Developmental Psychology
1974, Vol. 10, No. 5, 721-732

Development of Integration Processes Using Ability and Effort Information to Predict Outcome[1]

ANNA KUN[2]
University of California, Los Angeles

JACQUELYNNE E. PARSONS
Smith College

DIANE N. RUBLE
Princeton University

Three studies were conducted to examine developmental changes in the integration of ability and effort information to predict performance. Functional measurement procedures were used to determine if it is possible to use some simple algebraic operation such as addition or multiplication to describe the way these cues are combined. Children aged 6-11 years and adults were asked to predict how many puzzles a child could put together as a function of 3 levels of ability and 3 levels of effort. The results showed a developmental progression in the integration process, in which an additive rule characterized the responses of the youngest children while a multiplicative rule characterized the responses of the older children and adults. An additional finding indicated that even the youngest children were able to use both cues in forming judgments and did not center on only one cue as would be predicted from Piaget. Also the results showed that effort was increasingly more important than ability in predicting outcomes.

It has recently been postulated that individuals use four causal elements (ability, effort, task difficulty, and luck) to predict and to interpret the outcomes of achievement-related events (Weiner et al., 1971). According to Weiner et al., these four elements can be classified into two dimensions: locus of control (internal versus external) and degree of stability (fixed versus variable). The internal elements consist of a stable attribute, ability, and a variable attribute, effort. Likewise, the external elements consist of a stable attribute, task difficulty, and a variable attribute, luck. Much of the research based on this model has been focused on how a given attribution affects judgment processes. Thus far, however, the question of how individuals combine the various attributional elements in making judgments has been relatively neglected.

Heider (1958) makes a very specific prediction concerning the mathematical relationship between ability and effort:

> The personal constituents, namely power (ability) and trying (effort), are related as a multiplicative combination, since the effective personal force (performance) is zero if either of them is zero. For instance, if a person has the ability but does not try at all he will make no progress toward the goal [p. 83].

In a study using adult subjects, Anderson and Butzin (in press) partially confirmed Heider's conjecture. Subjects were asked to predict athletic performance from ability and effort information. The results showed that a multiplicative rule described the outcome prediction data.

[1] This research was supported in part by Grant GS-35216 to Bernard Weiner. The first author was supported by U.S. Public Health Service Training Grant MH11696-04. The authors wish to thank Bernard Weiner for helpful suggestions and comments and Katherine Zonana, Jane Hines, and Roseann Giarusso for their assistance in collecting and analyzing the data. Finally, the first author also thanks both her parents for liberating her sufficiently during the preparation of this article so that her newborn daughter could be an incentive rather than an obstacle to this work.

[2] Requests for reprints should be sent to Anna Kun, Department of Psychology, University of California, Los Angeles, California 90024.

It seems reasonable that a multiplicative model would describe the results when adults and older children combine ability and effort information. It is questionable, though, whether young children are able to perform the types of operations necessary to produce a multiplicative outcome. Inhelder and Piaget (1958) suggest that the capacity to form multiplicative combinations develops gradually over the period of concrete operations (7–11 years) but should not exist prior to this stage.

However, before one can ask the question of *how* information is combined, it is necessary to consider whether young children can use more than one bit of information in forming judgments. It has been suggested that children in the preoperational stage, typically 4–7 years, are not able to use more than one informational cue in any consistent way. In Piagetian theory and research, it is proposed that a general characteristic of these children is centration (Ginsberg & Opper, 1969). Young children tend to focus on a limited amount of information to make judgments. For example, in a test for conservation of quantity, young children may use only height information and ignore width in judging two glasses of liquid to be the same, or they may focus on width alone and ignore height. However, in a recent study of area judgments, Kempler (1971) found that even the youngest age group (6–7 years) was able to use both height and width information to make size judgments. Similarly, the results of several studies (Buchanan & Thompson, 1973; Costanzo, Coie, Grumet, & Farnill, 1973; Hebble, 1971) dealing with moral judgments have indicated that children still in the preoperational stage do use more than one cue in forming their judgments. These results also suggest that while the relative importance of a particular cue may change with age, children of all ages tested use intent as well as outcome in making evaluative judgments.

Based on these results, we expect that young children are also capable of using both ability and effort cues in forming outcome predictions in an achievement context. However, in view of Piaget's observation of the delayed development of multiplicative operations, we suspect that some simpler combinatorial rule than the multiplicative one found with adults represents the judgments of children under Age 7. On heuristic grounds alone, we expect that an additive rule would be simpler and may describe the younger children's data. There is also some empirical basis for considering an additive rule to represent simpler psychological processes than a multiplicative one. Anderson and Butzin (in press) found that while subjects used the multiplying rule to estimate performance from ability and motivation, for the presumably more complex task of inferring ability (motivation) from performance and motivation (ability), the multiplying rule did not hold. However, their judgments did not become unsystematic but rather conformed to an additive model.

The present study is primarily concerned with developmental changes in the integration of information in achievement outcome predictions. A preliminary question is whether young children are able to use both ability and effort information to form judgments of achievement outcomes. If both these cues are used in predictions of performance, the main question becomes how such information is integrated. Functional measurement (Anderson, 1971) provides a general methodology for answering these questions. Using this approach, it is possible to determine if some simple algebraic operation such as addition or multiplication can describe the way these types of information are combined.

