1977

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John H. Flowers
University of Nebraska-Lincoln, jflowers1@unl.edu

Charles M. Stoup
University of Nebraska-Lincoln

Memory & Cognition
1977, Vol. 5 (3), 299-307

Selective attention between words, shapes and colors in speeded classification and vocalization tasks

JOHN H. FLOWERS and CHARLES M. STOUP
University of Nebraska, Lincoln, Nebraska 68588

The presence of irrelevant words (incongruent color and shape names) substantially slowed the sorting of shapes and colors. This interference was maintained over four sessions of practice for color sorting, but essentially vanished for shape classification and color classification using stimuli in which the word and color were physically separated. Interference with oral naming was maintained over 4 days of practice for all types of stimuli, demonstrating that spatial selectivity of attention is highly dependent upon the response requirements of the task.

Human observers are often unable to ignore irrelevant visual information sources even though it is advantageous to do so. Such failures of selective attention are evidenced by decreases in speed and/or accuracy in making perceptual classifications of a stimulus attribute when the irrelevant visual information source is also present. The failure to ignore alphanumeric information (e.g., letters, numbers, etc.) in tasks such as the Stroop test (Stroop, 1935) and its many variants (Dyer, 1973) is of particular interest, since these highly overlearned stimuli seem to be particularly powerful initiators of perceptual processing even when they are "irrelevant" within the context of an experimental task (Posner & Snyder, 1975). As Norman (1976) points out, interference from the reading of words in the Stroop test and related tasks provides an excellent example of data-driven processing, in which higher level analysis of the word proceeds automatically, given its presence in the visual field.

Verbal Interference With Visual Classification

While the typical Stroop paradigm involves the oral naming of a sensory attribute such as an ink color in the presence of an incongruent word, similar interference effects can be found in tasks which require only a manual classification such as a keypress (Keele, 1972) or a card sort (Flowers & Dutch, 1976). A common property of those tasks in which incongruent words or letters interfere with manual classification is that they require more than a simple detection of a visual feature or attribute; such tasks usually require the sorting of stimuli into several response categories or the mapping of more than two different stimuli into a dichotomy. Flowers and Dutch (1976) have shown that the complexity of the response categories is a highly critical factor in determining whether incongruent color names will slow the speeded classification of ink colors. When subjects could focus either on a single ink color (e.g., scan for all instances of the color red) or a group of similar colors (e.g., scan for adjacent hues such as red, yellow, and orange), color classification proceeded as rapidly when the colors were displayed as incongruent color words as when they appeared as XXXXs. Substantial interference resulted, however, when subjects were required to group three nonadjacent hues into a single category (e.g., scan simultaneously for orange, green, and purple). Such findings suggest that, when response assignments can be made on the basis of a single sensory property or criterion, the classification decision can occur at a level which is unaffected by the verbal processing of the word. When response assignments require a more complex memory search rather than a simple attribute or feature evaluation (i.e., when the task truly becomes one of speeded classification as opposed to sensory discrimination), the processing of the word becomes disruptive even though no overt naming of the stimuli is required.

The present series of experiments was undertaken to investigate further the influence of several stimulus and task variables on the magnitude of verbal interference with visual classification. Experiment 1 substitutes geometric shape stimuli for the color stimuli used in previous investigations. Experiments 2 and 3 investigate the effects of extensive practice on verbal interference effects with both shape and color classification. Experiment 4 examines the effect of extensive practice on interference with oral naming of both shapes and colors.

Unlike hue, simple geometric shapes cannot be physically compounded with printed words; this suggests that ability to focus attention on a geometric shape

This research was partially supported by NIH Biomedical Research Grant RR-07055-09 to the University of Nebraska. Portions of this research were presented at the 1976 meeting of the American Psychological Association. We wish to thank two anonymous reviewers for their valuable comments which were very useful in shaping the final form of the discussion.

exclusive of reading a competing word may be greater than the ability to selectively attend to hue in a traditional Stroop color-word stimulus. Furthermore, extensive practice can have a substantial influence on the efficiency of perceptually processing visual form per se (e.g., Grill, 1971), and this could conceivably lead to a greater reduction in the verbal interference effect over time than would occur with color. By demonstrating the extent to which the form of the stimulus display and the level of practice influence the amount of interference from words in the classification tasks, and whether those same stimulus and task variables control interference with oral naming, the present authors hope to clarify the issue of whether the disruption of naming and sorting by incongruent words involves different cognitive "loci."

