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Development and individual differences in transitive reasoning: A fuzzy trace theory approach

Samantha Bouwmeester [a,*], Jeroen K. Vermunt [b], Klaas Sijtsma [b]

[a] *Institute for Psychology, Erasmus University, P.O. Box 1738, 3000 DR Rotterdam, The Netherlands*
[b] *Tilburg University, The Netherlands*

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Abstract

Fuzzy trace theory explains why children do not have to use rules of logic or premise information to infer transitive relationships. Instead, memory of the premises and performance on transitivity tasks is explained by a verbatim ability and a gist ability. Until recently, the processes involved in transitive reasoning and memory of the premises were studied by comparing mean performance in fixed-age groups. In this study, an individual-difference model of fuzzy trace theory for transitive reasoning was formulated and tested on a sample ($N = 409$) of 4- to 13-year-old children. Tasks were used which differed with respect to presentation ordering and position ordering. From this individual-difference model expectations could be derived about the individual performance on memory and transitivity test-pairs.

The multilevel latent class model was used to fit the formalized individual-difference fuzzy trace theory to the sample data. The model was shown to fit the data to a large extent. The results showed that verbatim ability and gist ability drove the activation of verbatim and gist traces, respectively, and that children used combinations of these traces to solve memory tasks (testing memory of the premises) and transitivity tasks. Task format had a stronger effect on transitivity task performance than on memory of the premises. Development of gist ability was found to be faster than development of verbatim ability. Another important finding was that some children remembered the premise information correctly but were not able to infer the transitive relationship, even though the premises provided all the necessary information. This contradicts Trabasso's linear ordering theory which posits that memory of the premises is sufficient to infer transitive relationships.

* Corresponding author.
E-mail address: bouwmeester@fsw.eur.nl (S. Bouwmeester).

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Theory of transitive reasoning

General introduction

A transitive reasoning task requires the inference of an unknown relationship between two objects from the known relationships between each of these objects and a third object. For example, let three sticks, A, B, and C, differ in length, denoted as Y, such that $Y_A > Y_B > Y_C$; then given $Y_A > Y_B$ and $Y_B > Y_C$, the relationship between A and C can be inferred from these two relationships. In this example, the pairs $[A, B]$ and $[B, C]$ are the premise pairs and the relationships between the objects in the premise pairs constitute the premises.

A transitive reasoning task consists of a presentation stage and a test stage. At the presentation stage, the premise pairs are shown to the child. During the test stage, (s)he is asked to infer the transitive relationship from the premises; in the example, $Y_A > Y_C$. The object pair $[A, C]$ is the transitivity test-pair, because it tests the ability to infer a transitive relationship from the premises. The premise pairs may also be shown to test whether the child is able to remember the premises. When memory of the premises is tested, the premise pairs—in this example $[A, B]$ and $[B, C]$—are used as memory test-pairs.

According to Piaget (1947), children are capable of drawing transitive inferences when they understand the necessity of using rules of logic. When children know how to use these rules, they are able to solve any transitive relationship provided they can remember the premises. This understanding of rules of logic is acquired at the concrete operational stage, at approximately seven years of age. Then, for the first time children understand the reversibility principle (Piaget, 1942, 1947). A transitive inference effectively demonstrates this principle: When A is longer than B, the reversibility principle says that B must be shorter than A; and when one knows that A is longer than B, and C is shorter than B, one can use the reversibility principle to conclude that A is longer than C.

Children at the pre-operational stage—that is, at two to seven years of age (Piaget, 1947; see also Flavell, 1970)—do not yet understand the reversibility principle. Alternatively, these children consider objects or characteristics of objects in a nominal way, that is, not in relationship to other objects (Piaget, 1942). Due to this nominal thinking children are not capable of performing internalized operations on objects and they do not understand the necessity of using rules of logic. When a cue is provided about the ordering of the objects in a task, an understanding of such rules of logic may not be necessary to solve the task. For example, when all objects are presented simultaneously and when they are ordered on the dimension on which they differ, the position of the objects can be used for inferring their mutual relationships. Reasoning based on the use of cues is called functional reasoning. Functional reasoning is typical of the pre-operational stage. Piaget used transitive-reasoning tasks to study children's understanding of operational reasoning (Piaget, 1942; Piaget, Inhelder, & Szeminska, 1948).

According to Piaget's theory, memory of the premises is a necessary condition to solve a transitive relationship. Only when the premise information is available can children use the rules of logic to draw the transitive inference. Braine (1959) showed that after the premises had been learned children were able to draw transitive inferences at five years of age. He