A Longitudinal Study of Developmental Synchrony between Conceptual Identity, Seriation, and Transitivity of Color, Number, and Length

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ACHENBACH, THOMAS M., and WEISZ, JOHN R. *A Longitudinal Study of Developmental Synchrony between Conceptual Identity, Seriation, and Transitivity of Color, Number, and Length.* CHILD DEVELOPMENT, 1975, 46, 840–848. Simplified tests of conceptual identity, seriation, and transitivity for the properties of color, number, and length were administered to 102 preschoolers on 2 occasions, 6 months apart. Contrary to a strict interpretation of Piaget's theory, the 3 achievements did not emerge simultaneously for any of the 3 properties. Instead, identity preceded seriation, which preceded transitivity across all 3 properties. There was a pronounced ordering among identity concepts, with color preceding number, which preceded length, but the ordering of properties was less consistent for seriation and transitivity. Relationships of Binet MA to identity, seriation, and transitivity suggested that Piaget finds synchrony among these operations because the verbal skills needed for his tasks do not emerge until all 3 operations are available.

One of the most troublesome issues relating to Piaget's logical models is that of asynchrony among accomplishments hypothesized to depend upon the same cognitive structures. Two types of asynchrony have been found. One, referred to by Piaget as a *horizontal décalage,* involves a disparity between the ages at which a particular concept is applied to different properties. Piaget attributes *horizontal décalages* to such factors as differences in the familiarity of materials and in the inherent resistance of certain properties to application of the relevant cognitive operations. For example, the concept of conservation may be more easily applied to number than to weight because the relevant units of number are discontinuous, visible, and frequently labeled for the child, whereas weight can be precisely quantified only by means of a mechanical aid such as a balance. The repeatedly found asynchrony between conservation of number and weight (see Brainerd & Allen 1971) is thus not surprising and does not create special problems for Piaget's theory of groupings.

More problematical, however, are asynchronies in the application of several concepts to the same property when each of the concepts is assumed to rest upon the same cognitive structures. For example, conservation, seriation, and transitivity of a *particular* property have not been found to emerge with the degree of synchrony implied by the assumption of common structures, and the order of emergence varies from one study to another (e.g., Brainerd 1973b; Keller & Hunter 1973; McManis 1970). Since differences in materials cannot account for asynchronies in the application of operations to a particular property, the explanation must be sought either in the specific task requirements for applying each operation or in inadequacies of the theory.

Much research has been directed at identifying aspects of Piaget's tasks which may

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confound the application of logical operations with artifacts that produce false positive or false negative responses. With respect to conservation, Elkind (1967) has pointed out that Piaget's theory is primarily concerned with conservation of the quantitative *identity* of single stimuli as they undergo perceptual changes, whereas his tasks require the subject to conserve the quantitative *equivalence* of two stimuli as one undergoes a perceptual change. Accordingly, preschoolers in several studies have been found to pass identity conservation tasks while failing equivalence conservation, although consistent differences between identity and equivalence conservation have not been found in older children (see Brainerd & Hooper, in press). In a similar vein, Youniss and Murray (1970) pointed out that nontransitive solutions to Piaget's transitivity tasks (if $A > B > C$, then A ? C) may be used by children who simply remember that A is longer than its comparison stimulus B, and C is shorter than its comparison stimulus (also B). Given the information that A is long and C is short, the correct response, $A > C$, is likely even if the child fails to make a transitive inference from the relationships $A > B$ and $B > C$. On the other hand, children who are capable of reasoning transitively may fail Piagetian transitivity tasks because they merely fail to remember the relationship between A and B when they are asked about the relationship between A and C. Memory failure is especially likely to produce false negatives when, as has often been done, optical illusions are used to distort the actual sizes of stimuli (see Gruen 1973; Roodin & Gruen 1970).

If systematic biases toward false positives or negatives could be removed from measures of conservation, seriation, and transitivity, it might be possible to answer the theoretically important question of whether asynchrony really does exist in the application of these three operations to similar materials. The purpose of the present study was to untangle the relationships among identity concepts, seriation, and transitivity by employing simplified tests of all three, as applied to three different properties, at two points during children's development. Other studies have reported various asynchronies among conservation, seriation, and transitivity, but differing task demands, limitation of content to one or two properties, built-in biases of procedures, and lack of longitudinal analysis have prevented them from yielding a clear picture of the degree of asynchrony.

