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ABSTRACT

Presented are the results of an investigation of stimulus integration capabilities of three- and four-year-old children in judgments of small and large numbers. There is much evidence that suggested young children have a concept of number for small numbers, but not for large ones. A concept of number was hypothesized by Piaget to rest on the child's ability to correctly integrate two stimulus dimensions, length and density. Piaget's analysis predicts that young children's judgments will obey the correct Length x Density Integration rule, whereas large number judgments would obey a one-dimensional rule. The study reveals that children's judgments of small numbers did follow the correct Length x Density rule, while the children used an incorrect Length + Density rule for large numbers. These results show that a concept of number is present for small numbers but not for large numbers, in line with previous work. Contrary to Piaget's analysis of previous work, the absence of a concept of number does not imply the absence of stimulus integration. (MP)

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Small Numbers vs. Large Numbers:
An Investigation of Stimulus Integration Rules

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Abstract

This study investigated stimulus integration capabilities of 3- and 4-year-olds in judgments of small and large numbers. Judgments of small numbers obeyed the correct Length x Density rule. Judgments of large numbers obeyed an "incorrect" Length + Density rule. These results show that a concept of number is present for small numbers but not for large numbers, in line with previous work. Contrary to Piaget's analysis of previous work, the absence of a concept of number does not imply the absence of stimulus integration.

Small Numbers vs. Large Numbers: An Investigation of Stimulus Integration Rules

There is much evidence to suggest that young children have a concept of number for small numbers, but not for large numbers. According to Piaget [& Szeminska] (1952), a concept of number rests on the ability to correctly integrate two stimulus dimensic.. length and density, in judgments of number. On the other hand, Piaget interp..s the absence of a concept of number in terms of the lack of ability to integrate stimulus dimensions. Piaget's analysis predicts that young children's judgments of small numbers will obey the correct Length x Density integration rule, whereas their judgments of large numbers will obey a one-dimensional rule. But these predictions have not been properly tested. Previous studies have not been designed to determine the algebraic nature of integration rules in judgments of small numbers or to detect the possible presence of stimulus integration in judgments of large numbers. Thus, this study was designed to provide a simple and straightforward investigation of stimulus integration in young children's judgments of small and large numbers. It goes beyond previous studies in two important ways. First, it allows for the possibility that integration rules in judgments of small numbers may in fact be different from the correct Length x Density rule. Second, it allows for the possibility that young children may in fact integrate stimulus dimensions in forming judgments of large numbers.

Method

A judgments of number, small or large, was conceptualized in terms of the integration of the length and density dimensions of a row of equally-spaced beads. Rows were generated factorially over multiple levels of length and density, and the children made quantitative ratings of individual rows. These simple methodological features provided the basis for precise and powerful examination of integrational capacity and of algebraic integration rules in young children's judgments of number; problems that lie at the heart of Piaget's analysis of the development of a concept of number.

Subjects. Twenty 3-year-olds and 20 4-year-olds made rating judgments of small and large numbers of beads in a row. Judgments were obtained in two different sessions, separated by an interval of about four months.

Response. The children made their rating judgments on the graphic rating scales shown in Figures 1 and 2. As shown in these figures, there were sad and happy faces at the ends of the scales. Children were told that the bar in between the two faces represented intermediate degrees of sadness and happiness, in a graded manner. The children were told about a story child who wanted some beads to make a necklace for mother. They were instructed to indicate how sad or happy the story child would be with a given number of beads by pointing to a location along the response bar. The larger the number of beads, the happier the story child would be. Counting was not allowed.

Stimuli slightly more numerous and slightly less numberous than the experimental stimuli were used to anchor the two sends of the scale. This establishes a frame of reference for a particular set of judgments, and also eliminates unwanted floor and ceiling effects.

It may be surprising that children as young as 3 years are able ~~to under~~stand these instructions and are able to make rating response. But they can, and they seem to find the rating response to be very easy and natural.

Stimuli. Small numbers were constructed from a 3 x 2, length x density, factorial design. Length refers to the distance between the two end beads of a row. Density refers to the spacing between the beads. The number of beads ranged from 2 to 7 for the 6 small number stimuli. Large numbers were constructed from a 3 x 3, length x density, factorial. The number of beads ranged from

Figure 1. The graphic rating scale used for judgments of small numbers.

