THE "FOUR STIMULUS - TWO CHOICE " - PARADIGM IN MULTIDIMENSIONAL PSYCHOPHYSICS: SIZE, BRIGHTNESS, AND COLOR DIMENSIONS COMBINED*

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Abstract

Multidimensional judgment strategies were investigated by means of a "Four Stimulus – Two Choice" – paradigm (4A2C) which combined different dimensions, namely two gradations of size and nine shades of brightness, two shades of brightness and nine gradations of size, or two colors and nine gradations of size. Three types of hypothetical strategies were analyzed: relative judgments based on only one dimension (type I), absolute judgments based on the similarity between test and training stimuli (type II), and relative judgments based on both dimensions (type III). The stimuli consisted of fairy-tale figures differing in size and brightness in the first condition, brightness and size in the second condition, and color and size in the last one. A total of 144 participants (4 and 18 year-olds) were tested individually. During the discrimination training a basic categorization was learned. Whereas the 18 years old did not show any categorization differences depending on the dimensions employed, the 4-year-olds did (weaker results with color and size). During the subsequent test period all three judgment types appeared in both age groups and characterized the main part of the analyzed judgments. Additionally, the 18-year-olds showed no distinct preference for one of the postulated judgment types, while the 4-year-olds changed their preferences depending on the combination of dimensions (type I with size and brightness, and type II with color and size). The two-dimensional judgment type III remained constant and was used infrequently in both age groups. Further investigations will be concerned with two-dimensional psychophysics in animals (see also Sarris, Hauf & Arlt, 2001 in this volume).

The frame-of-reference (FR) approach in psychophysics deals systematically with the interaction between focal stimuli and their context (Lockhead, 1992; Sarris, 1994, 2001). Until recently, most FR models predict context-induced changes in judgments solely in one-

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dimensional stimulus situations. They have neglected the fact that most natural objects differ in more than one stimulus dimension (Zoeke & Sarris, 1983). In everyday life perceptual judgments are usually based on *multi*-dimensional objects. Therefore different kinds of information have to be integrated before judgments can take place. A simple two-categorical example illustrates this problem:

> The size-judgment of a person will depend on the frame-of-reference which is used. Everyone knows that Jockeys are usually "small" and basketball players "tall"; but at the same time we are able to judge the same average-sized man as being tall, if he was introduced as a Jockey, and being small if he was classified as a basketball player.

Our present experiments illustrate this common phenomenon by analyzing context-induced judgments across a combination of the dimensions *size*, *brightness*, and *color*. Thereby, the main objective was the study of age-related developments of two-dimensional perceptual-cognitive judgment strategies.

METHOD

A total of 144 participants in two age groups was trained and tested individually. During a discrimination training, a set of two-dimensional psychophysical stimuli was learned by means of a "*Four Stimulus – Two Choice*" – Paradigm (4A2C-method). The two-dimensional stimulus-generalization tests were presented subsequently (test phase). One group was tested under a size-brightness context condition, another under a brightness-size condition, and the last group under a color-size context condition. The stimuli (fairytale figures) were shown with a special slide projector (see Fig.1). The participant sat in front of the screen and had to judge the size of each stimulus by pressing the corresponding response key (e.g. "small" = left button, "large" = right button). The stimuli differed in size (9 gradations) and color (blue and green) and were presented successively.

Fig.1: Apparatus.- Slide projector with screen and a board with two response keys. By pressing corresponding button (e.g. "small" = left button, "large" = right button) the participant had to judge the size of the stimuli which were presented successively.

During training the participant learned the correct categorization between the “small blue” and the “large blue” stimulus on the one hand and the “small green” and the “large green” on the other hand. The smaller stimulus of each pair belonged together in one category, the larger ones to the other category (4A2C-method). After reaching a test criterion of 20 correct responses in sequence two-dimensional generalization tests were administered (all sizes in both colors; see Fig. 2).