While Piaget (1968) reserves the term "conservation" for concepts of *quantitative* identity, the index of conservation used in the present study—surprise reactions to contrived changes in one property of a single stimulus—was also used to test children's concepts of the *nonquantitative* property of color. (To avoid ambiguity, the term "identity concept" rather than "conservation" will be used in reference both to invariance of color and to invariance of quantitative properties.) Children's concepts of seriation and transitivity were tested with varying shades of color, as well as with quantitative properties. Color, number, and length were chosen as the properties for study here because gradations within these dimensions are readily visible and young children are frequently reinforced for discriminating and labeling the gradations. Furthermore, previous work has shown that concepts of color, number, and length identity emerge within a short period at the relatively early mental ages (MAs) of about 40–72 months (Achenbach 1973).

The primary question to be answered was whether there were significant differences in performance on identity, seriation, and transitivity tasks within each property. If children succeeded simultaneously on identity, seriation, and transitivity for a particular quantitative property, this would support the strict interpretation of Piaget's theory that the same cognitive structures establish the necessary and sufficient conditions for all three. A *décalage* between the application of the three operations to number and to length would not contradict the theory, as long as the three operations were synchronous within each of these properties. Since color is viewed as a preoperational identity concept (Piaget & Voyat 1968), whereas seriation and transitivity are concrete operations, the concept of color identity would be expected to precede color seriation and transitivity. However, the theory makes no obvious prediction about whether seriation and transitivity of color should precede seriation and transitivity of the quantitative properties. If seriation and transitivity of color preceded seriation and transitivity of the quantitative properties, this would suggest that preoperational identity concepts can provide early "aliment" for concrete operations.

Another possible outcome would be a

uniform ordering of identity, seriation, and transitivity within each property. Such a sequence would suggest that the operations attained first were prerequisites for or components of those attained later. On a priori grounds, the most likely order would appear to be identity-seriation-transitivity, because both seriation and transitivity require a concept of the identity of the relevant property, and transitivity requires attention to seriated order.

Since the degree of asynchrony in performance may vary as development progresses (see Brainerd & Hooper, in press), the children were tested twice, at an interval of 6 months. Furthermore, recognition memory tasks were employed in addition to surprise tasks for color and number in order to obtain methodologically independent indices of identity concepts. No recognition memory task was employed for length because there is no intrinsic way of recognizing a particular length, as there is for color and number. The Stanford-Binet Short Form was also administered in order to extend the calibration of MA with simplified Piagetian tasks beyond what has been done in earlier studies (Achenbach 1969, 1973).

Method

Subjects and Procedure

Nursery school and day-care-center children received two 3-day series of testing, separated by a mean interval of 6.0 months. They were tested in a vacant room of their setting or in a mobile unit. Testing sessions lasted from about 20 to 30 minutes. On the first day of each series a female experimenter administered tests of number memory, seriation, and transitivity; surprise to a contrived change in number; color memory, seriation, and transitivity; and surprise to a contrived change of color, in that order. The Binet was administered on the second day of the series, using an optimizing procedure whereby easy items were alternated with difficult items. On the third day tests of length seriation, transitivity, and surprise to a contrived change of length were administered, along with some tasks not relevant to the present study. A female observer, sitting at an unobtrusive angle from the subject, made independent judgments of whether the subject understood relevant terms such as "bigger," "darker," "lighter," and "more," and whether the subject was surprised at the contrived changes of number, color, and length. Children were eliminated if they failed to understand the terms "bigger," etc., in the tasks described below.

From an initial subject pool of 120, 55 boys and 47 girls understood the relevant terms and completed both testing series. At the first testing, ages ranged from 35 to 74 months, mean = 50.0 and SD = 8.4. Mean SES was 3.0 (SD = 1.7) on Hollinghead's (1957) seven-point scale for breadwinner's occupation, where 1 represents the highest SES. Although the sample mean was above the middle of the scale, all seven steps were represented. Seventy-six of the children were white, 23 black, two Oriental, and one Asian Indian. All appeared competent in standard American English. At the first testing, IQs (1973 Binet norms) ranged from 66 to 156 (mean = 103.8, SD = 18.3) and MAs from 33 to 87 months (mean = 57.3, SD = 11.3).

