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AN INVESTIGATION OF THE GENERALITY
OF SIEGLER'S RULE I MODEL

by

Gerald T. McFadden

B.A., University of Windsor, 1977

A Thesis
Submitted to the Faculty of Graduate Studies
through the Department of Psychology
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ABSTRACT

The general purpose of the present study was to evaluate Siegler's (1976, 1978) rule models by determining (a) the extent to which children's performance on balance scale problems could be classified according to Siegler's procedure, and (b) the generality of Siegler's models when a different assessment procedure was used. The specific aims of this study were to replicate Siegler's (1976) original classification of children's balance scale knowledge with a "choice" procedure, and to investigate the generality of Rule I children's knowledge with an "adjustment" procedure. For these purposes, 60 5- and 7-year-old boys and girls were presented Siegler's (1978) balance scale problems using an "adjustment" procedure.

A majority of children were classified according to Siegler's rules with both the "choice" (pretest) and "adjustment" (posttest) procedures. Siegler's (1976) finding that young children rely on the weight dimension to solve balance scale problems during the choice procedure was replicated in the present research. However, an assessment of pretest Rule I use during the adjustment procedure revealed that many of these children could use the distance dimension to solve balance scale problems. A secondary finding of the present study demonstrated the potential of Siegler's (1976) rule-assessment method for detecting unanticipated rule use. These findings were discussed with reference to methodological issues and directions for future research.

ACKNOWLEDGEMENTS

I wish to extend my most sincere gratitude and respect to Dr. A. Kobasigawa for his invaluable counsel and patience during the course of this research. While working with Dr. Kobasigawa, I was deeply impressed at how he thought towards solutions, with great vigour and clarity. I thank him for sharing that clarity and introducing me to the relevance of information processing models. I also thank my thesis committee members Dr. A. Foster and Dr. A. McCabe for their helpful suggestions and comments.

I thank Dr. A. Smith for his timely advice regarding statistical problems. As well, I extend my appreciation to Dr. R. S. Siegler for his encouraging comments and for sending me his original balance scale problems.

I appreciate the efforts of the staff and supervisors at the various City of Windsor Day Nurseries and Community Centres who made this study possible with their earnest cooperation.

A special acknowledgement is also in order for my brother James P. McFadden who generously allowed the use of his home computer. Finally, I would like to extend a warm thank-you to my parents and family for their support and encouragement during this project.

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CHAPTER I

INTRODUCTION

Developmental psychologists have recently attempted to chart the growth of children's problem-solving abilities in terms of an explicit series of emerging skills (e.g., Gelman, 1978). A major goal of this approach is to construct developmental models reflecting changes in a child's competence levels (Brown & Deloache, 1978). According to Brown and Deloache (1978) this use of model construction has several important features. First, the purpose of the model is to diagnose children's knowledge levels. Second, the components of the model should adhere to the principal of developmental tractability. This means that the model allows the investigator to state clearly initial, intermediate, and final forms of competence in a developmental sequence. A third characteristic is that these models are applied to a narrowly defined task domain (e.g., children's understanding of counting). Finally, that the model provides information about the subject's task strategy which allows for the design of instructional programs.

As an example of a successful use of this approach, several authors (e.g., Brown & Deloache, 1978; Miller, 1983) have referred to Siegler's (1976) research. In this research, Siegler has constructed a sequence of four increasingly complex rule-models corresponding to initial, intermediate, and final levels of children's competence on balance scale[1] problems. The general purpose of the present study was to evaluate Siegler's rule models by determining (a) the extent to which children's performance on the balance scale problems could be classified according to Siegler's procedure, and (b) the generality of Siegler's models when a different assessment procedure was used. In the following sections, Siegler's rule models and his findings relevant to the present study will be summarized. Then, a description of the general procedure of the present study will be provided.

Siegler's Rule Models and Empirical Data

Balance Scale Task. The balance scale task is related to the concept of proportionality and is considered an indicator of formal operational thinking (Inhelder & Piaget, 1958). In order to solve balance scale problems consistently, a child must understand the proportional relationship between the two dimensions relevant to this task. These dimensions are the weight of the object placed on the balance scale and the distance it is placed from the balance scale fulcrum. The proportional relationship between weight and distance is expressed by the following ratio:

$$\frac{W_L}{W_R} \lesseqgtr \frac{D_R}{D_L}$$

In this ratio W_L and D_L represent the amount of weight and distance, respectively, for the left side of the balance scale. Similarily, W_R and D_R are associated with the amount of weight and distance for the right side of the balance scale. The symbols "$<$", "$>$", and "$=$"

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[1] See Appendix A for a selective review of balance scale studies.

represent "left side less than right side," "left side more than right side," and "left side equals right side," respectively.

As shown in Figure 1 the balance scale used by Siegler (1976) consists of two identical arms on either side of a fulcrum. There is a series of four equally spaced pegs on each arm of the balance scale. To create balance scale problems, small circular weights are placed on either side of the fulcrum at varying distances. When only one peg on each side of the fulcrum is occupied by weights (i.e., a one peg problem), the correct solution can be obtained by using the cross product rule represented below by Equation 1.

$$(W_L \times D_L) \lesseqgtr (W_R \times D_R)$$

If the cross product of one side is larger, then that side will go down. However, if the cross products of both sides are equal, then the scale will balance.

Representation of Knowledge about Balance Scale. Siegler's (1976) method of investigating children's knowledge about balance scale problems consisted of three phases. First he generated four rule models that correspond to the use of increasingly more complex problem-solving strategies. Second, Siegler devised six different types of balance scale problems for assessing a child's rule usage. Finally, he matched predicted error patterns to children's actual behavior in order to diagnose their rule usage. Each of these phases will now be illustrated in the present and subsequent sections.

Siegler (1976) suggested that different levels of knowledge chidren have about the balance scale task could be represented as a series of binary decisions (see Figure 2) regarding how children use

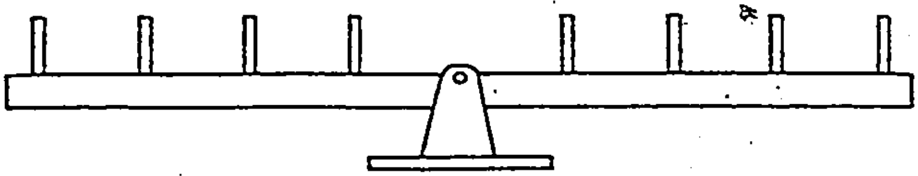


Figure 1. Balance scale apparatus

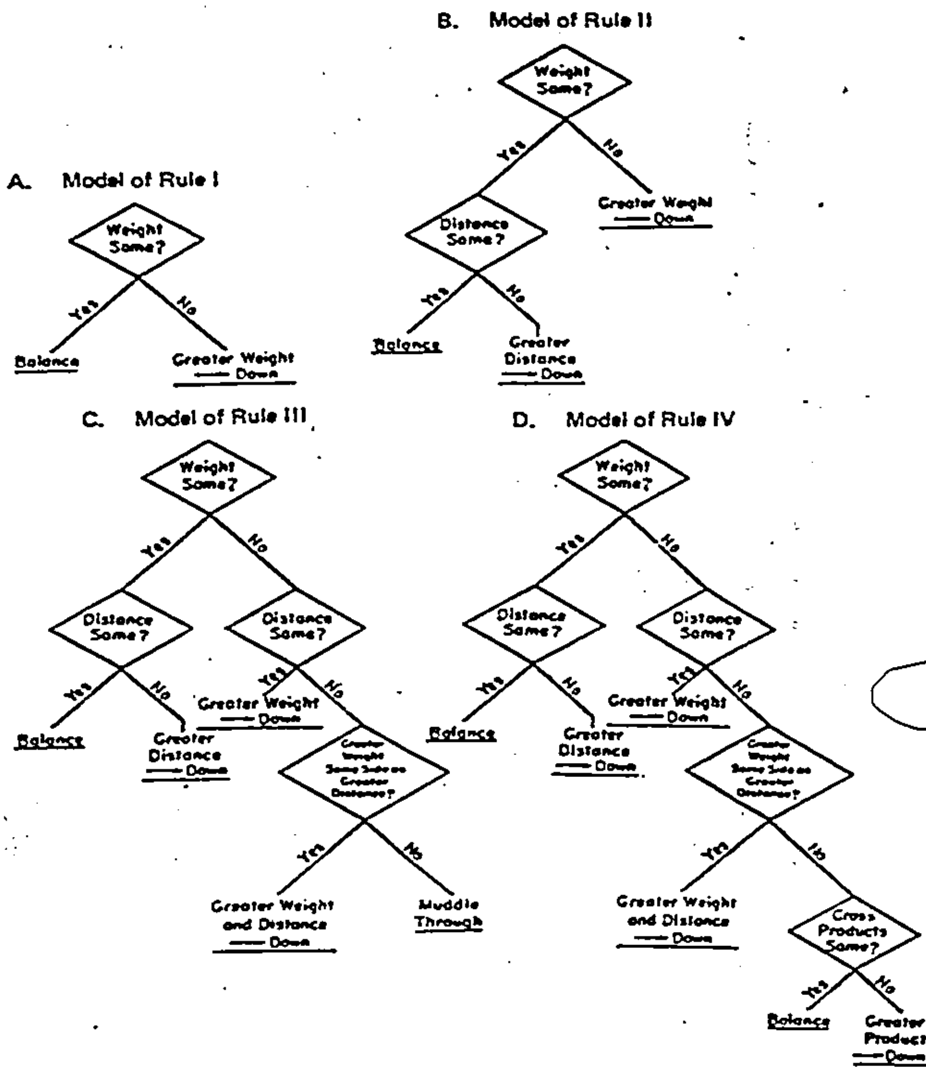


Figure 2. Decision tree rule models of balance scale performance (Siegler, 1978)

the two relevant dimensions, weight and distance. As can be seen in Figure 2, children using Rule I rely on only one of the two relevant dimensions, typically weight. Thus, a Rule I child will predict balance when the weights on each side are equivalent regardless of their respective distances from the fulcrum. If the weights are not the same, then the child will predict that the side with the greater weight will go down. A child using Rule II has a higher level of knowledge since he/she will take account of distance, but only in one case. When the weights on both sides are equal, the child looks for a difference in distance and predicts that the side with the greater distance will go down. When the weights are unequal, the child using Rule II will behave as a Rule I subject ignoring distance but considering only weight. A child following Rule III considers both weight and distance under any circumstances, and correctly solves problems as long as one or both dimensions are equal. However, the Rule III child has no consistent means to solve problems when one side has the greater weight and the other side has the greater distance. For such "conflict" problems, the child with Rule III will "muddle through" making random predictions. In Siegler's model, Rule IV represents the highest level of knowledge. A child using Rule IV behaves as Rule III users except in the case of conflict problems. In the conflict problem situations, the Rule IV subject uses the cross-products rule. Thus, Rule IV differs from Rule III in that "muddle through" is replaced with "compare cross-products."

<u>Assessment</u>. To determine which one of the four rules characterizes children's existing knowledge about the balance scale

task, Siegler (1976) constructed six types of problems (see Table 1, Problem-Type). Some of these problem-types can be solved by a child who primarily attends to either the weight or the distance dimension. Other problem-types require attention to both dimensions for a correct solution.

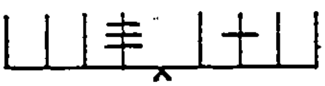
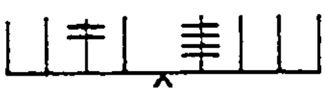
The first three problem-types (i.e., balance, weight, and distance) are solvable without any arithmetic computation. In balance scale problems, weight and distance are the same on either side of the fulcrum. For weight problems, the distances are equal but the number of weights on either side of the fulcrum are not equivalent. In distance problems, the amount of weight is equal but distance is different.

The second three problem-types are conflict-problems. In these problem-types the weight and distance cues are discrepant on either side of the fulcrum. In this case, the side of the balance scale with the greater weight is also associated with the shorter distance while the other side has the lesser weight associated with the longer distance. For example, two weights on the second peg to the left and one weight on the fourth peg to the right, is a conflict problem. The outcome for this example is that the balance scale remains level. Therefore, it is a conflict-balance problem. In conflict-weight problems, the side of the balance scale associated with the greater amount of weight goes down. For conflict-distance problems the side associated with the greater distance goes down.

Using Siegler's rule models, one can predict different response patterns for these six problems depending on which rule a particular

TABLE 1

Siegler's (1976, 1978) Predictions for Percentage of Correct Answers and Error Patterns by Problem-Type

Problem-Type	Rules: Random Model	I'	I	II	III	IV
(B) 	33	0*	100	100	100	100
(W) 	33	100	100	100	100	100
(D) 	33	50*	0	100	100	100
(CW) 	33	100	100	100	33	100
(CD) 	33	0	0	0	33	100
(CB) 	33	0	0	0	33	100

*A Rule I' child behaves as a Rule I user except on balance and distance problems. Where Rule I predicts a response of "balance" for these two problem-types, Rule I' predicts "left side" or "right side" down but not "balance" (Siegler, 1978). Thus on balance problems a Rule I' child would have two possible responses both always incorrect, therefore 0% correct answers are predicted. Similarily on distance problems a child using Rule I' chooses from two possible responses yielding a prediction of 50% correct answers child is using (see Table 1, Rule I-IV). According to the model, children using Rule I typically rely on the weight dimension when solving balance scale problems. A child using Rule I, therefore, would make correct predictions on all of the problems solvable by the weight dimension; that is, on the balance, weight, and conflict-weight problem-types. Children using Rule I are expected to predict incorrectly on all other problem-types since the model indicates they are not taking into account the distance dimension (see Table 1, Rule I).

As is shown in Table 1, a child adopting Rule II is expected to have the same correct prediction pattern as a Rule I user, except on distance problems. In this case, a child using Rule II is expected to consider the distance dimension, and therefore, predicts correctly. Children following Rule III consider both weight and distance in all situations and are expected to be correct on all three nonconflict problems. However, a child following Rule III has no means to resolve the conflicting dimensional cues on conflict problems, and is expected to perform at a chance level on the three types of conflict problems. As a result, his/her predictions will be correct 33 percent[2] of the time on conflict problems. A child adopting Rule IV is expected to perform correctly on all six problem-types as he/she is using the most mature rule.

Empirical Findings. Siegler's empirical findings will now be discussed. In his initial study, Siegler (1976, Experiment 1) presented 120 female subjects, ages 5- to 17-years-old, with a 30 item test. This test consisted of four items from each of the first

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[2]This percentage is derived because balance scale problems have three possible outcomes (right side down, left side down, or balance).

three problem-types (i.e., balance, weight, and distance), and six items from each conflict problem-type.

Siegler's major findings are summarized in Table 2. First, his findings indicate that age correlates with the maturity of rules that children use. Thus, virtually all of the 5- and 6-year-olds used Rule I, the 9- and 10-year-olds used Rules II and III most frequently, and 13- and 17-year-olds used Rule III most frequently. Also it is noteworthy that few children even at the oldest age level used Rule IV. Secondly, as evident in Table 2, classifiability improves with age. For example, in the youngest age group 23 percent of the children were unclassified while all subjects in the oldest age group were classified as using a rule. As will be shown next, many of these younger children may have been using a "random" rule.

In an investigation of 3- and 4-year-olds balance scale knowledge, Siegler (1978) found many of these young children responding randomly. These children were classified as Random Model users (see Table 1). After training and feedback, some of thse young children adopted what Siegler (1978) termed a Rule I' approach. Children using Rule I' behaved similarily to those using Rule I except where the model indicated a response of "balance." Rule I' users never say "balance" in these situations but either guess left side or right side down. Considering the large number of unclassified 5- and 6-year-olds in Siegler's (1976) Experiment 1, it is possible that their knowledge level could have been best represented by a Rule I' or Random Model description.