EXPERIMENT 1

Method

Subjects. Eight volunteers from an introductory psychology course participated in a single session lasting about 45 min. All subjects had normal or corrected. acuity and English as their native language.

Tasks. Each experimental trial required the sorting of a deck of 30 8.9 x 6.3 cm white stimulus cards into two piles of 15 cards each, according to a classification rule based upon the geometric shape printed on each card. Two different decks were used. The control deck (c) contained five instances of each of six shape alternatives (square, circle, cross, rectangle, oval,[1] and heart), each containing a string of five zs. The horizontal dimensions of each of the shapes varied from 2.4 cm for the cross to about 2.8 cm for the oval. The zs were printed in 18-point boldface Futura type, lowercase (Letraset 28-18-CLN). The word deck (w) also contained five instances each of the same six shapes, but each shape contained an incongruent shape name printed in 18-point lowercase type. Each shape in the word deck was paired with the name of each of the other shape alternatives once. Examples of the control and word stimuli are shown in Figure 1.

Each of the decks was sorted according to four different binary classification rules which are shown in Figure 2. These particular response groupings were chosen to vary in the extent to which stimuli within each of the two response categories shared a common perceptual property which contrasted with the stimuli in the alternative category. It can be seen by inspection of Figure 2 that Rules 1 and 2 each require groupings of stimuli which share a reasonably apparent visual attribute (curves vs lines for Rule 1; internal area for Rule 2). For Rules 3 and 4, there is far greater heterogeneity of the stimuli within each category, making it impossible to classify on the basis of a single perceptual feature or property. The four shape classification rules are thus analogous to the color classification rules used by Flowers and Dutch (1976) in that they vary in the amount of correlation between stimulus properties and response categories, and thus would presumably impose different degrees of memory load on performing the task.

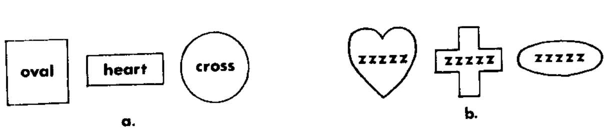

Figure 1. Examples of word stimuli (a) and control stimuli (b) used in Experiment 1.

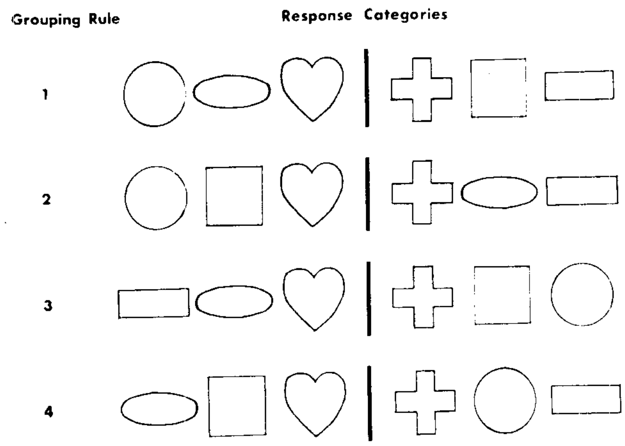

Figure 2. The four shape-classification rules used in Experiment 1.

Each of the four classification rules was combined with the two deck types, providing a total of eight conditions. Each of the eight subjects was given five blocks of trials within which each of the eight conditions was presented once. Order was determined by a Latin square with subjects assigned to rows. However, the first block of trials for each subject was considered practice and omitted from analysis, thus providing a total of four trials on each condition per subject.

