Cognitive Development 37 (2016) 28–41

Contents lists available at ScienceDirect

Cognitive Development

Continued development of recursive thinking in adolescence: Longitudinal analyses with a revised recursive thinking test

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ARTICLE INFO

Article history:
Received 14 August 2014
Received in revised form 21 October 2015
Accepted 20 November 2015
Available online 2 December 2015

Keywords:
Social cognition
Adolescence
Longitudinal study
Recursive thinking
Verbal intelligence
Psychometric properties

ABSTRACT

The present study adds to the emerging literature on the development of social cognition in adolescence by investigating the development of recursive thinking (i.e., thinking about thinking). Previous studies have indicated that the development of recursive thinking is not completed during childhood. The present study focused on late childhood and adolescence and presents the first longitudinal data on recursive thinking. At Time 1, 299 participants, aged 8 to 17 years, completed a revised version of the recursive thinking test developed by Miller, Kessel and Flavell (1970). At Time 2, two years later, 221 participants completed the test again. Psychometric properties of the revised test were found to be adequate. The developmental analysis showed that scores increased with age—both between- and within participants-, indicating that recursive thinking continues to develop throughout adolescence and does not level off before 18 years of age. Verbal abilities only partially explained this development.

1. Introduction

Interest in the development of social cognition during adolescence has been growing since neuroscience studies have demonstrated that brain regions associated with social cognition continue to develop throughout adolescence (Blakemore & Choudhury, 2006; Burnett & Blakemore, 2009; Nelson, Leibenluft, McClure, & Pine, 2005). These findings have raised the question how the changes affect social cognition and generated the hypothesis that some socio-cognitive processes should continue to develop during adolescence. The present study investigated whether recursive thinking is such a process.

Recursive thinking, or thinking about thinking (Miller, Kessel, & Flavell, 1970), is required to infer other people's thoughts. It is an aspect of social cognition that has been related to (cognitive) perspective taking (Landry & Lyons-Ruth, 1980; Veith, 1980) and theory of mind (Miller, 2012). For example, second-order (false) beliefs can be described as recursive thinking: John thinks that Mary thinks that the ice-cream van is in the park (Perner & Wimmer, 1985). Recursive thinking can be considered a specific form of Theory of Mind (ToM), restricted to epistemic states (Perner & Wimmer, 1985), whereas the broader ToM concept encompasses thinking about other mental states, such as desires, intentions (e.g., Blakemore & Choudhury, 2006) and feelings (e.g., Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001).

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http://dx.doi.org/10.1016/j.cogdev.2015.11.002
0885-2014/

The ability to think about thinking has been suggested to underlie successful social performance in domains such as the display of emotions (Saarni, 1979), self-presentation (Miller, 2012), persuasion (Hill & Palmquist, 1978), moral reasoning (Hill & Palmquist, 1978S; Miller, 2012; Veith, 1980) and communication (Miller, 2012). For example, Perner and Wimmer (1985) noted that children (under 8 years of age) may answer test questions incompletely, because they do not understand that the examiner wants to know what they know. In line with these proposals, several empirical studies have related recursive thinking to effective social functioning. Stiller and Dunbar (2007) demonstrated that adults who are better at recursive thinking maintain larger social networks, naming more persons they could turn to for support in case of personal problems. High performance on recursive thinking tests was also positively related to agreeableness (Nettle & Liddle, 2008; Ferguson & Austin, 2010), emotional intelligence as a trait and in specific situations (Ferguson & Austin, 2010) and self-reported cooperativeness (Paal & Bereczkei, 2012), though not to successful recognition of cooperativeness in others (Sylwester, Lyons, Buchanan, Nettle, & Roberts, 2012). Low performance on recursive thinking tests was associated with a tendency to blame other people for negative events (Kinderman, Dunbar, & Bentall, 1998) and to interpret their intentions as hostile (Jeon et al., 2013).