TABLE 2

Siegler's (1976) Predictions Data

Age	Rules				
	I	II	III	IV	Unclassified
5-6	23	0	0	0	7
9-10	3	9	12	2	4
13-14	3	7	17	1	2
16-17	0	6	19	5	0
Total	29	22	48	8	13

Present Study

In the preceding sections, Siegler's method of investigating children's knowledge about balance scale problems was summarized. Initially, he generated four rule models that would correspond to children's use of increasingly more complex problem-solving strategies. He then determined which rule models would best represent a particular child's knowledge by examining his/her responses to six different types of balance scale problems. It was indicated that the majority (i.e., 77% or better) of children's knowledge could be accurately classified by his rule models. Considering the significance of Siegler's methodology in revealing children's levels of knowledge (e.g., Brown & Deloache, 1978; Miller, 1983), it is interesting that, at present, attempts have not been made to replicate his rule-assessment approach. One purpose of the present study, therefore, was to determine if children's performance on the balance scale task could be classified as successfully as Siegler demonstrated (replication).

Another purpose of the present study was to determine the generality of Siegler's rule models. As was described in the preceding section, Siegler assessed children's knowledge about the balance scale using one type of assessment condition, namely a "choice" procedure. He has concluded that children's existing knowledge about the balance scale can be specified unambiguously (Siegler, 1976, 1981). It has been well known however, that the identification of the presence or absence of particular knowledge in children is not a simple matter, conclusions being dependent on the use of different procedures (e.g., Flavell, 1977; Gelman, 1979; Smedslund, 1969).

Consider, for example, Siegler's Rule I. Children who adopt this rule are known to focus only on the weight dimension while solving balance scale problems. If Siegler's method is actually assessing children's existing knowledge, then, the failure to use the distance dimension may be caused by their lack of knowledge of the importance of the distance dimension. Alternatively, it is possible that at least some of the children diagnosed as Rule I users may actually know that the distance dimension is important. These children may fail to use the distance dimension in Siegler's task perhaps because that dimension in some manner lacks perceptual salience. In light of these considerations, the present study was conducted to determine whether or not converging evidence for the use of Siegler's Rule I could be obtained with a different assessment condition.

For the purposes of the present study, 5- and 7-year-olds knowledge about the balance scale was initially assessed using Siegler's choice procedure (pretest). With regard to the replication purpose, the pretest data were used to determine what proportion of the subjects could be classified according to Siegler's rule models. At the same time, the age-related improvement in children's knowledge about balance scale problems was examined.

On the basis of their performances on the pretest, Rule I users were identified. The generality of children's Rule I knowledge was then determined using an "adjustment" procedure. Weights are placed on both sides of the balance scale fulcrum in Siegler's choice procedure. In contrast, the experimenter manipulates weight and distance only on one side of the balance scale for the adjustment procedure. Then the child is given a specific number of weights and asked to place them at a point on the other side where he/she thinks that the two sides will balance or that one side will go down. This procedure was selected for the present study because the task requires children to manipulate the amount of distance, and consequently, it may increase the perceptual salience of the distance dimension. In addition, this procedure also allows us to predict different patterns of responses by children using different rules. Suppose, for example, that weight x is placed on the left side at three distance units from the fulcrum. The child is asked to place an object of the same weight on the right side so that (a) a balance situation will result or (b) the right side will go down. For problem a, a child using Rule I, according to Siegler's model, will choose any point on the right side as a solution. However a child having a knowledge level of Rule II or higher should select the correct point, three distance units from the fulcrum on the right side. For problem b, a child adopting Rule I should find this task impossible to solve (since the scale should always balance when two weights are equal). As a result, if asked to place the weight, he/she will choose any point on the right side. A child adopting Rule II or a higher rule should choose to place the object at the fourth distance unit. (Specific patterns of responses to different balance scale problems for the adjustment task are described in detail in Table 3, see page 18). Using children of two age levels, it was possible to determine whether or not the generality of children's knowledge might be observed differently at different age levels.

Suppose that children perform better on the adjustment procedure items than on Siegler's (1976) balance scale task. Although this finding may indicate that Siegler's procedure underestimates children's existing knowledge, it is possible to interpret this result differently. As described previously, the adjustment task was always used during the posttest. Therefore, any improvement on this task over Siegler's task could have been attributed to "practice effects." In order to control for this alternative interpretation, Siegler's "distance problems", solvable by Rule II usage, were also administered to children during the posttest. The distance problem-type is not solved until Rule II of Siegler's model. Therefore inclusion of Siegler's distance problems during the posttest indicated whether subjects selected during the pretest were continuing to use Rule I.

CHAPTER II

METHOD

Subjects

Thirty 5-year-old (mean CA = 63.85 months; range = 60-70 months) and 30 7-year-old (mean CA = 87.67 months; range = 84-95 months) children from several Day Nurseries and Community Day Care facilities operated by the City of Windsor were used as subjects in the present study. There were an equal number of males and females in each age level. All subjects were given both the Siegler pretest and the adjustment posttest.

Materials

Balance Scale. The materials included a wooden balance scale, 14 differently coloured metal weights, and two aluminum posts. The balance scale's arm was 32 inches in length, with four pegs on each side of the fulcrum. The first peg was 3 inches from the fulcrum and the distance between each subsequent peg was also 3 inches. The balance scale arm could swing freely from the point of attachment to the fulcrum, 4 inches above the fulcrum's base. Two aluminum posts were placed under the arm of the balance scale to prevent it from tipping when the weights were arranged on the pegs. Every weight was circular and had a hole in its centre so that it could be fitted on the pegs. Each weight weighed approximately 28.1 grams (range 28.09-28.1) with an outside diameter of 1 1/4 inches and an inside diameter of 5/8 inches. As many as six weights could be placed on any given peg.

Pretest Items. The pretest consisted of 24 items from Siegler's (1976) Experiment 2. Four test items were selected from each of the following six problem-types: balance, weight, distance, conflict-weight, conflict-distance, and conflict-balance tasks (for examples of these problem-types, see Table 1). For balance problems, equal numbers of weights were arranged on both sides of the balance scale at identical distances from the fulcrum. Weight problems had different numbers of weights at identical distances from the fulcrum. Distance problems had equal numbers of weights at differing distances from the fulcrum. For the conflict problems, one side of the balance scale had the greater number of weights while the weights on the other side were further from the fulcrum. On conflict-weight problems the balance scale would tip towards the side associated with the greater weights. For conflict-distance problems the balance scale would tip to the side associated with the greater distance. On conflict-balance problems the balance scale would remain level. Specific problems appear in Appendix B.

Posttest Items. There were two sets of posttest items. Eight items were selected from Siegler's task (4 distance and 4 conflict-distance). These items were used for the "choice" task to determine whether or not the subjects continued to use Rule I during the posttest session. The remaining 20 items were prepared for the adjustment procedure of the posttest session.

During this adjustment procedure children were required to place weights on one side of the balance scale to generate a desired outcome (i.e., left/right side down, or balance). For example, a balance scale with three weights two pegs to the left was presented to a child. He/she was given three weights in this case and asked to place them on the empty side of the balance scale so that it would remain level. This particular problem was similar to Siegler's (1976) balance problem-types. It was referred to as an adjustment balance (AB) problem (see Table 3, Problem-Type). Similarly an adjustment weight (AW) problem required that the child place a predetermined number of weights on the empty side of the balance scale in order to make the heavier side go down. For adjustment distance (AD) problems the child was required to place an identical amount of weight on the empty side of the balance scale so that side would go down. On adjustment conflict-distance (ACD) problems the child had to place the less amount of weight on the empty side of the balance scale further from the fulcrum than the distance associated with the greater weight on the occupied side so that the lighter side of the scale would go down. For adjustment conflict-balance (ACB) problems the child was required to create a balance situation by placing the lesser amount of weight at the correct point of greater distance on the empty side. An example of each of these problem-types[3] is shown in Table 3. The arrow indicates the proper placement of the weights for a correct solution. Four adjustment problems of each type were given to every child.

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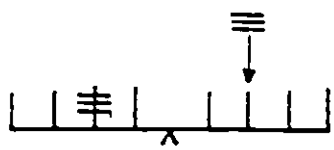
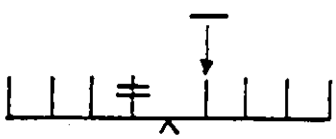
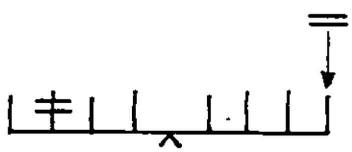
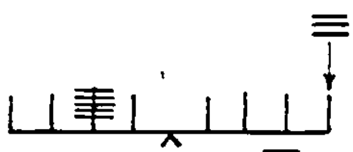
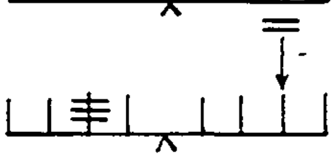
[3]Siegler's (1976) conflict-weight problem-type is not readily adapted to the adjustment procedure and therefore will not be included in the posttest.

TABLE 3

Predictions for Percentage of Correct Answers and Error Patterns by Problem-Type for the Balance Scale Task using the Adjustment Procedure

Problem-Type		Rules				
		RM*	I-D	II	III	IV
(AB)		25	100	100	100	100
(AW)		25	25	25	100	100
(AD)		25	100	100	100	100
(ACD)		25	100	25	100	100
(ACB)		25	0	25	50	100

*Note 1. For the adjustment procedure, the prediction pattern for the RM category also applies for Rule I' use, and for the use of Rule I by children who attend primarily ~~to~~ the weight dimension. This is possible since any children using Rule I' or Rule I (weight) during the adjustment procedure should respond at a chance level (i.e., 25 percent correct). It should be noted, that this RM category may contain children who are actually functioning at higher knowledge levels rperesented by Rule I' or Rule I (weight).

In order to generate the predictions of Table 3 one needs to consider the distinguishing features of Siegler's (1976) rule models in terms of the adjustment procedure. As indicated previously, children following Siegler's Rule I model focus only on the weight dimension or only on the distance dimension (Rule I-D) while solving balance scale problems. For the present study, children responding by emphasizing the weight dimension will be referred to as Random Model[4] users. Children responding on the basis of the distance dimension but ignoring weight will be called Rule I-D users. According to Siegler's model, a child using Rule I (weight) should not be able to solve balance scale problems on the basis of the distance dimension. Rule I (weight) children, therefore, will place the weights on any one of four possible pegs for any problem-type during the adjustment procedure and should be correct only 25 percent of the time. Rule I-D children, on the other hand, attend to the distance dimension during balance scale problems, disregarding the weight cue. A child using Rule I-D should predict "balance" when the distances on either side of the balance scale from the fulcrum are equivalent. Whenever one side of the balance scale is greater, the Rule I-D child should predict that side will go down. Children using Rule I-D during the adjustment procedure, therefore were expected to solve AB and AD problems correctly at all times (i.e., 100 percent). For AW problems, consider the example shown in Table 3 where two weights are on the first peg to the left of the fulcrum. In this example, the child is given one weight and asked to place the weight on one peg to the right of the fulcrum so that the left side will go down. A Rule I-D child should think

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[4] With the present adjustment procedure, RM, Rule I', and Rule I children will show the same prediction pattern, namely, 25 percent correct. As shown in Table 3, children responding at a chance level were placed in the RM category even though they may have had a Rule I' or a Rule I knowledge level.

that by placing his/her weight on the first peg of the right side, a "balance" situation will result since the distances on either side of the fulcrum are equal. A Rule I-D child also knows that choosing a greater distance from the fulcrum (second, third, and fourth pegs) may cause the right side to go down. For this AW problem, none of the pegs on the right side appear to be a correct solution to a Rule I-D user. Since the child is required to place the weight, he/she will respond randomly (i.e., 25 percent correct) by placing his/her weight on any one of the four available pegs on the right side. For the ACD problem-type, five weights are on the second peg to the left of the fulcrum and the child is given three weights and asked to place them on one peg to the right of the fulcrum in order to make the right side go down (see Table 3). A Rule I-D child knows that distance is important and should not place his/her weights on the first peg to the right of the fulcrum since, in this case, the left side will have the greater distance and should go down. This child should not choose the second peg to the right of the fulcrum because then the distances on either side of the fulcrum would be equal and the balance scale will remain level. To make the right side go down, the Rule I-D child will consider placing his/her weights on either the third or fourth peg on the right side since these pegs are at greater distances from the fulcrum than the occupied second peg on the left side. Since a Rule I-D child does not know that the weight dimension is important for solving the ACD problem, he/she should choose the correct peg (i.e., the fourth one) only 50 percent of the time. For ACB problem-types, consider the example shown in Table 3 where there are three weights on the second peg to the left of the fulcrum. The Rule I-D child is given two weights and asked to place them on one peg on the right side to make a balance. The Rule I-D child should neglect the differences in the amounts of weight and attempt to make a balance by equating the distances on either side of the fulcrum. In this example, a Rule I-D child should choose the second peg on the right side of the fulcrum which equates the distances. However, this strategy is never correct, so that a Rule I-D child never solves ACB problems (i.e., 0 percent correct).

Children using Rule II in Siegler's procedure solve balance scale problems using the weight dimension primarily. However, when the weight on either side of the fulcrum is equal, they attend to the distance dimension. In the case of AB problems, children are given an amount of weight to place on the empty side which is equal to the amount on the occupied side of the balance scale. Rule II users should correctly place their weights on the empty side of the balance scale at an identical distance from the fulcrum as the weights on the occupied side for the AB problems (i.e., 100 percent correct). For AW problems, the child is required to place one weight on the right side so that the left side will go down (see Table 3). In this case, the greater amount of weight (i.e., 2 weights) is on the left side of the fulcrum, and according to Siegler's Rule II model, the child should always think that the left side will go down, irrespective of the amount of distance. They will, therefore, choose any one of the four available pegs on the right side, and will be correct 25 percent of the time, since only the first peg on the right side solves the AW problem-type. For AD problems, as in the example shown in Table 3, the experimenter always places the weights for the occupied side on the third peg from the fulcrum. In these AD problems, Rule II children are required to place an amount of weight on the empty side of the balance scale which is equivalent to the amount of weight on the occupied side. Consequently, Rule II users should attend to the distance dimension and place their amount of weight further from the fulcrum than the weight on the occupied side. Rule II children, therefore, should always choose the fourth peg on the empty side to place their weight and will be correct 100 percent of the time. A child using a Rule II approach should solve the ACD and ACB problems similarily to a Rule I child (i.e., 25 percent correct), since he/she is unable to coordinate the distance and weight dimensions for conflict problem-types.

Children using Rule III are able to coordinate the dimensions of weight and distance for nonconflict problems and, therefore, were expected to solve AB, AW, and AD problem-types correctly at all times. For ACD problems, Rule III children were expected to be correct 100 percent of the time since they have knowledge that distance compensates for weight. For the ACB problem-type shown in Table 3, there are three weights on the second peg to the left of the fulcrum and the child is required to place two weights on the right side to make a "balance" situation. In this case, Rule III children should not choose to place their weights on the first peg of the right side (the greater weight on the left would be associated with the greater distance and, therefore, the left side would go down) or on the second peg (they should know that the greater weight is on the left side, which will go down). Rule III children cannot make precise predictions in this case since their knowledge that distance compensates for weight is not sufficient to solve the ACB problem-type. Therefore, they should "muddle through" and place their weights on either the third or fourth peg on the right side. Since choosing to place the weights on the fourth peg of the right side is the only correct solution, Rule III users will solve the ACB problem-type only 50 percent of the time.

Children using Rule IV should be able to coordinate the weight and distance dimensions in all situations and, therefore, will always choose correctly.

Procedure

Pretest. The children were interviewed individually in an available room at their Day Nursery or Community Centre. The children's knowledge levels were assessed during the pretest following Siegler's criteria (see Rule Assessment Criteria section).

