Selective Attention to Attributes and to Stimuli

W. R. Garner
Yale University

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SUMMARY

Recent experiments summarized by Garner (1974b, 1976) have explored the interaction of stimulus attributes, which may produce new stimulus entities or may maintain the identity of the individual attributes. Two speeded classification tasks of primary importance have been (a) discrimination of pairs of stimuli and (b) classification of orthogonal sets of stimuli so as to require selective attention to attributes. This last task in particular has helped differentiate between separable attributes, with which selective attention is possible, and configural attributes, with which it is not.

Selective attention to individual stimuli is also possible, and two additional tasks were used in the present study to elucidate the nature of such attention: (a) focusing, in which one stimulus must be classified against three others and (b) condensation, which requires the processing of two attributes.

A major stimulus variable concerns the distinction between dimensions, which have mutually exclusive positive levels, and features, which exist or do not exist in a given stimulus. With feature-generated stimuli, two stimuli have a special role: the null stimulus, in which all features are absent, and the complete stimulus, in which all features are present. A second stimulus variable concerns the homogeneity or heterogeneity of the attributes.

The present series of 11 experiments used four types of stimuli and 13 tasks. The conclusions are as follows: (a) Homogeneous dimensions produce stimuli in which selective attention to individual stimuli is good, and condensation classification is also good. (b) Heterogeneous dimensions produce stimuli that have separable attributes, with good selective attention to attributes but not to individual stimuli. Condensation classification is poor. (c) Homogeneous features produce stimuli which show poor selective attention to attributes but good selective attention to individual stimuli, especially the complete and the null stimuli. Condensation classification is good. (d) Heterogeneous features show good selective attention to the null stimulus and fairly good selective attention to other stimuli. Selective attention to attributes and condensation performance are fair.

It is concluded that good selective attention to individual stimuli occurs either because of the special role of the null stimulus when stimuli are generated from features or because the individual stimulus is well configured. Furthermore, the effect is probably due to the ease with which such stimuli are held in memory.
This article is concerned with two particular information-processing concepts: selective attention to the variable attributes that define the properties of sets of stimuli and selective attention to the particular stimuli within a set. Two types of stimulus property that can affect the relative ease or difficulty of each of these types of selective attention are also of concern. One of these stimulus properties relates to the nature of the variable attributes that define the properties of the set; specifically, whether dimensions with mutually exclusive positive levels are used to generate stimuli or whether features that can be present or absent are used. The second stimulus property relates to the relative homogeneity of the attributes used to generate the stimuli.

**Attribute Interaction in Information Processing**

There now exists a considerable literature on the various ways in which stimulus attributes (dimensions, in most cases) interact in various perceptual and information-processing tasks. Generally speaking, dimensions can either fail to allow any type of integrated stimulus or they can combine to allow newly perceived relations. Many experimental tasks show considerable convergence in differentiating the various types of interaction, including direct similarity scaling and various types of stimulus classification. Results from such experiments have been summarized by Garner (1974b, 1976). The most definitive experimental operations, however, have used information-processing tasks with reaction time (or some equivalent of it) as the measure of performance.

The types of task used and the types of attribute interaction that can be defined on the basis of results of these tasks can best be discussed by reference to Figure 1. This figure schematizes the minimal set of four stimuli which can be generated with two orthogonal attributes. Two major tasks have been used with such sets of stimuli:

Discrimination speed between any two of the four stimuli can be measured (1/1 tasks). There are six pairs of stimuli available, and they form two functionally different groups. (a) Four of the pairs involve discrimination between stimuli differing on a single attribute: The pairs A/B and C/D differ only on attribute X, and the pairs A/C and B/D differ only on attribute Y. These pairs provide baseline data for other tasks in which stimuli differ on both attributes. (b) Two of the pairs—pairs A/D and B/C—differ in both attributes, but necessarily in a correlated or redundant manner. If attributes interact, then one possible consequence of the interaction is that discrimination is faster with the redundant pairs of stimuli than with the pairs differing only on a single attribute. Normal expectation would be either better performance with redundancy or no improvement, since it is unreasonable for poorer performance to occur.

Classification speed with two stimuli mapped to each of two responses can also be measured (2/2 tasks). If a subject is required to classify stimuli A and B with one response, and C and D with a second response (designated AB/CD), then classification is on the basis of attribute Y, and attributes X and B/C are treated as redundant.

**Figure 1.** A schematic portrayal of four stimuli generated from two orthogonal attributes.
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tasks can best be illustrated by the following example. In Figure 1, this particular set of four tasks is designed to study the effect of attribute X on the classification of the stimuli. When the stimulus is not classified on the basis of attribute X, it is classified as irrelevant. If a subject is required to classify A and C with one response, and B and D with a second response (AC/B), then classification is on the basis of attribute X, and attribute Y is irrelevant. These two classification tasks are the primary ones which have been used, and they are designed to determine whether selective attention to the relevant attribute is possible while ignoring the irrelevant attribute. If classification with attribute X is relevant, for example, is as fast as discrimination between two stimuli differing only on attribute X, then selective attention to the relevant attribute is possible. If classification takes longer than the equivalent discrimination, then selective attention to the attribute is not possible. Posner (1964) has called this type of task filtering because of the requirement that the subject filter out one dimension while attending to the other.

There are thus two basic questions which these two types of task can ask: (a) Are stimuli that differ on redundant attributes discriminated more easily than those that differ on a single attribute? and (b) Can attributes be selectively attended? These two questions have shown four different types of attribute interaction: integral, when there is a redundancy gain and no selective attention; asymmetric integral, when there is a redundancy gain and selective attention for one attribute but not for the other; separable, when there is no redundancy gain but selective attention is possible for both attributes; and configurual, when there is no redundancy gain and also no selective attention. Once again, more detail on these distinctions can be found in Garner (1974b, 1976).

Configural Attributes and Stimulus Attention

The basic idea behind the term configural interaction is that the attributes used by the experimenter do not in fact define the properties of the stimuli as processed by the experimental subject. Rather, the stimuli generated become new entities, configurations, with emergent properties of their own. While these emergent properties can be influenced by the type of attribute used to generate them, the attribute structure of the set of stimuli becomes lost, while the structure of the new configurations dominates perception.

The present series of experiments is designed particularly to explore the nature of the configural interaction. The experiment that is the specific departure point for the present series of experiments, and that provided the basic definition for the configural interaction, was done by Pomerantz and Garner (1973). They used the ordinary parentheses on a typewriter to generate four stimuli, right and left locations providing the attribute, with right and left curvature providing the levels on the attributes. Thus their four stimuli were (,), (,), and ), respectively, as the A, B, C, and D stimuli of Figure 1, with the left parenthesis being attribute X, and the right being attribute Y. Their results showed no overall advantage for redundant dimensions. The stimulus pair ) ( and ) provided the fastest discrimination of any pair, including all of the pairs differing on a single attribute, while the pair ( ) provided the slowest discrimination of any pair. Thus the two redundant pairs were the fastest and the slowest. These results suggested that the configural properties of the stimuli rather than the attribute properties were determining performance, and indeed the results were quite in line with the idea that pattern goodness influences discrimination time, good patterns being easier to discriminate from each other than poor patterns.

Such a result suggests that properties of the individual stimulus, rather than simply the attributes of the set of stimuli, become important in the discrimination process. In fact, a further look at the data from that experiment showed that of the six pairs of stimuli, the three fastest discrimination times occurred when one stimulus of the pair was the ( ) stimulus. Thus the discrimination time between a pair of stimuli seems to be a function of the properties of one individual stimulus, not just the property of the stimuli as a pair. Clement and Varnadoe (1967) had earlier argued that the assumption of an individual encoding time for each stimulus in a pair could best account for their data on...
discrimination between pairs of stimuli, which were dot patterns differing in goodness. Thus in their experiment, discrimination between two good patterns was faster than discrimination between one good and one poor pattern, not because (they argued) the two patterns differed more, but because the two encoding times were faster. Garner and Sutliff (1974) demonstrated the legitimacy of this idea more directly by measuring the reaction time to good and to poor patterns in a discrete reaction experiment requiring discrimination between good and poor patterns. When a good pattern was discriminated from a poor pattern, the better pattern always showed the faster reaction time, although no such asymmetric effects existed when good–good or poor–poor pairs of patterns were discriminated.