STUDY 1

Method

Subjects

The subjects consisted of 72 children and 24 college students. The children were from three day care centers and a YMCA in a racially mixed (white, black, and Mexican-American), lower-middle-class, urban section of Los Angeles. There were 12 boys and 12 girls in each of three age groups (6, 8, and 10–11 years). The data from the children were collected during their summer vacation in August 1971. The college sample, drawn from a state college in the same city, was tested in the fall term of 1971. The college sample consisted entirely of male subjects. IQ information was not available on either of these samples.

Procedure

The children were tested individually by one of three female experimenters. All three experimenters were white, middle-class, psychology graduate students at the University of California, Los Angeles. The experimenter gave the following instructions to the child: "I'm going to tell you some stories about some boys who got seven puzzles for their birthday. After I tell you about each boy, I want you to tell me how many of his puzzles you think he got right." The stimuli consisted of descriptions of the ability and effort of nine boys. There were three levels of ability (very good at puzzles, O.K. at puzzles, and very bad at puzzles) and three levels of effort (tried very hard, tried a little, and didn't try at all). The levels of ability and effort were crossed factorially producing nine different stories. A sample story follows: "Frank is very good at puzzles but he didn't try at all. How many puzzles do you think he got right?".

A pictorial scale was used as the response measure. Pictures of completed puzzles were displayed on a 10 × 14 inch cardboard sheet. The puzzles were arranged in seven columns varying in length from one puzzle to seven puzzles. Thus, the children could use either the number of puzzles in the column or the increasing length of the column as the dimension along which to differentiate their responses. After each story was read, the children pointed to the number of puzzles they thought the boy was able to put together. Before the experimental stimuli were presented, the children were given practice using the puzzle scale. Once they demonstrated that they could use the scale the experimenter read them each of the nine stories in a random order.

The adult subjects (n = 24) were tested in a group with printed materials. They were told that their responses were to be used as standards against which to compare the data collected from a study with children. Thus, it was possible to use exactly the same stimuli with both the children and adult subjects, although in the latter case the responses were written. The nine stories were presented in two random orders.

Results

Preliminary analyses revealed no significant effects for sex alone or in interaction with any other variables ($F < 1$). Therefore, sex was eliminated as a factor in all further analyses.

A 4 × 3 × 3 composite analysis of variance was performed on the outcome predictions. The between-subjects factor was age (4 levels). Within-subjects factors were ability and effort (3 levels each). The results of this analysis show that the main effects for both Ability and Effort are highly significant ($F = 41.45$, $df = 2/88$, $p < .001$ and $F = 108.82$, $df = 2/88$, $p < .001$, respectively). Furthermore, both the Age × Ability and the Age × Effort interactions are nonsignificant ($F = 1.26$, $df = 6/88$ and $F = 1.33$, $df = 6/88$, respectively), indicating that both ability and effort information were used similarly across all age groups.

The relative size of these main effects suggests that effort was used more systematically or with greater emphasis than ability as a cue for outcome. A test for the proportion of variance due to these main effects (Kirk, 1969) resulted in 28.0% for effort and 9.4% for ability, indicating that the effort manipulation accounts for three times as much variance as the ability manipulation. In addition to the main effects, there is a significant Ability × Effort interaction ($F = 4.31$, $df = 4/176$, $p < .001$). The role of this interaction is discussed below in terms of the integrative model applicable to each age group. To examine how the integration of ability and effort cues may vary as a function of age, the data were analyzed separately for each age group, applying the principles of functional measurement.[3] Figure 1 shows the mean outcome judgments plotted against the marginal means of the three ability levels for each age group.

Six-Year-Olds

In the graph for the six-year-olds, the low- and medium-effort lines appear parallel, and overall parallelism seems violated only by a single point, the low-ability–high-effort combination. A statistical test for parallelism yielded significant main effects for ability ($F = 16.13$, $df = 2/46$, $p < .001$) and

[3] When the two informational cues ability and effort are combined factorially, graphical tests allow one to distinguish between the two algebraic relations: Outcome = Ability + Effort; Outcome = Ability × Effort. To determine which equation applies, the judgments are plotted against the subjective values of the stimulus cues (high, medium, low). These values are derived from the marginal means. If additivity applies, then the judgments, when plotted against the marginal means of one of the stimulus variables, should result in parallel lines. If, however, multiplication holds, then the responses should plot as a diverging fan of straight lines whose slopes are proportional to the subjective values of the second variable. Statistical tests from the analysis of variance are used to evaluate the goodness of fit of these models. The statistical test for parallelism is equivalent to the absence of any interaction between the two variables. The test for the multiplicative model requires a significant two-way interaction which is concentrated in the Linear × Linear component, leaving a nonsignificant residual interaction term.