Tasks

Number memory.—The experimenter presented a 13 × 21-cm piece of blue Masonite on which was glued the sliding drawer of a matchbox. Three 3.6-cm sticks were glued in the matchbox and three beside it. The child was asked to count the sticks and remember what he saw. After 20 seconds, the stimulus was removed. A 40 × 33-cm piece of blue Masonite was then presented on which were mounted eight matchbox drawers with eight different combinations of sticks glued inside and beside them. The child was to choose the array of sticks and box that was like the one seen previously.

Number seriation.—Six plastic petri dishes were presented. One wooden bead was glued in one dish, two beads in a second dish, and so on up to six beads. The child was asked how many beads were in each dish. If he did not count correctly, the experimenter helped him until he succeeded. This was merely to help the child attend to the differences in number of beads in each dish. As she placed the petri dishes on black circles painted in a row on a strip of cardboard, the experimenter said: "I'm going to put the dish with the *fewest* beads, the *smallest number* of beads here, and the dish with the next bigger number here, and this dish here, and this one here. And this dish with the *most* beads here." She thus formed a series of dishes containing from one to six beads. The child was asked to look carefully at the series. After 20 seconds, the experimenter mixed up the dishes and placed the dish containing one bead on the circle at one end of the cardboard and the dish containing six beads on the circle at the opposite end, telling the child, "Now I'll put the dish with the *smallest number* here again, and the dish with the *most* here again." The child was then instructed to place the other dishes in a series as before.

After the child had responded, the experimenter mixed up the dishes, placed the dish with one bead where the dish with six beads had been, and vice versa. She then instructed the child to make a series again, this time in the order opposite to the first. As on all the tests of seriation and transitivity, a child was scored as passing only if he passed both trials.

Number transitivity.—The experimenter presented a small jar having a blue lid and containing 21 blue buttons, plus a similar jar having a yellow lid and containing 21 yellow buttons (just enough to cover the bottom, but too many to count easily). The child was told that there were just as many blue buttons as yellow buttons. A similar jar with a black lid and 21 black buttons was presented and the child was told it contained just as many black buttons as there were yellow buttons. The experimenter then conspicuously added another black button and asked the child whether there were more black or more yellow buttons, and how he knew. Up to three repetitions of this sequence were provided if the child did not respond correctly.

When the child responded correctly, the experimenter said: "That's right. There are *more black* buttons than yellow buttons. Now here's a jar of orange buttons. There are *just as many orange* buttons as *black* buttons. But there are *more* black buttons than yellow buttons, aren't there? Okay, now [sliding the orange and blue jars toward the subject], which has *more*—the jar of orange buttons or the jar of blue buttons? Are there *more orange* buttons or *more blue* buttons, *or* do they both have the *same* number? [After the child responded] How do you know?"

A similar procedure was followed using four jars of pins having various colored heads, except that one pin was *removed from,* rather than being added to, the third jar of the series. The procedure was designed to control for the artifacts of nontransitive solutions (Youniss & Murray 1970) and memory failures (Roodin & Gruen 1970). Nontransitive solutions were controlled in that, after the relationships $A = B < C = D$ and $A = B > C = D$ had been presented, the child was asked the relationship between A and D, neither of which had previously been shown to be greater or less than anything else. Memory failure was minimized by reminding the child of the relationships among the terms just before the transitivity question was asked and by keeping all the elements in their original order throughout the task.

Number surprise.—Because children were tested twice, at a 6-month interval, alternate forms of this and the other surprise tasks were employed at the two testings. Half the children received an *AB* order and half a *BA* order. In number surprise task *A*, the child placed two toy Indians into a box. When he released a door in the bottom of the box, three Indians dropped out. In task *B*, the experimenter pretended to hide two toy teacups beneath one of two inverted bowls. When the child lifted a bowl, he found three teacups (see Achenbach [1973] for details of both tasks). As with the surprise tasks for color and length, the experimenter and observer made independent judgments of whether the child expressed surprise, suspicion, or an explanation for the trick indicative of an awareness that an invariance principle had been violated.

Color memory.—Similar in format to the number memory task, this task entailed asking the child to recognize a two-color figure of a cat from an array of eight cats (see Achenbach [1973] for details).

Color seriation.—The experimenter presented six 1.8-cm square × 0.4-cm thick pieces of Plexiglas on which had been glued pieces of paper, ranging in color from white, through four easily discriminable shades of gray, to black. The child was shown the black piece and the white piece in succession and asked the color of each. If the child did not know, he was told the color name. The experimenter then said: "See these other colors? Some of these other colors are a little bit like white and some are a little bit like black, aren't they? Can you show me one that is like white? And one that is like black?" The child was helped if he did not respond correctly. From then on, the procedure was like that for number seriation, except that the experimenter described the series of stimuli in terms of "the one most like white, the one next most like white, and so on, until you come to the one that is most like black." On the second trial, she began with the black stimulus and described the stimuli in terms of "the one most like black," etc.