These results all demonstrate the need to investigate more fully the role of selective attention to specific stimuli within sets of stimuli in addition to selective attention to attributes which generate the stimuli. Triesman (1969) and Garner (1974a) had both pointed out that it was necessary to distinguish between selective attention to the attribute and to the levels on the attribute, or even to the combination of levels. The levels, of course, define the specific stimulus, while the attribute can be attended only over a set of stimuli.

All of these considerations suggest that some additional experimental tasks could be added to those of pair discrimination and classification of the filtering type, and that performance on these additional tasks will help clarify how sets of configural stimuli are processed. There are two additional tasks which can be used:

Focusing requires classification of one stimulus versus the other three (1/3 tasks). In the notation being used here, and with the illustration of Figure 1, there are four different such tasks: A/BCD, B/ACD, C/ABD, and D/ABC. Thus two different responses are still used, but the stimulus assignment to the responses is 1/3. The term focusing is used for this task in the same sense that Posner (1964) used the term filtering. The term implies the psychological process rather than being simply a description of the task in terms of stimulus–response assignments, but the experimental question remains whether such a psychological process can in fact be carried out with any specific set of stimuli.

The term focusing implies that a 1/3 classification task can be handled by the subject's "focusing" on the single stimulus and then using a go–no go decision strategy. Thus the subject would not ask about the properties of stimuli in the larger class, but only about the properties of the single stimulus; then, for each presented stimulus the subject decides whether the presented stimulus is the focused item, responds appropriately if it is, and uses the alternative response if it is not. If such a strategy can be used, then it should take no longer to classify A/BCD than A/B, A/C, or A/D. Can psychological processors use such a strategy? Gottwald and Garner (1972) found that subjects can, when using the attributes of form and color. Hawkins and Hosking (1969) also found that subjects use a focusing strategy, especially when the difference between the two sets of stimuli mapped onto the two responses is great. On the other hand, a series of experiments by LaBerge and collaborators (LaBerge, Legrand, & Hbbie, 1969; LaBerge & Tweedy, 1964; LaBerge, Tweedy, & Ricker, 1976) have shown that such a strategy will not necessarily be used if differential probabilities of occurrence or differential incentives occur for the stimuli in the larger class. Thus the evidence is that a focusing strategy can be used, but is not necessarily used if there are conflicting task demands.

For purposes of the present research, however, the intention is to determine whether the ability to use a focusing strategy depends on which stimulus of a set is the focused stimulus. There is no reason to assume that all stimuli in a set will be equally effective in allowing a focusing strategy. In fact, Pomerantz (1977), using dot patterns as stimuli, showed that focusing is much easier if the focused stimulus has a good configuration rather than a poor configuration. So once again the goodness of the stimulus appears to influence the processing of that stimulus. S assume that effective in strategy. So to the disc tasks shoul tween stim between stim types of att: Condenser classificatio attribute ca tion. With densation t: uli forming of the two Posner's ( contrasted: denstion t: the subject t: concept would be c.

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stimulus. Still further, there is no reason to assume that all sets of stimuli will be equally effective in allowing the use of a focusing strategy. So the addition of the focusing task to the discrimination and (2/2) classification tasks should help clarify both relations between stimuli within a set and relations between stimulus sets generated from different types of attribute.

Condensation, another form of (2/2) classification, is a task in which no single attribute can serve as the basis of classification. With reference to Figure 1, the condensation task is AD/BC, in which two stimuli forming a redundant pair are put in each of the two classes. Once again I am using Posner's (1964) terminology, in which he contrasted the filtering task with the condensation task, in both cases implying what the subject does if successful. In the language of concept learning, the condensation task would be called biconditional classification.

Can the condensation task help clarify the nature of relations within and between sets of stimuli which in general produce the configurational interaction? The answer is clearly affirmative. Gottwald and Garner (1975) used the condensation task in comparing stimulus attributes that show the integral relation (thus no selective attention with the filtering type of classification) with stimulus attributes that show the separable relation (in which filtering, or selective attention to attributes, is possible). These authors found that while the condensation task was more difficult than the filtering task for either integral or separable dimensions, condensation was relatively easier with integral dimensions than with separable dimensions. More specifically for the types of stimuli discussed in the present article, Pomerantz and Schwartzberg (1975) showed that the condensation task was actually easier than the filtering task with the set of stimuli generated from parentheses. In this case, the condensation task requires the classification: ((), ) / ((), ). Still further, the condensation task became more difficult than the filtering task when the elements generating the stimuli were separated physically. Thus the relative difficulty of the condensation task as contrasted to the filtering task provided a very sensitive indicator of differences in processing with different stimulus properties.

Stimulus Attributes: Dimensions or Features

In most of the literature involving perception of stimulus properties, words such as features, cues, attributes, components, and dimensions have been used almost interchangeably to refer to any variable property of a set of stimuli. In a recent analysis of several cognitive and information-processing tasks (Garner, 1978), I have argued that there are important consequences of exactly what type of variable is used in generating or describing stimuli. Very specifically, I suggested that attribute be used as a general term for any variable property of sets of stimuli, but that we then distinguish between dimensions and features with the following definitions:

A dimension is an attribute of a stimulus such that if the dimension exists for the stimulus, it exists at some positive level, and these alternative positive levels are mutually exclusive. On the other hand, a feature is an attribute of a stimulus which either exists or does not exist, but if it exists, it has only a single level.

Consider once again the orthogonal attributes in Figure 1 and the stimuli that would be generated if the attributes are dimensions and those that would be generated if the attributes are features. If the attributes are dimensions, then the set of parentheses which Pomerantz and Garner (1973) first used, and which I have been using as illustrations, would be generated. Because of the requirement that dimensions have mutually exclusive positive levels, each stimulus thus generated has as many elements or components as any other stimulus, so that while the stimuli can differ in the configuration of the elements, they cannot differ in the sense of an amount of something.

If, however, the stimuli are generated from features, the individual stimuli can differ in an amount because when the feature does not exist in the individual stimulus, there is less of something. Suppose that attribute X is the presence (or absence) of a parenthesis on the left side and attribute Y is the pres-
ence (or absence) of a parenthesis on the right side. We would then have the following stimuli: -. )- -. (). (Incidentally, the hyphen is used to provide a "handle," so that no stimulus is literally nothing; this problem will be investigated in one of the experiments described here.) This set of stimuli now varies in the amount of something, and in fact, a feature-generated set of stimuli always has two special stimuli, both representing limits and thus being reference stimuli: the null stimulus, in which all features are missing, and the complete stimulus, in which all features are present.

There are several ways in which this difference between dimensions and features can influence the various information-processing tasks, and thus the kinds of configural properties which can exist for a set of stimuli. For example, the two redundant pairs of stimuli are now quite different, since one redundant pair contains the two stimuli with the most and the least amount of stimulus (the null and the complete stimulus), while the other redundant pair has an equal amount in each stimulus. To illustrate with the hyphen and the parentheses stimuli, one redundant pair is - / - ), while the other redundant pair is )- / - ). It seems entirely possible that there will be differences in speed of discrimination of these two pairs, as suggested by Garner (1978). Still further, consider the ability which subjects might show in focusing on the different stimuli. With dimension-generated stimuli, at least each stimulus starts with an equal status, while with feature-generated stimuli, some stimuli contain more features than others. In turn, the dimension-generated stimuli might make configural interaction much more possible, while feature-generated stimuli could be processed more in terms of the attributes used to generate the stimuli.

For these various reasons, then, the present set of experiments used both features and dimensions as the attributes in generating the stimulus sets, in order to clarify both the nature of the types of processing which can occur and the role of dimensions and features in producing configural sets of stimuli.

**Stimulus Homogeneity and Configuration**

While the difference between dimensions and features concerns a stimulus property, it is a very general property that will have little to contribute to an understanding of the particular stimulus factors that produce configuration. The primary definition so far available for the role of configural rather than attribute properties has been the selective attention task: If the elements of a stimulus configure, then the attributes defining the stimuli cannot be selectively attended.

While most of the classical work on gestalt properties of stimuli involved the principal use of phenomenal report in one form or another, there has been some recent work which is more in line of current information-processing approaches. Especially Beck (e.g., 1966, 1967, 1973) has shown that segregation of stimuli (i.e., selective attention) is better when the stimulus elements differ in orientation rather than in shape, and in one case Beck (1973) showed that a measure of processing time (time required to locate disparate items) was shorter if the angular orientation of the figures differed. The importance of this particular property in the type of task used in the present study has indeed been shown by Pomerantz and Garner (1973), who did carry out the filtering classification task with the parentheses stimuli described above, but with one parenthesis being oriented vertically and the other horizontally. Selective attention was possible with these stimuli, even though it had not been when both parentheses were oriented vertically. Still another stimulus property, distance between elements, has been shown by Pomerantz and Schwartzberg (1975) to influence the ability of subjects to attend selectively to the stimulus attributes, with selective attention being easier with greater distances.

