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Inter- and intra-individual variability in the process of change in the use of analogical strategies to solve geometric tasks in children: A microgenetic analysis

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Abstract

This study focused on unprompted changes in children's analogical reasoning on geometric tasks and the additional effect of a short training procedure. Participants were 36 grade 1 level children (M=6;8 years) divided over a not-trained and a trained condition. The study was a 5-sessions migrogenetic procedure, with a follow-up test session after 3 months. The results showed considerable inter-and intra-individual variability in the process of change in the use of analogical strategies in both not-trained and trained children. Repeated practice, without explicit prompting, caused a spontaneous improvement in analogical reasoning. This improvement was mainly due to an increase in implicit analogical reasoning. The short training procedure caused an improvement above and beyond that of practice alone (EStrained/not-trained=.96), inducing in 9 children a continuation of a gradual process of change, while in 4 other children it caused a rather rapid change in analogical performance. The training effect was greatly due to an increase in explicit analogical reasoning. Both effects were still visible after a period of 3 months. Because the study may have implications for geometric learning with young children, the authors recommend further investigations of young children's use of analogies on tasks involving geometric transformations. The authors also recommend further research into transfer to other mathematical competencies to investigate implications for mathematics besides geometry.

Keywords: Analogical reasoning; Microgenetic; Training; Repeated practice; Geometric tasks; Individual differences; Variability

1. Introduction

Our primary goal in this study was to gain insight into the nature of young children's analogical reasoning ability by investigating whether children's analogical performance changes due to practice alone, without explicit prompting, and whether a short training procedure that provides children with some explicit modeling and feedback improves their performance. Unlike other studies on young children's analogical ability (e.g., Alexander et al., 1989; Brown, 1989; Goswami & Brown, 1989; Hosenfeld, Van der Maas, & Van den Boom, 1997a,b; Tunteler & Resing, 2002), this study investigated children's unprompted analogical performances *over a period of weeks* both before and after a short training in analogical reasoning. This was compared with the performances of children of the same age who were given multiple practice opportunities over time, but no instructions or explicit prompting.

The ability to reason by analogy has long been regarded as central to human cognition (Goswami, 1991, 1992; Halford, 1993) and as an important skill for classroom learning (e.g., Csapó, 1997; Goswami, 1992; Vosniadou, 1989) and instruction (e.g., Kolodner, 1997). During the past few decades, a considerable number of researchers have focused on understanding the development of this reasoning ability in children (e.g., Alexander et al., 1989; Brown, 1989; Gentner, 1989; Goswami & Brown, 1989; Halford, 1993; Hosenfeld, Van der Maas et al., 1997a,b; Singer-Freeman, 2005; Singer-Freeman & Goswami, 2001). Although these studies have resulted in much information on children's analogical reasoning competency under various circumstances, there is still no consensus about the nature of this

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reasoning ability in young children. An increasing number of studies, in which a variety of analogy tasks were used, showed that very young children can already reason analogically after a certain amount of help on the condition that they understand the relationships on which the analogies are based (e.g., Brown, 1989; Chen, 1996; Chen & Daehler, 1989, 1992; Singer-Freeman, 2005; Singer-Freeman & Goswami, 2001). In this research tradition, developmental changes in children's analogical reasoning ability is generally assumed to be gradual and quantifiable, and driven by a growing knowledge base or increasing metacognitive skills (Brown, 1989; Goswami, 1991). However, other researchers (e.g., Halford & McCredden, 1998; Halford, Wilson & Phillips, 1998; Hosenfeld, Van der Maas et al., 1997a,b) are more apprehensive about young children's analogical capacity; they posit that developmental changes in analogical reasoning is a matter of changes in global cometence. This lack of consensus may cause one to question whether the claim for analogical reasoning at an early age made in some studies might be an artifact of the experimental manipulations in these studies.