Recursive thinking has long been assumed to emerge in childhood and to become more advanced in adolescence. *Indirect* support for the assumption comes from two studies on the development of related abilities. First, Miller (2012) reviewed findings from higher-order ToM tasks in which participants had to answer questions about a story character's beliefs about other story characters' beliefs (e.g., Kinderman et al., 1998). He concluded that, from childhood to adulthood, participants become able to deal with increasingly longer chains of beliefs. Second, recursive analogical reasoning, which is solving analogies between analogies (e.g., sand stands to beach as star stands to galaxy is analogous with water stands to ocean as air stands to sky), improved from grade five to seven and from grade seven to nine (ages 10–15), though not from grade nine to eleven (ages 14–17; Nippold, 1994). However, there is little *direct* evidence that recursive thinking continues to develop throughout adolescence. Several studies have demonstrated the emergence of recursive thinking in childhood (Eliot, Lovell, Dayton, & McGrady, 1979; Landry & Lyons-Ruth, 1980; Miller et al., 1970; Oppenheimer, 1986; Veith, 1980), but only one study included adolescents (Müller & Overton, 2010). It demonstrated further improvement in early adolescence, but not beyond.

1.1. Development of recursive thinking

The study of recursive thinking was initiated by Miller et al. (1970). They developed a test of children's understanding that representational actions, unlike physical actions, can be self-embedded (e.g., *I think that she thinks that I think that* her story is not interesting). Specifically, they hypothesized that the development of this understanding would follow an invariant sequence of (a) thinking about contiguous people (i.e., thinking about one or more persons), (b) thinking about an action between people (e.g., thinking about someone talking to another person), (c) one-loop recursive thinking (i.e., thinking about someone who is thinking about someone) and (d) two-loop recursive thinking (i.e., thinking about someone who is thinking about someone who is thinking about someone). They tested the hypothesis using a cartoon description task. Participants were presented with cartoons that contained thought clouds, speech bubbles and up to four different characters (a boy, a girl, a father and a mother). In each cartoon, the boy was depicted with a thought cloud over his head, in which all other elements were embedded. The participant had to tell what the boy was thinking. (See Appendix A for a two-loop recursion item used in the present study).

Miller et al. (1970) tested elementary school children from grades one to six (i.e., ages 6–12). They found that, in all grades, accuracy was higher for contiguity items than for action items, higher for action items than for one-loop recursion items and higher for one-loop recursion items than for two-loop recursion items. This pattern held for group means as well as the individual scores of 91.7% of the participants. Miller et al. (1970) concluded that the four types of items were scalable (i.e., constituting a scale with four distinct levels of difficulty), representing consecutive steps in the development of the understanding of recursive thinking. They also charted this development from grade one to six (i.e., ages 6–12). Performance on contiguity items was already at ceiling in first grade, but performance on the other items increased with grade level (percentages were derived from Fig. 2 in Miller et al., 1970): (a) accuracy on action items increased from about 43% in first grade to about 85% in fourth grade and remained fairly stable thereafter; (b) accuracy on one-loop recursion items increased from about 19% in first and second grade to about 46% in third and fourth grade and about 57% in fifth and sixth grade; (c) accuracy on two-loop recursion items was below 10% in grades one through three, about 17% in grade four and about 36% in grades five and six. Subsequent studies administering the cartoon description task replicated the developmental pattern in six to ten-year-olds (Eliot et al., 1979; Landry & Lyons-Ruth, 1980; Oppenheimer, 1986; Veith, 1980). The results indicate that the development of recursive thinking is still in progress in late childhood, in particular for one-loop and two-loop recursion.

Müller and Overton (2010) extended the study of recursive thinking into adolescence. In a study with participants from grades two, four, six and eight (ages 6–14), they largely replicated the results for grades two to six reported by Miller et al. (1970). Moreover, they demonstrated that performance on two-loop items continued to improve from grade six to grade eight (ages 11–14). In another study with participants from grades five, eight and eleven (ages 10–18) they found no further improvement between grades eight and eleven (ages 13–18) on action, one-loop recursion and two-loop recursion items. However, considerable variability in performance of the eight graders across the two studies prevents the conclusion that