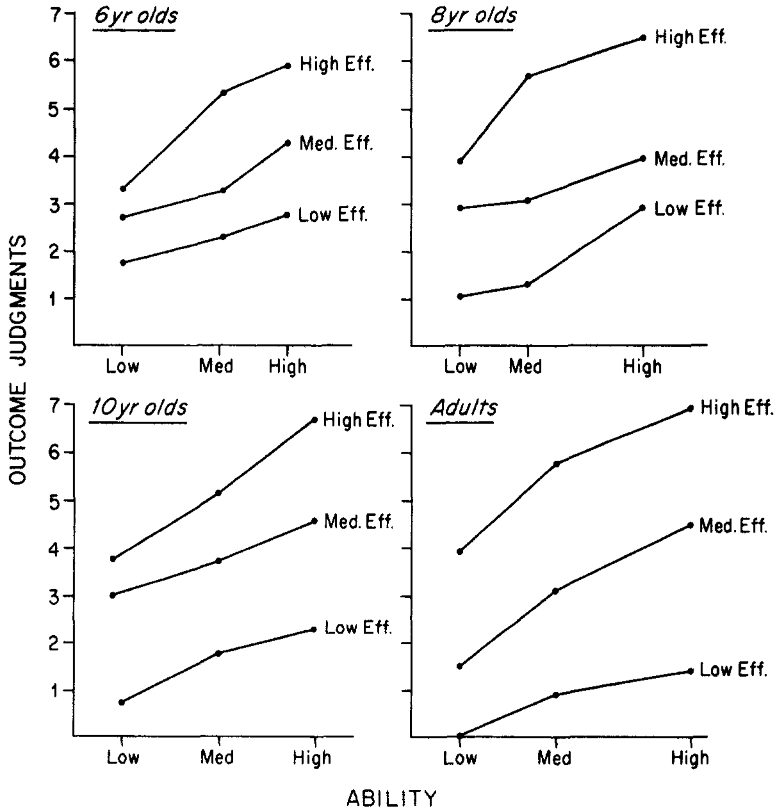

Figure 1. Outcome judgments as a function of age. The outcome judgments are plotted against the subjective values of ability for each level of effort.

for effort ($F = 32.60$, $df = 2/46$, $p < .001$) but gave a nonsignificant Ability × Effort interaction ($F = 1.95$, $df = 4/92$). Thus, the deviation from the graphical test of parallelism in this condition is not significant, and the judgment data for the six-year-olds is best described by an additive model.

Eight-Year-Olds

The graph of the eight-year-olds shows some similarities to that of the younger children. For both groups, the slope of the high-effort curve is considerably greater than the average slopes of the other two lines. The high-effort slope is 1.43 for the six-year-olds and 1.38 for the eight-year-olds, while the average slopes of the other two curves are .70 and .79, respectively. This difference in the slopes suggest that variations in the level of ability have more effect on judgments in the high-effort condition than in the medium- or low-effort conditions. The analysis for the eight-year-olds' data indicates that in addition to the significant main effects for ability ($F = 26.98$, $df = 2/46$, $p < .001$) and for effort ($F = 93.21$, $df = 2/46$, $p < .001$), the Ability × Effort interaction is significant ($F = 4.03$, $df = 4/92$, $p < .01$). This interaction rules out simple addition as a model for the integration process of these children. Decomposition of this interaction into its bilinear and residual parts shows that only 13% of this variance is due to the bilinear component. The test for the residual$_{L\times L}$ effect after removal of the bilinear component[4] indicates that the residual$_{L\times L}$ effect is significant ($F = 4.63$, $df = 3/69$, $p < .001$). This result also rules out

[4] The test is as follows:

$$F_{Res} = [SS_{Res_{L\times L}}/(i-1)]/\ [(\sum_{subjects} SS_{Res_{L\times L}})/(i-1)(n-1)],$$

where $i = df$ of the interaction, n = number of subjects.

multiplication as a model for these judgments.

The above analyses suggest that the integration process for the eight-year-olds is more complex than for the younger children, since a simple additive rule no longer holds. It appears from the graph that a multiplicative relation is perceived between ability and effort as the former changes from low to medium and the latter from medium to high, but this type of relationship is not yet extended uniformly to the rest of the stimulus conditions. For this reason, the complex Ability × Effort interaction may indicate a transitional phase in the judgment process.

Ten-Year-Olds and Adults

The responses of the 10-year-old and adult samples (see Figure 1) yield effort curves that approximate straight lines when plotted as a function of the marginal means of ability. This characteristic of the graphs meets one criterion for a multiplicative model. Furthermore, the effort curves of the 10-year-olds seem to form a diverging fan of straight lines. Although divergence is not as clearly evident from visual inspection of the adult data, there is a 33% increment in the distance between the high- and low-effort lines at the two extreme ability levels, indicating that these lines are diverging.

Next, the statistical evidence for a multiplicative model was examined. The main effects for ability and effort in the ten-year-olds' data follow the earlier patterns ($F = 62.61$, $df = 2/46$, $p < .001$ and $F = 104.53$, $df = 2/46$, $p < .001$, respectively). Similarly these effects are significant in the college sample ($F = 103.79$, $df = 2/46$, $p < .001$ for ability and $F = 247.77$, $df = 2/46$, $p < .001$ for effort). In addition, the Ability × Effort interaction is significant for both these groups (for the ten-year-olds $F = 3.04$, $df = 4/92$, $p < .002$ and for the adult sample $F = 7.93$, $df = 4/92$, $p < .001$).