It is difficult to attempt any investigation of all the possible stimulus properties that can influence the emergence of configural properties, and such an investigation is not attempted in the present experiments. At the same time, in investigating processing concepts, especially by contrasting experimental outcomes on several different processing
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tasks to seek a pattern of outcomes, it would be very useful in clarifying the meaning of any particular outcome if alternative outcomes could be shown to exist with stimuli having different properties. This is why the distinction between features and dimensions was introduced.

A second property that seemed likely to affect the ability of subjects to attend selectively to attributes, to perform the condensation task easily, and to use a focusing strategy is that of stimulus homogeneity. In these experiments, therefore, all stimulus sets were generated from either parentheses for both attributes, brackets for both attributes, or parentheses for one attribute and brackets for the other attribute. The former two cases are considered to provide homogeneous attributes, and the last case to provide heterogeneous attributes.

Overview of Experiments

Altogether, 11 experiments were run. These experiments are all identical except for the specific nature of the stimuli. Therefore the specific stimuli will be described for each separate experiment. Each experiment used a set of four stimuli generated from the orthogonal combination of two attributes, as diagrammed in Figure 1.

The 11 experiments are presented and discussed in four groups defined by the combinations of two kinds of stimulus property: type of attribute and homogeneity of stimulus property. The four groups of experiments involve (a) homogeneous dimensions, (b) heterogeneous dimensions, (c) homogeneous features, and (d) heterogeneous features.

Stimulus Construction

All the stimuli were typed on 6.3 × 8.9 cm white cards, with the upper right corner missing to maintain proper orientation of the card. The stimuli were oriented vertically on the card. The card itself was coated with a thin plastic to avoid soiling of the card and to allow easy sorting of the cards. All stimulus attributes were either the parenthesis or bracket, typed by an IBM typewriter, 10-pitch spacing, type style IBM Pica 72. In addition, in all experiments except one, there was a hyphen located in the center of the card, either separating the two elements of a stimulus by one space or being one space to the right or left of the stimulus element if there was only one element. Each parenthesis or bracket was approximately 4 mm tall. These measurements mean that at a typical viewing distance of about 30 cm, the stimuli subtended a visual angle between 1° and 2°.

Tasks

Each task required the subject to sort a deck of 36 stimulus cards into two piles based on the appropriate property of the stimuli. There were 13 different tasks used in each experiment, and these tasks can be described with reference to Figure 1 by denoting the stimuli as A, B, C, and D and by using the slash to indicate the appropriate classification into the two piles. Thus A/B indicates that only stimuli A and B are in the particular deck and that A stimuli are to be put into one pile and B into another pile. More generally these tasks can be described as 1/1, 1/3, or 2/2, the two numbers indicating the number of different stimuli to be sorted into each pile. These tasks are of three different basic types, with subtypes for two of them:

Discrimination tasks (1/1). These tasks require discrimination between just two stimuli. For these tasks the decks contained 18 stimuli of each type. There are six different pairs of 4 stimuli, and these form two subtypes of task:

1. One-attribute tasks involve stimuli which differ on only a single dimension. These tasks are A/B and C/D (with variation in attribute X only) and A/C and B/D (with variation in attribute Y only). These tasks provide the baseline data for all other experimental tasks.

2. Correlated- or redundant-attribute tasks involve stimuli that differ on both attributes X and Y but in a correlated manner. These tasks are A/D and B/C. These tasks should be faster than the one-attribute tasks if the subject can make use of the information provided by the redundant attribute. If, of course, the subject processes just one dimension at a time, there would be no improvement in discrimination speed. This is apparently what happens with separable attributes.

Focusing tasks (1/3). These tasks require that 1 stimulus be sorted into one pile (i.e., be given one response) while the other 3 stimuli are to be sorted into the other pile. There are four focusing tasks possible: A/BCD, B/ACD, C/ABD, and D/ABC. For these tasks, there are 18 focused stimuli and 6 each of the other 3 in each deck of 36 cards. If these tasks are performed as fast as the one-attribute tasks involving the same focused stimuli, then we can conclude that the subject is able to use a focusing strategy, with the implication that properties of the three stimuli which go into the unfocused class are not perceived.

Classification tasks (2/2). These tasks require that all four stimuli be classified, two into each class. For these tasks the decks contained nine of each of the four stimuli. There are three ways in which four stimuli can be classified into two subsets
of two each, and they form two meaningfully different subtypes of task.

1. Filtering tasks, using Posner's (1964) terminology, require classification with one attribute as the relevant, differentiating property and the other attribute as irrelevant. These two classifications are AB/CD and AC/BD. If these tasks can be carried out as fast as the equivalent discrimination task in which there is no irrelevant attribute, then we know that the subject can selectively attend to the attribute.

2. Condensation tasks, following Posner's terminology again, require classification in which no single attribute can serve as the relevant basis of classification. There is one task of this type: AD/BC. This task requires that the two redundant subsets of two stimuli each be sorted into a single class. Condensation tasks, or alternatively, biconditional classifications, ordinarily cannot be carried out as fast as any of the one-attribute control tasks, or the filtering tasks, since both attributes must be processed in order for correct classification to occur. However, if the condensation task can be carried out more easily than the filtering task, this result would indicate that classification is being carried out on the basis of some emergent configural property, and not on the basis of the attributes used by the experimenter to generate the stimuli.

**Procedure**

The specific task for the subject was to sort the deck of 36 cards into two piles as rapidly and as accurately as possible. On each trial the subject was handed a shuffled deck of cards, face up, along with the two or four example cards indicating the particular classification required on that trial. The subject arranged the example piles on the table in any way desired. The experimenter said "ready," then "set," and the "go" signal was the actual click of the stopwatch. After each sort the subject was told the sorting time for the trial, the time and errors (indicated by the subject to the experimenter) were recorded, and the next trial was begun.

The experiment was carried out in an office, with the subject sitting across a table from the experimenter. The experimenter operated the stopwatch, shuffled decks, handed them to the subject, and did all the recording. Times per deck of cards were recorded to the nearest tenth of a second.

Each experiment involved all 13 tasks. Each subject was first run on all tasks once in a particular order, then was run on all tasks in the reverse order, and then was run on all tasks a third time, this last time again in the original order. Thus each subject was run on three blocks of trials, each block containing all tasks. The total time per subject was approximately 1 hr.

The orders of the tasks were counterbalanced across subjects, each subject having one particular order. These orders were pseudorandom, constrained so that each of the three types of task occurred equally often at all points in the order.

**Subjects**

In all, 110 subjects were used, 10 different subjects for each of the 11 experiments. The subjects were all fulfilling a requirement of the undergraduate introductory psychology course at Yale University.

**Data Analysis**

Both time and errors were recorded. As is typical in these experiments, errors are too few to warrant analysis, with the great majority of trials being errorless.

Of the three blocks of trials, the first block was considered practice, and no data from this block were analyzed. For each experiment a preliminary analysis of variance was carried out in which effects between the second two blocks were examined. In each experiment, there was a statistically significant improvement in speed of sorting, ranging from .5 to 1.4 sec, with an average of .9 sec. In 10 of the 11 experiments, there was no statistically significant interaction of blocks and tasks, and the product-moment correlations across tasks between the two blocks ranged from .79 to .97, with a mean correlation of .92 for all 11 experiments. The one experiment (Experiment 4) for which there was a statistically significant interaction had an idiosyncratic factor producing the effect, and it will be discussed in the appropriate section. The overall picture, however, is one of high reliability in ordering of task difficulty from the second to the third block.

For these reasons, all further analyses were done with sorting times averaged over the last two blocks. Many different analyses of variance were carried out, both within and between experiments as necessary. In addition, various nonparametric tests were used (most commonly, the sign test within experiments and the Mann-Whitney U test across experiments) to check on specific comparisons between tasks within and between experiments.

Specific analyses will not ordinarily be described in the main body of this article because to do so would unduly complicate the exposition, although statements about effects will only be made with a p of .01. Furthermore, often the arguments to be made will depend primarily on patterns of outcomes involving the 13 different tasks, and the consistency of these patterns is usually far more powerful than any ordinary statistical test can describe.