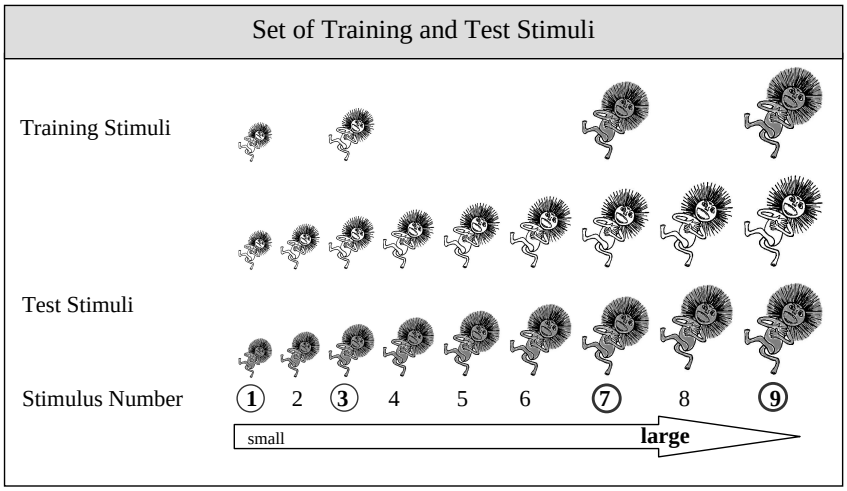

Fig.2: Set of Training and Test Stimuli.- Shown are the training and test stimuli in *blue* or *green* (color-size condition: blue printed in white, green in grey). During training the participant learned the discrimination between the “small blue” and the “large blue” stimulus on the one hand and the “small green” and the “large green” on the other hand. The smaller ones of each pair belonged together to one category, the larger ones to the other (4A2C-method). During the test *all* sizes in *both* colors were shown. (The *marked* numbers refer to the training stimuli) – The training and test stimuli of the other conditions were analogous.

Predictions

Based on this paradigm three hypothetical judgment types were expected: relative judgments based on only one dimension (type I), absolute judgments based on the similarity between test and training stimuli (type II), and relative judgments based on both dimensions (type III; see Fig. 3, next page).

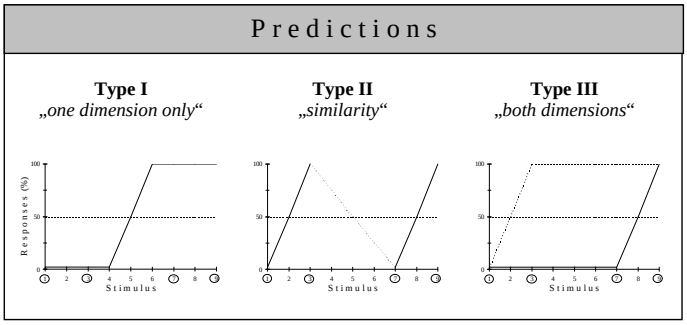

Fig.3: Predictions.- Shown are three types of hypothetical judgment strategies (*test phase)*: Judgments based on *one* dimension only (Type I); judgments based on the *similarity* between test and training stimuli (Type II); judgments based on *both* dimensions (Type III).

RESULTS

Two-dimensional Discrimination Training.- During the discrimination training a basic two-dimensional categorization was learned. All participants showed at least 90% correct responses. Whereas the 18 year-old participants did not show any differences depending on the dimensions employed, the 4-year-olds did. There were weaker results for the color-size condition in this age group.

Two-dimensional Choice Behavior.- For analyzing the choice behavior during the test sessions the percentage of choice responses were plotted separately for both age groups as well as for the three judgment types. These empirical psychophysical functions are shown in Figure 4. During the test period all three predicted types of judgment were found in both age groups and characterized the main part of the analyzed behavior. No significant differences in the manifestation of the types were found, neither between the age groups, nor between the combination of stimulus dimensions used.

Age-related Frequency of Strategies.- Subsequent analyses were occupied with the frequencies of the three postulated judgment types depending on the combination of dimensions used. Figure 5 shows the age-related occurrence of the three judgment types for the size-brightness condition, the brightness-size condition and the color-size condition. The 18-year-olds showed no distinct preference for one of the postulated judgment types, while the 4-year-olds changed their preferences depending on the combination of dimensions: type I (based on one dimension only) with size and brightness resp. brightness and size, and type II (based on similarity) with color and size. The two-dimensional type III (based on both dimensions) remained constant and was used infrequently in both age groups.