The critical test for the multiplicative model was next applied to these interactions. For the 10-year-olds' data, the bilinear component accounts for 74% of the total interaction. Using the F-test formula (see Footnote 4), we find that the $\text{residual}_{L \times L}$ component is nonsignificant ($F = 1.04$, $df = 3/69$). Similar decomposition of the interaction in the adult data shows that 76% of the variance is due to the bilinear term and that the $\text{residual}_{L \times L}$ is nonsignificant ($F = 2.24$, $df = 3/69$, $p < .10$). On the basis of these analyses we conclude that a multiplicative integration rule provides an appropriate description of the outcome judgments for both the ten-year-old and the college sample.

Discussion

In general, the results turned out as anticipated. Main effects for both ability and effort were present at all age levels, suggesting that even the youngest children are able to use both ability and effort cues. In addition, a definite age trend appeared in the mathematical relationship between effort and ability as used to predict outcome. The data from the six-year-olds conform to an additive model, while the data for the ten-year-olds and the adults conform to a multiplicative model. On the other hand, neither an additive nor a multiplicative rule could be used to characterize the judgments of the eight-year-olds. However, the responses of the eight-year-olds were more systematic than the responses of the six-year-olds in that more variance was accounted for by the manipulation of the independent variables. Furthermore, the eight-year-olds' data were more complex than the six-year-olds' in that a significant Ability × Effort interaction was obtained. This suggests that the eight-year-olds were already beginning to perceive that the effect of one variable (e.g., ability) is modified by the level of the other variable (e.g., effort). One thus suspects that the eight-year-olds' data represents some transition in the integrative process. However, we need to be cautious about overinterpreting at this time the qualitative difference between the six- and eight-year-olds' judgments, since the graphs of these two groups appeared to be very similar.

Another finding of interest was that outcome predictions covaried more with effort than with ability. This relationship was found to hold at all age levels. There are a number of possible reasons for this finding.

First, it may be that effort information carried more weight than ability for predicting outcome. On the other hand, the psychological distance between the points of the scales for effort and ability may have been different. That is, effort that varies between "not try at all" and "try very hard" may represent a subjectively wider range of stimulus values than ability that ranges between "very bad" and "very good." Unfortunately, for the adding and multiplying models there is no presently known technique for isolating differential weighting from differential subjective stimulus values as possible causes for this result.

Another possible cause for the relatively greater effort effect is the order of presentation of the two stimulus cues. In all judgment conditions, each subject received the ability information first and the effort information second. A typical story was phrased: "Johnny got seven puzzles for his birthday. Johnny is *very good* at puzzles and he *tried very hard.*" It is conceivable that the relatively greater amount of variance accounted for by the effort manipulation simply indicates a "recency" effect. A recency effect in memory experiments with children has been documented in the literature (Cole, Frankel, & Sharp, 1971).

STUDY 2

Study 2 was conducted to examine the possibility that the order of presentation of the ability and effort stimuli partially accounted for the relatively stronger main effects for effort. In Study 1, effort information was always presented after the ability information. It is especially likely that the youngest children tested in Study 1 were affected by order, since the capacity to remember and reproduce information improves with age. However, since the strength of the effort effect increased over age, it is improbable that order of stimulus presentation totally accounts for the relatively greater covariation of outcome judgments with effort than with ability. Rather it may be that effort does become a more important judgmental cue over age. If this were the case we should find that counterbalancing the order of stimulus presentation affects more the relative importance of effort for the younger than for the older children.

Method

Subjects

The subjects were 72 first, third, and fifth graders, drawn from an all-white middle-class public elementary school in a suburb of a large metropolitan area. There were 12 boys and 12 girls in each grade. The children were tested during the spring of 1973. No IQ data were available on the subjects.

Procedure

The procedure and the experimenters were the same as in Study 1 except that half of the children at each grade level received ability information first, while the other half received effort information first. An additional minor change was that the fifth graders were tested in groups of four. As with the younger subjects, the stories were read aloud by the experimenter, but these subjects responded by writing their judgments rather than by pointing to the puzzle scale as the younger subjects did.

Results and Discussion

Analysis of Order Effects

A $2 \times 3 \times 3$ analysis of variance was performed separately for each grade level. The between-subjects factor was order (2 levels) and the within-subjects factors were ability and effort information (3 levels each). The results for the first graders yielded both an Order × Ability interaction ($F = 4.27$, $df = 2/44$, $p < .05$) and an Order × Effort interaction ($F = 6.25$, $df = 2/44$, $p < .01$). These interactions are shown in Figure 2. The Order × Ability interaction indicates that ability is more important for outcome prediction when it is presented as the last stimulus cue. This is shown in Figure 2a by a steeper slope for the outcome judgments under Order 2 (effort first, ability second). Similarly, the Order × Effort interaction indicates that effort is more important for outcome prediction when it is the final cue. This can also be seen in Figure 2b where the slope of the outcome judgment is steeper for Order 1 (ability first, effort second).

