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20.1 Introduction

In this chapter, the problem of strategy shifts in problem-solving is discussed within the framework of an extended Rasch model (RM) theory. A strategy-shift model is formulated that is similar to the (generalized) solution-error response-error model of Westers & Kelderman (1991). Modeling of strategy shifts is illustrated by means of the balance-beam task of Siegler (1981), which was administered to 484 Dutch 12-to-13-year-old children. Different hypotheses regarding the strategy shifts of subjects based on Siegler’s theory concerning the balance task are specified and empirically tested.

We present ways to deal with testing hypotheses on strategy shifts in problem-solving processes within the framework of loglinear RMs. Strategy shift is a phenomenon that frequently occurs when subjects solve test items. Siegler (1991) reports multiple-strategy use by children in domains such as arithmetic, causal reasoning, judgments of plausibility, reading and spelling, referential communications, serial recall, and spatial reasoning. Also, Siegler (1987) and Siegler & McGilly (1989) report frequent strategy shifts when children are presented identical problems on two successive days. In a study of spatial intelligence, Kyllonen, Lohman, and Woltz found that different subjects used different strategies for accomplishing the same goal in various spatial tasks, and that subjects shifted strategies depending on the demands of the task. The phenomenon of strategy shift seems to be an important aspect of intelligent behavior. It enables a person to “...flexibly adapt to problems to maximize performance” (Kyllonen, Lohman, & Woltz, 1984, p. 1343). Siegler & Campbell (1989) noted that:

Good reasons exist for us to know and to use multiple strategies. Strategies differ in their accuracy, in the amounts of time needed for execution, in their memory demands, and in the range of problems to which they apply. Strategy choices involve trade-offs among these properties; people try to choose strategies that enable them to cope
with cognitive and situational constraints. The broader the range of strategies we know, the more we can shape our approaches to the demands of particular circumstances.

Two kinds of strategy shifts can be distinguished in problem-solving: (1) shifts that primarily originate in the person, and (2) strategy shifts that are induced by the items. A strategy shift originates primarily in the person when the task characteristics of the items do not influence the strategy shift. For example, when a subject shifts strategy between two parallel items with the same difficulty, this is a person-dependent strategy shift. A strategy shift between two items is item-induced when the strategy shift depends only on task characteristics and is independent of the ability of the subjects. This would, for example, probably be the case when all subjects in a population solve one item using strategy 1 and solve an other item using strategy 2.

Usually, a person-dependent strategy shift cannot be distinguished from an item-induced strategy shift when they both can occur at the same time. The strategy-shift model that is presented in this paper can distinguish between the two types of shifts only on the basis of additional theory. The theory should describe which items have identical task characteristics. Item-induced strategy shifts are not expected to occur between structurally parallel items with the same difficulty, and the strategy-shift model of this paper can test this assumption.

In cognitive psychology, linear regression models were used to study strategy shifts of subjects in problem-solving by Ippel & Beem (1987) and Kyllonen, Lohman, & Woltz (1984). In IRT, a number of psychometric models have been formulated that can account for different strategies. Important references are Embretson et al. (1986), Kelderman & Macready (1990), Kelderman & Rijkes (1994), Mislevy & Verhelst (1990), Paulson (1986), Rost (1990), Samejima (1983), Tatsuoka et al. (1988), and Wilson (1989). However, most of these models focus on the case of consistent strategy use of subjects during the test and do not take strategy shifts into account.

In this chapter, the use of a strategy-shift model will be illustrated by means of its application to the balance (beam) task of Inhelder & Piaget (1958). The balance task is well known in developmental psychology, e.g., Case (1985), Inhelder & Piaget (1958), Klahr (1978), Siegler (1981), Wilkening & Anderson (1982). The task is used in this field to assess the knowledge structures and solution strategies of children in the context of a stagewise cognitive development. In this paper, a specific version of the balance task of Siegler (1981) will be used.

A number of measurement models have been formulated to model the subject’s response behavior on the balance task (Mislevy, Yamamoto, & Anacker, 1992; Kempf, 1983; Spada & Kluwe, 1980; van Maanen et al., 1989; Wilson, 1989). The balance task is an intriguing problem for psychometricians due to a number of characteristics revealed in Siegler’s theory (Mislevy, Yamamoto, & Anacker, 1992). First of all, according to Siegler, differences in understanding