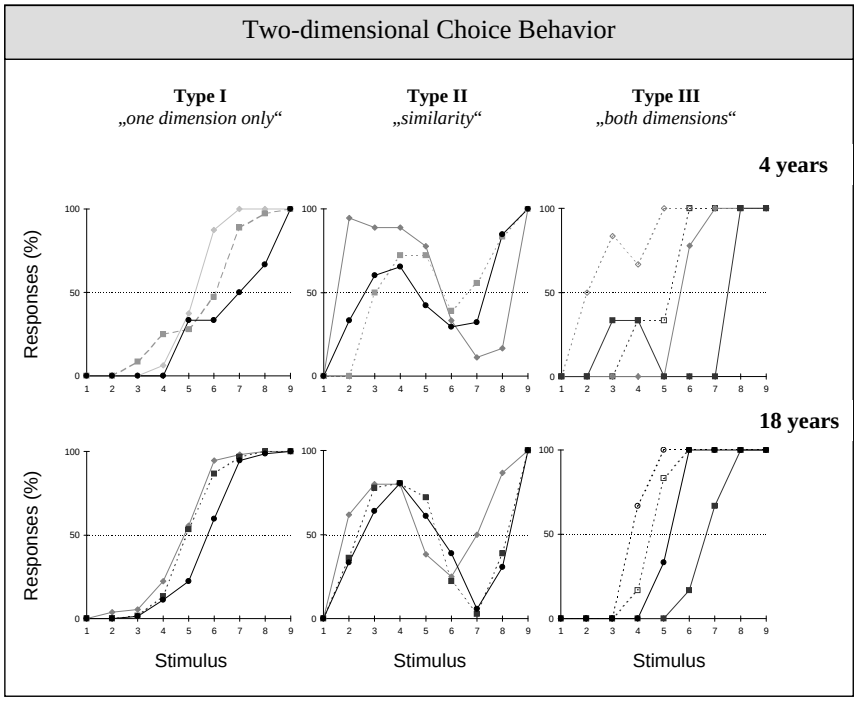

Fig.4: Two-dimensional choice behavior.- Shown are the empirical psychophysical functions of choice responses (%) separately for both age groups as well as for the three judgment types depending on the used combination of dimensions (—— size-brightness; - - - - brightness-size; —— color-size).

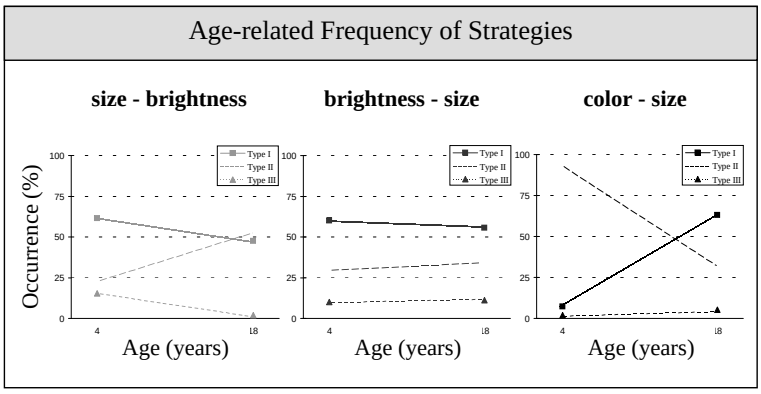

Fig.5: Age-related frequency of strategies.- Shown are the age-related percentage of occurrence for the three judgment types. Left: size-brightness condition; middle: brightness-size condition and right color-size condition. The 18-year-olds showed no distinct preference, while the 4-year-olds did (Type I with the dimensions “size and brightness,” but type II with the dimension “color.”

DISCUSSION AND CONCLUSIONS

During the discrimination training not only the older participants, but even the 4-year-old children were able to manage the two-dimensional categorization task. In the subsequent generalization test conditions the predicted context-induced judgment strategies occurred in both age groups, regardless of which psychophysical dimensions were used. This occurrence demonstrated age-related differences depending on the combination of dimensions used. The 4-year-old children preferred Type II judgments for the color-size condition, and Type I judgments for the remaining conditions. Summarizing the training and test data, the color dimension seems to be particularly important for the 4-year-olds. In sessions with color dimension, they master the discrimination training using a strategy of *memorizing* the "absolute" values of the stimuli and afterwards demonstrating one-dimensional, absolute choice behavior (Type II) during the test sessions. In contrast the dimensions size and brightness are learned "relative" relative to each other and therefore lead to a preference in Type I judgments. Interestingly enough comparative studies with baby chickens also indicate a distinct difference in the absolute resp. relative components of choice behavior depending on color or size dimensions (see Sarris, Hauf & Arlt, 2001, this volume). Further investigations should not only continue to analyze dimension-related differences in choice behavior, but also how age-related differences in cognitive abilities, such as memory and problem solving interact with judgment types (Hauf, 2001).

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