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The Process of Knowledge Redescription as Underlying Mechanism for the Development of Children's Problem-solving Strategies: an example from arithmetic.

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Background

Research on children's strategies in arithmetic has revealed important aspects of strategy choice, discovery, and variability (Baroody, 1987; Siegler and Stern, 1998). This study aimed at exploring ways by which 5-6 year-old children organise different pieces of knowledge to develop strategies for solving a specific arithmetical task and furthermore, ways by which children evolve their successful problem solving approaches acquiring increasing control over the procedural and conceptual knowledge that supports their strategies. Karmiloff-Smith's (1992) *Representational-Redescription* theory comes to complement traditional theories of learning such as the Piagetian and the Vygotskian theories, according to which externally driven factors, such as failure or communicative procedures, contribute to representational change and therefore to learning. Representational-Redescription (RR) is a process of *internal exploitation of already existing knowledge*. Grounded on the idea of 'success-based' cognitive change the RR-model describes the movement from implicit information embedded in an efficient problem solving procedure, to rendering the knowledge progressively more flexible and explicit.

In problem solving, the notion of knowledge explicitation has been studied in spatial, physics, linguistic and notational tasks (Karmiloff-Smith, 1984; Spensley, 1997; Spensley and Taylor, 1999). Currently, it is under-researched in the domain of mathematics. The paper presents a specific path of strategy change, and explains the general analytical direction which was followed to infer different levels of knowledge accessibility and explicitness which supported the *after-success* change process.

Methodology

Ten 5-6 year old children selected from a Year 1 class of a Southern-England infant school constituted the sample of the study. The microgenetic method was used as the overall framework of research. Changes in children's problem solving behaviour were observed very densely, in the course of a sequence of sessions, during which children were individually involved in solving a specific form of additive task after they had already been successful in solving it. The microgenetic method was combined with the clinical method.

Children’s overt behaviour (verbalisations-movements-hesitations) was video-recorded and analysed. The task required from children to find, all the possible number pairs that add up to a specific number each time: the ‘target’ number. The produced number bonds were put in a column. The task was repeated with different ‘target’ numbers. The researcher was asking the children to describe how they completed each solution step and to explain the effectiveness of their strategy.

Outcomes

A representative path of *after-success* changes.

Phase-A	▪ Production of each number bond as a separate problem. ▪ Application of variety of methods and types of mathematical knowledge (factual-procedural-conceptual). ▪ Checking of numbers used *in order*.
Phase-B	▪ Choice of first addends in order. ▪ Variety of methods to find second addend. ▪ Application of the *‘deriving’* method at isolated solution steps.
Phase-C	▪ Choice of first addends in order. ▪ Consistent application of the *‘deriving’* method to find second addend. ▪ Noticing-abstracting ordered pattern of numbers in the columns of first-second addends.
Phase-D	▪ Application of ‘ordering’ for first-second addends.

The RR-levels of explicitness were ascribed to knowledge that supported the procedural and the conceptual facet of the ‘deriving’ method. The procedural facet refers to the *know how*. The method involves a combination of operations that children apply on the addends of a known number bond. (if 9 is the target, and the 5+4 has been produced, a new number bond is produced by adding 1 on 5 and taking away 1 from 4 → 6+3). The RR-levels of explicitness were ascribed to the procedural facet considering: appreciation of the operations/procedures that are combined, verbal report (or not) of these operations/procedures. The conceptual facet refers to the *know why*. It involves having conceptualised why the combination of these procedures/operations results in the production of a number bond that gives the same sum as the known number bond. This conceptualisation was found to be supported by gradually increasing RR-levels of explicitness, based on children’s ability to explain the relationships that supported their method.

The consistent application of the ‘deriving’ method resulted in the ordered arrangement of numbers in the columns of first and second addends. Children abstracted this number pattern and developed the 'ordering' strategy. Some children recognised that the arithmetical relations involved in the 'deriving' method were integrated into the 'ordering' strategy. In these cases, a high level of explicitness was ascribed to the representational system which supported the application of the strategy. Other children developed the strategy without having a high-level explicit representation of the underlying arithmetical relations. The ascription of different representational formats indicated a variable, but gradually increasing, degree of accessibility of the knowledge that supported this strategy.

Conclusions

This study shows that children move from initial success-oriented behaviour to an organisation-oriented phase (Voutsina and Jones, 2001) during which new strategies are introduced or known strategies are evolved procedurally and conceptually. At different moments of this change process strategies were found to be underlain by different degrees of knowledge explicitness, leading children to acquire increasing conscious access to knowledge that they already have. These findings support the idea that the Representational-Redescription process constitutes another way of constructing knowledge, and that better understanding and learning follows not only from failure but also from success. Representational-Redescription is a cognitive process which can be triggered by classroom teaching: an important educational implication.

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