Procedure. Before beginning the experiment, each subject was seated at a table and shown examples of the stimuli. He/she was then instructed that all tasks would require sorting the cards on the basis of the geometric shape appearing on each card and not on the basis of the words or letters enclosed by the shapes. Prior to beginning each trial, the stimulus deck was shuffled and a card illustrating the classification rule to be used on that trial was shown to the subject. This card was removed from view when the subject indicated that he/she understood the required classification. Subjects held the deck face up in one hand and on an oral signal of "ready, set, go!" subjects sorted each card into the required categories. Subjects were told to sort as rapidly as possible, avoiding errors. Sorting times were measured with a stopwatch; both time and errors were recorded following each trial. Feedback about errors but not time was given after each trial.

Following completion of the five blocks of trials, each subject was given three blocks of two each in which he/she was required to orally name each shape contained in a deck as the cards were dealt into a single pile. Each of these blocks of naming trials were identical to those used on the sorting trials, and subjects were instructed to name each shape "as rapidly as possible, avoiding errors." Naming times were recorded with a stopwatch. The purpose of collecting data in the naming trials was simply to provide a measure of the interference effects obtainable with these stimuli in the more traditional Stroop naming paradigm, for comparison with any interference effects which might be obtained in the sorting tasks of the main experiment.

Results and Discussion

Error rates were sufficiently low that only sorting times were used in data analysis.[2] Table 1 shows the mean sorting times for each combination of deck and classification rules, averaged across the eight subjects and four blocks of trials. While it can be seen that substantial differences between sorting times resulted

Table 1
Mean Classification Times (in seconds) for Deck of 30 Stimuli for Each Classification Rule in Experiment 1

Task	Control Deck	Word Deck	Interference	SE*
Rule 1	13.81	13.95	.14	.15
Rule 2	14.83	15.54	.71	.45
Rule 3	16.20	18.44	2.24	.74
Rule 4	19.24	22.88	3.64	.90
Naming Task	19.23	22.72	3.49	.47

*Note–Classification times are means across eight subjects and four blocks of trials for the four classification tasks; for the naming tasks, the means are based on three trials per subject. *Standard error of the amount of interference calculated from each subject's mean difference between the control deck and word deck times.*

from classifying according to the four different rules,[3] the primary interest was in possible interference effects caused by the words. This was assessed by comparing the sorting times of the control and word decks for each classification rule. Table 1 displays the mean difference between decks for each rule (amount of interference) and the standard error of the differences, based upon the four-trial deck means for each subject. It can be seen that this interference was negligible for the Rule 1 classification ($t < 1$, and only four of the eight subjects sorted the word stimuli more slowly than the control stimuli). The .71-sec difference in sorting times between the word and control decks for Rule 2 suggests a small amount of interference, although only six of the eight subjects sorted the word deck more slowly. However, substantially larger amounts of interference occurred for Rules 3 and 4 (seven of the eight subjects sorted the word deck more slowly for Rule 3, while all eight showed interference for Rule 4). Comparisons of the interference scores with their standard errors reveals their significance [$t(7) = 3.03$, $p < .05$, and $t(7) = 4.04$, $p < .01$]; more importantly, however, it should be noted that the overall size of the effects is large in comparison with interference effects reported in previous studies using a similar card-sorting methodology (e.g., Garner & Felfody, 1970). Table 1 also summarizes the data from the naming tasks collected at the end of the experiment. It is interesting to note that the naming times for each deck (hence the large amount of interference) are very close to those obtained with sorting for Rule 4.

In summary, the present findings with the shape-classification tasks correspond very closely to those obtained with color classification by Flowers and Dutch (1976). When subjects can attend to a visual attribute common to the stimuli within a response category, there is little or no interference from incongruent names in a manual classification task. When the task requires memory comparisons involving several attributes, a substantial amount of interference, comparable to that obtained with oral naming, occurs in the presence of competing shape names.