In general, each child was asked to sit next to the experimenter at a table with the balance scale in front of them. After briefly establishing rapport with the child, the pretest session began with the following instructions: "Today we are going to play with this balance scale. The balance scale has these pieces of wood that are all the same distance from each other (E points to the pegs) and these pieces of metal that all weigh the same." At this point the child was encouraged to hold some of the weights to see that they all weighed the same.

The child was then told: "Now lets see what you know about the balance scale. This side of the balance scale (E points to left side) will be your side. I'll put weights on the pegs in different ways and you tell me whether my side or your side would go down or whether they would stay like they are now if I took these supporting posts away. The balance scale won't actually move but you tell me how the scale would go if the supporting posts were not there. Any questions? OK. Let's begin."

The experimenter then presented the first problem to the child by placing the metal weights on the pegs on the two sides of the balance scale. The child was asked to predict which side would go down or whether the scale would balance if the supporting posts "were not there." After the child's prediction, the experimenter said "Good," and moved on to the next problem. The 24 items (problems) were ordered within the pretest by means of stratified random sampling so that one item of each problem-type was included in the first six problems, one in the next six problems, and so on.

Posttest. One week from the collection of the pretest data, all of the children were assessed first with eight Siegler items, followed with 20 adjustment procedure items. For the Siegler items the children were given the same instructions as in the pretest. For the adjustment items the instructions were as given below.

The adjustment procedure began with the following instructions: "This time we will play a different game with this balance scale toy. Like the last time we played, this side (E points to left side), will be your side and this side (E points to right side) will be my side. I will place some weights on only one peg, for example, on my side (E points to right side). Then I will give you some weights to place on your side (E points to left side). Sometimes I will ask you to place the weights where you think it will make your side go down. But sometimes I will ask you to place the weights on your side (E points to left side) where you think it will make my side (E points to right side) go down. And sometimes I will ask you to place the weights where you think it will make the scale balance if these posts (E points to support posts) were taken away. The balance scale won't actually move but you place your weights pretending that these posts were not there. Any questions? OK. Let's begin."

The experimenter then placed a number of weights on one side (i.e., E's side) of the empty balance scale. The child was given some weights and asked to place them on one peg of the remaining empty side (i.e., S's side) in order to generate a specific outcome (e.g., E's side down) if the support posts "were not there." After the child's response, the experimenter said "Good," and moved on to the next problem. The eight Siegler items were given first during the posttest. These items were ordered again by means of stratified random sampling so that one item of each problem-type was included in the first two problems, one in the next two problems, and so on. The 20 adjustment procedure items followed and were similarily ordered by means of stratified random sampling.

Rule Assessment Criteria

The performance of each child on every pretest and posttest item was dichotomously scored "1" to indicate a correct response, and "0" to indicate an incorrect response. The criteria[5] for assessing rule usage in the Siegler procedure was as follows: Rules I, II, or IV were assessed if at least 20 of the 24 responses corresponded to the predictions made by that rule (see Table 1). Also for Rule I, at least three predictions of "balance" in the four distance problems were required. For Rule III at least 10 predicted responses in the 12 problems for which determinate predictions could be made and at least three exceptions to the simple weight (distance) cue on the 12 conflict items (Siegler, 1976, p. 493, pp. 502-503).

Criteria for assessing rule usage for the Siegler items in the posttest were constructed[6] as follows: Rules I, II, or IV were assessed if at least 6 of the 8 responses corresponded to the predictions made by that rule (see Table 1). Also for Rule I, at least three predictions of "balance" in the four distance problems were required. For Rule III, at least three predicted responses in the four problems for which determinate predictions could be made and at least one exception to the simple weight (distance) cue on the four conflict items (Siegler, 1976, p. 493, pp. 502-503).

The criteria for assessing rule usage in the adjustment procedure were arbitrarily derived following the hypothetical response patterns shown in Table 3. Rules RM, I-D, II, III, or IV

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[5] From Wilkening and Anderson (1982, p. 218).

[6] Adapted from Siegler (1976) and Wilkening and Anderson (1982).

were assessed if at least 16 out of 20 responses corresponded to predictions made by that rule. With this arbitrary criteria to determine rule usage, it was possible that some children could achieve 16 out of 20 responses which corresponded to more than one rule model. If this was the case, any child assessed as using more than one rule was classified conservatively in one of these rule categories which represented the least amount of knowledge about the adjustment problem-types. For example, if this situation of "double classification" occurred for some children between Rules I-D and II, they would be classified at a Rule I-D level. As an additional example, suppose that some children were classified at both a Rule II and a Rule III level. Then, for the present study, they would be considered as Rule II users.

CHAPTER III

RESULTS

The results of the present study will be summarized in two sections. In the first section, the rule model classification of children's performance for Siegler's (1976) version of the balance scale task will be presented (replication). Then the correct responses children made during the Siegler pretest will be examined for age-related differences in performance. In the second section, the rule model classification of children's performance during the adjustment procedure will be presented. Following this, a rule-assessment of the pretest Rule I children's performance on the adjustment balance scale problems will be illustrated (generality). These assessments will be necessary for an analysis in the following section of children's use of the distance dimension during the present study. In this analysis, changes in the use of the distance dimension between the pretest and posttest sessions will be indicated. In addition, any age-related differences in the use of the distance dimension will be reported for the pretest Rule I users. Finally, an analysis of the correct responses made by the pretest Rule I children during the adjustment posttest will be examined. The purpose of this analysis is to determine differences between observed and predicted performance for the pretest Rule I users during the adjustment procedure (generality).

Predictions Data for the Siegler Pretest

Classification by Rule Models. Children's predictions of "balance" and "left/right side down" for Siegler's (1976, 1978) balance scale problems were used to assess their rule usage during the pretest. The number of children classified for each level of age and sex according to Siegler's rule models are shown in Table 4. Using Siegler's (1976) original four rule models, 48 of the 60 children (i.e., 80%) in the present study were classified as rule users. With the addition of the Random Model and Rule I' categories, 52 of these 60 children (i.e., 87%) were classified as using one of Siegler's rule models. Three children were found to use the Random Model rule; one used Rule I'; 42 used Rule I; and six used Rule II. No children using Rules III or IV were found. Only eight children (i.e., 13%) could not be classified following the criteria for Siegler's rule models.

Seven of the 8 unclassified children solved the balance scale problems by predicting "less weight down" (i.e., LWD) whenever the amount of weight was different on either side of the fulcrum. When the weight on either side of the fulcrum was equivalent, these LWD children predicted "balance" as would a Rule I user. The LWD children, therefore, predicted correctly for the balance problem-type identical to Rule I children. Unlike Rule I users, however, the LWD children predicted incorrectly for the weight and conflict-weight problems. In addition, LWD children predicted incorrectly for distance problems, as did Rule I users, that the balance scale would remain level. However, for the adjustment conflict-balance problems,

TABLE 4

Number of 5- and 7-Year-old Male and Female Children Assessed for Rule Usage in the Siegler Pretest with Predictions Data

Age	Sex	RM	I'	I	II	III	IV	Unclassified ?*	Unclassified LWD
5	M	0	0	11	1	0	0	1	2
	F	3	1	8	0	0	0	0	3
7	M	0	0	13	2	0	0	0	0
	F	0	0	10	3	0	0	0	2
Totals		3	1	42	6	0	0	1	7

*Note 1. The "?" sybmol represents the category of children who were not using an LWD approach but were unclassified with predictions data.

the LWD children predicted incorrectly that the side with less weight would go down, instead of the side with more weight, as would a Rule I child. The LWD children predicted correctly for conflict-distance problems since a "less weight down" approach solves this problem-type. This finding was unanticipated since Siegler (1976, 1978) proposed that Rule IV use was necessary to consistently solve the conflict-distance problem-type. Because these LWD children used only the weight dimension but with a different rule (lighter side down), they could be considered as a special case of Rule I users.

The remaining unclassified child, a 5-year-old male, made 20 out of 24 responses which corresponded to Rule I use. However, this child was unclassified in the present study since he predicted "balance" for two instead of three distance problems as required for Rule I assessment.

Analysis of Correct Predictions. The mean number of correct predictions for each problem-type for all experimental groups is illustrated in Figure 3. These data were analyzed by a 2 (age: 5- versus 7-year-olds) X 2 (sex: male vs. female) X 6 (problem-type: balance, weight, distance, conflict-weight, conflict-distance, or conflict-balance) analysis of variance with repeated measures on problem-type. This analysis revealed significant main effects for age and for problem-type, F (1,56) = 10.19, $p < .01$, and F (5,280) = 151.36, $p < .001$, respectively. In addition, the analysis revealed two significant interaction effects, one between age and problem-type, F (5,280) = 3.66, $p < .01$, and another between sex and problem-type, F (5,280) = 2.78, $p < .05$.

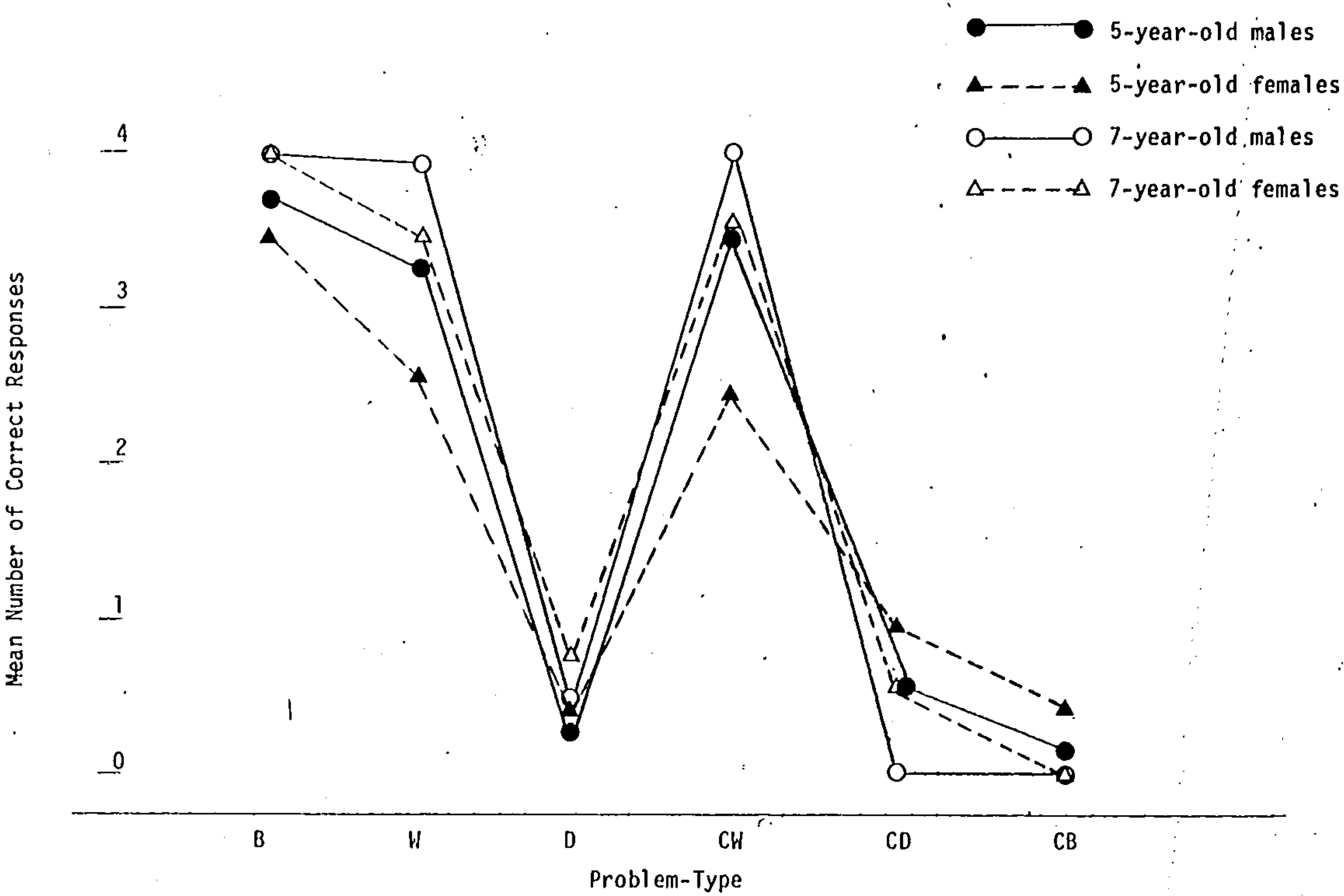

Figure 3. Mean number of correct responses for each problem-type for each group during the pretest.

In order to analyze these significant interactions, Tukey's (HSD) procedure was used (Horvath, in press). As shown in Figure 4, the significant age and problem-type interaction can be explained by the fact that the 7-year-olds performed better than the 5-year-olds on the two problems that can be solved by Rule I, namely, the weight and conflict-weight problems, $p < .05$, whereas other age-related differences in performance on the remaining problems were not significant. The further analysis of this interaction showed that, irrespective of age level, the balance, weight, and conflict-weight problems were solved significantly more often than the distance, conflict-distance, and conflict-balance problems. These findings are reasonable since the first three problems can be solved with Rule I while the remaining three require a knowledge level of Rule II or higher.

As shown in Figure 5, the significant sex and problem-type interaction can be explained by the fact that the males performed better than the females on the two problems that can be solved by Rule I, namely, the weight and conflict-weight problems, $p < .05$, whereas, other sex-related differences in performance on the remaining problems were not significant. A further analysis of the sex and problem-type interaction indicated that, irrespective of sex, the balance, weight, and conflict-weight problems were solved significantly more often than the distance, conflict-distance, and conflict-balance problems. As was the case for the age and problem-type interaction, these findings indicate the use of Rule I by children during the pretest.

In summary, the pretest predictions data demonstrated that

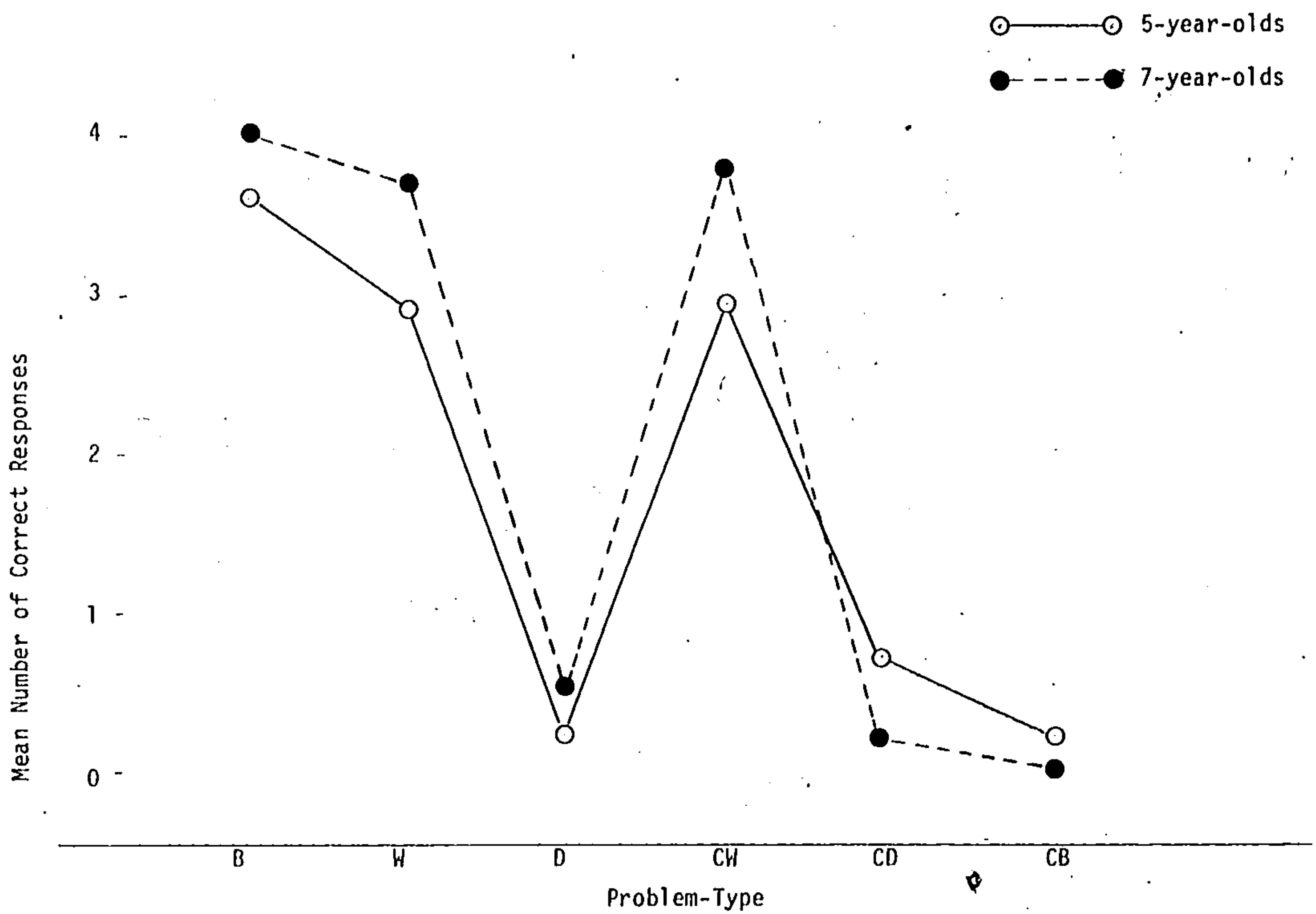

Figure 4. Mean number of correct responses for each problem type for 5- and 7-year olds (Siegler Pretest).