**Homogeneous Dimensions:**

Experiments 1 and 2

**Stimuli**

The stimuli used in Experiments 1 and 2 are shown in Figure 2. The stimuli for Experiment 1 consist of the two parentheses, in all four combina-

Figure 2 used in Table
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Table 1  
Sorting Times for the Stimuli of Figure 2:  
Homogeneous Dimensions

<table>
<thead>
<tr>
<th>Task</th>
<th>Experiment 1</th>
<th>Experiment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discrimination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A/B</td>
<td>19.6</td>
<td>20.8</td>
</tr>
<tr>
<td>C/D</td>
<td>19.1</td>
<td>19.1</td>
</tr>
<tr>
<td>A/C</td>
<td>19.2</td>
<td>19.2</td>
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<tr>
<td>B/D</td>
<td>19.9</td>
<td>19.7</td>
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<tr>
<td>B/C</td>
<td>18.7</td>
<td>18.6</td>
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<tr>
<td>A/D</td>
<td>20.5</td>
<td>20.4</td>
</tr>
<tr>
<td>M</td>
<td>19.50</td>
<td>19.63</td>
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<tr>
<td>Focusing</td>
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<tr>
<td>A/BCD</td>
<td>21.0</td>
<td>20.9</td>
</tr>
<tr>
<td>B/ACD</td>
<td>20.9</td>
<td>20.1</td>
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<tr>
<td>C/ABD</td>
<td>18.5</td>
<td>18.6</td>
</tr>
<tr>
<td>D/ABC</td>
<td>20.6</td>
<td>21.1</td>
</tr>
<tr>
<td>M</td>
<td>20.25</td>
<td>20.18</td>
</tr>
<tr>
<td>Classification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AB/CD</td>
<td>24.4</td>
<td>23.6</td>
</tr>
<tr>
<td>AC/BD</td>
<td>23.3</td>
<td>22.9</td>
</tr>
<tr>
<td>AD/BC</td>
<td>21.8</td>
<td>21.5</td>
</tr>
<tr>
<td>M</td>
<td>23.17</td>
<td>22.67</td>
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</tbody>
</table>

Note. Entries are mean times (in sec) required to sort a deck of 36 cards into two piles.

provide faster discrimination than single dimensions only if stimulus C is in the pair of stimuli, and redundancy per se is not important.

Focusing. In both experiments one of the four focusing tasks is faster than the other three, which are not different from each other. This task is the C/ABD focus, involving the same stimulus which provides the best pair discriminations. Furthermore, in each experiment the C stimulus can be used as a focus as well as it can be used in any of the three different pair discrimination tasks in which it is involved. The other three focus tasks are in general higher than their counterparts in the discrimination tasks, but not by a large amount. Thus focusing is fairly good for all stimuli in these experiments, but is especially good with stimulus C.

Classification. Two of the classification tasks (AB/CD and AC/BD) are filtering tasks, and these are performed very poorly, being substantially slower than any of the discrimination tasks. Thus there is no evidence that selective attention to the dimen-

Results

The results for these two experiments are shown in Table 1, grouped according to the three major types of task. The average times for the different tasks in each experiment are very similar. The product-moment correlation between the two experiments across the 13 tasks is .96. Thus the use of the curved attributes rather than straight attributes is not of importance in determining how these stimuli are processed, and results for both experiments are considered together.

Discrimination. There are differences in the six discrimination tasks. The fastest task in each experiment is the B/C task involving discrimination of one of the two redundant pairs of stimuli. However, an even more important result is that the three fastest times in each experiment occur with tasks in which stimulus C is one member of the pair to be discriminated. Thus correlated dimensions...
sions is possible. On the other hand, the condensation task (AD/BC) is performed faster than either filtering task, although not as fast as the discrimination tasks.

**Discussion**

First, for the purposes of determining the stability of these kinds of results, comparison with previous research can be made. In Experiment 1, eight tasks (six discrimination and two filtering) correspond to tasks used in the previous research of Pomerantz and Garner (1973). The rank correlation between the times for these eight tasks in the two experiments is 1.0. Further, Pomerantz and Swartzberg (1975), also using the parenthesis stimuli, had found the condensation task to give times intermediate between the discrimination tasks and the filtering tasks, as was found in Experiment 1 here also. Thus the addition of the hyphen to the stimuli in the present experiment did not produce stimuli with different basic properties.

Second, the overall picture presented by this pattern of results is that the dimensions used in generating the stimuli were quite irrelevant in the processing of the stimuli in any of the three tasks. Clearly these stimuli are configured, each stimulus having properties appropriate to its configuration. With such stimuli, processing is carried out with the individual stimulus. This effect is shown most clearly by the relative ease with which the focusing tasks can be carried out and the relative difficulty with which the filtering tasks are carried out.

The fact that the condensation task is carried out more easily than the filtering tasks suggests that some reorganization of the set of stimuli occurs, with the two stimuli that are mirror images of each other (A and D) forming a similar subset of stimuli.

Except for this one task, however, it appears that the properties of the individual stimuli determine both discrimination and focusing performances, not properties of the pair or set of stimuli. Thus the one stimulus that provides the easiest focus is also the stimulus that provides the easiest discrimination when paired with each of the other three stimuli. Certainly these results suggest a processing mode of focusing even when the task involves only discrimination between two stimuli. Thus the speed of such discrimination is less dependent on properties of the pair of stimuli than on properties of one of the stimuli within the pair. The property most pertinent to providing good focusing is the gestalt concept of goodness, as shown by Pomerantz (1977) and as indicated in the previous experiment by Pomerantz and Garner (1973).

**Heterogeneous Dimensions: Experiments 3 and 4**

**Stimuli**

The stimuli for Experiments 3 and 4 are shown in Figure 3. These stimuli are generated by recombining the dimensions used in Experiments 1 and 2 so that the stimuli contain heterogeneous elements. The two experiments involved two ways of mixing the dimensions from Experiments 1 and 2.

For Experiment 3, the parenthesis is used for the left attribute, with left and right curvatures for its levels, and the bracket is used for the right attribute, again with right and left openings for its levels. This way of combining dimensions produces four stimuli which are identical to the stimuli used in the first two experiments in terms of levels and orientations, but with the elements always consisting of both curved and straight lines. Thus stimuli A and D still have both elements oriented in the same direction, while stimulus C has its elements oriented inward and stimulus B has its elements oriented outward.

For Experiment 4, the brackets and parentheses are combined so that brackets and parentheses are levels on the left and right dimensions, but with all orientations being the same. Thus the dimensions themselves are heterogeneous, but two of the stimuli actually have homogeneous elements corresponding to a stimulus from Experiment 1 or 2. Specifically, stimulus A in Experiment 4 is the same as stimulus A in Experiment 1, and stimulus D in Experiment 4 is the same as stimulus A in Experiment 2.

**Results**

These two experiments produced quite different results, as shown in Table 2. Sorting times for Experiment 4 are significantly faster than those for Experiment 3 on the average ($p = .05$), and the product-moment correlation between these two experiments across the 13 tasks is only .64. But these overall results are best understood by ex-
suggest a difference when the discrimination of the properties of one stimulus is used for the task of another stimulus as shown in the present experiments.

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Experiment 3</th>
<th>Experiment 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>C</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>D</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Figure 3. Heterogeneous dimensions: The stimuli used in Experiments 3 and 4. (Data are presented in Table 2.)*

Examining differences between the two experiments for each type of task.

**Discrimination.** There are no statistically significant differences between any of the six discrimination tasks in either experiment, although the fact that the A/D task in Experiment 4 was the fastest is of some interest.

**Focusing.** For Experiment 3 there is relatively poor focusing overall, with all tasks giving poorer performance (by about 2 sec) than any of the discrimination tasks. In Experiment 4, however, focusing with stimuli A and D is faster than it is with stimuli B and C. These are the two stimuli that are homogeneous within themselves and that when used in Experiments 1 and 2, provided good, although not the best, focusing performance. Focusing performance with stimuli A and D is nearly as good as is performance on the equivalent discrimination tasks, but is poorer by approximately 3 sec for stimuli B and C.

**Classification.** In both experiments, filtering performance (AB/CD and AC/BD) is moderately good, with average times less than 1 sec slower than the average times for the discrimination tasks. Performance on the condensation task (AD/BC), however, was poorer than that on the filtering task in both experiments, although it was better in Experiment 4 than in Experiment 3.