EXPERIMENT 2

While Experiment 1 demonstrated that the speeded classification of geometric shapes can be substantially slowed by incongruent shape names, it seems possible that the experimental setting may have produced considerably less than optimal performance. Flowers and Blair (1976) have shown that block randomization of different color-classification rules could lead to verbal interference for tasks which produced little or no interference when subjects could use one rule exclusively throughout a block of trials. Providing exclusive practice with a single classification rule might, therefore, lead to a more efficient visual encoding strategy and, thus, a reduction or elimination of verbal interference. Second, it is known that there are some types of learning effects in visual classification tasks, such as learning to visually scan for 10 targets simultaneously as rapidly as a single target (Neisser, Novick, & Lazar, 1963), which require several sessions of practice. Although verbal interference with color naming does not seem to be substantially attenuated with extensive practice (Dyer, 1973), extensive practice with speeded classifications which are initially subject to a comparable amount of interference might conceivably provide a different pattern of results. Experiment 2 was therefore performed to evaluate and compare the effects of extensive practice on two classification tasks which produced very large amounts of interference in previous research: the Rule 4 sorting task of Experiment 1 and the red, yellow, and blue vs orange, green, and purple color-sorting task used by Flowers and Blair (1976) and Flowers and Dutch (1976).

Method

Subjects. Twelve volunteers from an introductory psychology class each served in four 30-min sessions run on consecutive days. All subjects spoke English as a native language and had normal color vision and normal or corrected acuity.

Tasks. As in Experiment 1, each trial required a binary classification of a deck of 30 stimulus cards into two piles of 15 cards each. Two of the four decks of cards used were identical to the stimuli used in Experiment 1 (a word deck and a control deck each containing five instances of six geometric forms). The classification rule used to sort the stimuli was held constant throughout the experiment, and was the Rule 4 task used in Experiment 1, which required the grouping of the oval, square, and heart vs the cross, circle, and rectangle.

The other two decks (one word deck and one control deck) were identical to stimulus decks used by Flowers and Blair (1976). In the present study, these decks will be referred to as "color-compounded" stimuli. The control deck contained five instances each of red, yellow, orange, green, blue, and purple color patches, each shaped as an XXXX pattern. The word deck also contained five instances each of six different ink colors, but the color patches formed printed incongruent color names. The letters were in boldface capitals, about .5-cm high. As with the shapes, a single classification rule was used to sort the color stimuli throughout the experiment. This rule was based on the hue of the ink color (not the words) and was a red, yellow, and blue vs orange, green, and purple split.

Procedure. The shape tasks and color tasks were performed in separate parts of each experimental session. On Days 1 and 3, half the subjects were given six blocks of trials with the shape stimuli followed by six blocks of trials with the color stimuli; this order was reversed on Days 2 and 4. The remaining subjects received the complementary ordering of tasks. The ordering of which of the two decks came first within each block (control or word) was similarly balanced across days and subjects. The first block of trials on each day for each stimulus type was considered practice and omitted from analysis; thus, data from each subject was obtained for five blocks of trials for each stimulus type (shape or color) on each of the four days. The general instructions to subjects and data-collection procedures were essentially identical to those in Experiment 1.

Results and Discussion

Figure 3 displays the mean sorting times for both the shape and color-compounded tasks as a function of days of practice. Since primary interest was again in the interference effect (difference between the control and word decks for each stimulus type), Table 2 provides both the mean amount of interference and its standard error as a function of days for both the color-compounded and shape tasks. It can be seen that interference from the words is maintained in the color-classification task throughout the experiment, and that, while the absolute size of the effect is greatest