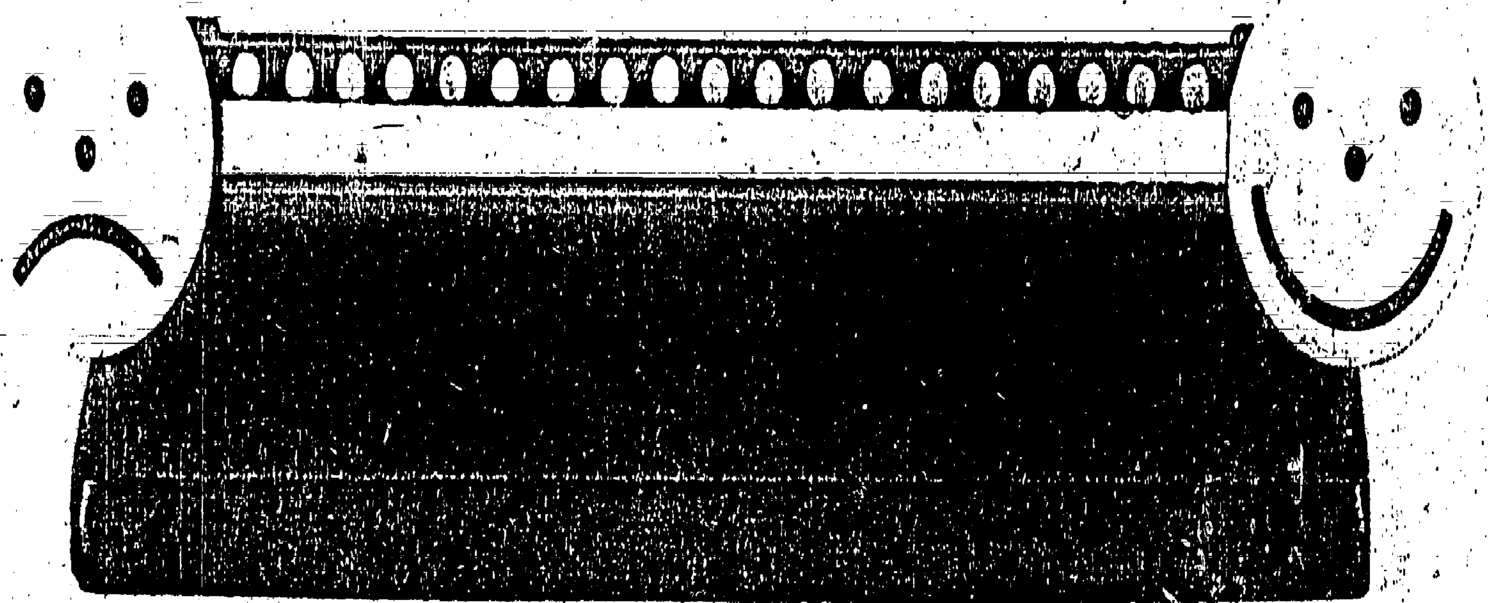

Figure 2. The graphic rating scale used for judgments of large numbers.

4 to 29 for the 9 large number stimuli.

Results

The results are shown in Figures 3 and 4. In each panel, mean judgments are plotted against the levels of the length factor, with a separate curve for each level of the density factor. Each point stnads for one cell in a length x density factorial design.

Small numbers. When the children were presented with small numbers, judgments obeyed a Length x Density integration rule. The Length x Density rule is shown graphically by the linear divergence of the two curves in each panel of Figure 3. It was confirmed statistically by a significant bilinear component of the length x density interaction.

Large numbers. When the children were presented with large numbers, however, judgments obeyed a Length + Density integration rule. The Length + Density rule is shown graphically by the vertically separate and approximately parallel curves in each panel of Figure 4. It was confirmed statistically by significant main effects of both length and density, and by a nonsignificant length x density interaction.

Conclusions

The Length x Density rule provides a striking demonstration of the presence of a concept of number for small numbers in young children, and powerful support for Piaget's prediction that a concept of number implies correct integration of length and density dimensions.