This good performance on the condensation task relative to the filtering tasks in Experiment 4 is related to the statistically significant interaction between blocks and tasks mentioned above under Data Analysis. During the second block (i.e., the first block of trials analyzed), condensation performance was quite poor, being 23.8 sec compared to an average for the two filtering tasks of 20.5 sec. Thus in this block the results for Experiment 4 are very similar to those for Experiment 3. By the third block of trials, however, most subjects appeared to shift to a different strategy in the condensation task, in which the stimulus elements are simply classed as same or as different. To be specific, stimuli A and D, forming one class in condensation, have same elements, while stimuli B and C, forming the other class, have different elements. This strategy gave classification times not appreciably faster than those obtained with the filtering tasks: thus the interaction between blocks and tasks. The availability of this strategy is unique to Experiment 4 and does not cause problems with any other analyses.

**Discussion**

Overall, these two patterns of results are quite different from that obtained with

**Table 2**

<table>
<thead>
<tr>
<th>Task</th>
<th>Experiment 3</th>
<th>Experiment 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discrimination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A/B</td>
<td>20.5</td>
<td>18.9</td>
</tr>
<tr>
<td>C/D</td>
<td>20.7</td>
<td>19.1</td>
</tr>
<tr>
<td>A/C</td>
<td>20.6</td>
<td>19.2</td>
</tr>
<tr>
<td>B/D</td>
<td>21.2</td>
<td>19.5</td>
</tr>
<tr>
<td>B/C</td>
<td>20.3</td>
<td>19.4</td>
</tr>
<tr>
<td>A/D</td>
<td>20.3</td>
<td>18.8</td>
</tr>
<tr>
<td>M</td>
<td>20.60</td>
<td>19.15</td>
</tr>
<tr>
<td>Focusing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A/BCD</td>
<td>22.6</td>
<td>19.4</td>
</tr>
<tr>
<td>B/ACD</td>
<td>22.8</td>
<td>22.6</td>
</tr>
<tr>
<td>C/ABD</td>
<td>21.6</td>
<td>22.6</td>
</tr>
<tr>
<td>D/ABC</td>
<td>22.6</td>
<td>20.1</td>
</tr>
<tr>
<td>M</td>
<td>22.40</td>
<td>21.18</td>
</tr>
<tr>
<td>Classification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AB/CD</td>
<td>21.7</td>
<td>20.0</td>
</tr>
<tr>
<td>AC/BD</td>
<td>21.4</td>
<td>19.8</td>
</tr>
<tr>
<td>AD/BC</td>
<td>26.6</td>
<td>22.0</td>
</tr>
<tr>
<td>M</td>
<td>23.23</td>
<td>20.60</td>
</tr>
</tbody>
</table>

*Note. Entries are mean times (in sec) required to sort a deck of 36 cards into two piles.*
homogeneous dimensions, indicating a different type of dimensional interaction and consequently different modes of processing.

First, consider the pattern of results from Experiment 3. From previous research we know what results to expect for the type of dimensional interaction called separable (see Garner, 1976): There is no facilitation of discrimination time with redundant stimulus dimensions, filtering is good, and condensation performance is considerably poorer than filtering performance (Gottwald & Garner, 1975). Except for the fact that filtering performance was not ideal, this is exactly the pattern of performance across tasks obtained in Experiment 3. Still further, Gottwald and Garner (1972) had found that the focusing task (which Gottwald and Garner called asymmetric condensation) was performed only as well as the poorer of the two single dimensions, thus not as well as the average of the two dimensions used separately. The present results show fairly poor focusing when contrasted to the discrimination tasks, and even to the filtering tasks. It does seem reasonable that if dimensions cannot become integral or configural, but are always processed as independent dimensions, it should be difficult to carry out the focusing task, since the fact of separability means that each dimension must be processed separately, and the task cannot be changed to one involving unitary, well-configured single stimuli. In summary, the overall pattern of results obtained with the heterogeneous dimensions of Experiment 3 is best interpreted as indicating complete separability of the two dimensions.

Second, the results of Experiment 4 can be seen as indicating separable dimensions but with modification produced by the availability of two stimuli which are configured. Thus while these two stimuli (A and D) do not provide a sufficiently strong focus to show better focusing performance in the various discrimination pairs, they do show better focusing performance than do the other two stimuli. It is of interest, as noted above, that when these two stimuli are paired with each other in the discrimination task, they do give the fastest performance, although not sufficiently to establish statistical significance. Still further, until the subjects apparently discovered a way of changing the condensation task to one of same-different, their performance on the condensation task relative to that on the filtering tasks was that expected with separable dimensions. Thus Experiment 4 gives a picture of separable dimensions except that focusing performance is better with two of the stimuli.

An overall comparison of the first three experiments does indicate that simply changing stimulus elements from homogeneous to heterogenous produces a considerable difference in the pattern of results obtained with the different information-processing tasks, and that this change is easily described as a change in dimensional interaction from configural to separable. In addition, however, the results of Experiment 4 show that sets of stimuli can be generated in which some of the stimuli have configural dimensions while other stimuli in the same set have separable dimensions. So the attribute interactions need not be consistent across a total set of stimuli.

Homogeneous Features: Experiments 5 and 6

In the next seven experiments, all stimuli are generated from features which exist or do not exist in any particular stimulus, rather than from dimensions with positive levels, as were used with the first four experiments. Insofar as possible, however, the experiments done with features parallel those done with dimensions, with the addition of some special conditions which check on some problems that occur when stimuli are generated from features.

Stimuli

The stimuli for Experiments 5 and 6 are shown in Figure 4. These two sets of stimuli parallel those for Experiments 1 and 2. Experiment 5 having parentheses and Experiment 6 having brackets. However, the two levels in each experiment are the presence or absence of the feature. With both features, the orientation is inward so that the complete stimulus (with both features present) has the best configuration possible as indicated by the results of Experiments 1 and 2.

One of the major reasons for using features rather than dimensions as the attributes to generate stimuli is to investigate the special role of the null...
SELECTIVE ATTENTION TO ATTRIBUTES AND TO STIMULI

The subjects ranging the different, sation task was that ons. Thus separable performance first three imply changing homo-geneous to able differ- ting with sing tasks, cribed as a from con- however, that sets of some of the ions while separable interactions set of stimuli the stimulus for which both features are absent. This stimulus appears as the isolated hyphen. When stimuli were generated from dimensions, the configural properties of the stimuli determined their ease of processing. The null stimulus could well play a role comparable to the well-configured stimulus, being sort of an anchor or reference stimulus.

Results

The results obtained with these two experiments are shown in Table 3. As in Experiments 1 and 2, with homogeneous dimensions, the overall pattern of results is very similar for the two sets of stimuli, the product-moment correlation between experiments across the 13 tasks being .96. However, there was a small but statistically significant interaction between tasks and experiments, whose nature will be discussed below. Thus with a small exception, the two experiments can be considered together.

Discrimination. There are differences in speed of performance between the six discrimination tasks. The three tasks involving the null stimulus A provide the three fastest discriminations, but the tasks involving the stimulus D, the complete stimulus, are also fairly good. In both experiments, the discrimination task involving neither the A nor D stimulus is the poorest. As with homogeneous dimensions, there is no evidence that attribute redundancy per se aids discrimination, since the fastest and the slowest tasks are the two with redundant features.

Focusing. In both experiments, two of the focusing tasks are faster than the other two, the tasks in which the A or the D stimulus is the focused stimulus. However, focusing performance is very good for all stimuli, since in both experiments focusing performance with stimuli B and C is as good as is performance on the B/C discrimination task.

Classification. As with homogeneous dimensions, filtering is fairly poor with the homogeneous features, and is clearly inferior to performance on the AD/BC condensation task. Filtering performance is somewhat better for the parentheses of Experiment 5 than for the brackets of Experiment 6, and this discrepancy is what produced the small interaction between tasks and experiments noted above. There is no apparent reason for this result. Performance on the condensation task is very good for both experiments, being as fast as performance on the B/C discrimination task. On the other hand, the important factor may simply be that discrimination between the two stimuli containing a single feature is poor rather than that performance on the condensation task is necessarily so good.