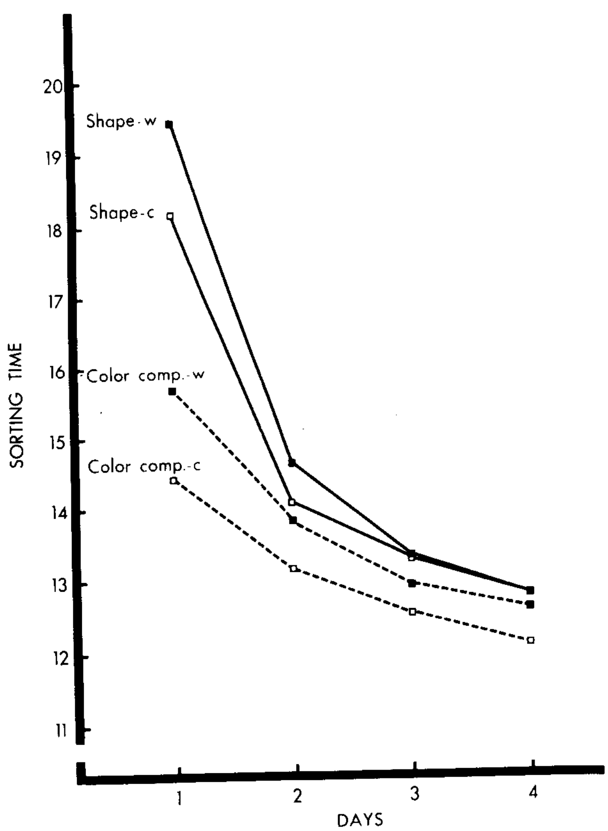

Figure 3. Mean sorting times (in seconds) for the shape stimuli and color-compounded stimuli used in Experiment 2, plotted as a function of days of practice.

Table 2
Amount of Verbal Interference Observed as a Function of Days of Practice in Experiment 2

	Days of Practice			
	1	2	3	4
Shape Task	1.24	.56	.03	.01
SE	.38	.21	.13	.13
Color Task	1.28	.70	.37	.47
SE	.30	.16	.14	.08

Note–Main cell entries are mean differences (in seconds) between sorting times for the word and control decks based upon five sorts on each day. SE = standard errors of these differences.

on the first day, its magnitude relative to the standard error is actually greatest on the last day [$t(11) = 5.77$, $p < .01$]. Such is not the case for the shape-classification tasks. While interference appears to be present on Day 1 [$t(11) = 3.24$, $p < .01$], it essentially vanished by Days 3 and 4 [$t(11) = .12$ and .08, respectively]. Since the sorting times for the shapes were actually somewhat slower than for the colors, as is evident from Figure 3, the attenuation of the interference effect with the shape stimuli cannot be attributed to a simple floor effect in card-sorting time. The data thus suggest quite strongly that subjects were able to "learn to ignore" the shape names while sorting shapes, but were unable to ignore color names after equivalent practice with color classification.

Does the successful gating of the word after a few days of practice reflect a fundamental change to a more efficient encoding strategy or decision process which is possible with shapes but not with colors? Such an interpretation is plausible, given the differences in the nature of the attributes. On the other hand, the reduction in the interference could also result from changes in processing prior to the level of stimulus identification or categorization. Specifically, subjects might be learning to "preattentively" narrow the spatial span of visual selective attention within which a critical portion of the shape is sampled, such that the interfering printed word largely falls outside a region of figural emphasis and detailed processing (Kahneman, 1973). Such focusing of attention might be possible with the shape stimuli because of the spatial separation of the outline form from the printed word, whereas the compounding of the ink color with the word might make such focusing impossible. Eriksen and Eriksen (1974) and Eriksen and Hoffman (1973) have argued that such focused attention is possible with letter displays, but limited to a span of about 1 deg of visual angle. With the visual shape stimuli used in the present experiments, the average separation between the edge of the shapes and the nearest letters was very close to that value.

If a focused attention hypothesis is a valid interpretation of the disappearance of verbal interference in

the shape-classification task, it might be possible for subjects to learn to suppress color names in a color-classification task in which the ink color is spatially separated from the word. A test of this hypothesis was conducted in Experiment 3.

EXPERIMENT 3

Method

Subjects. Twelve volunteers from an introductory psychology class, having normal color vision and English as the native language, served as subjects in four 30-min sessions run on consecutive days. None of the subjects had served in Experiments 1 or 2.