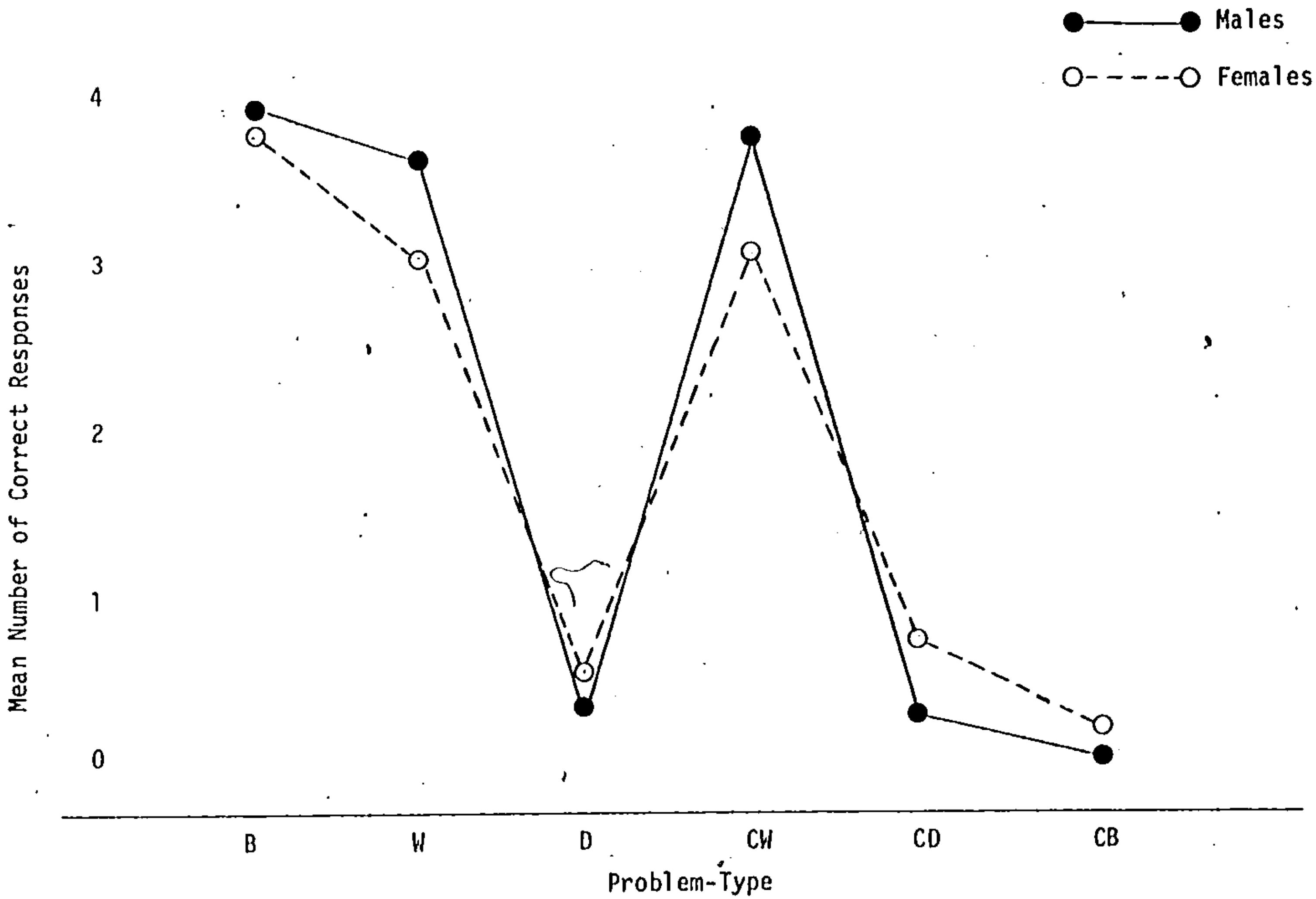

Figure 5. Mean number of correct responses for each Siegler pretest problem-type for males and females.

most children (87%) could be classified as using one of Siegler's (1976, 1978) rule models. In addition, seven children were found using a "less weight down" rule to solve balance scale problems during the pretest session. While these children's rule was not included in Siegler's models, their response patterns were, as Siegler assumes, clearly controlled by a rule. The analysis of variance revealed that, for weight and conflict-weight problems, the 7-year-olds performed better than the 5-year-olds, and the males performed better than the females. In addition, irrespective of age or sex, the balance, weight, and conflict-weight problems (Rule I problems) were solved more often than the remaining three problem-types that require Rule II or higher. In the next section, the findings of the posttest session will be reported.

Adjustment Posttest

Siegler's (1976, 1978) rule-assessment method was used to determine children's knowledge levels for the adjustment procedure. In the following analysis, these rule-assessments will be used to categorize children's use of the distance dimension. Then, the generality of Siegler's Rule I model will be determined by assessing for changes in children's use of the distance dimension between the pretest and posttest sessions. (Recall that 54 of 60 children did not use the distance dimension for the choice task.) In addition, the generality of Siegler's Rule I model will be assessed by comparing the observed posttest performance of pretest Rule I users with their expected performance.

Classification by Rule Models. The method of assessing rule usage for the adjustment procedure was described in detail in a previous section of the present study. To review this method, children were initially assessed as using any of Rules RM, I-D, II, III, or IV if 16 of their 20 responses corresponded to the predictions of that rule (see Table 3). Whenever a situation of "double classification" occurred, the children assessed in two categories were arbitrarily assigned to the lower of the two rule classifications. By assigning these children to the rule classification representing the least amount of knowledge about the adjustment balance scale task, it was hoped that children's knowledge was not overestimated.

The number of children classified with the adjustment procedure are shown in Table 5. It should be noted that the numbers in parentheses in Table 5 indicate the number of children who achieved 16 out of 20 responses according to the next highest rule (i.e., double classification). For example, consider the children classified as shown in Table 5 at a Rule I-D level. For the 7-year-old males, four are classified at the Rule I-D level. In this example, the "2" in parentheses indicates the number of these 7-year-old males who were also classified at a Rule II level. In other words, 2 of the 4 7-year-old male Rule I-D users could have been classified at a Rule II level. Twelve of the 60 children (i.e., 20%) were "double classified" into both of two rule categories.

As shown in Table 5, 46 of the 60 children in the present study (i.e., 77%) were classified according to the rule models for the adjustment procedure. Seventeen children responded at a chance level

TABLE 5

Number of 5- and 7-year-old Male and Female Children Assessed for Rule Usage in the Adjustment Posttest

Age	Sex	RULES					
		RM*	I-D	II	III	IV	?***
5	M	6(0)**	2(2)	3(2)	1(0)	0	3
	F	7 (0)	1(1)	1(0)	0	0	6
7	M	1(0)	4(2)	1(1)	4(1)	1(0)	4
	F	3(0)	4(3)	2(0)	5(0)	0	1
Totals		17(0)	11(8)	7(3)	10(1)	1(0)	14

*Note 1. For the adjustment procedure, the prediction pattern for the RM category also applies for Rule I' use, and for the use of Rule I by children who attend primarily to the weight dimension. This is possible since any children using Rule I' or Rule I (weight) during the adjustment procedure should respond at a chance level (i.e., 25 percent correct). It should be noted, that this RM category may contain children who are actually functioning at higher knowledge levels represented by Rule I' or Rule I (weight).

**Note 2. Parenthesis indicates the number of children in that category who are also classified at the next highest rule level (i.e., "Double Classification").

***Note 3. The "?" symbol represents the category of children unclassified by the adjustment procedure.

(i.e., 25 percent correct) and were classified as Random Model users. Eleven children were classified as using Rule I-D during the adjustment posttest since their responses conformed to the predictions of that rule model. Seven children were assessed as Rule II users; ten children were categorized as using Rule III; and only one child was assigned a Rule IV classification. Fourteen of the 60 children in the present study (i.e., 23%) were unclassified according to the rule assessment criteria for the adjustment procedure.

Rule Model Classification of Pretest Rule I Children. The method of assessing rule use during the adjustment procedure for the 42 pretest Rule I children was identical to the description given in the previous section for all children in the present study. As shown in Table 6, 33 of the 42 pretest Rule I users (i.e., 79%) were classified according to the rule model predictions for the adjustment procedure (see Table 3). Twelve of the pretest Rule I children responded at a chance level (i.e., 25 percent correct) during the adjustment posttest and were classified at the Random Model level. Nine pretest Rule I children were classified by the adjustment procedure as using a Rule I-D approach. Five of the pretest Rule I children were assigned a Rule II classification due to their performance on the adjustment posttest. Seven pretest Rule I children were classified with the adjustment procedure as Rule III users. However, none of the pretest Rule I children were classified at a Rule IV level during the adjustment posttest.

Nine of the 42 pretest Rule I users (i.e., 21%) were unclassified according to the criteria, 16 out of 20 responses

TABLE 6

Number of 5- and 7-year-old Male and

Female Pretest Rule I Children

Assessed for Rule Usage in the

Adjustment Posttest

Age	Sex	RM*	I-D	II	III	IV	?***
		RULES					
5	M	5(0)**	1(1)	2(1)	1(0)	0	2
	F	4(0)	1(1)	0	0	0	3
7	M	1(0)	4(2)	1(1)	3(0)	0	4
	F	2(0)	3(3)	2(0)	3(0)	0	0
Totals		12(0)	9(7)	5(2)	7(0)	0	9

*Note 1. For the adjustment procedure, the prediction pattern for the RM category also applies for Rule I' use, and for the use of Rule I by children who attend primarily to the weight dimension. This is possible since any children using Rule I' or Rule I (weight) during the adjustment procedure should respond at a chance level (i.e., 25 percent correct). It should be noted, that this RM category may contain children who are actually functioning at higher knowledge levels represented by Rule I' or Rule I (weight).

**Note 2. Parenthesis indicates the number of children in that category who are also classified at the next highest rule level (i.e., "Double Classification").

***Note 3. The "?" symbol represents the category of children unclassified by the adjustment procedure.

conforming to a rule, for the adjustment procedure. Of these unclassified pretest Rule I children; seven had 13 to 15 responses according to the Random Model; one child responded 14 out of 20 times according to Rule II; and, one child responded 14 out of 20 times according to Rule III.

As shown in Table 6, nine of the pretest Rule I children were in a situation of double classification for the adjustment procedure. In the group of 5-year-old males, one child could have been classified as Rule I-D or Rule II, and another child as using either Rule II or Rule III. Only one 5-year-old female was double classified as either Rule I-D or Rule II. For the 7-year-old males, two children were classified as Rule I-D or Rule II; and one child was classified as either a Rule II or Rule III user. Three 7-year-old females were categorized as either Rule I-D or Rule II children. None of the other pretest Rule I children were found in a situation of double classification during the adjustment procedure. In the following section, the previous classifications will be used to assess distance usage during the pretest and posttest sessions.

<u>Distance Usage: Pretest vs. Posttest</u>. Siegler's (1976, 1978) rule models predict that a child does not attend to the distance dimension while solving balance scale problems unless he/she is using one of Rules II-IV. On the other hand, Siegler's models may underestimate children's balance scale knowledge. If this is indeed the case, then pretest Rule I users may be assessed at a Rule I-D or Rule II level with a different procedure. This possibility was investigated in the present study by categorizing children's

distance use and then assessing the significance of any changes in the use of the distance dimension to solve balance scale problems.

Children in the present study were categorized as non-distance (ND) users if they had been classified as Random Model, Rule I', or Rule I users during the Siegler pretest or posttest. Unclassified children, including those predicting LWD, were also categorized as ND users. Any child using one of Rules II-IV during the Siegler pretest or posttest was categorized as a distance (D) user. For the Siegler pretest, there were 54 children categorized as ND users, and six as D users (see Table 7). In the Siegler posttest, 55 children were categorized as ND users, while five used the distance dimension (see Table 8). McNemar's test for the significance of changes (Siegel, 1956), was used to assess changes from ND in the Siegler pretest to D usage for the Siegler posttest. As shown in Table 9, this nonparametric method revealed no significant change from ND to D usage between the Siegler pretest and posttest, $\underline{p} < .05$. This analysis indicated that children were not solving balance scale problems by attending to the distance dimension immediately prior to the presentation of the adjustment posttest. It was unlikely, then, that any changes in rule usage indicating that children were using the distance dimension to solve adjustment problems were due to "practice effects."

A child was categorized as a D user on the adjustment posttest if he/she was classified at a knowledge level represented by one of Rules I-D, II, III, or IV. Unclassified children and those using

TABLE 7

Number of 5- and 7-year-old Male and Female Children Assessed for Distance Use during the Siegler Pretest

		Category of Distance Use	
		ND*	D**
Age	Sex		
5	M	14	1
	F	15	0
7	M	13	2
	F	12	3
Totals		54	6

*ND = non-distance use
**D = distance use

TABLE 8

Number of 5- and 7-year-old Male

and Female Children Assessed

for Distance Use During the Siegler Posttest

		Category of Distance Use	
		ND	D
Age	Sex		
5	M	14	1
	F	14	1
7	M	14	1
	F	13	2
Totals		55	5

TABLE 9

Number of Children Assessed for Changes in the Use of the Distance Dimension Between the Siegler Pretest and the Siegler Posttest

		Category of Distance Use for the Siegler Posttest	
		ND	D
Category of Distance Use for the Siegler Pretest	D	2	4
	ND	53	1
Totals		55	5

a Random Model approach to solve the adjustment problems were categorized as ND users. With this method of assessing distance knowledge, 31 children were categorized as ND users and 29 as D users for the adjustment posttest.

