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When do you know what you know? The emergence of memory monitoring

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ABSTRACT

Recent research on comparative metacognition shows that animals, like humans, can differentiate between what they know and what they do not know. However, not much is known about the metacognitive behaviors of human children during their early years. To explore the emergence of memory-monitoring skills, two experiments were conducted using nonverbal tasks adapted from the work of Kornell, Son, and Terrace (2007) and Hampton (2001). Experiment 1 endeavored to determine when children began to show the ability to monitor their memories retrospectively. Experiment 2 aimed to reveal when young children knew what they knew by assessing their prospective monitoring. The results suggested that 4- to 5-year-olds had the ability to judge retrospectively their accuracy in a serial position task, whereas 3- to 4-year-olds did not. In contrast, 4.5- to 5-year-olds could discern items present in and absent from their memory before recognition, whereas 4- to 4.5-year-olds could not. In conclusion, 4-year-olds began to make accurate confidence judgments retrospectively, and children who are approximately 4.5 years old began to demonstrate prospective memory-monitoring skills.

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Introduction

During the process of evolution, metacognition (thinking about one's own thoughts) has a particular adaptive value, allowing individuals capable of it to reflect on their actions and make better choices to survive in difficult circumstances (Metcalfe, 2008). As the core element of metacognition, an increasing number of researchers have become interested in the development of metacognitive monitoring, which refers to judgments or evaluation of the objective level by the meta level (T. Nelson & Narens, 1990). They found that children who were over 7 years old could give higher ratings for correct answers than for incorrect answers (Roebers & Howie, 2003; Schneider & Lockl, 2002) and could make rather accurate *retrospective judgments* (confidence judgments about learned items) for entire word lists and individual items (Pressley, Levin, Ghatala, & Ahmad, 1987). Meanwhile, predictions about subsequent recall (*prospective monitoring*) after a delay were found to be accurate for kindergarteners and second- and fourth-graders (Schneider, Vise, Lockl, & Nelson, 2000). Moreover, solid metacognitive monitoring and control skills are evident during middle childhood and continue to improve during this period (see Ghetti, Hembacher, & Coughlin, 2013).

Infants might have an implicit ability to monitor their own learning progress. For example, 17-month-olds paid more attention to learnable linguistic patterns than to unlearnable patterns (Gerken, Balcomb, & Minton, 2011). Goupil and Kouider (2016) found that 12- and 18-month-olds were able to retrospectively evaluate the accuracy of their own decisions. At the behavioral level, infants showed increased persistence in their initial choice after making a correct response as compared with an incorrect response. At the neural level, infants produced the same neuronal signature of error monitoring as in adults after a mistake. The researchers also found that 20-month-olds given the opportunity to ask for help used this option strategically to improve their performance when they forgot the location of a toy (Goupil, Romand-Monnier, & Kouider, 2016). Brinck and Liljenfors (2013) believed that behavioral indicators such as wavering and deliberating over problems might exist before children were aware of their connection with accuracy.

However, the early childhood origins of metacognition have been considered difficult to study due to methodological constraints (Vo, Li, Kornell, Pouget, & Cantlon, 2014). Traditional studies of metacognition usually depend on verbal reports, which do not lend themselves well to measuring the subjective experiences of young children. Over the past decade, for comparative studies of metacognition, a series of effective tools have been designed to explore animals' abilities to monitor and control their own cognitive process (Basile, Schroeder, Brown, Templer, & Hampton, 2015; Czaczkes & Heinze, 2015; Goto & Watanabe, 2012; Malassis, Gheusi, & Fagot, 2015; Morgan, Kornell, Kornblum, & Terrace, 2014; Watanabe & Clayton, 2016). For example, Smith and colleagues designed a paradigm to explore the ability to monitor uncertainty based on traditional psychophysical methods in animal research (e.g., Smith, Shields, Schull, & Washburn, 1997; Zakrzewski, Perdue, Beran, Church, & Smith, 2014). In the typical uncertainty-monitoring paradigm, participants are assigned a psychophysical task (such as the threshold paradigm) and given two primary discrimination responses and an option to avoid chosen trials. If participants use uncertain responses to selectively avoid the most difficult trials, they might have the capacity to monitor their ongoing cognition (Smith, Shields, & Washburn, 2003). With the adoption of nonverbal paradigms in animal research, the emergence of metacognitive monitoring in children has become a topic of increasing research interest.

Recently, researchers explored the ability to use retrospective confidence judgment on perceptual decisions during the preschool years. Coughlin, Hembacher, Lyons, and Ghetti (2015) found that children as young as 3 years could report lower confidence when they were inaccurate than when they were accurate in a perceptual identification task. Meanwhile, prospective monitoring ability in a perceptual identification task was also examined in 3- to 5-year-old children. Bernard, Proust, and Clement (2015) found that accuracy for accepted items in the opt-out task was significantly higher than accuracy for rejected items in the recognition task, suggesting that young children could reliably assess their discriminative ability prospectively.