Table 3

<table>
<thead>
<tr>
<th>Sorting Times for the Stimuli of Figure 4: Homogeneous Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Discrimination</td>
</tr>
<tr>
<td>A/B</td>
</tr>
<tr>
<td>C/D</td>
</tr>
<tr>
<td>A/C</td>
</tr>
<tr>
<td>B/D</td>
</tr>
<tr>
<td>B/C</td>
</tr>
<tr>
<td>A/D</td>
</tr>
<tr>
<td>M</td>
</tr>
<tr>
<td>Focusing</td>
</tr>
<tr>
<td>A/BCD</td>
</tr>
<tr>
<td>B/ACD</td>
</tr>
<tr>
<td>C/ABD</td>
</tr>
<tr>
<td>D/ABC</td>
</tr>
<tr>
<td>M</td>
</tr>
<tr>
<td>Classification</td>
</tr>
<tr>
<td>AB/CD</td>
</tr>
<tr>
<td>AC/BD</td>
</tr>
<tr>
<td>AD/BC</td>
</tr>
<tr>
<td>M</td>
</tr>
</tbody>
</table>

Note. Entries are mean times (in sec) required to sort a deck of 36 cards into two piles.
Discussion

These results are very much like those obtained with homogeneous dimensions, indicating that the features interact configururally, with processing being done primarily with the individual stimuli rather than with the features which generate them. In terms of the overall pattern of results, these homogeneous features give the same results as homogeneous dimensions: Filtering performance is poor, condensation performance is good, focusing performance is good overall but with some stimuli providing better foci than others, and discrimination performance is related to the ease of focusing performance rather than to properties of particular pairs of stimuli.

The one important difference for these particular features and dimensions, however, is that there are two good stimuli for focusing with feature-generated stimuli, although there appeared to be just one with dimensions. These two good focusing stimuli were the null stimulus and the complete stimulus, although the null stimulus provided the better focus of the two. It thus appears that with feature-generated stimuli, the reference or anchor stimulus is the null stimulus, while the secondary reference stimulus is the complete stimulus, at least when the stimuli are generated with homogeneous features.

Homogeneous Features: Supplemental Experiments 7, 8, and 9

Experiments of this sort have rarely been done with stimuli generated from features rather than dimensions, and there were several questions about their use that seemed to require some clarification. So Experiments 7, 8, and 9 were run to obtain answers to at least two such questions: (a) Does the null stimulus have to have some positive, albeit constant, property to allow it to be processed effectively, particularly when it is the focus task? In other words, is it difficult to focus on nothing? (b) Does the role of the complete stimulus as the second best focus depend on its own configural properties, or is it simply a function of the fact that it is the one complete stimulus? Thus these supplemental experiments were designed to clarify the role of the two special stimuli in a feature-generated set: the null stimulus and the complete stimulus.

Stimuli

Experiment 7 was designed to examine the role of the null stimulus, and it used stimuli identical to those of Experiment 5 (with parentheses oriented inward), but with no hyphen as the constant element or handle onto which the features are attached. These stimuli are shown in Figure 5.

Experiments 8 and 9, with stimuli also shown in Figure 5, were designed to examine the role of the complete stimulus. Features can be used with a variety of subarrangements. Those used in Experiment 5 were arranged so that the complete stimulus was also the best configuration, as determined from the results of Experiment 1. The features of Experiment 8 are the same as those of Experiment 5 except that both features are now oriented outward rather than inward. The effect of this change is to make the complete stimulus one of the less well-focused stimuli in Experiment 1. Likewise, in Experiment 9, both parentheses had a leftward orientation, and the complete stimulus was once again one of the stimuli from Experiment 1, but one of the more poorly focused stimuli.

There were only four different stimuli in Experiment 1, and two of them were mirror images of each other. Experiments 5, 8, and 9 together are arranged so that each of the types of stimuli in Experiment 1 is in turn the complete stimulus.

Results

The null stimulus. The results of Experiment 7, shown in Table 4, are as follows: Focusing is easiest with either the null (A) stimulus or the complete (D) stimulus, although quite good with the other two stimuli as well. The best discrimination pairs are those involving stimulus A, and the best discrimination of all is provided by the A/D pair, with poorest discrimination from the B/C pair. Filtering performance is poor, and condensation performance (AD/BC) is quite good, better than the B/C discrimination performance. Qualitatively, this pattern of results is identical to that obtained in Experiment 5. In fact, the product-moment correlation between the two experiments across tasks is .94. However, while there is no significant difference between the two experiments in overall performance, there is a marginally significant interaction between...
tasks and experiments ($p < .05$). This interaction is due to the fact that filtering performance is poorer in Experiment 7 than it was in Experiment 5. Since, however, filtering performance in Experiment 5 had also been better than it was when the brackets were used in Experiment 6, it would appear that the anomalous result is the better filtering in Experiment 5. Except for that one result, the results of Experiments 5, 6, and 7 are indistinguishable.

The complete stimulus. The results for Experiments 8 and 9 show the same pattern: Focusing performance is best with the A and the D stimuli; discrimination performance is best with the three pairs containing the A stimulus and is poorest with the one pair (B/C) containing neither the A nor the D stimulus; of the classification tasks, filtering performance is relatively poor, but condensation performance is quite good, with faster times than the slowest times found with discrimination tasks. This pattern of results, of course, is once again identical to that found in Experiment 5 (and 6 as well). An analysis of variance with Experiments 5, 8, and 9 showed no overall significant difference in performance, but a significant interaction of small effect between experiments and tasks. This interaction is due to slightly greater differences in the discrimination and focusing tasks in Experiment 9 than in the other two experiments. Nevertheless, the three product-moment correlations between the three pairs of Experiments 5, 8, and 9 are, respectively, .93, .93, and .95. Kendall's coefficient of concordance ($W$) for the three experiments together is .93.

Discussion

The results of these three supplemental experiments are very much like each other and like the results of Experiment 5, which is the control experiment for each of the present experiments. These results answer nearly unequivocally the two questions raised:

First, the null stimulus does not have to have a constant feature in order to be used effectively as a focus or reference stimulus. At least within the bounds of the kind of stimulus presentation used in these experiments, a literally null stimulus is as good as one which simply contains some minimum amount of positive stimulus which is constant for all stimuli in the set.

Second, the specific configural properties of the complete stimulus seem to be unimportant in determining the effectiveness of the complete stimulus as a focus. There were no

\begin{table}
\centering
\begin{tabular}{|l|c|c|c|}
\hline
 & & & \\
Stimulus & 7 & 8 & 9 \\
\hline
A & & & \\
B & ( ) & ( ) & ( ) \\
C & & ( ) & ( ) \\
D & ( ) & ( ) & ( ) \\
\hline
\end{tabular}
\caption{Homogeneous features: The stimuli used in supplemental Experiments 7, 8, and 9. (Data are presented in Table 4.)}
\end{table}

\begin{table}
\centering
\begin{tabular}{|l|c|c|c|}
\hline
 & & & \\
Task & 7 & 8 & 9 \\
\hline
Discrimination & & & \\
A/B & 18.9 & 16.7 & 16.9 \\
C/D & 19.0 & 17.0 & 17.5 \\
A/C & 19.0 & 16.9 & 17.1 \\
B/D & 19.2 & 16.9 & 17.4 \\
B/C & 21.9 & 18.2 & 19.9 \\
A/D & 18.8 & 16.9 & 16.7 \\
$M$ & 19.47 & 17.10 & 17.58 \\
\hline
Focusing & & & \\
A/BCD & 19.1 & 16.5 & 17.1 \\
B/ACD & 20.7 & 18.4 & 20.2 \\
C/ABD & 21.1 & 17.8 & 19.3 \\
D/ABC & 19.6 & 16.9 & 17.8 \\
$M$ & 20.13 & 17.40 & 18.60 \\
\hline
Classification & & & \\
AB/CD & 23.4 & 19.0 & 21.6 \\
AC/BD & 24.0 & 19.7 & 20.4 \\
AD/BC & 20.3 & 17.8 & 19.6 \\
$M$ & 22.57 & 18.83 & 20.53 \\
\hline
\end{tabular}
\caption{Sorting Times for the Stimuli of Figure 5: Homogeneous Features (Supplemental)}
\end{table}

Note. Entries are mean times (in sec) required to sort a deck of 36 cards into two piles.
differences in performance as a function of what the specific nature of the complete stimulus was, even though these specific stimuli within the same stimulus set showed considerable differences in ability to provide a good focus and to facilitate discrimination performance.