The results also showed main effects for ability and effort, as in Study 1. However, contrary to Study 1 where the main effect for effort was stronger than the effect for ability,

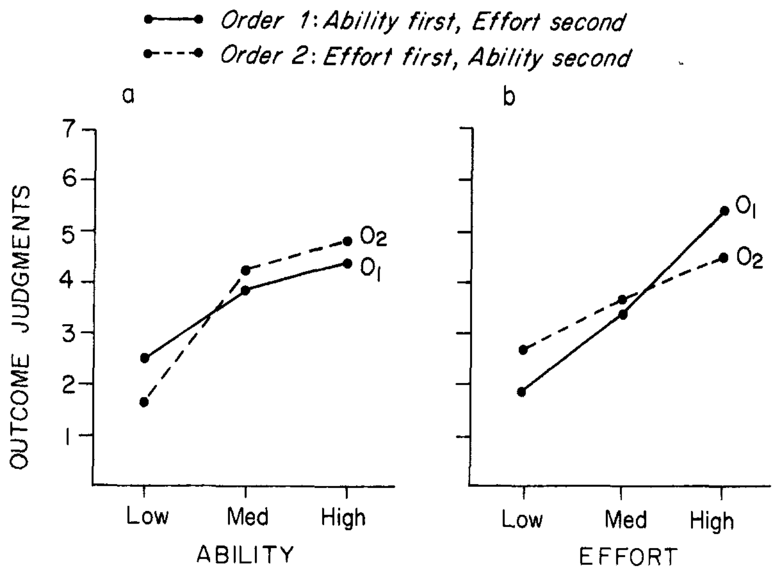

Figure 2. Order effect for Grade 1. Figure 2a represents the Order × Ability interaction. Figure 2b represents the Order × Effort interaction.

in the present study the magnitude of these two effects were essentially the same ($F = 59.71$, $df = 2/44$, $p < .001$ and $F = 61.07$, $df = 2/44$, $p < .001$, respectively). An additional test indicated that these two effects accounted for approximately an equal proportion of the variance: ability 20.5% and effort 21.0%. This implies that when order is controlled, outcome judgments covary similarly with ability and effort information. Thus, we may conclude that the greater effort effect for the six-year-olds in Study 1 can be attributed to "recency."

The results for the third and fifth graders are presented together. In both groups, there were no Order × Ability nor Order × Effort interactions ($F < 1$). There were main effects for both ability and effort, and in both cases, the effort effects were stronger (for the third graders, $F = 67.41$, $df = 2/44$ for ability and $F = 105.37$, $df = 2/44$ for effort; for the fifth graders, $F = 67.76$, $df = 2/44$ for ability and $F = 141.45$, $df = 2/44$ for effort; $p < .001$ for all Fs). The proportion of variance accounted for by each of these effects was, respectively, 23.6%, 35.0%, 18.3%, and 40.0%. The absence of the order interactions means that for the older two grade levels, the outcome judgments were not affected by the order of stimulus presentation. Furthermore, the differential main effects indicate that effort is a more important determinant of outcome judgments. Thus, as expected, when order is controlled, the importance of effort cues increases over age.

Analysis of the Integration Rule

Since there were no three-way interactions with order at any of the grade levels (Order × Ability × Effort, $F < 1$), the data from the two order conditions within each grade were combined for the purpose of examining which algebraic model best describes the data. The results for all three grades show significant Ability × Effort interactions (in order of increasing grade level, $F = 10.98$, $df = 4/92$, $p < .001$; $F = 4.10$, $df = 4/92$, $p < .01$; $F = 5.72$, $df = 4/92$, $p < .001$). Thus, the data from all three grades fail to meet the requirements for an additive model.

Next, the test for a multiplicative model was performed on the data. Decomposition of the interaction into its Linear × Linear and $\text{residual}_{L \times L}$ components for Grade 1 shows that 74% of the variance is due to the bilinear component. However, since the $\text{residual}_{L \times L}$ component is also highly significant ($F = 5.10$, $df = 3/69$, $p < .01$), a multiplicative model cannot be used to describe the judgments in this instance.

Decomposition of the interaction for Grade 3 shows that 86% of the variance is due to the bilinear component, while the residual is not significant ($F < 1$). Similarly for Grade 5, 76% of the variance is due to the bilinear component and the residual is once again not significant ($F = 1.61$, $df = 3/69$). These results indicate that a multiplicative integration rule fits the outcome judgments for Grades 3 and 5.

Study 2, therefore, provides a partial replication of Study 1. This study supports the conclusion that older children (9–11 years) combine ability and effort information in a multiplicative way. However, the judgments of the youngest subjects in this study (first graders) are not similar to the judgments of the youngest subjects in Study 1 (six-year-olds). Instead, their judgments resemble the judgments of the second age group (eight-year-olds) in Study 1. That is, the data from both the eight-year-olds in Study 1 and the first graders from Study 2 showed highly significant Ability × Effort interactions that were due, in part, to significant nonlinear components. As discussed earlier, nonlinear terms suggest some transitive stage between an additive and a multiplicative operation. The similarity of these two different age groups across studies might be explained by the fact that the children in Study 2 were drawn from a higher socioeconomic group than those in Study 1. In addition, the subjects in Study 2 were tested in late spring, by which time the majority of first graders were 7 years old rather than 6.

Consistent with this explanation is the finding that the third graders in Study 2 were using a multiplicative judgment rule, as did the 10-year-olds in Study 1. Taken together, the results of these two studies indicate that there is a developmental trend in the use of a multiplicative rule for combining ability and effort information, although the exact age of the shift from addition to multiplication appears to be a function of the characteristics of the sample.