Changes in the use of the distance dimension between the Siegler pretest and the adjustment posttest were examined for both levels of the age and sex variables. In these cases, the binomial test (Siegel, 1956) was used due to the smaller sample sizes. As shown in Table 10-A, for the group of 5-year-old males, nine children were categorized as ND users and one as a D user for both the Siegler pretest and adjustment posttest. Five of the 5-year-old males changed from ND use on the Siegler pretest to D use on the adjustment posttest. However, none of the 5-year-old males changed from D use on the Siegler pretest to ND use on the adjustment posttest. An analysis indicated a significant change from pretest ND use to D use during the adjustment procedure for the 5-year-old males, $\underline{p} < .05$. In the group of 5-year-old females, shown in Table 10-B, 13 children were categorized as ND users for both the pretest and adjustment posttest. Only two of the 5-year-old females changed from ND use on the pretest to D use for the adjustment procedure. None of the 5-year-old females were categorized as D users on the Siegler pretest. An analysis revealed no significant change from pretest ND to adjustment D use for the 5-year-old females, $\underline{p} > .05$. In the group of 7-year-old males, shown in Table 11-A, six children were categorized as ND users and two as D users for both the pretest and adjustment posttest. Seven of the 7-year-old males changed from ND use in the pretest to D use for

TABLE 10

Number of 5-year-old Male and Female Children Assessed for Changes in the Use of the Distance Dimension between the Siegler Pretest and Adjustment Posttest

Category of Distance Use for the Siegler Pretest		Category of Distance Use for the Adjustment Posttest	
	(A) 5-year-old Males		
		ND	D
	D	0	1
	ND	9	5
	(B) 5-year-old Females		
		ND	D
	D	0	0
	ND	13	2

TABLE 11

Number of 7-year-old Male and Female Children Assessed for Changes in the Use of the Distance Dimension Between the Siegler Pretest and Adjustment Posttest

Category of Distance Use for the Siegler Pretest		Category of Distance Use For the Adjustment Posttest	
	(A)	7-year-old Males	
		ND	D
	D	0	2
	ND	6	7
	(B)	7-year-old Females	
		ND	D
	D	0	3
	ND	4	8

the adjustment posttest. However, none of the 7-year-old males changed from D use in the pretest to ND use in the adjustment procedure. In this case, an analysis indicated a significant change from pretest ND to adjustment D use, $\underline{p} < .01$. As can be seen in Table 11-B, for the group of 7-year-old females, four children were categorized as ND users and three as D users for both the Siegler pretest and the adjustment posttest. Eight of the 7-year-old females changed from ND use on the pretest to D use on the adjustment posttest. None of the 7-year-old females changed from pretest D use to adjustment posttest ND use. The analysis revealed a significant change from pretest ND use to adjustment D use for the 7-year-old females, $\underline{p} < .01$. To summarize these analyses, the change from pretest ND to adjustment posttest D use was significant for each level of age and sex with the exception of the 5-year-old females.

Distance use during the adjustment procedure was further examined at the two age levels for the pretest Rule I children. As shown in Table 12, 15 of the 19 5-year-old and eight of the 23 7-year-old pretest Rule I children were categorized as ND users for the adjustment posttest. In addition, four 5-year-old and 15 7-year-old pretest Rule I children were categorized as D users with the adjustment procedure. A chi-square analysis of these data revealed that the 7-year-old pretest Rule I children were more likely to use the distance dimension while solving adjustment problems than were the 5-year-olds classified with the Siegler pretest according to the Rule I model, X^2 (1) = 8.20, $\underline{p} < .05$.

TABLE 12

Number of 5- and 7-year-old Pretest Rule I Users Assessed for Distance Use During the Adjustment Procedure

		ND	D	Totals
Age	5	15	4	19
	7	8	15	23
Totals		23	19	42

Analysis of Correct Responses for Pretest Rule I Users. The correct responses of the 42 pretest Rule I children during the adjustment posttest were examined with an analysis of variance procedure. The major intent of this analysis was to test the generality of the Rule I knowledge level. The adjustment posttest performance of the eleven 5-year-old males, the eight 5-year-old females, the thirteen 7-year-old males, and the ten 7-year-old female pretest Rule I users is shown in Figure 6. These data were analyzed by a 2 (age: 5- versus 7-year-olds) X 2 (sex: male vs. female) X 5 (problem-type: AB, AW, AD, ACD, or ACB) analysis of variance with repeated measures on problem-type. Significant main effects for age and problem-type were found, F (1,38) = 11.66, $p < .01$, and F (4,152) = 13.63, $p < .001$, respectively.

In addition, a significant interaction effect between age and problem-type, was found, F (4,152) = 2.99, $p < .05$. This interaction is illustrated in Figure 7. The significant age by problem-type interaction can be explained by the fact that the 7-year-olds made significantly more correct responses than the 5-year-olds for the AB, AD, and ACD problems while such age differences were not observed for the AW and ACB problems, $p < .05$ (Tukey's HSD procedure). This significant interaction was further examined by analyzing the simple effect of problem-type within each age level. The 5-year-olds solved only the adjustment balance problems significantly more often than the other problem-types, $p < .05$. The 7-year-olds solved the AB, AD, and ACD problem-types significantly more often than the AW and ACB problem-types, $p < .05$.

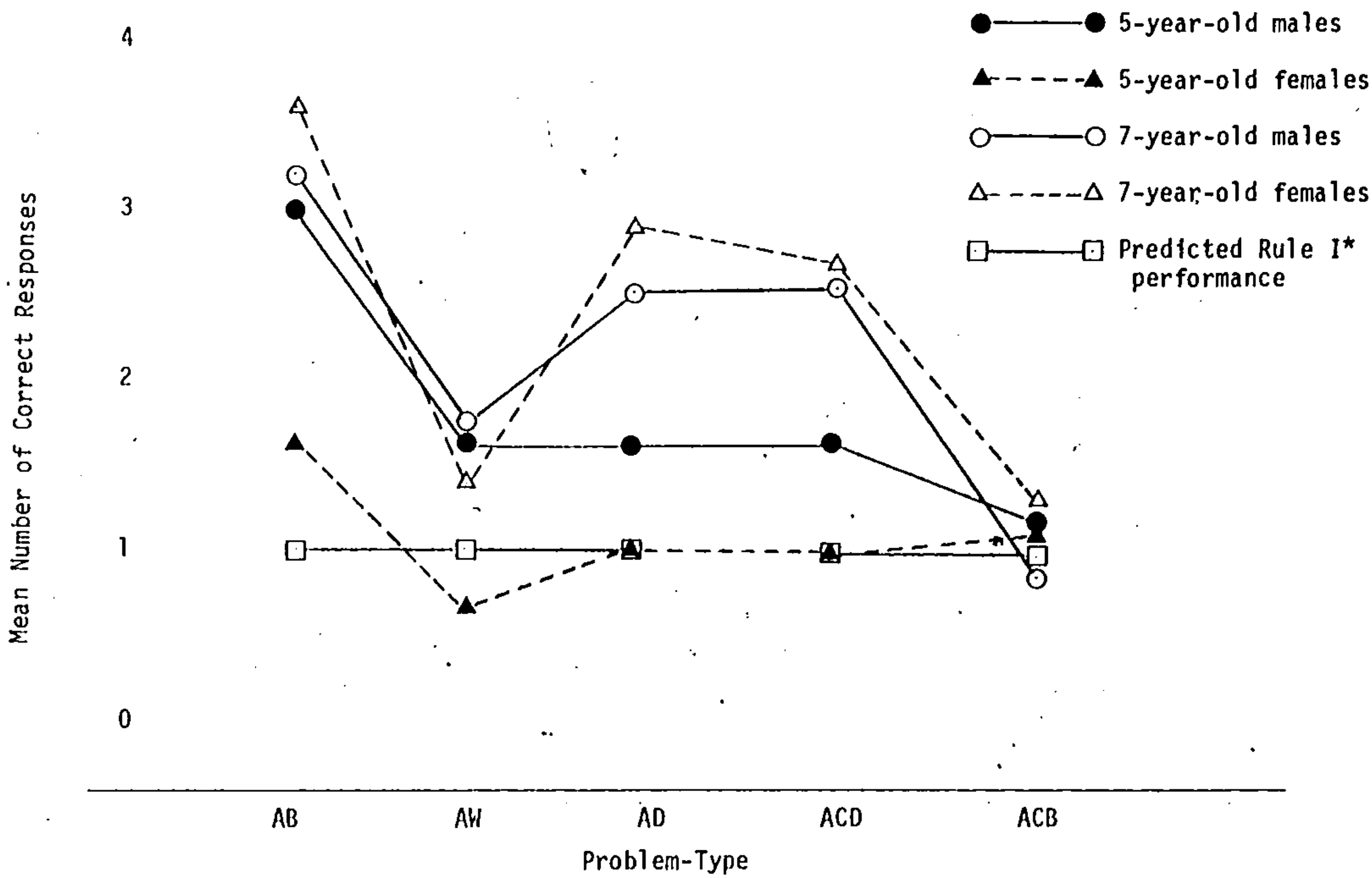

Figure 6. Mean number of correct responses for each adjustment posttest problem-type for pretest Rule I users.

*It should be noted that the predicted correct response curve for Rule I use illustrated here also represents RM or Rule I' use during the adjustment procedure.

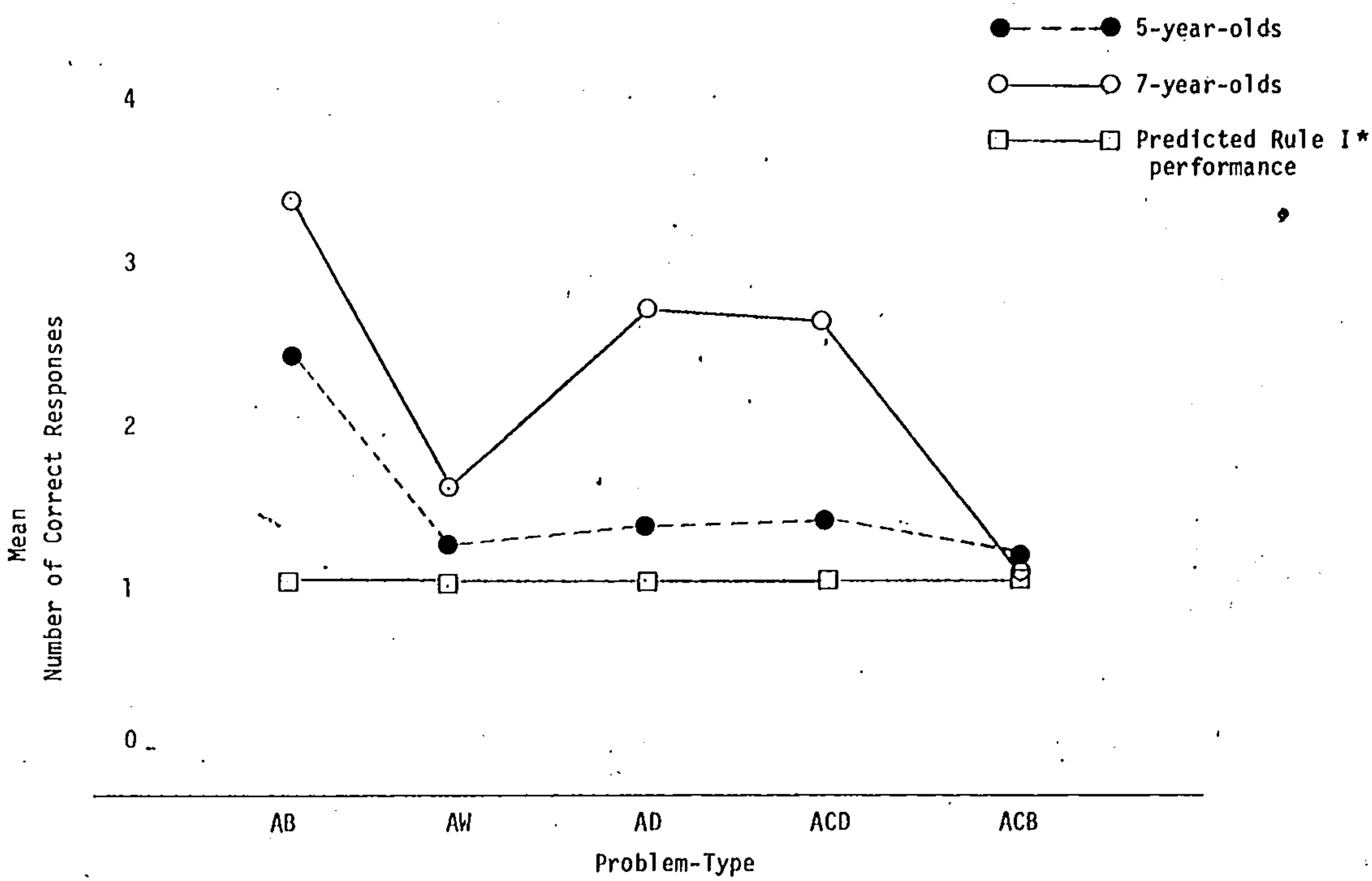

Figure 7. Mean number of correct responses for each adjustment posttest problem-type for 5- and 7-year-old pretest Rule I users.

*It should be noted that the predicted correct response curve for Rule I use illustrated here also represents RM or Rule I' use during the adjustment procedure.

Also illustrated in Figure 7 is the predicted correct response curve of a typical Rule I[7] user. Initial inspection of Figure 7 suggested that both age groups were performing superior to a 25 percent correct response level. This hypothesis was tested using an adaptation of the t-test which allows for comparisons between the sample and population means when the population variance is unknown, (Dixon & Massey, 1951). For the purposes of the present study, the mean scores received by both age groups on each problem-type were used as sample means. These observed mean scores were compared to the predicted mean scores for each problem-type, which for this analysis were considered as population means. The measure of variance required for the t-test was derived from a pooling of the error terms and associated degrees of freedom obtained from the previous analysis of pretest Rule I users. This t-test analysis revealed that the 5-year-olds differed significantly from predicted Rule I use only for the AB, t (190) = 4.79, problem-type, $p < .01$. However, the 7-year-olds differed significantly from Rule I for problem-types, AB, t (190) = 8.87; AD, t (190) = 6.27; ACD, t (190) = 5.97; $p < .01$; and AW, t (190) = 2.26, $p < .05$. The 7-year-olds did not differ significantly from predicted Rule I use on the ACB problem-type, $p > .05$. These analyses indicated that the older children performed

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[7]The predicted correct response curve for Rule I use illustrated in Figure 7 also represents RM or Rule I' use for the adjustment procedure.

the adjustment balance task at a knowledge level consistently higher than predicted by the Rule I model for all adjustment problems with the exception of the ACB problem-type. The younger children performed at a higher knowledge level than expected for Rule I use only on the AB problem-type.

In summary, the posttest data indicated that a majority of the children in the present study could be classified according to Siegler's (1976, 1978) rule models with the adjustment procedure. In addition, many of the pretest Rule I children were assessed as using one of Siegler's rules during the adjustment posttest. An assessment of distance usage revealed that 19 of the 54 children who were initially diagnosed as using the weight dimension only, used the distance dimension during the adjustment procedure. Significant changes in the use of the distance dimension were found between the Siegler pretest and adjustment posttest. An analysis of these changes indicated that the 5-year-old males and 7-year-old males and females used the distance dimension more often during the adjustment posttest than during the Siegler pretest. In addition, the analysis of the posttest performance of pretest Rule I children revealed age-related differences, in that, the 7-year-olds were more likely to use the distance dimension for solving adjustment problems than were the 5-year-olds. Finally, the pretest Rule I users were expected to be correct only 25 percent of the time when solving adjustment problems. However, these children achieved more correct responses than predicted during the posttest, especially the 7-year-olds.

CHAPTER IV

DISCUSSION

The general purpose of the present study was to evaluate Siegler's (1976, 1978) rule-assessment procedure for describing children's knowledge about balance scale problems by (a) determining if children's performance on Siegler's original balance scale task (choice procedure) could be classified as successfully as Siegler demonstrated, and (b) investigating children's use of the weight and distance dimensions while solving problems during an "adjustment" procedure. In particular, the present study was conducted to determine whether or not converging evidence for the use of Siegler's Rule I could be obtained using an adjustment procedure. In the following discussion, the findings of the present research relevant to an evaluation of Siegler's rule-assessment procedure will be considered initially. Next, the discussion will address age- and sex-related differences in balance scale performance. The methodological issues of the present study will then be examined and directions for future research will be suggested.

