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The role of intelligence and feedback in children's strategy competence

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ABSTRACT

A test–intervention–test study was conducted investigating the role of intelligence on four parameters of strategy competence in the context of a numerosity judgment task. Moreover, the effectiveness of two feedback types on these four parameters was tested. In the two test sessions, the choice/no-choice method was used to assess the strategy repertoire, frequency, efficiency, and adaptivity of a group of low-, average-, and high-intelligence children. During the intervention, half of the participants from each intelligence group were given outcome feedback (OFB), whereas the other half received strategy feedback (SFB). The pretest data showed large differences among the three intelligence groups on all four strategy parameters. These differences had disappeared at the posttest due to a particularly strong improvement on all strategy parameters in the low-intelligence group. Furthermore, it was found that SFB was more beneficial than OFB for all parameters involving strategy selection. These results indicate that intelligence plays an important role in children's strategy use and suggest that strategy feedback can be a powerful instructional tool, especially for low-intelligence children.

Introduction

The past 20 years have witnessed great progress in research on the selection and execution of strategies in many domains of human cognition (Siegler, 1996, 2005). This has resulted in new theoretical insights regarding strategy choice and change, in important methodological innovations, and in

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educational applications aimed at supporting varied and flexible use of strategies (see Torbeyns, Arnaud, Lemaire, & Verschaffel, 2004, for a critical review).

Lemaire and Siegler (1995) proposed a powerful theoretical framework for analyzing individuals' strategy competence consisting of four dimensions: (a) the strategy *repertoire* (i.e., which strategies an individual uses to solve a specific task), (b) the relative *frequency* of strategy use (i.e., how often each of the different strategies is applied), (c) the *efficiency* of strategy execution (i.e., how fast and accurate each strategy is executed), and (d) the *adaptivity* of strategy choices (i.e., the calibration of one's strategy choices toward problem characteristics as well as toward one's own strategy efficiency). According to Lemaire and Siegler, improvements in overall task performance can be the result of changes in any of these dimensions.

Although Lemaire and Siegler's (1995) framework was originally used to study the *development* in individuals' strategy use (Luwel, Lemaire, & Verschaffel, 2005; Siegler & Lemaire, 1997), its range of application has gradually been extended over the years. Recently, it has also been used to examine the effects of situational variables (Luwel, Verschaffel, Onghena, & De Corte, 2003b), working memory load (Imbo & Vandierendonck, 2007), mathematical ability (Torbeyns, Verschaffel, & Ghesquière, 2006), and cultural differences (Imbo & LeFevre, 2009) on individuals' strategy performance. Interestingly, this powerful theoretical framework has, to the best of our knowledge, never been used to systematically assess the role of intelligence in children's strategy performance. Of course, several studies have already been conducted investigating intelligence-related differences in children's strategic functioning. For example, it has been observed that, compared with less intelligent children, high-intelligence children not only seem to have a broader repertoire of strategies but also are more consistent, efficient, and adaptive in their strategy choices (see, e.g., Carr, Alexander, & Schwanenflugel, 1996; Jausovec, 1991; Montague, 1991). Moreover, it has been found that high-intelligence children also use more complex and sophisticated strategies compared with their average-intelligence peers (Muir-Broaddus, 1995; Scruggs & Mastropieri, 1988).

Although these earlier studies have already provided a number of interesting findings about the involvement of intelligence in children's strategy competence, they seem to suffer from three important shortcomings. First, previous work has yielded only a fragmented picture of the role of intelligence in individuals' strategy competence because none of these earlier studies ever looked at all four parameters of strategy competence within a single task. Indeed, the majority of them looked only at strategy repertoire and frequency of strategy use (Bouffard-Bouchard, Parent, & Larivée, 1993; Cho & Ahn, 2003; Coyle, Read, Gaultney, & Bjorklund, 1998; Hettinger-Steiner, 2006; Scruggs & Mastropieri, 1988). A limited number of studies also considered a third parameter in addition to the repertoire and frequency parameters—either efficiency (e.g., Geary & Brown, 1991; Muir-Broaddus, 1995) or adaptivity (Gaultney, Bjorklund, & Goldstein, 1996)—but never all four of them. Arguably, by addressing only a restricted number of strategy parameters within different kinds of tasks, these studies can only lead to partial conclusions regarding the role of intelligence in individuals' strategy performance.

A second limitation is that all studies that previously assessed the role of intelligence in strategy performance relied solely on the so-called *choice method* that allows participants to freely choose a strategy on each problem of the task. As a consequence, participants are given the opportunity to selectively assign their strategies to particular problems, resulting in potential biased estimates of a strategy's efficiency. Moreover, a lack of unbiased performance measures makes it difficult to properly assess the adaptivity of one's strategy choices because there is no optimal profile of strategy choices with which the actual strategy choices can be compared. These problems can be avoided by applying the *choice/no-choice method* (Siegler & Lemaire, 1997; see also Luwel, Onghena, Torbeyns, Schillemans, & Verschaffel, 2009). This method involves testing each participant under two types of conditions: (a) a choice condition in which one can freely choose which strategy to use from a set of available strategies on each problem of the task and (b) a number of no-choice conditions in which one must use one specific strategy on all problems. In principle, the number of no-choice conditions equals the number of strategies that are made available in the choice condition. As such, the choice/no-choice method allows a proper analysis of all four parameters of strategy competence. Data from the choice condition provide information about participants' strategy repertoire and their strategy frequencies. The application of a given strategy on all items of the task under