Color transitivity.—A piece of 17 × 23-cm white cardboard was placed flat on the table between the experimenter and subject. On the cardboard were a white square and a light gray square similar to those employed in the color seriation task. The squares were positioned on the vertical midline of the cardboard, with the white square 1.5 cm beyond the gray square from where the child sat. The child was asked to point to the white square. When he responded, the experimenter said: "That's right. This one is white and this one is *darker* than the white one." A medium gray square was then placed below the light square and the child was asked to choose the darker of the two. After he had done so, the experimenter removed the medium gray square, leaving in its place a square of paper of the same shade of gray. The experimenter pointed out that the paper was the same color as the square. She then said: "Now I'm going to move this [medium gray] piece here [1.5 cm above a dark gray square positioned on the vertical midline of a 17 × 23-cm piece of black cardboard next to the white cardboard]. But I'm going to leave this mark here [the medium gray paper at the bottom of the first column] to help you remember that this [medium gray] piece is *darker* than this one [light gray piece]."

The child was then asked which one was darker, the medium gray piece (now at the top of the second column), or the dark gray piece 1.5 cm below it. Finally, the child was asked which was darker, the dark gray piece or a black piece placed 1.5 cm below it. The transitivity question was, "Now, which one of these is darker, this one [light gray piece in the middle of column 1] or this one [dark gray piece in the middle of column 2], or are they both the same?" The child was asked to explain his answer. Because the effects of the black background behind the dark gray square and the white background behind the light gray square made it difficult to discriminate their differences in shade by eye, transitive inference was the most appropriate way to solve the problem (i.e., $A < B < C = C < D < E$, therefore $B < D$, where $<$ indicates "darker than"). The procedure was designed to eliminate artifacts arising from memory failure (all relationships remained visible throughout the task), as well as those arising from nontransitive cues regarding the B and D elements (each had been darker and lighter than one comparison element).

After removing the stimuli, the experimenter administered a second trial in which she began with the black square, placed at the top of the column on the black background, proceeded in sequence toward the white, and used the term "lighter" for each comparison and the transitivity question.

Color surprise.—In color surprise task *A*, a white toy car was changed into a black toy car, using a procedure like that used for changing the number of teacups, except that tin cans rather than bowls were used to hide the car. In color surprise task *B*, marbles were changed in color (see Achenbach 1973).

Length seriation.—The procedure was similar to that for number and color seriation, except that the materials consisted of six blue Masonite sticks, 0.9 cm in width, 0.5 cm in thickness, and ranging in length from 9 to 14 cm by 0.9-cm increments. The sticks were placed into a 6 × 14-cm recess cut in an 18 × 25-cm piece of 0.5-cm thick Masonite. The comparison term "bigger" was used on trial 1 and "littler" on trial 2.

Length transitivity.—The procedure was similar to that for color transitivity except that comparisons were made with respect to length. On trial 1, the stimuli were 1.9-cm wide × 0.5-cm thick slats, arranged as illustrated in figure 1, and the comparison question was, "Which is bigger?" After the comparison between the blue slat and the black slat on the left had been made, the black slat was moved into the recess above the purple slat on the right, leaving a black recess where the slat had been on the left. Following comparison of the black and purple slats and the purple and gray slats, the transitivity question was: "Which is bigger, the purple stick or the blue stick, or are they both the same?" On trial 2, a similar array was displayed, except that the components were 1-cm dowels ranging in length from 18.4 to 20.4 cm and painted other colors, and the comparative term was "littler" rather than "bigger."