Based on the present findings, what can be said about the extent to which children's balance scale knowledge can be described using Siegler's rule-assessment method? This question will be addressed first in terms of classifying children's balance scale performance and then with regard to the generality of pretest Rule I knowledge.

Three major pieces of evidence from the pretest and posttest sessions suggest that Siegler's rule-assessment method successfully identifies children's knowledge about the balance scale task. First, using Siegler's procedure, 87 percent of the 5- and 7-year-old children were assessed as using one of the rule models to solve balance scale problems. Secondly, of the eight unclassified children in the pretest session, seven were found to use a "less weight down" (LWD) rule to solve the Siegler balance scale items. Siegler (1976, 1978) has not reported identifying an LWD knowledge level in his research, and therefore, this finding was unexpected. However, these seven LWD children predicted consistently on the basis of the weight dimension, and for the present study, were considered a special case of the Rule I model. An important point is that, once we identify a specific rule (i.e., "less weight down"), we can, as Siegler claims, unambiguously classify children on the basis of their patterns of correct answers and errors. Thirdly, when Siegler's rule-assessment procedure was applied to the novel balance scale problems (i.e., adjustment items), a majority of the children (i.e., 77%) were successfully classified as rule users. These three pieces of evidence indicate that the present study confirmed Siegler's contention that individual children's knowledge about the balance scale can be identified with his rule-assessment technique.

An adjustment procedure was used in a posttest session to evaluate the generality of Siegler's (1976) rule models for describing children's balance scale knowledge. Siegler has claimed that young children classified as Rule I users by his method primarily rely on the weight dimension to solve balance scale problems. However, two results of the present research suggest that some of the pretest Rule I users apparently knew the importance of the distance dimension for solving the adjustment problems. First, when all 60 children were classified for rule usage with the adjustment procedure, 29 were assessed at a Rule I-D level or higher (i.e., distance users). This finding indicates that 48 percent of the children were using the distance dimension to solve adjustment problems, although only 10 percent were assessed as using that dimension during the pretest (Siegler's task). More specifically, with the exception of the 5-year-old girls, children used the distance dimension more frequently when they performed on the adjustment task than when they responded to the Siegler choice task. Second, the analysis of the posttest performance of the 42 pretest Rule I users revealed that these children used the distance dimension for solving the adjustment problems. The pretest Rule I users were expected to use the weight dimension only, and consequently, would be correct only 25 percent of the time for adjustment problems. Contrary to this expectation, these children, especially 7-year-olds, achieved a performance level significantly higher than the predicted level. Thus, the generality of pretest Rule I knowledge was not evident with the adjustment procedure.

In summary, then, two conclusions can be drawn regarding the Siegler rule-assessment method for describing children's knowledge about balance scale problems. First, Siegler's method is a useful procedure for identifying individual children's rule usage while solving the present novel version of the balance scale task as well as Siegler's (1976) original version. Researchers, therefore, may not learn as much about children's knowledge for solving balance scale problems by merely comparing the mean number of correct responses between different age levels as by using Siegler's method. Second, the use of Siegler's task alone may limit our understanding of children's knowledge about balance scale problems. At the same time however, the use of the present adjustment problems alone will underestimate children's knowledge. Recall that several children attended only to the distance dimension while solving the adjustment problems, although they were able to use the weight dimension for Siegler's choice task. What is implied in this second conclusion is that one must administer a relatively large number of problems under different task demands in order to understand children's full knowledge about the balance scale problems. This last point may be regarded as a shortcoming of Siegler's rule-assessment methodology. In the absence of precise developmental models for children's strategy use, however, the advantage of Siegler's method (i.e., first conclusion) should not be ignored.

I will now consider several findings of the present study that indicated age-related differences in young children's balance scale performance. First, in the pretest session, the 7-year-olds made significantly more correct responses for weight and conflict-weight problems than the 5-year-olds. Since these problem-types are solved by Rule I use, this finding shows that the 7-year-olds are better Rule I users for Siegler's procedure. Secondly, for the adjustment posttest, the 7-year-olds solved the adjustment balance, distance, and conflict-distance problems significantly more often than the 5-year-olds. This suggests that the 7-year-olds were more adept at using the distance dimension to solve adjustment problems. Further evidence for this conclusion was found in an analysis of distance use during the adjustment procedure. An examination of age-related use of the distance dimension during the adjustment posttest revealed that for pretest Rule I users, the 7-year-olds were more likely than the 5-year-olds to use this dimension to solve adjustment problems.

The preceeding findings that some of the pretest Rule I 7-year-olds used the distance dimension during the adjustment posttest may be comparable to Siegler's (1976, Experiment 2) own findings. In this previous study, Siegler reported age-related differences when children had been equated for possessing only Rule I knowledge of the balance scale problems. These Rule I 5- and 8-year-olds were given additional experience (i.e., feedback training) with distance and conflict-distance problems. Siegler found that more 8-year-olds moved to Rule II and Rule III levels than did 5-year-olds. Siegler (1976) investigated possible causes for this age-related difference in an additional study (Experiment 3). He concluded that, for the balance scale task, older children were better at encoding the relevant weight and distance dimensions after feedback training. With regard to the present age-related findings, it is possible that 7-year-olds are better pretest Rule I users since they encode the weight dimension more accurately than 5-year-olds. Considering that the distance dimension is more salient for the adjustment procedure, age-related findings in posttest performance probably indicate that 7-year-olds encode distance in a novel task situation more accurately than 5-year-olds.

At any rate, the observed age-related differences in children's performance on balance scale problems suggest the following sequence in which children may acquire knowledge about these problems. When children begin to use rules to solve balance scale problems, as Siegler has hypothesized, a majority of them attend only to the weight dimension (Rule I). At this first (weight) level, just as many of the 5-year-old Rule I users did in this study, children apply this rule to a wide variety of situations (e.g., both choice and adjustment tasks). At the second level, children become aware of the importance of the distance as well as the weight dimension. These children, just as many of the 7-year-old pretest Rule I children demonstrated in the present study, use the weight dimension only for one set of situations (e.g., Siegler's choice task) and the distance dimension only for another set of situations (e.g., adjustment task). Children then move on to Siegler's Rule II level at which they can use the two dimensions simultaneously under limited tasks demands (e.g., two sides of the fulcrum have the same amount of weight but different distances). Presumably, it should be easier to teach Rule II to those children at the second level than at the first level.

Regarding the sex-related finding, the analysis of correct responses during the pretest indicated that the males were more successful than the females at solving weight and conflict-weight problems. This suggests that males are better Rule I users than females. Sex-related findings have not been reported by Siegler (1976, 1978) for the balance scale task. Possibly, the performance of the five female LWD children was responsible for this sex-related finding. According to predictions for Siegler's rule-assessment procedure, Rule I users, relying on the weight dimension, will be correct on three problem-types (balance, weight, and conflict-weight), whereas "less weight down" rule users will be correct only for two problem-types (balance and conflict-distance). It should be mentioned that an additional analysis of the pretest data which excluded all seven LWD children revealed no significant sex and problem-type interaction.

We will now turn to methodological issues associated with the adjustment procedure. The first issue is related to the problem of "double classification" which occurred in the present research for some children. Situations of double classification emerged because the different response patterns between two different rules used in the present study were too close to discriminate. In these situations, the arbitrary assignment of children to the lower knowledge level when they were assessed into two rule classifications was carried out to avoid false positive errors (Brainerd, 1977). These response patterns were difficult to precisely discriminate due to (a) the selection of items, and (b) the arbitrary criteria (16 out of 20 responses conforming to a rule) for assessing rule usage.

In order to illustrate this double classification problem, consider a Rule I-D child who predicts as expected for the first three adjustment problem-types (see Table 3). Notice that for these problems, the expected Rule I-D and Rule II response patterns are identical. So far, this Rule I-D child has achieved 12 out of 20 responses corresponding to both Rule I-D and Rule II use. This leaves the remaining two adjustment problem-types to discriminate between the two rules. However, if the Rule I-D child solves the adjustment conflict-distance problems at the expected 50 percent level and guesses correctly once (25 percent) for the adjustment conflict-balance problems, then 19 out of 20 responses are possible which correspond to both Rule I-D and Rule II use. It should be noted that a similar situation can occur between Rule II and Rule III for the adjustment conflict-balance problems. One suggestion for future research with this task is to select adjustment items so that the expected response level between these rules differs by 50 percent or more for the adjustment conflict problems.

The second methodological issue involves the actual test administration. In its present form, a child responding to the adjustment procedure <u>must</u> place his/her amount of weight on one of the four available pegs. In the case of diagnosing Rule I-D use, for example, this creates a situation where the child is forced to guess during adjustment weight problems. Since the child should think that by choosing the first peg on the empty side a "balance" will result, he/she considers the other available pegs. However, a Rule I-D child should know that distance will cause the scale to tip, and this will result, as far as he/she is concerned, if either the second, third, or fourth peg is selected. To show Rule I-D knowledge, then, the child should say "impossible." Since this is not allowed in the present procedure, the child is forced to choose one of the four available pegs. The adjustment procedure could be modified to correct for this difficulty, simply by allowing children the opportunity to leave the balance scale empty.

Concluding Remarks

Most developmental psychologists would agree that models of development should state both early and later forms of competence and provide an easy interpretation of each model as both a precursor and successor to other models in a developmental sequence (e.g., Brown & Deloache, 1978). Siegler's rule models examined in the present study certainly meet this criterion by specifying distinctive characteristics of early limited competence, intermediate skills, and the final level of proficiency. When Siegler's (1976, 1978) rule-assessment procedure was applied in the present research to children's responses to balance scale problems (pretest "choice" task), it was demonstrated that individual children's rules were unambiguously classified. In addition, Siegler's methodology revealed some young children using an unanticipated "less weight down" rule to solve balance scale problems. These findings indicate that Siegler's method is very useful for diagnosing children's knowledge levels for his version of the balance scale task. However, the performance of children during the adjustment procedure for the balance scale revealed that the use of Siegler's "choice" task alone may underestimate children's knowledge of the distance dimension. This finding supports the claims of previous investigators (e.g., Gelman, 1979; Smedslund, 1963) who have stated that identification of children's knowledge may be dependent on the different saliency of different relevant task dimensions, and variations in task procedure. In particular, the findings of the present study suggest that some Rule I children have knowledge of the distance dimension when assessed with adjustment balance scale problems. To this extent, the generality of Siegler's Rule I knowledge level was not found in the present study. For future research with the present adjustment procedure it is suggested that children's knowledge levels would be more clearly identified if they were allowed not to place their weight(s) (i.e., say "impossible"). In addition, it was recommended that adjustment items be selected which would allow for more precise discriminations between rule levels.

APPENDIX A

Selective Review of Research Employing Balance Scale Task

Inhelder and Piaget (1958) introduced the balance scale task as part of a series of science related tasks designed to elicit formal operational thinking in children and adolescents. Since its introduction, the balance scale task has been employed to replicate Piaget's findings (Jackson, 1965; Lovell, 1961), investigate the nature of the relationship of formal operational tasks (Bady, 1978; Bart & Airasian, 1974), and in research involving information processing approaches (Siegler, 1976, in press; Wilkening & Anderson, 1982). The balance scale task has also been used as a measure of cross-cultural differences in formal operations ability (Kishta, 1979) and studied in relation to other non-Piagetian tasks measuring proportional thinking (Lawson & Wollman, 1980).

The aim of the present review is to demonstrate that, until recently (i.e., Siegler, 1976), investigations of the balance scale task have suffered from the lack of a standardized procedure and an inadequate task analysis. In order to accomplish this, an initial explanation of Inhelder and Piaget's (1958) conception of the balance scale task will be presented. Then, in subsequent sections, studies employing the balance scale in replication research will be reviewed. Finally Siegler's (1976) analysis of the balance scale task will be considered.

Piaget's stage of formal operations is characterized by the child's increasing ability to solve science related tasks such as the projection of shadows, bending rods, pendulum, and the balance scale. To solve these tasks with a formal operational approach meant that the child would isolate and combine variables in an abstract, hypothetico-deductive manner. Consider the balance scale task. According to Piaget (Inhelder & Piaget, 1958) success in this problem-solving situation occurred when the child systematically varied the relevant dimensions of weight and distance to discover their proportional relationship. A simple trial and error method of combining the relevant variables was not interpreted as formal operational reasoning. The child was required to express the idea of adjusting a certain distance, for example, to compensate for a change in a particular weight.

Apparently, Inhelder and Piaget (1958) employed two different types of balance scale tasks. One simply consisted of a crossbar from which baskets containing toy dolls were hung. In this version, the subject could not assign a numerical value to distance (the crossbar was unmarked) and the dolls did not have a specific numerical weight. Unfortunately, Piaget does not indicate where he uses this particular task, but it seems reasonable to assume it was used with young children to investigate qualitative correspondences between weight and distance. The other version consisted of a crossbar perforated with holes equidistant and symmetrical about a pivot point. Differing weights were hung through the holes in the crossbar. It is this second version which has been adapted for use in most formal operations research (e.g., Siegler, 1976; Wilkening & Anderson, 1982).

In a typical Piagetian assessment, the experimenter placed weights on the crossbar and asked the child to create a balance (Inhelder & Piaget, 1958). The child was free to adjust the weights and distances while being prompted and questioned by the experimenter. The data from these sessions consisted of the child's manipulations and verbal explanations. This data was interpreted within a structure of three stages, each with two substages. Inhelder and Piaget (1958) reported that 3- to 5-year-old children were not able to separate their own actions from those of the balance scale. This was considered indicative of substage IA. Children progressed from substage IA until they discovered the correct proportional relationship between weight and distance in substages IIIA and IIIB (ages 12- to 15-years-old). Piaget observed that children tended to realize the importance of the weight dimension first (substage IB, 5- to 7-years-old) but did not coordinate the two dimensions until substage IIB (ages 10- to 12-years-old).

The methodology employed by Inhelder and Piaget (1958) has been criticized for being too open-ended and clinical in nature, lacking a standardized procedure (Brainerd, 1978). For example, it is unclear how many weight arrangements Piaget presented to each child. As well, the number of prompts and questions from the experimenter varied with each child. It will be indicated next that in the initial replication studies this situation did not improve.

The initial replication studies (Lee, 1971; Lovell, 1961; Jackson, 1965) were carried out to verify Piaget's description of the transition to formal operations, and to investigate the relationship between the formal operational tasks. These studies supported Piaget's claim that the transition occurred during early adolescence (12- to 15-years-old). However in each of these studies few adolescents were found who understood the balance scale task in terms of numerical proportions. Keating (1975) in a study of intellectually precocious individuals, and Martorano (1977) also found that a majority of their subjects did not perform at the level of formal operations on the balance scale task.

As well, Piaget indicated that an individual should exhibit similar performance on all formal operational tasks. However research investigating the concurrent performance of Piagetian formal operations tasks has been inconsistent. Lee (1971) found similar levels of performance on the projections of shadows and balance scale tasks. Keating (1975) did not report any significant task differences in performance between four formal operational tasks. Lawson (1979) and Bond (1979) both reported correlations between scores on the balance scale and two other formal operational tasks which supported Piaget's contention that they measured the same underlying structure. However, in previous research, Lawson et al. (1975) failed to find a high correlation between scores on the bending rods and balance scale task. They concluded that this result was obtained because their sample was not drawn from a diverse population.

As indicated by Bady (1978) and Martorano (1977) several methodological issues inhibit any attempt to draw general conclusions from these studies. According to Bady (1978) many of these studies use only one or two Piagetian tasks to rate a subject as formal or concrete operational. For example, Lawson (1978) used only two balance scale items to determine formal operational performance on this task. As well many researchers employing the balance scale task do not report what type of problems or how many are presented to the subjects (Keating, 1975; Kishta, 1979; Martorano, 1977). Many of these researchers used different methods of scoring. Bady (1978) simply dichotomized his subjects as formal or nonformal. Lawson (1979) initially scored the subjects responses on a seven point scale and then derived three categories; either concrete, transitional, or formal. Martorano (1977) initially used a five point scale but dichotomized these scores for analysis. Some researchers (e.g., Spada & Kluwe, 1980; Spada, 1978) have attempted to measure formal operations with a pencil and paper test. These difficulties due to inconsistent procedure, different task materials, and scoring criteria, may have been resolved by Siegler's (1976) introduction of the rule-assessment methodology.

