FACILITATING TRANSITION FROM INTUITIVE TO EARLY SCIENTIFIC KNOWLEDGE: THE CASE OF QUANTITY AND NUMBERS

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Abstract

The aim of the study is to explore a new approach to the acquisition of early scientific knowledge that is consistent with the nature and origins of human knowledge and limitations of our cognitive architecture as viewed in contemporary areas of evolutionary, developmental, and educational psychology. Our main hypothesis is that cognitive load involved in early learning of scientific (or secondary) knowledge could be reduced if the transition from intuitive (or primary) knowledge is staged gradually thus artificially limiting the amount of novel essential elements of information to be processed at a time. The "number sense" is primary knowledge (Dehaene, 1992). "Number sense" makes humans able to distinguish quantities that are less than 4 (1, 2, 3 and 4). However, when quantities are bigger than 4, the "number sense" produces approximations: for example, young babies distinguish a group of 4 from a group of 12, but are not able to distinguish groups 4 and 8 (Izard, Sann, Spelke & Streri, 2009). The "number sense" of an adult is able to distinguish 60 from 55 points, but not 60 from 59 (Piazza et al., 2010). How can the transition from approximation to exactitude be facilitated? For example, Siegler and Ramani (2009) suggested games with the linear representation of digits on a line. This research project investigates an alternative approach. As the first stage of the project, a series of three experiments were conducted to evaluate the plausibility of some basic assumptions.

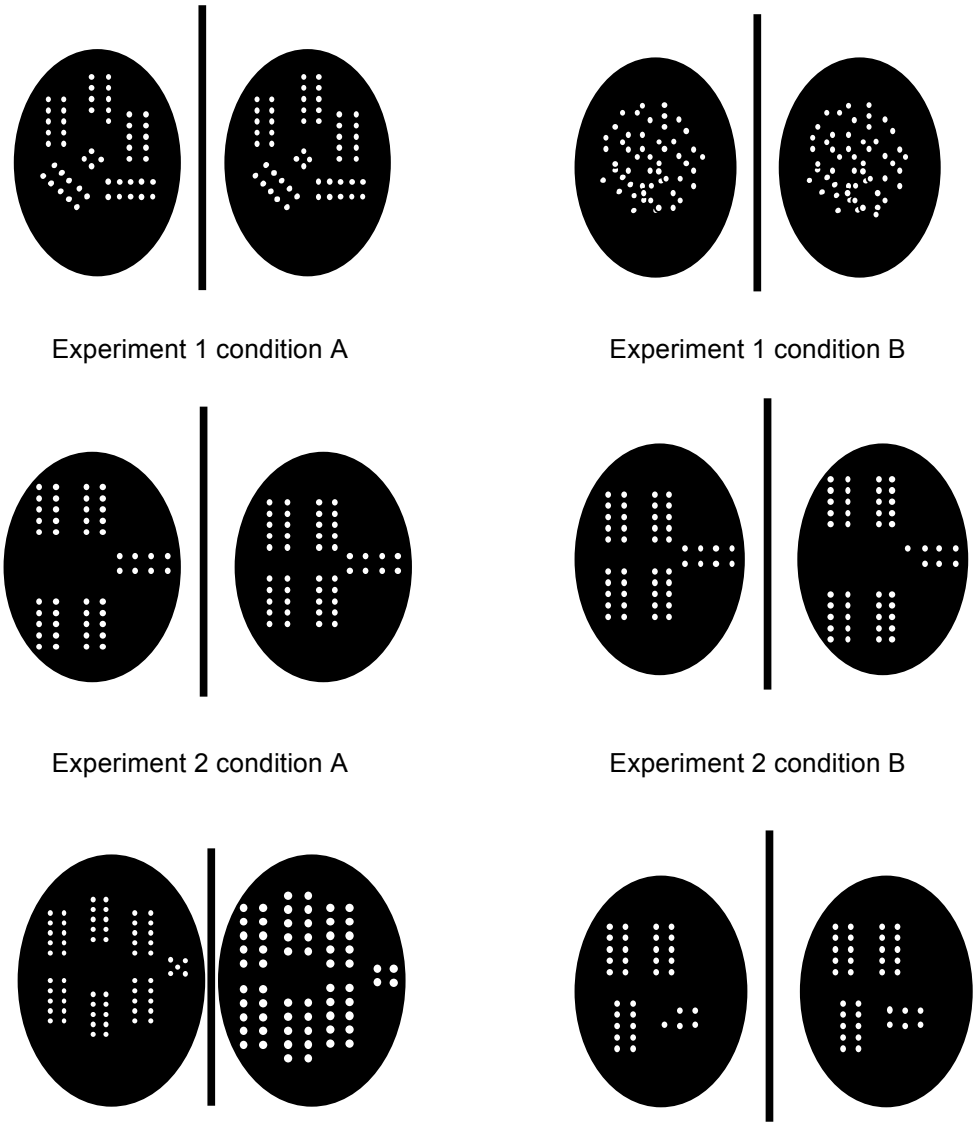
Hypothesis

Human beings can perform exact quantities evaluation if they process them as groups or groups of groups. Children should be able to quickly distinguish 53 and 54, if these two quantities are organised as groups of 10 (53 = 5 groups of 10 objects and one group of 3). Transition from the "number sense" to exact quantification could be facilitated by appropriate spatial organization of quantities to enable the perception of identical groups in each collection. Using the visual system to compare two quantities could possibly be used as an effective tool of transition between primary and secondary knowledge.

Experiments

Method. Three experiments were realized with grade 3 students who were asked to indicate what part of a computer screen was presenting the group with the highest number of points (5s presentation). Experimental conditions are presented in Figure 1.

Experiment 1 (n = 87; M = 8.62 years old): in condition A, 10 pairs of sets of points were presented. The points were grouped by sub-groups of 10. The amount of points varies between 30 and 59; in condition B, the points are not grouped. The positions of the points are similar on both sides on the screen



Experiment 1 condition A | Experiment 1 condition B

Experiment 2 condition A | Experiment 2 condition B

Experiment 3 condition A | Experiment 3 condition B

Figure 1: Conditions of each experiment

Experiment 2 (n= 50; M = 8.65 years old): in condition A, the points were grouped and the quantities were the same, but the surface was different. In condition B, the quantities and the surface were different.

Experiment 3 (n = 56; M = 8.69 years old): in condition A, the quantities and the size of the points were different. In condition B, the instruction changed: students were asked to count. The points were grouped; the quantities were different but the size of the points were the same.

Results

In experiment 1, Group A performances were far better than group B: 96% vs 52% of correct answers. Grouping the points by 10 enhanced the comparison of large numbers.

In experiment 2, there was no difference between group A and B (95% correct answer in both groups).

In experiment 3, the rate of correct answers in condition A was very high (91%). Students actually consider quantities and not other aspect of the material. With condition B, the rate of correct answer was only 15%: students were not able to count.

Discussion

Our results support the hypothesis that the “number sense”, the primary knowledge that is used by humans before they learn numbers, could be based on the visual perception of groups. Humans could use it even after they have learnt numbers. The ability to use visual perception of groups could potentially act as a facilitator in transitioning from intuitive “number sense” to number systems. Specific instructional techniques and their cognitive load implications will be investigated in the following experiments. It will be interesting to see if younger children are able to use visual perception of groups in the same comparison tasks.

References

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