At first glance, this result would imply that the role of the complete stimulus as an effective focus is due to its completeness rather than to its configural properties. Certainly within the ranges of configural goodness which these stimuli provide, that is the appropriate conclusion. But it may well be that the differences in configural goodness are simply too small to show any real effects within these experimental designs, and particularly so when the null stimulus is an even stronger focal stimulus. The next pair of experiments will help clarify this issue.

Heterogeneous Features: Experiments 10 and 11

Experiments 10 and 11 (stimuli shown in Figure 6) are comparable to Experiments 3 and 4, except for the change from dimensions to features. In Experiment 10 the features are presence or absence of a parenthesis or bracket, one on each side of the center hyphen, and both oriented inward so that the complete stimulus is comparable to stimulus C in Experiment 3. In Experiment 11, the feature is presence or absence of the parenthesis or the bracket, but with both oriented to the right and with both located on the left side when occurring as single features. The complete stimulus is thus the same as stimulus C in Experiment 4. The reason for putting the single feature to the left of the

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Experiment 10</th>
<th>Experiment 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B</td>
<td>[ ( ) ]</td>
<td>[ ( ) ]</td>
</tr>
<tr>
<td>C</td>
<td>[ ( ) ]</td>
<td>[ ( ) ]</td>
</tr>
<tr>
<td>D</td>
<td>[ ( ) ]</td>
<td>[ ( ) ]</td>
</tr>
</tbody>
</table>

Figure 6. Heterogeneous features: The stimuli used in Experiments 10 and 11. (Data are presented in Table 5.)

hyphen was to explore the possibility that locational factors were important in the processing of these stimuli.

Results

The results for Experiment 10 and for Experiment 11, shown in Table 5, are essentially the same. The product-moment correlation between the two experiments across tasks is .94, and there is no significant interaction between experiments and tasks. Thus these two experiments can be considered together.

Discrimination. There are differences in speed of performance between the six discrimination tasks. The three tasks involving stimulus A are the three fastest, but there are no meaningful differences between the other three stimulus pairs. Once again, there is no faster performance with the two redundant pairs (B/C and A/D), so that feature redundancy is not a factor in the results.

Focusing. Focusing performance is on the whole fairly good, although there is clearly better performance with the null stimulus (stimuli). Performance essentially formance.

Classification difference two filter worse than classification slower than

Discussion

The pattern of heterogeneity of the pattern and the response can only be achieved by two separate, one of features: the other the use of

If we consider the focusing features those objections: For quite good provides much three. Further, which include the three features.

The only one that with vored sti gestalt features the stimulus, which best refers to stimuli.

It should conclusion dr homogeneity important role it was: good condition wrong. The features of role as complete stimuli.
stimulus (A) than with the other three stimuli. Performance with this one stimulus is essentially as good as is discrimination performance when the A stimulus is involved.

Classification. There are no significant differences in classification performance, the two filtering tasks being no better and no worse than the condensation task. Overall, classification performance runs about 2 sec slower than does discrimination performance.

Discussion

The pattern of results obtained with these heterogeneous features is different from any other pattern obtained in these experiments, and the nature of the attribute interaction can only be understood by considering that two separate types of interaction are occurring, one due to the special characteristics of features as contrasted to dimensions and the other due to the special consequences of the use of heterogeneous features.

If we consider only the discrimination and the matching tasks, the results with heterogeneous features are in fact very similar to those obtained with homogeneous dimensions: Focusing performance on the whole is quite good, but one particular stimulus provides much better focusing than do the other three. Furthermore, the discrimination pairs which include this favored stimulus provide the three fastest discrimination performances. The only difference between the two cases is that with homogeneous dimensions the favored stimulus is the best configured in a gestalt sense, while with heterogeneous features the favored stimulus is the null stimulus, which is best by virtue of its being the best reference or anchor for the other three stimuli.

It should be noted that the tentative conclusion drawn with stimuli generated from homogeneous features, namely, that the important role of the complete stimulus was that it was complete rather than that it had good configuration, is now shown to be wrong. These results with heterogeneous features completely clarify that it is not the role as complete stimulus, but that the complete stimulus must have good configuration. Therefore the failure to find differences due to goodness of the complete stimulus in the previous experiments was due to the fact that the range of goodness in configuration was simply too small. In effect, and in contrast to the results with heterogeneous features, all of the complete stimuli obtained with homogeneous features had good configuration.

It is the classification tasks which give a pattern of data with heterogeneous features so different from all other sets of stimuli. In all other sets the condensation task gave clearly inferior performance to filtering performance (as with heterogeneous dimensions) or clearly superior performance to filtering performance (as with homogeneous dimensions and homogeneous features). In fact, this difference was an important factor in differentiating the nature of the attribute interaction. With the heterogeneous features, however, there is no difference in performance between condensation and filtering, and once again the explanation seems to require consideration both of the nature of features and the role of heterogeneity. The use of features is probably what allows reasonably good performance in condensation because even though the features are heterogeneous, the B and C stimuli are certainly much more alike than are any other pair of stimuli, and so form a fairly effective subclass for classification purposes. On the other hand, the use of heterogeneous features allows moderately good selective attention to the attributes (almost, but not quite, as good as that obtained with heterogeneous dimensions).

Overall, then, the picture obtained with heterogeneous features is very mixed. Such stimuli seem to allow most of the information-processing tasks to be carried out reasonably well, but the only stimulus with clearly superior properties for such tasks is the null stimulus itself. Otherwise the stimuli do not provide good focusing, but do make reasonably good selective attention to features possible. These are truly hybrid sets of stimuli, with equivalent mixed performances in the information-processing tasks.
General Discussion

Attribute Interaction

The general thrust of this line of research has been the determination of various types of attribute interaction, and in previous summaries of this research (see especially Garner, 1976), I have outlined the several types of interaction for which experimental evidence exists, as well as some for which there is no evidence but which are nevertheless logical possibilities.

Dimensional interaction. Previous summaries have been concerned with dimensional, rather than feature, interaction because dimensions were the only type of attribute used. The dimensional interaction shown for the types of stimuli used in the present research was termed **configural** (called new nominal in some earlier writings, e.g., Garner, 1974b). The basic defining properties for configural interaction were the ineffectiveness of the two redundant pairs of stimuli in providing better discrimination performance and yet the failure of selective attention to the dimensions. However, not all stimuli consisting of visual elements are configural, since under some circumstances (see Pomerantz & Garner, 1973), the dimensions are separable, showing no gain in discrimination with redundant dimensions but showing effective selective attention to dimensions.

The present experiments require no new types of dimensional interaction, since the results show clearly the pattern for configural dimensions when the dimensions are homogeneous and show the pattern for separable dimensions when the dimensions are heterogeneous. The addition of the focusing and the condensation tasks has, however, clarified the properties of these two types of dimensional interaction, since both condensation and focusing are better with configural dimensions than they are with separable dimensions. In fact, the contrast between condensation and filtering performance with classification tasks completely differentiates the configural from the separable interaction, the condensation task being easier than the filtering task for configural interaction and being more difficult than filtering for the separable interaction. Still further, the focusing tasks did show the importance of the role of the individual stimulus with configural dimensions, since the ability to use focusing so clearly depends on configural properties such as goodness.

Feature interaction. The problem of attribute interaction becomes more complicated when stimuli are generated from features rather than from dimensions. Homogeneous features do provide much the same pattern of results as that obtained with homogeneous dimensions, except that the null stimulus provides a strong reference or anchor stimulus. So homogeneous features interact very much as homogeneous dimensions do.

Heterogeneous features, however, provide quite a different picture, one which is very complex. The pattern of results across the different tasks in this case could suggest that a new type of attribute interaction is established. I have, in the appropriate discussion, suggested that performance with these stimuli is due to the combined properties of features and of heterogeneity, and that some tasks are responsive to one of these properties and other tasks are responsive to the other property. It would not be far wrong, however, to describe the obtained pattern of results as indicating a truly nominal interaction, in which all stimuli simply have equivalent status for all tasks, except that whenever the null stimulus is used in discrimination or focusing tasks, it provides better performance.

One surprising result with both homogeneous and heterogeneous features is that the complete stimulus has no clear special role in information processing. The logical structure of a set of stimuli generated from features is that there should be two special anchors or reference stimuli: the one with all features present and the one with no features present. But the data of the last several experiments clearly indicate that the complete stimulus has a special role only if it has a better configuration than the stimuli with just one feature present.