Siegler (1976) attempted to characterize children's knowledge about the balance scale task in terms of four rule models. These rule models corresponded to increases in a subject's ability to solve balance scale problems. Also, Siegler (1976), classified balance scale problems into six different categories. For each rule model (representing a certain knowledge level) different predictions were made according to how a child following the rule would solve the six types of problems. These predictions were then matched to observed performance very closely in Siegler's (1976) Experiment I.

Siegler's analysis of the balance scale task also enabled him to suggest that children who were poor at solving balance scale problems did so because of inadequate encoding of the relevant dimensions of weight and distance (Siegler, 1976, Experiment III). Siegler (1981, in press) has extended his use of rule-assessment to other formal operational tasks.

Although Siegler's method represents a potentially powerful research approach, it has been recently criticized. Wilkening and Anderson (1982) claimed that Siegler's forced choice method generates nonintegration rules (i.e., binary decision trees). Siegler's rules suggest that children compare the relevant dimensions of weight and distance one at a time. Wilkening and Anderson (1982) suggested that subjects actually do integrate these dimensions when solving balance scale problems. To test this they used a balance scale similar to Siegler's, however, on one side of the fulcrum a sliding peg replaced the usual four pegs. The children were required to slide the weighted peg to a position of balance with a weight arrangement on the other side. Wilkening and Anderson (1982) reported that with this procedure the children appeared to use an adding and a multiplicative rule for integrating the weight and distance dimensions.

Although it may be premature to assess the adequacy of Siegler's (1976, 1981) rule-assessment methodology, it certainly represents an advance over previously used procedures. As well his method is very clear in detailing the types of problems and the procedures used for their administration to subjects. It has been applied to a variety of Piagetian tasks with impressive results. However, whether or not his method generates nonintegration rules due to a forced choice procedure is an issue requiring further research.

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APPENDIX B

PRETEST AND POSTTEST BALANCE

SCALE PROBLEMS

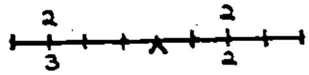
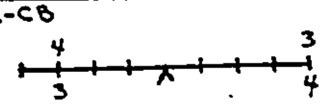
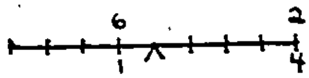
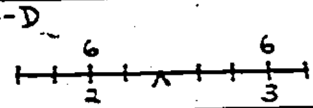
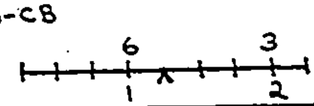
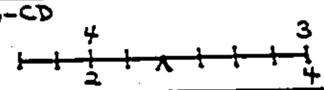
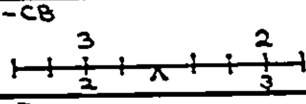
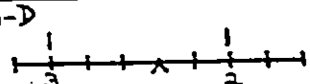
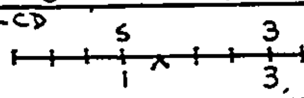
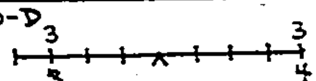
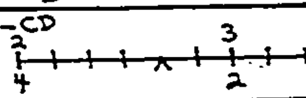
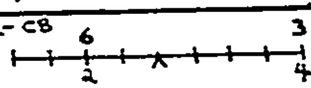
BALANCE SCALE - PRETEST - SIEGLER ITEMS

NAME: AGE: SEX:

PROBLEM	L	R	B	PROBLEM	L	R	B
1-W 2 4 4 4				13-W 4 6 4 4			
2-D 2 2 4 3				14-CB 6 2 1 3			
3-CD 4 6 4 2				15-B 3 3 4 4			
4-CW 5 3 3 4				16-CD 3 1 1 4			
5-CB 3 1 1 3				17-D 4 4 4 3			
6-B 4 4 4 4				18-CW 2 4 4 3			
7-D 3 3 2 4				19-W 3 1 4 4			
8-CW 6 4 3 4				20-B 5 5 4 4			
9-B 2 2 4 4				21-CD 3 5 4 2			
10-W 5 3 4 4				22-CB 4 2 2 4			
11-CD 4 2 1 4				23-D 5 5 2 4			
12-CB 6 4 2 3				24-CW 1 3 4 2			

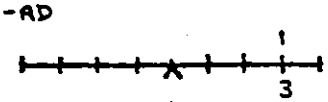
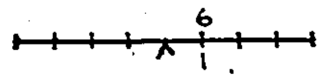
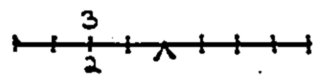
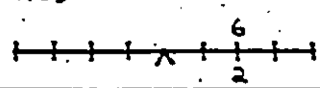
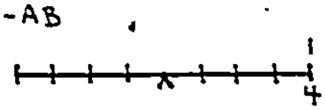
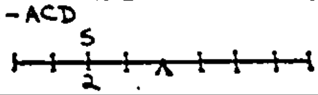
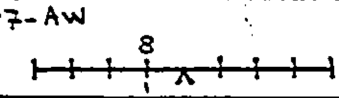
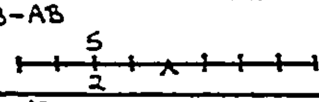
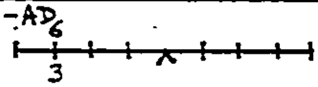
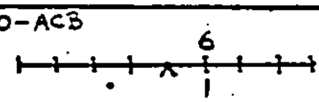
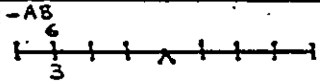
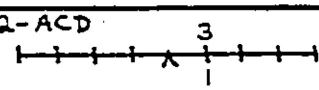
BALANCE SCALE – POSTTEST – SIEGLER ITEMS

NAME: AGE: SEX:

PROBLEM	L	R	B	
1-D 				
2-CB 				
3-CD 				
4-D 				
5-CB 				
6-CD 				
7-CB 				
8-D 				
9-CD 				
10-D 				
11-CD 				
12-CB 				

BALANCE SCALE – POSTTEST – ADJUSTMENT ITEMS

NAME: AGE: SEX:

L.S. PROBLEM TYPE R.S.		INSTRUCTION
1-AD 		give 1 – place weight on L.S. so that L.S. will go down (1,4)
2-AW 		give 3 – place weights on L.S. so that R.S. will go down (3,1)
3-ACB 		give 2 – place weights on R.S. to make a balance (2,3)
4-ACD 		give 4 – place weights on L.S. so that L.S. will go down (4,4)
5-AB 		give 1 – place weight on L.S. to make a balance (1,4)
6-ACD 		give 3 – place weights on R.S. so that R.S. will go down (3,4)
7-AW 		give 4 – place weights on R.S. so that L.S. will go down (4,1)
8-AB 		give 5 – place weights on R.S. to make a balance (5,2)
9-AD 		give 6 – place weights on R.S. so that R.S. will go down (6,4)
10-ACB 		give 3 – place weights on L.S. to make a balance (3,2)
11-AB 		give 6 – place weights on R.S. to make a balance (6,3)
12-ACD 		give 1 – place weight on L.S. so that L.S. will go down (1,4)

BALANCE SCALE – POSTTEST-ADJUSTMENT ITEMS

NAME: AGE: SEX:

L.S. PROBLEM TYPE R.S.			INSTRUCTION
13-AW	2 / 1		give 1 - place weight on L.S. so that R.S. will go down (1,1)
14-ACB	4 / 3		give 3 - place weights on L.S. to make a balance (3,4
15-AD	2 / 3		give 2 - place weights on L.S. so that L.S. will go down (2,4)
16-AD	4 / 3		give 4 - place weights on R.S. so that R.S. will go down (4,4
17-ACB	2 / 1		give 1 - place weight on R.S. to make a balance (1,2)
18-AW	4 / 1		give 2 - place weights on R.S. so that L.S. will go down (2,1)
19-AS	3 / 1		give 3 - place weights on L.S. to make a balance (3,1)
20-ACD	6 / 3		give 5 - place weights on R.S. so that R.S. will go down (5,4)

APPENDIX C

SOURCE TABLES OF ANALYSES

TABLE A

Analysis of Children's Correct Predictions for

Siegler's (1976) Version of the Balance Scale Task

Source	SS	df	MS	F
Between Subjects				
Age	6.400	1	6.400	10.19*
Sex	0.900	1	0.900	1.43
Age by Sex	0.711	1	0.711	1.13
Error	35.156	56	0.628	
Within Subjects				
Problem-type	897.133	5	179.427	151.36**
Age by Problem-type	21.700	5	4.340	3.66**
Sex by Problem-type	16.467	5	3.293	2.78***
Age by Sex by Problem-type	1.122	5	0.224	0.19
Error	331.911	280	1.185	

*$F_{.99}$ (df 56 and 1) = 7.126

**$F_{.99}$ (df ∞ and 5) = 3.02

***$F_{.95}$ (df ∞ and 5) = 2.21

TABLE B

Analysis of Pretest Rule I Children's Correct Responses for the Adjustment Balance Scale Task

Source	SS	df	MS	F
Between Subjects				
Age	34.841	1	34.841	11.66*
Sex	3.600	1	3.600	1.20
Age by Sex	10.268	1	10.268	3.44
Error	113.562	38	2.988	
Within Subjects				
Problem-type	73.113	4	18.278	13.63**
Age by Problem-type	16.037	4	4.009	2.99***
Sex by Problem-type	3.929	4	0.982	0.73
Age by Sex by Problem-type	2.792	4	0.698	0.52
Error	203.861	152	1.341	

*$F_{.99}$ (df 38 and 1) = 7.36

**$F_{.99}$ (df 152 and 4) = 3.452

***$F_{.95}$ (df 152 and 4) = 2.438

APPENDIX D

RAW DATA

Children's responses and classifications for the Siegler (1976, 1978) balance scale task

SIEGLER PRETEST

Problem type:		Balance	Weight	Distance	Conflict-Weight	Conflict-Distance	Conflict-Balance	
Item number:		6 9 15 20	1 10 13 19	2 7 17 23	4 8 18 24	3 11 16 21	5 12 14 22	
Correct response:		B B B B	R L R L	L R L R	L L R R	L R R L	B B B B	
	S's No.							Rule
5-year-old males	1	B B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I
	2	B B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I
	3	B B B B	R L R L	B B B B	L L R R	R L L R	B L L L	I
	4	B B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I
	5	B B B B	L R L R	B B B B	R R L L	L R R L	R R R R	LWD
	6	L L B B	B L R L	B B B B	L L R R	B L L R	L L L L	I
	7	B B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I
	8	B B B B	L R L R	B B B B	R R L L	L R R L	L R R R	LWD
	9	R B B B	R L R B	R B R B	B L R R	R B B R	B L L L	?
	10	B B B B	R L R L	B B B L	L L R R	R L L R	L L L L	I
	11	B B B B	L L R L	B B B B	L L R R	R L L R	L L L L	I
	12	L B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I
	13	B B B B	R L R L	L R L B	L L R R	R L L R	L L L L	II
	14	B B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I
	15	B B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I

B = balance
L = left side down
R = right side down

RM = Random Model
I' = Rule I'
I = Rule I

II = Rule II
III = Rule III
IV = Rule IV

? = unclassified
LWD = "less weight down"

Children's responses and classifications for the Siegler (1976, 1978) balance scale task

SIEGLER PRETEST

		Balance	Weight	Distance	Conflict-Weight	Conflict-Distance	Conflict-Balance	
Problem type:		Balance	Weight	Distance	Conflict-Weight	Conflict-Distance	Conflict-Balance	
Item number:		6 9 15 20	1 10 13 19	2 7 17 23	4 8 18 24	3 11 16 21	5 12 14 22	
Correct response:		B B B B	R L R L	L R L R	L L R R	L R R L	B B B B	
	S's No.							Rule
5-year-old females	16	B B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I
	17	B B B L	B L B B	B B B L	B R R B	B B L B	B R R R	RM
	18	B B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I
	19	B L L B	R B B B	R B B L	B L B B	B B L B	L B B B	RM
	20	B B B B	B R L R	B B B B	R R L L	L R R L	R R R R	LWD
	21	B B B B	L L R L	B B B B	L L R R	L L L R	L L L L	I
	22	L L L L	R L R L	R R L L	L L R L	R R L R	L L L L	I'
	23	B B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I
	24	B B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I
	25	B B B B	L R L R	B B B B	R R L L	L R R L	R R R R	LWD
	26	B B B B	B B L L	L L R B	B R B B	L B B B	L L L B	RM
	27	B B B B	B L R L	B B B B	L L R R	B L L R	L L L L	I
	28	B B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I
	29	B B B B	R L R L	B B B B	L L R R	R L L R	R L L L	I
	30	B L B B	R R B R	L R B B	R R L L	B R R L	R B R R	LWD

B = balance
L = left side down
R = right side down

RM = Random Model
I' = Rule I'
I = Rule I

II = Rule II
III = Rule III
IV = Rule IV

? = unclassified
LWD = "less weight down"

Children's responses and classifications for the Siegler (1976, 1978) balance scale task

SIEGLER PRETEST

Problem type:		Balance				Weight				Distance				Conflict-Weight				Conflict-Distance				Conflict-Balance				
Item number:		6	9	15	20	1	10	13	19	2	7	17	23	4	8	18	24	3	11	16	21	5	12	14	22	
Correct response:		B	B	B	B	R	L	R	L	L	R	L	R	L	L	R	R	L	R	R	L	B	B	B	B	
	S's No.																									Rule
	31	B	B	B	B	R	L	R	L	B	B	B	B	L	L	R	R	R	L	L	R	L	L	L	L	I
	32	B	B	B	B	R	L	R	L	B	B	B	B	L	L	R	R	R	L	L	R	L	L	L	L	I
	33	B	B	B	B	L	L	R	L	B	B	B	B	L	L	R	R	R	L	L	R	L	L	L	L	I
	34	B	B	B	B	R	L	R	L	B	B	B	B	L	L	R	R	R	L	L	R	L	L	L	L	I
	35	B	B	B	B	R	L	R	L	R	B	B	B	L	L	R	R	R	L	L	R	L	L	L	L	I
7-year-old	36	B	B	B	B	R	L	R	L	B	B	B	B	L	L	R	R	R	L	L	R	L	L	L	L	I
males	37	B	B	B	B	R	L	R	L	B	B	B	B	L	L	R	R	R	L	L	R	L	L	L	L	I
	38	B	B	B	B	R	L	R	L	B	B	B	B	L	L	R	R	R	L	L	R	L	L	L	L	I
	39	B	B	B	B	R	L	R	L	B	B	B	B	L	L	R	R	R	L	L	R	L	L	L	L	I
	40	B	B	B	B	R	L	R	L	B	B	B	B	L	L	R	R	R	L	L	R	L	L	L	L	I
	41	B	B	B	B	R	L	R	L	B	B	B	B	L	L	R	R	R	L	L	R	L	L	L	L	I
	42	B	B	B	B	R	L	R	L	B	B	B	B	L	L	R	R	R	L	L	R	L	L	L	L	I
	43	B	B	B	B	R	L	R	L	L	R	L	R	L	L	R	R	R	L	L	R	L	L	L	L	II
	44	B	B	B	B	R	L	R	L	B	B	B	B	L	L	R	R	R	L	L	R	L	L	L	L	I
	45	B	B	B	B	R	L	R	L	L	R	B	B	L	L	R	R	R	L	L	R	L	L	L	L	II

