Cognitive Psychology 68 (2014) 98–112

Contents lists available at ScienceDirect

Cognitive Psychology

journal homepage: www.elsevier.com/locate/cogpsych

Can infants make transitive inferences?

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ARTICLE INFO

Article history:
Accepted 15 November 2013
Available online 5 December 2013

Keywords:
Transitive reasoning
Infants
Preferences

ABSTRACT

Researchers have long been interested in the emergence of transitive reasoning abilities (e.g., if A > B and B > C, then A > C). Preschool-aged children are found to make transitive inferences. Additionally, nonhuman animals demonstrate parallel abilities, pointing to evolutionary roots of transitive reasoning. The present research examines whether 16-month-old infants can make transitive inferences about other people's preferences. If an agent prefers object-A over B ($A > B$) and B over C ($B > C$), infants seem to reason that she also prefers A over C ($A > C$) (Experiment 1). Experiment 2 provides indirect evidence that a one-directional linear ordering of the three items ($A > B > C$) may have helped infants to succeed in the task. These and control results present the first piece of evidence that precursors of transitive reasoning cognitive abilities exist in infancy.

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1. Introduction

The ability to make transitive inferences is an important element of logical thinking (e.g., Breslow, 1981; Piaget, Inhelder, & Szeminska, 1960; Thayer & Collyer, 1978). Making transitive inferences involves learning relationships among objects or entities and reasoning inductively about these relationships. For example, if told that "Jon is taller than Drew, and Drew is taller than Jory" and then asked "who is taller, Jon or Jory," adults can answer "Jon" by reasoning transitively; based on the relationship between Jon and Drew and that between Drew and Jory, they make inferences about the relationship between Jon and Jory.

Researchers have long been interested in the emergence of transitivity reasoning. Piaget was the first one to ask when children can make transitive inferences. In his theory, children's transitive reasoning abilities develop as they engage in flexible and logical thinking at around 7 or 8 years of age

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http://dx.doi.org/10.1016/j.cogpsych.2013.11.003

(Piaget, 1970; Piaget et al., 1960). Accordingly, younger children should have difficulty understanding transitivity since they still reason rigidly. In the previous example, they should be puzzled by the presence of two seemingly conflicting relationships, that is, Drew is both taller and shorter than others. As a result, children cannot integrate these two premises to draw the logical conclusion. Piaget used the inference task to gauge children's transitive reasoning abilities. In the task, children were asked to build a tower of blocks identical in height to one built by an experimenter. The two towers stood on surfaces of different heights, and various sticks were provided. To succeed, children had to spontaneously use the sticks as the intermediate measure of the heights of the towers. For example, the child needed to pick a stick (B), mark the height of the experimenter's tower (A) on the stick, and check if his own tower (C) had the same height as the mark on the stick. If his tower was taller or shorter (A = B < C or A = B > C), then he needed to remove or add blocks to get the same height (A = B = C). Children younger than 7 or 8 typically failed to do so. Other researchers also reported negative results with young children in various transitivity tasks (e.g., DeBoysson-Bardies & O'Regan, 1973; Murray & Youniss, 1968; Smedslund, 1963).

However, theorists have challenged Piaget's view on cognitive development. Instead of characterizing the difference between younger and older children as a qualitative shift from rigid to more flexible and logical thinking, they propose that cognitive abilities develop more continuously than Piaget thought (e.g., Carey, 1995; Gelman & Baillargeon, 1983; Gelman & Spelke, 1981; Spelke, 1994; Trabasso, 1975; Wellman & Gelman, 1998). In the case of transitive reasoning, many investigations reported preschoolers' success in tasks more straightforward than Piaget's (e.g., Braine, 1964; Bryant & Trabasso, 1971; Harris & Bassett, 1975; Riley & Trabasso, 1974; Trabasso, Riley, & Wilson, 1975). For example, in Bryant and Trabasso (1971), five sticks of different lengths and colors (denoted here as A, B, C, D, and E) were used. During training, 4- to 7-year-old children learned the relative heights of the sticks in four comparison pairs (A > B, B > C, C > D, D > E). The sticks were partly occluded so that their lengths were hidden; the children had to remember which colored stick was longer or shorter in a pair. During testing, children were asked to make length comparisons for learned and unlearned (and hence transitive) pairs. Critically, children's transitive comparisons, i.e., AC, AD, AE, BD, BE, and CE, were well above chance level, demonstrating their abilities to make transitive inferences about the sticks' relative lengths.

The task described above differs from Piaget's inference task in several aspects (e.g., Riley, 1976; Riley & Trabasso, 1974). For one, children did not have to discover the premise relationships among the items themselves; instead, they learned the premises through training, which ensured their comprehension and memory of the premises. Task comparisons such as these suggest that preschoolers can demonstrate their transitive reasoning abilities in supportive and optimal conditions (e.g., Thayer & Collyer, 1978). This speaks to the possibility of finding even earlier evidence of transitivity reasoning with age-appropriate methods.

Nevertheless, it remains unclear what accounts for the origins of transitive reasoning abilities. Findings from nonhuman animal studies shed light on this issue. Many investigations report that a wide variety of animal species succeed in transitivity tasks, including chimpanzees (e.g., Boysen, Berntson, Shreyer, & Quigley, 1993), squirrel monkeys (e.g., McGonigle & Chalmers, 1977), lemurs (e.g., MacLean, Merritt, & Brannon, 2008), rats (e.g., Roberts & Phelps, 1994), pigeons (e.g., von Fersen, Wynne, Delius, & Staddon, 1991), pinyon jays (e.g., Paz-y-Miño, Bond, Kamil, & Balda, 2004), and fish (e.g., Grosenick, Clement, & Fernald, 2007). These tasks involve transitivity along physical dimensions, e.g., orders in which images are presented, as well as social dimensions, e.g., linear dominance hierarchies. To illustrate, consider the study by Grosenick et al. (2007). During training, a bystander fish watched paired fights among other fish. For example, fish-A won over fish-B in fighting, thus demonstrating "A > B." As such, the bystander was trained on premises "B > C," "C > D," as well as "D > E." During test, when allowed to choose between A and E and between B and D by swimming towards one, the bystander fish was more likely to choose the potential "loser" in the pair, i.e., E and D, respectively. These results suggest that the fish used its observations during training to make transitive inferences about the untrained pairs, AE and BD.

These findings across various nonhuman animal species are consistent with the hypothesis that transitive reasoning abilities may be beneficial for the species' survival and are thus selected by evolution. As shown by the fish study described above (Grosenick et al., 2007), even without being

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