STUDY 3

Study 3 had two distinct purposes. First, it seemed important to replicate the difference found in Study 1 in the integration rule of ability and effort that distinguished the six- from the eight-year-olds' data. The responses of the six-year-olds conformed to an additive model, while the responses of the eight-year-olds showed a nonsystematic Ability × Effort interaction which suggested a transitional phase between addition and multiplication. However, in Study 2 the youngest age group, the first graders, also gave this nonsystematic interaction instead of the additivity originally expected. Hence, the question arose whether additivity would be found with a sufficiently young age group or if it was a chance finding in Study 1. Therefore, to replicate the difference between the two youngest age groups found in Study 1, it was necessary to match the subjects' age as closely to the subjects in Study 1 as possible. Since this study was conducted during the late spring, a kindergarten and second-grade sample was selected as being closest in age to the Study 1 sample.

This study was also conducted as a further examination of the issue of centration. The main effects of ability and effort found in Study 1 suggested that even the six-year-olds are able to use both cues in forming outcome judgments. However, it is possible that the effects from the group data could reflect a combination of data from two subsets of children who use only one or the other cue consistently. To examine this possibility, Study 1 was repeated, the procedure modified so that each child received the set of nine stories twice. Repeating the measures makes it possible to obtain an error term for each subject and thus run individual analyses of variances. In this way, it is possible to specify the percentage of children who actually use both cues as opposed to those who use only one cue. In addition, these analyses can be used to describe the integration process at the individual-subject level.

Method

Subjects

The subjects ($N = 32$) were kindergarten and second graders from the same school used in Study 2. There were 8 girls and 8 boys at each grade level. These children were also tested in the spring of 1973.

Procedure

The experimenters and procedure were identical to Study 1 except that the first presentation of the nine stories was followed by a second presentation. The order of the nine stories was randomized for each subject, but the same order was used for the first and second presentation of the stories. As in Study 1, ability information was always given first and effort information second. Counterbalancing was not done because the differential main effects due to order of stimulus presentation were not of concern in this study and because it was desirable to replicate Study 1 as closely as possible.

Results and Discussion

Analysis of the Integration Rule

The group analyses of variance were performed on the first nine judgments in order to compare this data with Study 1. For the kindergarten subjects, the statistical test for parallelism yields main effects for ability ($F = 27.09$, $df = 2/60$, $p < .001$) and effort ($F = 80.05$, $df = 2/60$, $p < .001$), but the Ability × Effort interaction is not significant ($F = 1.86$, $df = 4/60$). These results indicate that the kindergarten subjects are using an additive integration rule. Thus, the data replicate the additivity obtained for the six-year-olds in Study 1.

For the second graders, the results also show main effects for ability ($F = 14.89$, $df = 2/60$, $p < .001$) and effort ($F = 172.10$, $df = 2/60$, $p < .001$). In addition, there is a significant Ability × Effort interaction ($F = 4.91$, $df = 4/60$, $p < .01$). Decomposition of this interaction into its Linear × Linear and $\text{residual}_{L \times L}$ components shows that 82% of the variance is accounted for by the bilinear component while the $\text{residual}_{L \times L}$ is not significant ($F = 1.28$, $df = 3/45$). These results indicate that the second graders are using a multiplicative judgment rule. These data do not replicate the nonsystematic interaction obtained for the eight-year-olds in Study 1, but rather conform to the multiplying model as the ten-year-olds in that study. As in Study 2, these findings may be explained by the fact that the sample in Study 3 was developmentally more advanced than the sample in Study 1.

Individual-Subject Analysis

To describe the integration process at the individual level and, in particular, to examine the issue of centration, it is necessary to perform individual-subject analyses of variances on the judgment data. This requires at least one replication of each experimental condition for obtaining an error term. When large error variance is anticipated which may obscure true effects, it is customary to increase the number of replicates. For the design of this study, the analysis requires a minimum of 18 judgments per subject and each replication calls for an additional 9 judgments. Because of the short attention span of our subjects, it was deemed inadvisable to increase the conditions beyond the minimum 18 judgments required, at the same time that large error variances were to be expected. Consequently, to increase the probability of detecting true effects, it was decided to relax the level of significance from the usual $\alpha = .05$ to $\alpha = .10$.

To determine if centration is a tenable explanation for the group main effects for ability and effort, these effects are examined in the individual-subject analyses. These results appear in Table 1. The data for the kindergarten subjects show that 68.7% of these children used both the ability and effort information, while the remainder of these children used effort only. Similarly, the

Table 1: Percentage of Kindergarten and Second-Grade Subjects Whose Judgments Are Characterized by Centration, Addition, or Multiplication

Significant effect[a]	Judgment model	Kindergarten ($n = 16$)	Second grade ($n = 16$)
Ability (A)	Centration	.0% (0)[b]	.0% (0)
Effort (E)	Centration	31.25% (5)	18.75% (3)
A, E	Multiple cue utilization—Addition	37.50% (6)	37.50% (6)
A, E, A × E (nonsystematic)	Multiple cue utilization	18.75% (3)	6.25% (1)
A, E, A × E (bilinear)	Multiple cue utilization—Multiplication	12.50% (2)	37.50% (6)

[a] Significance level set at $\alpha = .10$.
[b] Cell *ns* are given in parentheses.

data from the second graders indicate that 81.25% of these children used both the ability and effort cues, while the rest of these children again relied on effort only. These results confirm that the main effects for ability and effort in the group analysis were not produced by a combination of two subsets of children, part of whom used only ability and part of whom used only effort, since none of the subjects relied on ability information alone and since a large majority (75%) of all of the children used both cues simultaneously. These results, in combination with the finding of order effects in Study 2, indicate that all of the subjects were either using both cues or, when using only one cue, used the cue given last, effort. The difference in cue utilization between the two grades as reflected via the main effects in Table 1 is not statistically significant ($\chi^2 < 1$).

