Filtering and condensation tasks with integral and separable dimensions

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Speed of classification was measured with a filtering task (only one dimension relevant) and a condensation task (two dimensions relevant) with integral dimensions of Munsell value and chroma and separable dimensions of value and size. The filtering task was easier with separable than with integral dimensions, but the condensation task was easier with integral than with separable dimensions. The results emphasize the importance of dimensional structure with separable dimensions and similarity or distance structure with integral dimensions.

A classification task is one in which more than one stimulus is paired with a single response. If stimuli used in a classification task are generated from two (or more) dimensions, then there are two basic methods of defining the mapping of stimuli to responses (Posner, 1964). In a *filtering* task, one dimension only is used as relevant to classification, the other dimension being irrelevant, and to be ignored or "filtered" out. In a *condensation* task, the mapping is such that both dimensions must be attended and used to determine the correct response. If stimuli are generated from a single dimension, it is still possible to pair more than one stimulus with a single response, and such a task is called *grouping* (Gottwald & Garner, 1972). Comparisons among these tasks, with time of classification the dependent variable, generally show that the filtering task is easiest, the *grouping* task next, and the condensation task most difficult.

Garner (1974) has summarized data of many types indicating that there are two basically different kinds of relation between stimulus dimensions. In brief form, *separable* dimensions are analyzable and the dimensions can be attended separately. *Integral* dimensions are unanalyzable and seem to fuse into a single complex dimension. In stimulus sets generated with separable dimensions, the dimensional structure is dominant, while with stimulus sets generated with integral dimensions, distance and similarity relations are dominant.

Two of the classification tasks described above, filtering and condensation, involve two dimensions, and performance in these tasks should be affected by

the type of dimensions used. The filtering task requires attending to one dimension and ignoring another. This task should be more difficult with integral than with separable dimensions because of the fusion of the integral dimensions. Garner and Felfoldy (1970) have demonstrated this effect. With separable dimensions, subjects filtered efficiently and sorting times were about the same as those in a two-choice reaction time task with levels on a single dimension. With integral dimensions, subjects could not filter and sorting times were much slower than those in the two-choice task.

The condensation task requires processing information from both dimensions. With separable dimensions, the subject must attend to two discrete dimensions, while with integral dimensions, the subject should be able to attend to both dimensions as a unit. Thus, the condensation task should be more difficult when separable dimensions are used. However, the effects of dimension type have not yet been evaluated in this task.

It should be noted that when integral dimensions are used in the filtering and condensation tasks, both of these tasks are somewhat similar to the grouping task. This similarity is due to the fusion of the integral dimensions which obscures the multidimensionality of the stimuli. However, task difficulty is affected by interstimulus distances as well as by dimensional structure. Since the within- and between-category distances cannot be equated in all of these tasks, the tasks should still vary in difficulty.

The present study was designed to examine the effects of dimension type upon performance in both the filtering and condensation tasks within a single experiment. Integral and separable dimensions of approximately equal discriminabilities were used in

each task. An interaction was anticipated. It was expected that the condensation task would be easier with integral than with separable dimensions, although the filtering task would be easier with separable than with integral dimensions, as had been shown by Garner and Felfoldy (1970).

METHOD

Subjects

A total of 16 subjects was used. Eight were paid volunteers from the summer subject pool at Yale University and eight were from the subject pool at Indiana University at South Bend who received class credit for participating. There were no effects due to type of subject.

Conditions

Two pairs of dimensions were used. One pair consisted of the Munsell dimensions of value and chroma, and the other pair consisted of value and size. Previous research has shown that value and chroma are integral (Garner & Felfoldy, 1970, using speeded classification), while value and size are separable (Handel & Imai, 1972, using free classification and similarity judgment). The levels of the dimensions in the present experiment were selected so that the discriminabilities were approximately equal. The integral dimensions varied on glossy 1.9-cm-sq chips with a hue of 5R. The levels of value were 4, 5, or 6, and those of chroma were 2, 4, or 6. The separable dimensions varied on gray chips. The levels of value were 4, 5, or 6, and the sizes were 1.9, 2.3, or 2.7 cm sq. All stimuli were centered on white cards, 8.9 cm high x 6.3 cm wide.

Each pair of dimensions was used in four logically different card-sorting tasks. In the first three tasks, only the extreme two levels of each dimension were used.

The first task was a *control* task in which only one dimension varied and the other dimension was held constant. Each dimension was used twice—once at each level of the constant dimension.

The second task was *filtering*. Each dimension was used once.

The third task was *condensation* (2). The two levels used on each dimension form a 2 by 2 matrix. This task involved sorting one diagonal of the matrix against the other. Specifically, with integral dimensions, the classification involved value 4 chroma 2 and value 6 chroma 6 vs. value 4 chroma 6 and value 6 chroma 2. With separable dimensions, the classification involved value 4 size 1.9 cm and value 6 size 2.7 cm vs. value 4 size 2.7 cm and value 6 size 1.9 cm.

The fourth task was *condensation* (3). All three levels on each dimension were used, and thus the stimuli were taken from a 3 by 3 matrix. Two conditions were used here. One condition involved sorting the stimuli above the positive diagonal vs. the stimuli below the positive diagonal. The other condition involved sorting the stimuli above the negative diagonal vs. the stimuli below the negative diagonal. With integral dimensions, one condition involved sorting value 4 chroma 2, value 4 chroma 4, and value 5 chroma 6 vs. value 5 chroma 2, value 6 chroma 4, and value 6 chroma 6. The other condition involved sorting value 4 chroma 4, value 4 chroma 6, and value 5 chroma 6 vs. value 5 chroma 2, value 6 chroma 2, and value 6 chroma 4. With separable dimensions, one condition involved sorting value 4 size 1.9 cm, value 4 size 2.3 cm, and value 5 size 1.9 cm vs. value 5 size 2.7 cm, value 6 size 2.3 cm, and value 6 size 2.7 cm and the other condition involved sorting value 4 size 2.3 cm, value 4 size 2.7 cm, and value 5 size 2.7 cm vs. value 5 size 1.9 cm, value 6 size 1.9 cm, and value 6 size 2.3 cm.