Even more striking and important is the Length + Density rule in young children's judgments of large numbers. The Length + Density rule demonstrates the absence of a concept of number for large numbers, but indicates that young children are nonetheless capable of stimulus integration in their judgments of large numbers. The discovery of this integration rule presents serious problems for

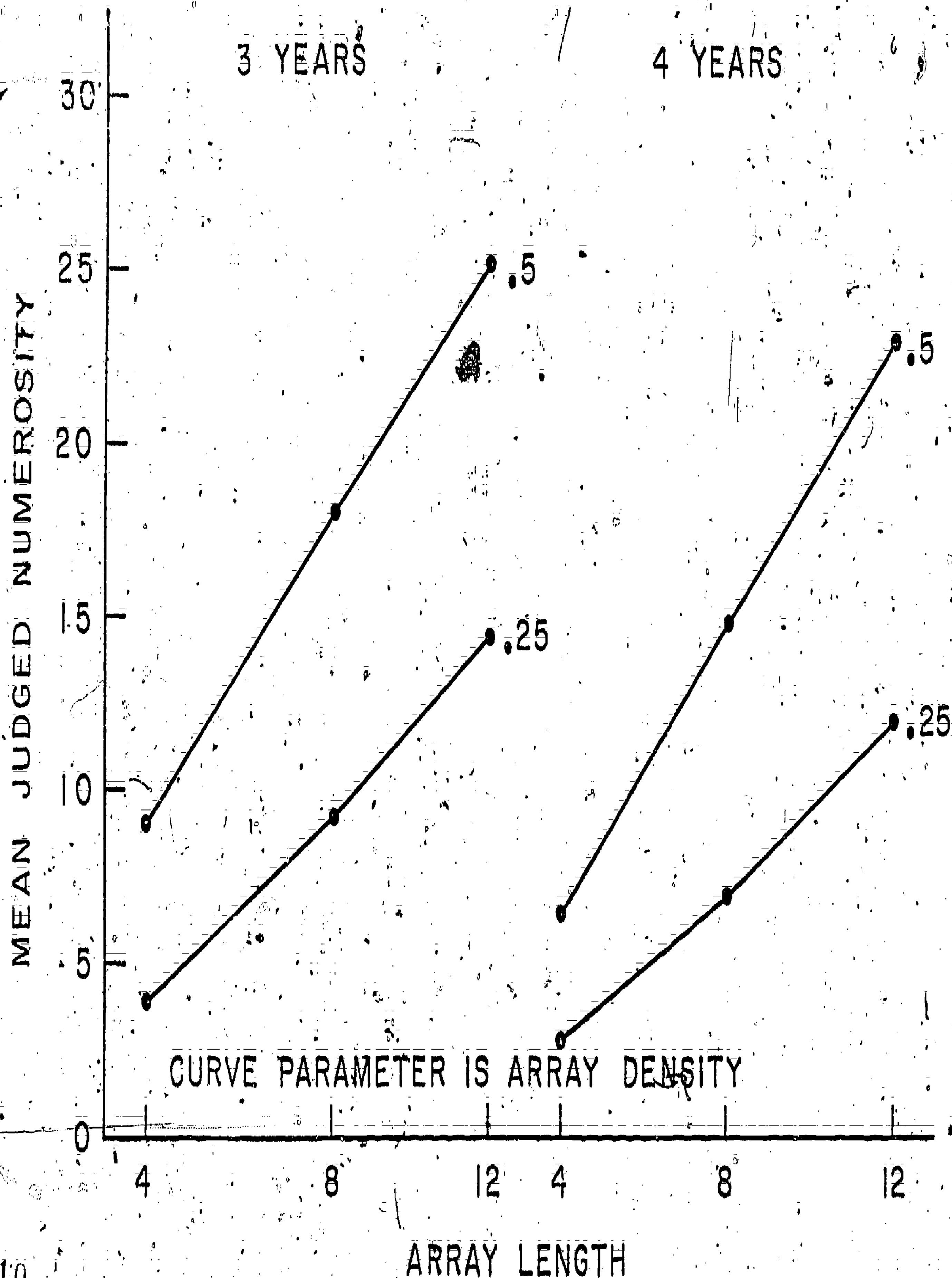

Figure 3. Judgments of small numbers: A Length x Density rule.