Length surprise.—Task *A* was the "barbells" task employed by Achenbach (1973) to

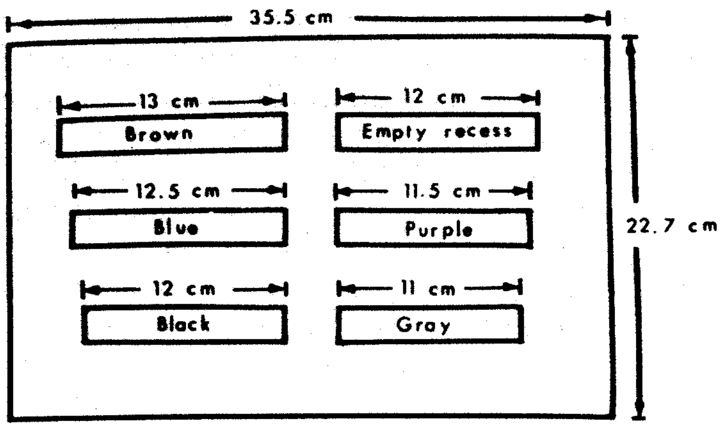

FIG. 1.—Length transitivity trial 1. All sticks except the black one were glued into recesses in the Masonite board. The child was asked whether the brown or blue stick was bigger; then, the blue or black one. Moving the black stick to the empty recess, leaving open the black recess where the stick had been, the experimenter asked whether the black or purple stick was bigger; then the purple or gray one. Transitivity question: "Which stick is bigger, the purple stick or the blue stick, or are they both the same?"

create a contrived change of length. In this task the experimenter surreptitiously changed the stimuli so that a rod which had once fit into a barbell-like configuration was too long the second time the child tried it. Task *B* followed a similar procedure with the Mueller-Lyer rather than the barbells illusion.

Results

Scoring of the memory, transitivity, and seriation judgments was completely objective. So few explanations for transitivity were obtained that no meaningful analysis seemed possible, and they will not be discussed further. In any event, children's judgments (including surprise reactions) are likely to be more sensitive indices of cognitive structures than are verbal explanations (see Brainerd 1973a). Nine of the 1,122 responses in the first testing and four of the 1,122 in the second testing were considered unscorable due to subject distractibility.

Synchrony of Memory, Surprise, Seriation, and Transitivity

The relation between successes and failures on each pair of tasks was analyzed by means of McNemar's (1962) test, using the binomial distribution, in order to compare the number of subjects passing one task and failing another and those showing the reverse pattern. This was done separately for the initial testing and the final testing.

Figure 2 portrays the relations between success and failure on each pair of tasks at the initial and final testing. The tasks are ordered according to previous findings on the order of emergence of identity concepts for color, number, and length (Achenbach 1973) and the relationships between these and seriation and transitivity performance found in the present study. Since all pairwise comparisons are considered, the ordering of presentation does not affect the conclusions to be drawn.

Comparison of operations.—Surprise and memory performance significantly surpassed seriation and transitivity in all 60 comparisons for the three properties (see box *II* in fig. 2). Seriation was significantly superior to transitivity in eight of the 18 comparisons and nonsignificantly superior in seven others (see box *IV* in fig. 2). In the remaining three comparisons, color transitivity was superior to seriation of each property at the second testing (2 at $p < .01$, 1 N.S.).

Performance on the three operations was also compared by calculating each child's

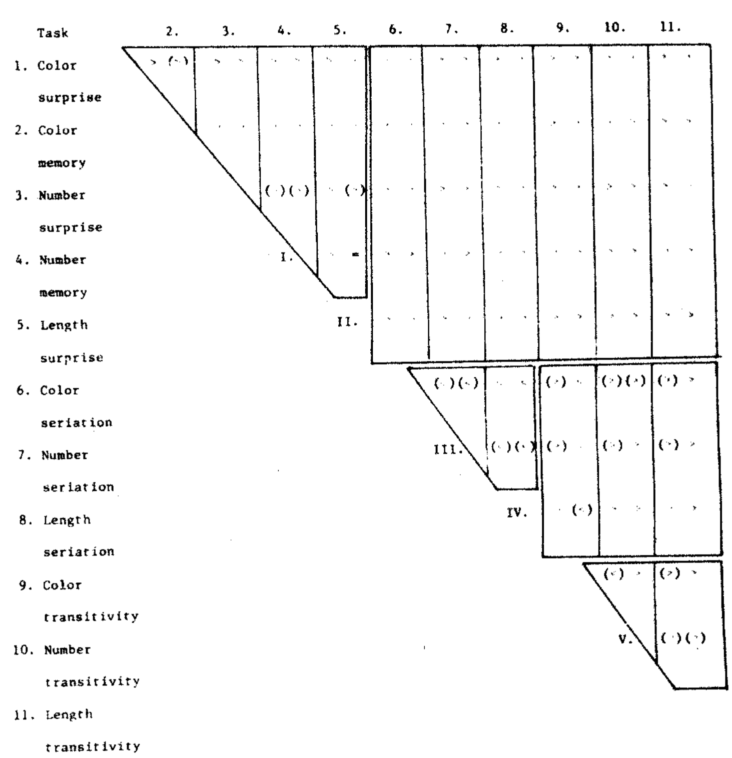

FIG. 2.—Ordering of successes for each pair of tasks. > indicates that a greater proportion of subjects passed the task designated to the left than the task designated at the top; < indicates the opposite pattern. Parentheses indicate that the difference was not significant ($p > .05$, two-tailed). The first testing is represented on the left side of each cell, the second testing on the right. See text for explanation of boxes *I–V*.