Tasks. Experiment 3 was essentially a replication of Experiment 2, substituting two new decks for the color-classification task. The two new decks (which will henceforth be termed the "color-separated" decks) consisted of stimulus cards containing a .5-cm wide rectangular band of colored ink (in red, orange, yellow, green, blue, or purple) which enclosed either XXXXs (in the control deck) or incongruent color names (in the word deck). Five instances of each color appeared in each deck. The enclosed letters were boldface capitals about .5-cm high, and the distance between the inner edge of the color band and the lettering averaged about .4 cm. These values were selected to provide spatial separations between the color attribute and the words or letters which were roughly equivalent to the spatial separation between the outline shapes and letters or words in the shape stimuli. At the viewing distance which most subjects seemed to choose while sorting the cards, the spatial separation between the center of the color band and the edge of the nearest letter would be close to 1 deg of visual angle. The classification rule for the color stimuli was identical to that used in Experiment 2; it required a red, yellow, and blue vs orange, green, and purple split. For the shape task, the stimulus decks and the classification rule were both identical to Experiment 2.

Procedure. The ordering of conditions was identical to that used in Experiment 2. The shape and color tasks were run in separate blocks of trials; both the order of tasks and the order of the two decks within blocks were balanced across subjects and days. The only minor change in procedure from the previous experiment was that subjects were run in groups of four; each subject sorted cards in one of four experimental booths controlled by the experimenter. Each of the four subjects was given a common visual "start" signal which was projected on a viewing screen in front of the experimental booths. Upon sorting the last card, each subject pressed a response key in the booth which stopped one of four Hunter Klockcounters located in a control booth. Shuffling the decks between trials as well as recording of errors was performed by a research assistant, while the primary experimenter initiated the trials and recorded sorting times.

Results and Discussion

Figure 4 displays the mean sorting times for each deck as a function of days of practice. Table 3 displays the amount of interference and the standard error of the interference scores for both the color and word tasks as a function of days of practice. Although the overall sorting times were slightly faster for Experiment 3 than for Experiment 2 (most likely owing to different experimental settings), it can be seen that the pattern of results obtained in the shape task is nearly identical to that obtained in Experiment 2. Interference essentially vanished after 2 days of practice. In sharp contrast to Experiment 2, however, the verbal interference in the color-classification task also disappeared, strongly suggesting that the spatial separation between the relevant sensory attribute and the competing word is a critical variable in determining whether successful focusing of attention on the relevant attribute (and gating of the word) can occur.

Following the completion of the last experimental trial on Day 4, an informal check was performed on whether the subjects had learned a spatial focusing strategy by which they could avoid the verbal interference (as opposed to a higher level color encoding strategy which would be generalizable to other stimuli

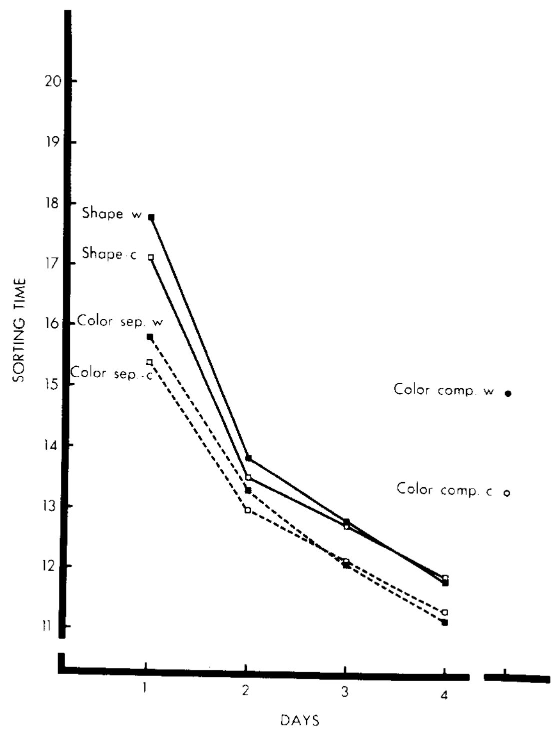

Figure 4. Mean sorting times (in seconds) for the shape stimuli and color-separated stimuli used in Experiment 3, plotted as a function of days of practice.