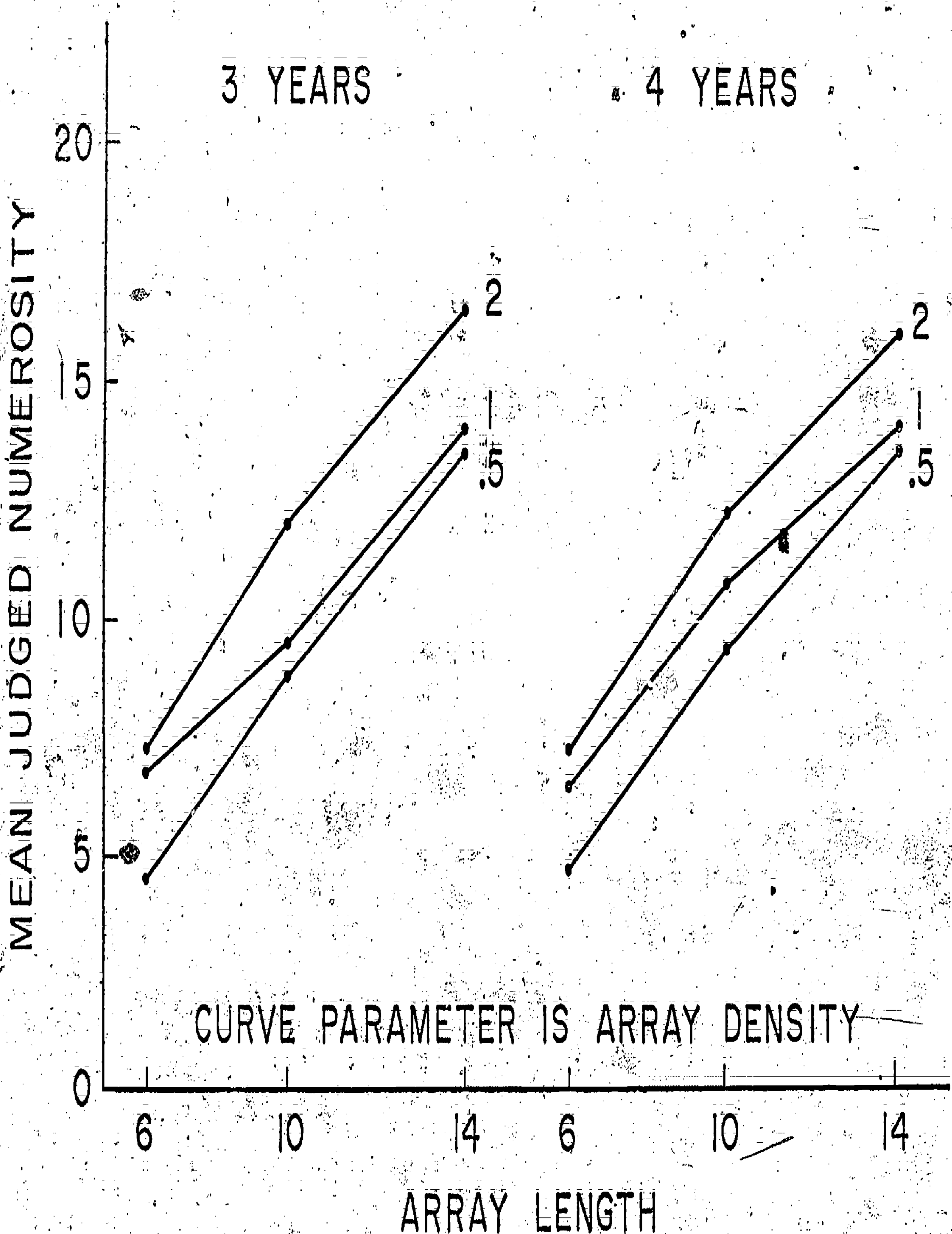

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Figure 4. Judgments of large numbers: A Length + Density rule.

Piaget's interpretation that young children lack a concept of number because they lack the ability to integrate stimulus dimensions. In the absence of a concept of number, integration of length and density dimensions is "incorrect" rather than nonexistent.

The "incorrect" Length + Density rule is evidence for a remarkable knowledge about large numbers. It indicates that young children are aware of the two stimulus dimensions that are relevant to number. That is, they know that number increases with the length of a row and, also, that number increases with the density of a row. Furthermore, they know that length and density, together, are important. Thus, they integrate these dimensions by an adding rule. The use of a Length + Density rule, as a substitute for a Length x Density rule, is an extremely practical resolution of the task of judging large numbers. On the one hand, it takes account of the appropriate stimulus dimensions. On the other hand, it yields a fairly good approximation of number.