & Kalpakiori, 2014). So, when asked to reason about a group of guppies that live together, they may draw upon their experience with families and family resemblance. For instance, child 3 drew the companions of the blue guppy in blue as well (Figure 2c), whereas he claimed that *'in nature there may be also yellow guppies, or orange or red'* and that *'guppies in nature may also have other differences except their colour',* but *'all these different guppies do not live with the blue one; blue guppies live with other blue guppies'.* Although, we do not have an explicit reference to the idea of family and family resemblance here, we think that it is not unlikely for child 3 and probably others to use it implicitly. This possibility of having a child's 'V-within-pops'-notion masked by the idea of family resemblance underlines the importance of engaging young children in justifying their claims. Requiring a justification makes it possible for us to unmask the 'V-within-pops'-notion within a non-variation claim: *'it is not possible to find a yellow guppy with the blue in nature* [not because all guppies are blue: they aren't; but] *because guppies that live together are of the same colour'.*

Feedback about Task 2

The second task of the protocol, which was a forced-choice one, worked quite well. Children seemed to be interested in the story of the discovery of an individual mammal of a new kind with a funny name (MUP) and a funny appearance and they were very prompt to choose the 'V-within-pops'-option. Even child 2 who provided a non-variation drawing in task 1 and a non-variation claim in task 3, did use the 'V-within-pops'-option in this task. It might be that the nature of the task, which is a forced-choice one, helps children express easier the V-within-pops'-option, since choosing something may be easier than articulating it themselves. On the other hand, it might also be that thinking about individual animals of a *newly* discovered kind, makes it easier for the children to be more flexible with what they expect from their appearance. Nevertheless, our feedback from child 1 showed that it is possible that referring to a *group* of MUPs discovered by the scientists after the first MUP, as well as defining the group of each option by using a plastic circle, promotes the 'non-V-within-pops'-option for some children. Child 1 accepted that all MUPs would look like the first one *'because they belong to the same group'.* We cannot be sure that he would stick to the 'non-V-within-pops'-option if he was given the impression of more individual MUPs found in several places after the first one rather than the impression of a group.

Feedback about Task 3

The third task of the protocol, which was a problem-exploring one, worked also quite well. Children did not seem to have problems in understanding the scenario, they seemed interested in it and they tried to be creative in finding a solution for the deer that need to go through the tunnel and reach their food on the other side. So, they first thought about possible techniques that would get the deer to the other side of the tunnel *('they can stoop' or 'they can go around' or 'the younger ones can pass the tunnel')* and only when all these were challenged by the interviewer *('even if they stoop, they still cannot go through the tunnel' or 'they cannot go around, they need to go through the tunnel' or 'they cannot send a baby deer, because they are all the same age')*, they moved on to articulate and justify a variation-claim or a non variation-claim. Regarding the justification, we note that it seemed to be demanding for children. Child 4 who was pretty sure that there may be some deer in the group with shorter antlers, had difficulties in justifying her

claim with a more general statement about the possibly different appearance of the members of an animal population: '*I don't know why; it's just a smart thought of my mind'.* Nevertheless, a child *did* manage to come up with how it would be possible to have some deer with shorter antlers in the group; he suggested that 'b*ecause in fact they* (meaning the deer with the shorter antlers) *did not eat too much, so their antlers remained short* (making gesture with both hands on the head) *and that means they can pass".*

CONCLUSIONS

The piloting of the interview protocol revealed some things that may undermine the accuracy of the data it helps us gather. The ways in which we could deal with these, are summarized below.
Problem 1 *('children' drawings vs children's reality')* indicates that the 1st task requires from the interviewer to make clear to the children that when they draw on a sheet of paper the companions of the blue guppy next to it, they should always keep in mind that they need to come up with a drawing which represents how they think that the *real* companions of a *real* blue guppy will look like, in the *real* lake where they *really* live. In other words, during the drawing task children need to realize that the guppy-drawing they create shouldn't contradict their view about the guppies in the wild, but describe it. Problem 2 (*'V-within-pops'-notion vs 'family resemblance'-notion*), indicates that the 1st task also requires from the interviewer to make clear to the children that the companions of the blue guppy are not actually its family. The term 'group' should be clarified explicitly by the interviewer so that the confusion between 'group' and 'family' and the masking of the notion of 'V-within-pops' by the notion of 'family resemblance', won't be possible anymore.

The term 'group' may be problematic even on its own, as shown in the 2nd task. Children tend to prioritize resemblances rather than differences within groups (actually they are taught to do so) and thus it might be a better idea to adapt the scenario of task 2 so that after the discovery of the first individual, scientists will be supposed to discover 'more *individuals'* of the kind at several places, rather than 'a *group* of individuals'. Finally, the 3rd task seems to work quite well. However, justifications need to be emphasized by the interviewer and requiring they should probably be done in a more children-friendly language.

In fact, it is *throughout* the protocol that the interviewer needs to be aware of the power that justifications may have as 'unmasking' or 'confirmatory' tools. For instance, (a) unmasking the 'V-within-pops'-notion in a 'non variation'-claim: '*the guppies that live with the blue one are also blue* [not because there are not yellow guppies as well, but] *because guppies that live together must have the same colour*, and (b) confirming the 'V-within-pops'-notion in a 'variation-claim': *'it is possible to find a yellow guppy with the blue in nature,* [not because yellow is a nice colour, but] *because there are also yellow guppies in nature'.*

In sum, the interview protocol we designed seems to have potential in identifying qualitatively children's understanding about variation within populations of animals, and thus in evaluating the corresponding part of our teaching-learning sequence. This potential seems to be supported by further piloting done in France but data analysis is still in progress.

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