To describe the integration process at the individual level further, the Ability × Effort interaction is examined for those subjects who use both these cues in their outcome predictions. The data from 37.50% of the kindergarten subjects and from an equal proportion of the second graders show no Ability × Effort interaction (see Table 1), indicating that an additive model fits these judgments. In a similar fashion, a nearly equal proportion of kindergarten (31.25%) and second grade (43.25%) subjects' data show significant Ability × Effort interactions. However, decomposition of the interaction into its components reveals the critical difference between the two age groups. For the kindergarten subjects, on the average, 32.47% of the interaction is in the bilinear component, and of the five significant interactions only two are concentrated in the Linear × Linear component. For the second graders, however, on the average 58.0% of the interaction is in the bilinear component, and of the seven significant interactions, six are concentrated in the Linear × Linear component, thus obeying the multiplicative judgment rule. Although these differences in the interactions of the two groups do not reach statistical significance (Fisher's exact test $p = .25$), the obtained trend is in the expected direction.

In conclusion, the individual-subject analyses provide additional evidence that five- and six-year-olds are not centering when they make achievement-related judgments. However, as suggested by Kagan and Kogan (1970), the capacity of these young children to use multiple information fully may be limited by their relatively small immediate memory storage. Furthermore, these analyses suggest that the qualitative difference found between the judgments of these two age groups are supported by differences in the integration process at the individual-subject level.

DISCUSSION

The main purpose in this study was to investigate developmental changes in the integration of ability and effort information in predicting achievement outcomes. A related concern was the issue of centration. Specifically, we examined whether very young children are able to use both ability and effort cues in forming judgments. The results showed significant main effects for both ability and effort for all age groups studied with supportive data provided by individual-subject analyses. Thus, it was concluded that centration was not a problem for the youngest children in forming achievement-related judgments.

The integration of these cues was examined by functional measurement procedures. The results of three studies show a clear developmental progression in the integration process which can be characterized by simple algebraic operations. These results are summarized in Table 2. An additive model characterizes the responses of the youngest children in each sample. However, an additive model is insufficient to describe the responses of the children in the next age group because, in addition to the main effects, an interaction between the two cues begins to emerge. The pattern of this graph may mean that these children are already beginning to perceive that differences in ability have a greater effect on outcome when a person tries hard than when his efforts are only mediocre. Such differential effects of ability in combination with effort suggest the rudiments of a multiplicative judgmental process, which we have labeled transitional. Following this

Table 2: Summary of the Appropriate Judgmental Models

Model	Sample 1[a] (n = 96) 6 yrs.	8 yrs.	10 yrs.	Adults	Sample 2 (n = 104) Kinder-garten	1st grade	2nd grade	3rd grade	5th grade
Additive	*				*				
Transitional		*				*			
Multiplicative			*	*			*	*	*

[a] Sample 1 refers to the subjects used in Study 1. Sample 2 refers to the subjects used in Study 2 and 3.

stage, the interaction becomes so systematic that a multiplicative model can describe the judgments of the older children. These results confirm Heider's prediction for adults and older children. Thus, development proceeds from a simple additive integration process to these more complex multiplicative relationships. There is also tentative evidence to suggest that these mathematical relationships describe integration processes at the individual as well as at the group level.

One possible psychological interpretation for an additive versus a multiplicative judgment rule relates to the perceived efficacy of effort relative to one's level of ability. The additive rule implies that effort facilitates equally the performance of low- and high-ability persons. The multiplicative rule, on the other hand, implies that effort is more facilitative for the high- than for the low-ability individual. This suggests that those who use a multiplicative judgment rule believe that persons with high ability can exercise considerable control over their outcomes, but those with low ability cannot affect their outcomes substantially by their efforts. Assuming that level of need achievement is equivalent to the level of one's self-perceived ability (Kukla, 1972b), the latter interpretation is consistent with the differential attributional patterns of high- versus low-resultant achievers. Kukla (1972a) found that when adults were asked to attribute their own outcomes, subjects classified as high in need for achievement exhibited a strong effort/outcome covariation, while those classified as low in need for achievement did not.