Table 3
Amount of Verbal Interference Observed as a Function of Days of Practice in Experiment 3

	Days of Practice			
	1	2	3	4
Shape Task	.69	.28	.03	−.06
SE	.41	.18	.10	.15
Color Task	.44	.31	−.05	−.15
SE	.18	.12	.15	.14

Note—Main cell entries are mean differences (in seconds) between sorting times for the word and control decks based upon five sorts on each day. SE = standard errors of these differences.

requiring the same color groupings). Six subjects who had received the color-separated decks on the last series of trials were presented with two blocks of trials, using the word deck and control deck with the color-compounded stimuli used in Experiment 2. The mean sorting times on these stimuli are also shown in Figure 4. The amount of interference which occurred on these trials (1.66 sec) is actually somewhat greater than that obtained at the beginning of Experiment 3 for the color-separated stimuli, and is statistically significant [$t(5) = 3.35$, $p < .025$, $SE = .45$]. Oral comments obtained from several of the subjects following these trials suggested that they were indeed frustrated by an inability to "shut out" the word, even though they felt they could do so while sorting the color-separated stimuli. While some caution is warranted in the interpretation of the return of a substantial interference effect when the color-compounded stimuli were exchanged for the color-separated stimuli (since it was not possible to find ink colors for construction of the color-separated stimuli which precisely matched the inks used in the color-compounded stimuli),[4] the informal findings are nevertheless consistent with a "spatial focusing" interpretation for the attenuation of the interference in the shape and color-separated tasks. The use of a focusing strategy would, however, appear to depend on some degree of learning, since the elimination of the interference required more than a single session of practice. On the other hand, it would appear that such spatial focusing is not effective in reducing interference when the attended attribute is spatially compounded with the word, as was the case with the color-compounded stimuli. This finding is consistent with the views of Eriksen and Eriksen (1974) and Eriksen and Hoffman (1973) that there exists a critical region within the visual field, perhaps somewhat less than 1 deg of visual angle, within which selective attention between elements of a display is not possible and within which alphanumeric elements are automatically subjected to rather extensive processing.

EXPERIMENT 4

The previous three experiments have demonstrated a Stroop-like interference effect in tasks requiring only a manual classification of stimuli. They have shown that the spatial relationship between the relevant sensory attribute (color or shape) and the interfering word is perhaps a critical variable in determining whether the interference effects will be maintained over a rather extensive period of practice. The final experiment was designed to test whether the spatial factors were equally critical in tasks requiring attribute naming as in the more traditional Stroop task. It has been shown previously that for color-compounded stimuli in a color-naming task (the traditional Stroop test), extensive practice has relatively little effect on the magnitude of the large interference effect (Dyer, 1973; Stroop, 1935). It was shown in Experiment 2 that extensive practice did not substantially attenuate interference with sorting color-compounded stimuli either. Since it was found that the interference with sorting disappeared with practice in both the shape-classification task and the color task using color-separated stimuli, it was decided to use these stimuli in the naming task. If selection mechanisms or strategies which eliminate interference from words are stimulus specific rather than task specific, one might expect to observe a substantial attenuation of naming interference using these stimuli. On the other hand, a failure to find much reduction in a naming interference effect with the "separated" stimuli, given an amount of practice equivalent to that used in the sorting tasks, would require serious qualification of any conclusions about the effective spatial focus of attention in processing these stimuli, and would suggest that the "locus" of the interference effect in sorting and naming tasks may be somewhat different.

Method

Subjects. Subjects were six volunteers from an introductory psychology course, having normal color vision and English as their native language. Each subject served in four 30-min sessions run on consecutive days.