B = balance
L = left side down
R = right side down

RM = Random Model
I' = Rule I'
I = Rule I

II = Rule II
III = Rule III
IV = Rule IV

? = unclassified
LWD = "less weight down"

Children's responses and classifications for the Siegler (1976, 1978) balance scale task

SIEGLER PRETEST

Problem type:		Balance	Weight	Distance	Conflict-Weight	Conflict-Distance	Conflict-Balance	
Item number:		6 9 15 20	1 10 13 19	2 7 17 23	4 8 18 24	3 11 16 21	5 12 14 22	
Correct response:		B B B B	R L R L	L R L R	L L R R	L R R L	B B B B	
	S's No.							Rule
	46	B B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I
	47	B B B B	R L R L	L B B B	L L R R	R L L R	L L L L	I
	48	B B B B	R L R L	L R B B	L L R R	R L L R	L L L L	II
	49	B B B B	R L R L	L R L R	L L R R	R L L R	L L L L	II
	50	B B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I
7-year-old	51	B B B B	L R L R	R B B B	L R L L	R R R L	R R R R	LWD
females	52	B B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I
	53	B B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I
	54	B B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I
	55	B B B B	R L R L	L R L R	L L R R	R L L L	L L L R	II
	56	B B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I
	57	B B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I
	58	B B B B	L R L R	B B B B	R R L L	L R R L	R R R R	LWD
	59	B B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I
	60	B B B B	R L R L	B B B B	L L R R	R L L R	L L L L	I

B = balance
L = left side down
R = right side down

RM = Random Model
I' = Rule I'
I = Rule I

II = Rule II
III = Rule III
IV = Rule IV

? = unclassified
LWD = "less weight down"

Children's responses and classifications for the Siegler (1976, 1978) balance scale task

SIEGLER POSTTEST

Problem type:		Distance				Conflict-Distance							Distance				Conflict-Distance				
Item number:		1	3	5	7	2	4	6	8				1	3	5	7	2	4	6	8	
Correct response:		L	R	L	R	R	R	L	L				L	R	L	R	R	R	L	L	
	S's No.									Rule		S's No.									Rule
	1	B	B	B	B	L	L	R	R	I		16	B	B	B	B	L	L	R	R	I
	2	B	B	B	B	L	L	R	R	I		17	R	L	L	L	B	B	B	B	I
	3	B	B	B	B	L	L	R	R	I		18	B	B	B	B	L	L	R	R	I
	4	B	B	B	B	L	L	R	R	I		19	L	L	B	B	B	B	B	L	?
	5	B	B	B	B	R	R	L	L	LWD		20	B	B	B	B	R	R	L	L	LWD
5-year-old	6	B	B	B	B	L	L	R	R	I	5-year-old	21	B	B	B	B	L	L	R	R	I
males	7	B	B	B	B	L	L	R	R	I	females	22	L	R	R	R	L	L	R	L	I'
	8	B	B	B	B	L	L	R	R	I		23	B	B	B	B	L	L	R	R	I
	9	B	B	B	B	L	L	R	R	I		24	B	B	B	B	L	L	R	R	I
	10	B	B	B	B	L	L	R	R	I		25	B	B	B	B	R	R	L	L	LWD
	11	B	B	B	B	L	L	R	R	I		26	B	B	B	B	L	B	B	B	I
	12	B	B	B	B	L	L	R	R	I		27	B	B	B	B	L	L	R	R	I
	13	L	R	L	R	R	R	L	L	II		28	B	B	B	B	L	L	R	R	I
	14	B	B	B	B	L	L	R	R	I		29	B	B	B	B	L	B	R	R	I
	15	B	B	B	B	L	L	R	R	I		30	B	B	B	B	R	R	L	L	LWD

B = balance
L = left side down
R = right side down

RM = Random Model
I' = Rule I'
I = Rule I

II = Rule II
III = Rule III
IV = Rule IV

? = unclassified
LWD = "less weight down"

Children's responses and classifications for the Siegler (1976, 1978) balance scale task

SIEGLER POSTTEST

Problem type:		Distance				Conflict-Distance							Distance				Conflict-Distance				
Item number:		1	3	5	7	2	4	6	8				1	3	5	7	2	4	6	8	
Correct response:		L	R	L	R	R	R	L	L				L	R	L	R	R	R	L	L	
	S's No.									Rule		S's No.									Rule
	31	B	B	B	B	L	L	R	R	I		46	B	L	B	B	L	L	R	R	I
	32	B	B	B	B	L	L	R	R	I		47	B	B	B	B	L	L	R	R	I
	33	B	B	B	B	L	L	R	R	I		48	B	B	B	B	L	L	R	R	I
	34	B	B	B	B	L	L	R	R	I		49	L	R	L	R	L	L	R	R	II
	35	B	R	B	B	L	R	R	R	I		50	B	B	B	B	L	L	R	R	I
7-year-old males	36	B	B	B	B	L	L	R	R	I	7-year-old females	51	B	B	B	B	R	R	L	L	LWD
	37	L	B	B	B	L	L	R	R	I		52	B	B	B	B	L	L	R	R	I
	38	B	B	B	B	L	L	R	R	I		53	B	B	B	B	L	L	R	R	I
	39	B	B	B	B	L	L	R	R	I		54	B	B	B	B	L	L	R	R	I
	40	B	B	B	B	L	L	R	R	I		55	L	R	L	R	L	L	R	R	II
	41	B	B	B	B	L	L	R	R	I		56	B	B	B	B	L	L	R	R	I
	42	B	B	B	B	L	L	R	R	I		57	B	B	B	B	L	L	R	R	I
	43	L	R	L	R	L	L	R	R	II		58	B	B	B	B	R	R	L	L	LWD
	44	B	B	B	B	L	L	R	R	I		59	B	B	B	B	L	L	R	R	I
	45	B	B	B	B	L	L	R	R	I		60	B	B	B	B	L	L	R	R	I

B = balance
L = left side down
R = right side down

RM = Random Model
I' = Rule I'
I = Rule I

II = Rule II
III = Rule III
IV = Rule IV

? = unclassified
LWD = "less weight down"

Children's responses and classifications for the Adjustment balance scale task

ADJUSTMENT POSTTEST

Problem type:		Adj. Balance				Adj. Weight				Adj. Distance				Adj. Conflict-Distance				Adj. Conflict-Balance				
Item number:		5	8	11	19	2	7	13	18	1	9	15	16	4	6	12	20	3	10	14	17	
Correct response:		*1,4	5,2	6,3	3,1	3,1	4,1	1,1	2,1	1,4	6,4	2,4	4,4	4,4	3,4	1,4	5,4	2,3	3,2	3,4	1,2	
	S's No.																					Rule
	1	**2	3	3	3	1	3	3	2	3	2	4	2	2	3	4	2	2	2	4	3	I
	2	4	3	1	1	2	1	1	1	2	1	2	2	2	3	4	1	3	4	1	4	I
	3	2	3	2	1	2	3	2	2	2	3	2	3	2	3	2	3	3	2	2	2	?
	4	4	2	3	1	1	1	1	4	4	4	3	4	4	4	4	4	1	2	3	1	III
	5	4	2	3	1	4	1	2	2	4	4	4	4	3	4	4	4	2	1	3	1	Id/II
5-year-old	6	3	2	3	1	2	3	1	4	2	3	2	4	2	2	2	3	2	1	3	3	I
males	7	2	2	3	1	2	4	4	3	3	4	1	4	4	4	4	3	4	4	4	4	?
	8	1	2	2	1	3	1	1	1	3	3	3	2	1	4	1	3	3	1	2	2	?
	9	2	2	2	4	4	1	3	4	3	4	4	4	4	2	4	4	3	4	2	3	I
	10	4	2	3	1	2	1	1	1	1	4	4	4	4	4	4	4	2	1	3	1	II/III
	11	4	2	3	1	1	2	1	3	4	3	4	4	3	2	4	4	2	2	1	3	Id/II
	12	2	2	3	1	2	2	1	2	4	3	2	2	2	2	4	2	2	1	2	2	I
	13	4	2	3	1	1	1	1	1	4	4	4	4	3	4	4	4	2	1	3	1	II/III
	14	4	2	3	1	2	3	1	1	3	4	4	4	1	3	3	4	2	2	4	1	II
	15	4	2	3	1	1	4	2	1	2	3	3	4	4	3	3	2	3	1	1	4	I

*e.g. 1,4 = child is given one weight; correct answer is the 4th peg.
**indicates peg # on which child placed weight(s)

I = Rule I
Id= Rule I-D
II= Rule II
III= Rule III
IV= Rule IV
? = unclassified

Id/II - indicates double classification (i.e. Rule I-D & Rule II)

Children's responses and classifications for the Adjustment balance scale task

ADJUSTMENT POSTTEST

Problem type:		Adj. Balance				Adj. Weight				Adj. Distance				Adj. Conflict-Distance				Adj. Conflict-Balance				
Item number:		5	8	11	19	2	7	13	18	1	9	15	16	4	6	12	20	3	10	14	17	
Correct response:		*1,4	5,2	6,3	3,1	3,1	4,1	1,1	2,1	1,4	6,4	2,4	4,4	4,4	3,4	1,4	5,4	2,3	3,2	3,4	1,2	
	S's No.																					Rule
	16	2	2	1	1	1	2	1	4	2	2	2	1	2	3	2	1	1	2	2	1	I
	17	4	2	3	4	3	4	2	1	1	1	1	2	1	1	1	1	2	1	4	2	?
	18	4	2	2	2	2	3	2	3	1	2	4	2	3	3	2	2	2	1	3	3	?
	19	2	3	3	3	3	2	3	1	3	3	3	4	3	3	2	3	3	3	3	4	I
	20	4	2	3	1	1	1	1	2	3	4	4	4	2	2	4	4	2	1	3	1	II
5-year-old	21	4	2	4	1	2	3	2	2	4	4	4	4	3	3	4	4	4	2	3	1	Id/II
females	22	4	2	4	1	1	4	1	1	2	2	1	1	3	4	1	3	2	3	1	2	?
	23	3	4	4	4	3	4	4	4	2	4	4	4	3	4	4	4	2	3	3	2	?
	24	4	2	2	1	4	1	1	1	3	2	3	3	3	3	1	3	3	2	3	4	?
	25	4	3	3	3	3	2	4	2	4	2	4	4	2	3	4	3	2	4	4	3	I
	26	1	2	1	1	4	1	2	4	3	3	4	4	4	1	4	3	3	4	2	2	I
	27	1	2	2	3	3	3	2	3	2	3	2	1	1	3	2	3	3	2	2	4	I
	28	4	4	2	2	4	2	3	1	3	3	2	4	1	4	4	4	3	4	1	3	I
	29	2	2	2	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	I
	30	2	2	3	1	1	1	1	1	2	3	2	1	1	3	1	2	2	1	3	1	?

*e.g. 1,4 = child is given one weight; correct answer is the 4th peg.
**indicates peg # on which child placed weight(s)

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Children's responses and classifications for the Adjustment balance scale task

ADJUSTMENT POSTTEST

Problem type:		Adj. Balance				Adj. Weight				Adj. Distance				Adj. Conflict-Distance				Adj. Conflict-Balance				
Item number:		5	8	11	19	2	7	13	18	1	9	15	16	4	6	12	20	3	10	14	17	
Correct response:		*1,4	5,2	6,3	3,1	3,1	4,1	1,1	2,1	1,4	6,4	2,4	4,4	4,4	3,4	1,4	5,4	2,3	3,2	3,4	1,2	
	S's No.																					Rule
	31	4	2	3	1	3	1	1	1	4	4	4	4	4	4	4	4	2	4	3	3	II/III
	32	4	3	3	1	1	3	2	1	4	4	4	4	4	4	1	4	4	4	3	2	Id/II
	33	1	2	9	2	2	2	1	2	3	2	2	2	3	3	2	1	2	1	2	2	I
	34	4	2	3	1	1	4	1	4	4	4	4	4	4	4	4	4	4	2	3	2	III
	35	4	2	3	1	4	3	1	4	1	1	1	1	1	1	4	1	2	2	4	2	?
7-year-old	36	4	2	3	1	1	1	3	2	4	4	4	4	4	4	4	4	2	1	3	2	III
males	37	4	2	3	1	4	3	4	4	1	1	1	1	1	1	1	1	1	4	2	2	?
	38	4	2	1	2	1	4	4	4	3	4	4	4	4	4	4	2	2	1	1	4	Id
	39	4	2	3	1	1	4	1	1	4	4	4	4	4	4	4	4	4	4	4	4	III
	40	2	2	3	1	2	1	2	2	4	4	4	4	4	4	4	4	3	1	3	1	Id/II
	41	4	2	3	1	1	1	1	1	3	3	3	3	2	2	1	3	2	1	3	1	?
	42	4	2	2	1	1	2	2	4	2	3	4	4	4	2	4	4	4	1	3	1	Id
	43	4	2	3	1	1	1	1	1	4	4	4	4	4	4	4	4	3	2	4	2	IV
	44	1	1	1	1	2	1	1	4	4	4	4	4	4	4	3	4	3	1	2	2	?
	45	4	3	3	1	1	1	1	1	4	4	4	4	4	4	4	4	3	3	4	2	III/IV

*e.g. 1,4 = child is given one weight; correct answer is the 4th peg.
**indicates peg # on which child placed weight(s)

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Id/II - indicates double classification (i.e. Rule I-D & Rule II)

Children's responses and classifications for the Adjustment balance scale task

ADJUSTMENT POSTTEST

Problem type:		Adj. Balance				Adj. Weight				Adj. Distance				Adj. Conflict-Distance				Adj. Conflict-Balance				
Item number:		5	8	11	19	2	7	13	18	1	9	15	16	4	6	12	20	3	10	14	17	
Correct response:		*1,4	5,2	6,3	3,1	3,1	4,1	1,1	2,1	1,4	6,4	2,4	4,4	4,4	3,4	1,4	5,4	2,3	3,2	3,4	1,2	
	S's No.																					Rule
	46	4	2	3	1	2	1	1	1	2	3	4	4	3	2	4	4	3	1	3	1	II
	47	4	2	3	1	3	3	4	2	4	3	3	4	1	1	1	4	4	4	4	2	II
	48	4	2	3	1	1	4	1	4	4	4	4	4	1	4	4	4	3	1	3	2	III
	49	4	2	3	1	2	2	2	2	4	4	4	4	4	4	4	4	2	2	3	2	III
	50	2	2	3	1	1	4	4	4	2	3	2	2	2	2	1	2	1	1	3	2	I
7-year-old	51	4	4	2	4	3	2	3	4	2	3	3	1	3	3	4	1	2	4	2	4	I
females	52	4	2	3	1	2	2	2	2	4	4	4	4	4	4	4	4	1	2	4	2	III
	53	4	2	3	1	2	3	2	3	4	4	4	4	4	4	4	4	3	1	3	1	Id/II
	54	4	2	3	1	1	2	2	2	4	4	4	4	4	4	4	4	2	2	3	1	Id/II
	55	4	2	3	1	4	2	4	4	4	4	4	4	4	4	4	4	2	1	3	2	Id
	56	4	2	3	1	1	1	1	1	4	4	4	4	4	4	4	4	2	1	3	2	III
	57	2	3	3	2	3	3	3	3	2	3	2	4	2	3	1	2	3	2	1	2	I
	58	4	2	2	1	4	4	4	4	4	4	4	4	4	4	4	4	2	1	3	2	?
	59	4	2	3	1	1	4	4	4	4	4	4	4	4	4	4	4	2	1	3	1	Id/II
	60	4	2	3	1	1	1	1	1	4	4	4	4	4	4	4	4	2	2	2	1	III

*e.g. 1,4 = child is given one weight; correct answer is the 4th peg.
**indicates peg # on which child placed weight(s)

I = Rule I
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III= Rule III
IV= Rule IV
? = unclassified

Id/II - indicates double classification (i.e. Rule I-D & Rule II)

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