One additional finding is the perceived increasing importance of effort over age (see Figure 3). These data show that effort is clearly more important than ability in predicting achievement outcomes for all de-

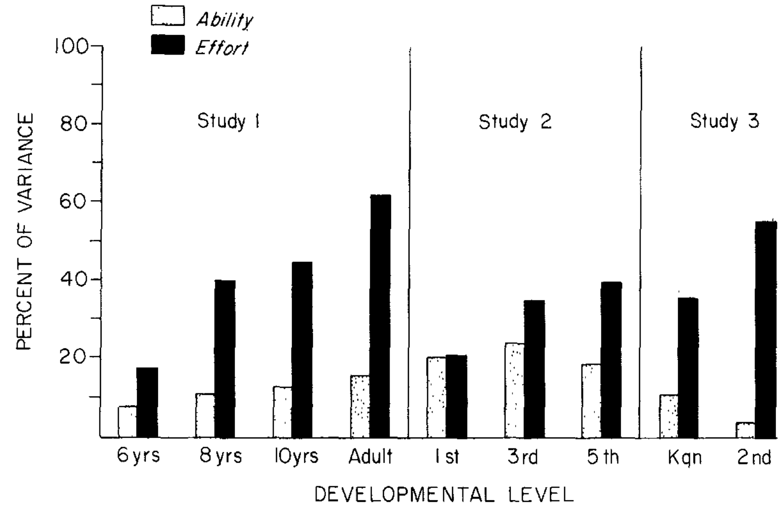

Figure 3. Proportion of variance accounted for by ability and effort as a function of age. (Kgn = Kindergarten.)

velopmental levels except the youngest.[5] This finding is related to previous studies in which the importance of effort relative to ability for evaluation of others' performance has been documented (Leventhal & Michaels, 1971; Weiner & Kukla, 1970; Weiner & Peter, 1973). However, there is a clear distinction between the implications of the two sets of findings. The belief that effort leads to social reinforcement is clearly important for maintaining goal striving behavior. On the other hand, it is also important for children's sense of competence that they perceive that effort leads to successful outcomes as well as to social reinforcement. The perception that effort covaries with outcome provides the child with a greater sense of control. For example, if children perceive that ability is the primary determinant of outcome, then low-ability children will have little sense of control over their environment. While their efforts can lead to social reinforcement, they will not lead to a real sense of accomplishment. In contrast, if children see that effort is the major determinant of outcome, then even low-ability children can develop a sense of competence through their efforts.

The present study provides evidence that effort in fact can be perceived as a more important determinant of outcome than ability by about age 7. This finding has clear practical implications. Because of the importance of the perception of effort/outcome covariation, it is important for teachers and parents not only to provide social reinforcements for trying but also to structure situations so that efforts in fact lead to success.

REFERENCES

Anderson, N. H. Integration theory and attitude change. *Psychological Review*, 1971, **78**, 171-206.

Anderson, N. H., & Butzin, C. A. Performance = Motivation × Ability: Integration theoretical analysis. *Journal of Personality and Social Psychology*, in press.

Buchanan, J. P., & Thompson, S. K. A quantitative methodology to examine the development of moral judgments. *Child Development*, 1973, **44**, 186-189.

Cole, M., Frankel, F., & Sharp, D. Development of free recall learning in children. *Developmental Psychology*, 1971, **4**, 109-123.

Costanzo, P. R., Coie, J. D., Grumet, J. F., & Farnill, D. A re-examination of the effects of intent and consequences on children's moral judgments. *Child Development*, 1973, **44**, 154-161.

Ginsberg, H., & Opper, S. *Piaget's theory of intellectual development: An introduction*. Englewood Cliffs, N.J.: Prentice-Hall, 1969.

Hebble, P. The development of elementary school children's judgment of intent. *Child Development*, 1971, **42**, 1203-1215.

Heider, F. *The psychology of interpersonal relations*. New York: Wiley, 1958.

Inhelder, B., & Piaget, J. *The growth of logical thinking from childhood to adolescence*. New York: Basic Books, 1958.

Kagan, J. E., & Kogan, N. Individuality and cognitive performance. In P. H. Mussen (Ed.), *Carmichael's manual of child psychology*. Vol. 1. New York: Wiley, 1970.

Kempler, B. Stimulus correlates of area judgments: A psychophysical developmental study. *Developmental Psychology*, 1971, **4**, 158-163.

Kirk, R. *Experimental design: Procedures for the behavioral sciences*. Belmont, Calif.: Brooks/Cole, 1969.

Kukla, A. Attributional determinants of achievement-related behavior. *Journal of Personality and Social Psychology*, 1972, **21**, 166-174. (a)

Kukla, A. Foundations of an attributional theory of performance. *Psychological Review*, 1972, **79**, 454-470. (b)

Leventhal, G. S., & Michaels, J. W. Locus of control and equity motivation as determinants of reward allocation. *Journal of Personality and Social Psychology*, 1971, **17**, 229-235.

Weiner, B., Frieze, I., Kukla, A., Reed, L., Rest, S., & Rosenbaum, R. M. *Perceiving the causes of success and failure*. Morristown, N. J. General Learning Press, 1971.

Weiner, B., & Kukla, A. An attributional analysis of achievement motivation. *Journal of Personality and Social Psychology*, 1970, **15**, 1-20.

Weiner, B., & Peter, N. V. A cognitive-developmental analysis of achievement and moral judgments. *Developmental Psychology*, 1973, **9**, 290-309.

(Received October 1, 1973)

[5] Note that there is an increased ability effect and a decreased effort effect in Study 2 relative to Studies 1 and 3. This difference is attributed to the counterbalancing of order of the ability and effort cues in Study 2.