total score for surprise, seriation, and transitivity across all three properties. Thus, if a child was not surprised at the change of color, number, or length, his score for identity concepts was 0, while he was given 1 point for each property he was surprised at, for a maximum total of 3 points, and likewise for seriation and transitivity. (Memory tasks were not included because there was none for length; including the other two would have caused the scoring of identity to differ from that of seriation and transitivity.) A 2 (sex) $\times$ 2 (SES 1–3 vs. 4–7) $\times$ 2 (testing 1 vs. testing 2) $\times$ 3 (surprise vs. seriation vs. transitivity) unweighted means ANOVA, with the last two dimensions being repeated measures, was performed for the 92 children having scorable responses on all measures. The ANOVA showed no significant effects of sex, SES, or any interactions, but a significant difference among the operations, $F(2,176) = 249.45$, $p < .001$, and a significant improvement in performance from the first to the second testing, $F(1,88) = 46.89$, $p < .001$. Mean scores were 2.10 out of a possible 3 for surprise, 0.63 for seriation, and 0.38 for transitivity. A priori contrasts showed that the surprise scores were significantly greater than the seriation scores, $F(1,176) = 162.51$, $p < .001$, which were, in turn, significantly greater than the transitivity scores, $F(1,176) = 4.56$, $p < .05$.

Comparison of properties.—Among the 20 comparisons of color surprise and memory, number surprise and memory, and length surprise, 19 revealed the following order of emergence for identity concepts (see box *I* in fig. 2): color, as measured by surprise and then memory; number, as measured by surprise and then memory; length, as measured by surprise (no memory task employed). Fifteen of the 20 comparisons were statistically significant and four were not significant. Equal numbers of children passed number memory and length surprise at the second testing.

The ordering of seriation performance among the three properties was less consistent than that for surprise and memory in that only two of the six comparisons were significant, both at the .05 level. Furthermore, the ordering was opposite to that found for surprise and memory in that length seriation was superior to number seriation and number seriation was superior to color seriation (see box *III* in fig. 2). The ordering of transitivity performance was also less consistent than that for surprise and memory, although this could have been due to the small number passing length transitivity (six at each testing) and number transitivity (nine at first and 12 at second testing). Five of the six comparisons among the transitivity tasks showed an order like that found for surprise and memory, with color transitivity being superior to number transitivity which, in turn, was superior to length transitivity. Two of the comparisons were statistically significant, while four were not (see box *V* in fig. 2).

An ANOVA analogous to the 2 $\times$ 2 $\times$ 2 $\times$ 3 ANOVA on total scores for each operation was performed on total scores for each property, calculated across the three operations. As with the ANOVA on operations, there was no significant effect due to sex, SES, or any interactions. However, there was a significant effect of property, $F(2,176) = 23.87$, $p < .001$, and, again, an improvement in performance from the first to second testing, $F(1,88) = 46.89$, $p < .001$. A priori contrasts showed that scores for color (mean = 1.28) were significantly higher than for number (mean = .97), $F = 12.42$, and for length (mean = .86), $F = 23.12$ (both 1,88), $p < .001$. The difference between number and length was not significant, $F = 1.64$. Table 1 summarizes the data employed in the two ANOVAs in terms of the percentage of subjects manifesting each operation for each property.