The Focused Stimulus

Probably the most important result to come from this series of experiments is that
the individual stimulus is a very important factor in information processing. In discrimination tasks, and certainly in focusing tasks, it is not only the relations between stimuli which are important, but it is also the properties of the individual stimulus which are important in determining performance. The strength of this conclusion can be seen from the following statistics: Of the 11 experiments, in 9 of them the six discrimination tasks were ordered in speed of discrimination such that the three best pairs of stimuli all contained one stimulus in common. The probability of such an ordering for a single experiment is .20. Furthermore, in every one of the 9 experiments, the single stimulus item that was common was also the single stimulus that gave the best focusing performance. The probability per experiment of this event is reduced to .05, and the composite probability for all 9 experiments is, of course, very, very small. In fact, it is the consistency of patterns of results such as these which makes one feel that there is far more stability in the experimental outcomes than seems indicated by analyses of variance and related techniques.

What is a good focus? The particular stimulus which was favored was stimulus C for Experiments 1 and 2 (the “closed” stimulus). The other seven experiments showing a favored stimulus were those in which features generated the stimuli, and the favored stimulus in each case was the null stimulus. There is no doubt that the null stimulus is a strong reference stimulus.

The two experiments which did not show a favored stimulus were 3 and 4, the experiments using heterogeneous dimensions. There was no pattern of consistency in either of these experiments with regard to the discrimination tasks or the focusing tasks. Thus it is quite clear that a good stimulus for focusing purposes in information processing must either be a stimulus which is configurally good or one which is the reference. It is of interest that the properties which make a good configuration have relatively little to do with the role of the stimulus in a set of stimuli; these are the properties of the stimulus itself, existing without regard to properties of the set of stimuli. On the other hand, the null stimulus can be defined only with respect to properties of the set of stimuli, since the null stimulus may in fact have properties which are invariant across the set of stimuli (as in the present experiments), so that its role as the null stimulus depends on knowledge of what the other stimuli are.

The advantage of a focus. In this discussion I am clearly assuming that information-processing tasks are carried out better by the subject’s use of a focusing strategy and that therefore the stimuli that serve as a focus have some special advantage. Certainly the data show that the stimulus which can be used effectively in the focusing task is the one which also produces the best set of pairwise discriminations with the other three stimuli. I have argued that the advantage comes because of how the subject processes the individual stimulus and that it does not come from altered relations between stimuli. But there is an interesting possible anomaly in this regard.

Rosch (1975) has shown that if reference stimuli are the fixed stimuli in a similarity judgment task, the judged similarity to another stimulus is greater than if the non-reference stimulus is used as the fixed stimulus. In interpreted form, a nonreference stimulus such as a desaturated color is assimilated (in similarity judgment) to a reference stimulus such as a highly saturated color. In the present experiments, the reference stimulus is assumed to be the stable one which can be held in memory or otherwise has a processing advantage. But by interpretation, such a mechanism ought to assimilate other stimuli to it, thus increasing the perceived similarity. This increased similarity should produce a greater reaction time, not a shorter one.

The possibility that the use of a focused stimulus simultaneously gives an advantage to the processing of the individual stimulus while also increasing the similarity of other stimuli to it must be entertained, even though at first glance the consequences of the use of a focus and the increased similarity seem opposed. If a focusing strategy is successfully
used, then in the kinds of information-processing tasks used in the present experiments, the similarity of the alternative stimuli to the focused stimulus is not very important because the subject presumably uses a go–no–go strategy. However, it should be clear that the various information processing and perceptual consequences of the existence of focal or reference stimuli may be fairly complicated.

This discrepancy between results obtained with similarity judgment and the speeded classification task argues against the possibility that the present results are themselves due solely to perceived similarity relations. There is an additional, even stronger, argument that the results are not due to similarity relations: The focusing task can be carried out as fast as the simple discrimination task if the best focus stimulus is used in focusing. The similarity argument would seem to require that the addition of other stimuli to one of the two classes should slow classification, unless the stimuli can be ordered along a single perceptual dimension. In that case, the stimulus which is at the end of the continuum and also farthest from the next stimulus might allow fast classification. It is highly unlikely, however, that any of the stimuli used in the present experiments can be ordered on a single continuum, so it seems unreasonable to assume that similarity relations cause the results obtained.

**Encoding or memory?** When Clement and Varnadoe (1967) pointed out that properties of individual stimuli (pattern goodness, in their case) influence stimulus discrimination, they attributed the effect to difference in encoding time of the individual stimuli. Garner and Sutliff (1974), in their experiment directly comparing reaction times to good and poor dot patterns in a discrete reaction time experiment, also used the term **encoding**, while pointing out that such a term has very poor definition. Pomerantz (1977) argued that there are at least three possible explanations for the effect of individual items: the ability to hold items in memory, the ability to encode the items, and the ability to compare the items. His own research, which demonstrated that focusing strategies can be used with visual patterns (in experimental tasks comparable to the focusing tasks used in the present experiments), seemed to favor the role of memory in the effect. Certainly the present experiments do not argue for an encoding effect in the sense of simple registration time, since it seems unreasonable that both the null stimulus and a configurably good stimulus would produce equally fast registration times. On the other hand, it seems very reasonable that both such stimuli would be easy to hold in memory.

Probably the focusing effect is due to the ability of the subject to maintain the focused item in memory and thus also to maintain an expectancy for that item. The present data, however, do not unequivocally eliminate the possibility that the effect is due to some aspect of encoding, particularly if the term is defined broadly. The present data do seem to reject the possibility that the effect lies in a comparison process, however, since there is no special advantage in the discrimination task in discriminating the null stimulus from the complete stimulus (when the stimuli are feature generated), unless the complete stimulus itself had good configuration.

Thus at present the most likely explanation of the ability of subjects to use a focusing strategy is that the focused stimulus is easy to hold in memory, that it can be used to provide an accurate anticipation of one stimulus, and that a yes–no decision can then be made without actual processing of the alternative stimuli, those in effect in the negative set. And the pattern of results with the discrimination tasks indicates that subjects do use a focusing strategy even in the simple two-stimuli discrimination tasks, at least as long as there is a stimulus which is easy to hold in memory.

**What is attended?** While these experiments have emphasized attention to the single stimulus, and although I have argued that the stimulus properties which make attention possible are those of the single stimulus rather than of the set, this emphasis should not lead to the conclusion that
properties of sets of stimuli have nothing to do with the attention process. Certainly with separable dimensions, the attribute itself is attended, and an attribute can only be defined with respect to a set of stimuli. So properties of the set still are important.

And even with attention to the single stimulus, the evidence contained in these experiments is not that there is no effect of the context of the stimulus set used; rather, the evidence is that there are properties of the individual stimulus which determine the effectiveness of attention to the stimulus over and above the properties as defined by the attributes of the set of stimuli. These properties, of course, are what I mean by my use of the term configural. However, the nature of the set still is of some importance, especially in determining the ability of subjects to carry out the focusing task.

One last comment here pertains to the role of the null stimulus in providing a good focus stimulus. Needless to say, my use of the hyphen as a constant element across a set of stimuli was done because I found it difficult to believe that subjects could attend literally to nothing. The fact that attention to the null stimulus was just as good without the hyphen as with it seems to imply that a truly null stimulus can indeed be attended. This interpretation should be made with caution, however, since a blank card still has many stimulus properties, such as its brightness and its contours. Thus it may have been that the hyphen was too small an increment to the fixed properties of the card to show any effect, and that if the stimulus were indeed nothing, it could not be attended. Operationally, of course, it is very difficult to run an experiment with nothing for a stimulus, because at a minimum some time mark has to be used to tell the subject that the time to respond has arrived. So it may be that the question of the role of the null stimulus in attention will have to remain fairly conjectural.

To what extent learning? One last comment concerns the possible role of learning in tasks requiring attention either to attributes or to individual stimuli. Previous evidence has suggested very little effect of learning in such tasks, and it is for this reason that I (Garner, 1976) have argued that the various types of attribute interaction are mandatory. However, in all of the experiments carried out with this experimental paradigm, no more than a few hours' practice has been used for an individual subject. The present Experiment 4 did show considerable improvement in carrying out the condensation task within one hour, an improvement apparently related to a shift in strategy from simple condensation to the use of a same-different judgment with respect to the two elements of each stimulus. Thus it is clear that at least under some circumstances learning can occur and that the learning is related to a change in how the stimulus elements are perceived or encoded. Thus the issue of the extent to which subjects can learn to use selective attention to attributes when that is functionally desirable, to integrate information when that is desirable, or to focus on a single stimulus when that is desirable must remain rather open.

References


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