A 36-card deck was used for each condition. Within each deck, the sizes of the stimulus sets assigned to each response were equal, and within each set, each of the different stimuli occurred equally often.

Procedure

All measures were obtained from the sorting of decks of stimulus cards into two piles. Subjects were instructed to sort as fast as possible but without making any errors. With each deck to be sorted, examples of the stimuli that belonged in each pile were laid out in front of the subject, who held the deck in either hand face up and sorted the cards into two piles corresponding to the examples which were left in view.

The subject was given 18 practice trials (one on each of the 18 different decks) and then 54 test trials (three on each of the 18 different decks). After each deck had been sorted, time to the nearest 0.01 sec was noted from an electronic counter operated by the experimenter, and any errors were recorded. While the subject was sorting, the experimenter checked errors, recorded scores, and shuffled the next deck of cards to be used. The subject was not informed about either his time or error scores.

Deck order was determined with a Latin square. One row of this Latin square determined the order of the first 18 trials for the subject. Then this order was reversed for the next 18 trials, reversed again for the next 18 trials, etc. The subject was given a 5-min rest after the second block of 18 trials.

RESULTS

The primary measure was sorting speed in terms of time per deck. In the control and filtering tasks, error frequency was low, averaging 0.11 per deck, while in the condensation tasks, error frequency was significantly greater, averaging 1.14 per deck. There were no other differences in error frequency due to either tasks or type of dimensions. There were no large differences between the different decks used within each condition, so the data from the different decks were pooled. Unless otherwise noted, statistical analyses involved Subjects by Conditions analyses of variances and statements of significance are for $p < .01$.

Table 1 shows mean sorting times for the different tasks when integral dimensions were used. In the control task, chroma was sorted faster than value. In the filtering task, the difference between relevant dimensions was not significant ($p > .20$). The filtering task was slower than the control task for both relevant dimensions. The two condensation tasks did not differ from each other ($p > .20$), but both were slower than the filtering tasks.

Table 2 shows mean sorting times for the different tasks when separable dimensions were used. In both the control and filtering tasks, value was sorted faster than size (in filtering, $p < .05$). The filtering task did not differ from the control task for either dimension (smaller $p > .10$). The two condensation tasks did not differ ($p > .20$), but both were slower than the filtering tasks.

Comparisons between the two types of dimensions in the control task show that the overall mean sorting time was faster when integral dimensions were used. This effect is due to differences between chroma and size since there was no difference due to type of

Table 1
Mean Sorting Times for Various Tasks With Integral Dimensions

Tasks	Relevant Dimensions		
	Value	Chroma	Mean
Control	14.39*	14.17	14.28
Filter	17.45	17.31	17.38
Condensation (2)			21.52
Condensation (3)			21.37

*Seconds to sort a deck of 36 cards.

Table 2
Mean Sorting Times for Various Tasks
With Separable Dimensions

Tasks	Relevant Dimensions		
	Value	Size	Mean
Control	14.48*	15.03	14.75
Filter	14.72	15.09	14.90
Condensation (2)			23.54
Condensation (3)			23.28

*Seconds to sort a deck of 36 cards.

dimension when value was relevant ($p > .20$). An analysis involving dimension type and task (filter vs. mean condensation) showed that dimension type did not affect sorting time ($F < 1$), but the filtering task was faster than the condensation task and there was an interaction between dimension type and task. The filtering task was faster with separable than with integral dimensions, and the condensation task was faster with integral than with separable dimensions.

DISCUSSION

The primary finding was the anticipated interaction between task and type of dimensions. These results are quite reasonable when one considers the requirements of the tasks and the nature of the types of dimensions. The filtering task requires selective attention to one dimension and performance is facilitated when the dimensions are perceptually distinct. The condensation task requires processing of two dimensions, and here performance is facilitated when the dimensions are perceptually fused.

The two different condensation tasks were included to examine the effects of spatial separation of the stimuli. In condensation (2), each stimulus is actually closer to the stimuli in the other category than to the

other stimulus in the same category. In condensation (3), the stimuli within a category are clustered and fairly distinct from the stimuli in the other category. It had been anticipated that the difference between integral and separable dimensions would be greater in condensation (3) than in condensation (2), since there is a clearer spatial separation between the stimuli in each class with condensation (3). The data show no such effect, but it is possible that any advantage due to the spatial separation may have been offset by the increased number of stimuli per class.

When stimuli are composed of integral rather than separable dimensions, both the filtering and condensation tasks become more similar to the grouping task. Thus, sorting speeds should be (and were) intermediate between those obtained for the control conditions and those obtained for classification of separable dimensions with the condensation task. However, even though these speeds should be intermediate, there will still be large differences in sorting speeds because of the different kinds of distance or similarity relations that can exist both between and within classes. Thus the filtering task with integral dimensions is easier than the condensation tasks with these same dimensions, because the relations of the between vs. within distances are simpler.

In summary, however, this experiment has shown that the relations between task difficulties in classification does depend on the particular nature of the dimensions that are used to generate the stimuli.

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