Relations between MA and Cognitive Tasks

Figure 3 portrays the relation between Binet MA and mean scores for surprise, seriation, and transitivity, calculated across all three properties, as done for the first ANOVA

TABLE 1

PERCENTAGE OF SUBJECTS PASSING EACH OPERATION FOR EACH PROPERTY

	Operation		
Property	Identity	Seriation	Transitivity
Color:			
Testing 1	84	11	8
Testing 2	96	20	35
Number:			
Testing 1	58	14	9
Testing 2	73	24	12
Length:			
Testing 1	35	20	6
Testing 2	70	31	6

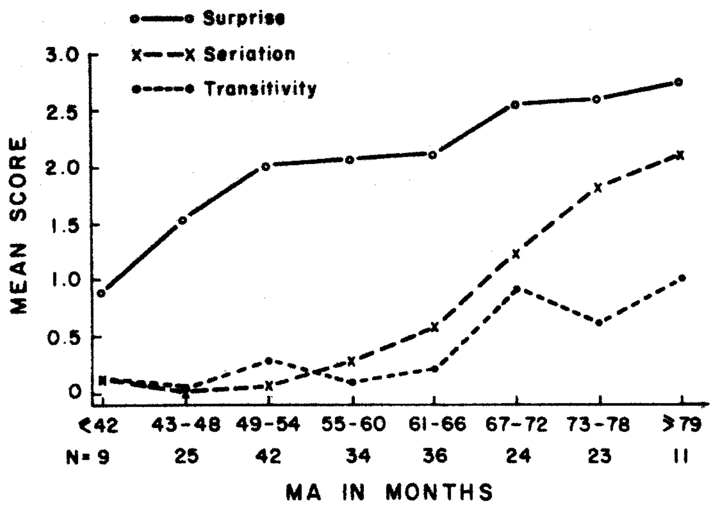

FIG. 3.—Mean scores for surprise, seriation, and transitivity summed across color, number, and length.

described above. Scores for each subject are entered twice, once for the first testing and once for the second testing. Because of increases in MA from the first testing to the second, only 23 subjects remained in the same MA interval at both testings. As the figure shows, surprise reactions increased progressively from the lowest to the highest MA interval, being well ahead of seriation and transitivity at all points. Seriation and transitivity performance did not begin to rise above zero-order levels until about the 61–66 month MA interval, after which seriation remained above transitivity. Thus, at all MA levels where performance was above the zero-order level, the surprise-seriation-transitivity order was maintained.

Discussion

The overall picture is one of considerable asynchrony in the application of conceptual identity, seriation, and transitivity to the properties of color, number, and length. However, there was great regularity in the order in which the operations emerged, with identity preceding seriation, and seriation preceding transitivity. The order in which each was applied to the three properties was highly consistent for identity, somewhat less consistent but in the same direction for transitivity, and least consistent for seriation. Perhaps, as suggested by Brainerd (1974), the stronger ordering in the applicaticn of identity concepts to the three properties occurred because identity concepts are more closely bound to specific physical properties than are seriation and transitivity, which are logical principles of greater generality. Across the three operations, performance on color tasks was significantly superior to performance on number and length, while number was nonsignificantly superior to length. The strength of ordering among pairs of tasks is indicated by the fact that, of the 110 pairwise comparisons shown in figure 2, 89 were statistically significant. In 11 comparisons, no subjects showed a pass-fail pattern opposite that found for the majority. In 28 comparisons, only one or two subjects were exceptions to the general pattern.

The ordering of performance did not support the Piagetian prediction of synchrony among identity, seriation, and transitivity within particular properties. Conceptual identity appeared first for all three properties, followed by seriation for all three, and transitivity for all three. The only notable exception to this pattern was the superiority of color transitivity to the three seriations at the second testing. Since color transitivity showed proportionally the greatest improvement of any task, from eight passing at the first testing to 35 at the second, it is possible that a unique practice effect was involved. Although the differences in background colors on this task were designed to make it difficult to discriminate visually the shades of the two comparison stimuli, *B* and *D*, it is conceivable that performance at the second testing was enhanced because some children learned to make this discrimination visually. Whether or not the ordering of color transitivity at the second testing was due to an artifact of this sort, the overall pattern is strong enough to suggest that identity concepts for the three properties become available in a regular sequence, that seriation presupposes identity concepts, and that transitivity presupposes seriation.

Extrapolation of identity, seriation, and transitivity performance from the curves shown in figure 1 suggests that they would converge above the MA of about 7, the age range at which Piaget generally places success in conservation, seriation, and transitivity of the most precocious quantitative properties. Since Piaget's evidence for synchrony among the operations is based largely upon verbal responses and explanations to tasks formulated primarily in verbal terms, synchrony on his tasks may occur because the relevant verbal abilities do not emerge until about the MA of 7, even though the ability to conceptualize identity, seriation, and transitivity emerge in a consistent order before that age.

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