Review of the literature on analogical reasoning showed that the conclusions with respect to the nature of changes in the ability to reason by analogy described above were frequently drawn on the basis of results from cross-sectional training studies (e.g., Brown, 1989; Gholson, Morgan, Dattel, & Pierce, 1990; Gentner, 1989; Chen, 1996; Chen & Daehler, 1989, 1992). Yet, Bjorklund, Miller, Coyle and Slawinsky (1997) asserted that natural, unprompted changes, as opposed to changes induced by training, may show a different path. Moreover, various other authors stressed that such single-occasion assessments could produce an incomplete or even over-optimistic picture of the process of change of the cognitive strategy under investigation because they address changes indirectly (e.g., Granott & Parziale, 2002; Kuhn, 1995; Siegler, 1995, 2006).

Despite the many studies in the field of analogical reasoning conducted in the past, very few of them have focused on a comparison of changes over time in children's analogical reasoning performance induced by practice and changes induced by a training procedure. Two exceptions worth mentioning are the longitudinal studies conducted by Alexander et al. (1989) and Hosenfeld, Van der Maas et al., 1997b). Alexander et al. (1989) used simple 3-dimensional geometric analogical tasks of type A:B::C:D, and monitored the analogical performances of trained 4–5 year-old children and that of not-trained children of the same age over a period of months. They showed that children of this age were able to benefit from an extensive training in analogical reasoning skills, but revealed little about the paths of change in the two conditions. Moreover, it should be noted that the not-trained children in the Alexander et al. (1989) study were repeatedly given explicit instructions to the tasks before and during testing, and explicit instructions may also be seen as a form of training. Hosenfeld, Van der Maas et al. (1997b) observed 6–8 year-old children's analogical performance on paper and pencil classical geometric tasks over a period of months. These authors posited an age-related transition in analogical reasoning on geometric tasks in children of this age. However, the children in their study were given extensive instructions for the tasks, both before and during testing so that we are unable to determine the natural and unprompted analogical reasoning of those children. Such natural reasoning might not proceed in the same way suggested by the sequence of instructions given by Hosenfeld, Van der Maas et al.

More recently Tunteler and Resing (2007a) microgenetically investigated the performances on problem analogy tasks over a period of weeks of 5–7 year-old children who were given repeated practice opportunities without any instruction or feedback in comparison to the performances of children who were previously given a short training consisting of some instructions in how to use analogies. A microgenetic procedure allows close observation of change mechanisms over a relatively short period of time, as well as the identification of the conditions and transition strategies leading up to change (Siegler & Crowley, 1991). The microgenetic procedure used in the Tunteler and Resing study allowed the authors to distinguish three groups of reasoners: 1) children showing consistent analogical reasoning over trials; 2) children showing consistent inadequate, non-analogical reasoning; and 3) children showing variable, adequate and inadequate, reasoning. Some children had difficulty with using analogies despite of the training, while other children of the same age and even some younger children consistently used analogies over trials without reminding. Over time, an increasing number of children, particularly in the trained group, showed very consistent analogical reasoning, while a decreasing number demonstrated inadequate, non-analogical reasoning. However, variable and diverse strategy use over trials existed in a considerable number of both the trained and not-trained children of the two age groups. The authors concluded that variability in strategy use on problem analogy tasks is not only common in situations in which children are not explicitly given instructions as they demonstrated earlier (Tunteler & Resing, 2002, 2007b), but apparently exists in trained children as well.

According to Tunteler and Resing (2007a), this pervasiveness in variability in children's strategy use on analogical problem-solving tasks indicates that the ability to reason by analogy on this type of analogy tasks develops over a protracted age range. It also underlines the importance of a microgenetic research method in studying the process of change in the domain of analogical reasoning. Therefore, we realized that in order to gain more insight into the nature of young children's analogical reasoning ability, we needed, in addition to the Tunteler and Resing study, to microgenetically examine changes in young children's analogical reasoning under different conditions–trained and not-trained–on another type of analogy task. In this study we used classical geometric analogy tasks. This type of analogy tasks is said to measure analogical reasoning more purely than verbal analogical tasks, since they need no vocabulary and domain specific knowledge (Goswami, 1992).

The advantages of the microgenetic approach have been extensively described elsewhere (e.g. Kuhn, 1995; Siegler & Crowley, 1991; Siegler, 2006). It should however be noted that even though most older microgenetic studies sought to accelerate the natural process of developmental changes by increasing the density of exercises within the domain under investigation, this research method is not restricted to this purpose (Siegler, 2006). Adding an element of training is assumed to be informative