Tasks. On each experimental trial, subjects were required to orally name the 30 stimuli contained in a deck of cards "as rapidly as possible, avoiding errors." The four decks of stimulus cards used in the sorting tasks in Experiment 3 were used in these naming tasks. There were thus four different conditions in the experiment. Two of these (those using the shape control and shape words) required the oral naming of geometric shapes (square, rectangle, cross, circle, oval, heart). The other two conditions (which used the two color-separated decks) required the oral naming of ink colors (red, orange, yellow, green, blue, and purple). In all cases, subjects were requested to name the visual attribute (shape or color) and to try to ignore the words or letters. The color-naming and shape-naming tasks were performed in separate parts of the experiment. On Days 1 and 3, half the subjects received six blocks of shape-naming trials, followed by six blocks of color-naming trials, and this order was reversed on Days 2 and 4. The remaining subjects received a complementary ordering. The first block of trials for each stimulus type on each day was omitted from analysis, so that each subject provided data from five blocks of trials for each stimulus type on each of 4 days. Each block of trials consisted of one trial with the control deck and one trial with the name deck; the order of which deck was presented first within a block was counterbalanced across subjects and days.

Procedure. Subjects were run individually. Before beginning the experiment, each subject was seated at a table and shown examples of the stimuli. He/she was then instructed that the tasks would require them to name shape or ink colors and to ignore the words or letters. The subject then held the deck face up in one hand and on the oral signal of "ready, set, go!" dealt each card from the top of the deck, orally named the attribute it displayed, and discarded it onto the table. The experimenter timed the naming of the 30 cards in the deck by using a stopwatch. Decks were shuffled by the experimenter between trials.

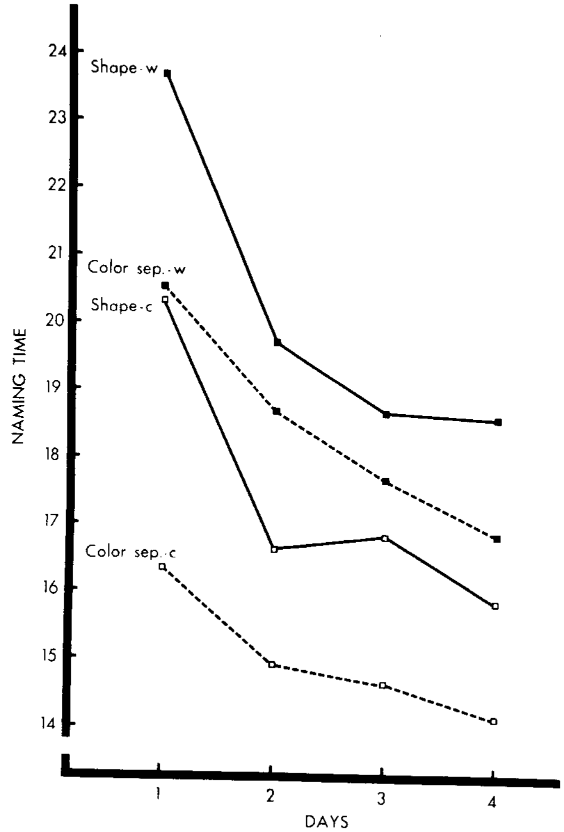

Figure 5. Mean naming times (in seconds) per deck of 30 stimuli for the shape and color-separated stimuli used in Experiment 4.

Results and Discussion

Figure 5 displays the mean naming times per deck as a function of days. Table 4 gives the interference amounts and their standard errors as a function of days. Clearly, a very large interference effect is maintained through the experiment for both types of stimuli, since the word decks are over five standard errors slower than the control decks, even on Day 4. There is thus little or no evidence that subjects were able to learn to narrow their focus of attention sufficiently to reduce the interference from the processing of the word, even though they were able to do so when manually classifying the very same stimuli in Experiment 3. While it cannot be determined whether much greater levels of practice would have attenuated the interference, the present data make it evident that it is not possible to interpret the disappearance of the interference effects in the sorting tasks (Experiments 2 and 3) to a spatial narrowing of visual attention span which is generalizable across tasks.

GENERAL DISCUSSION

Experiment 1 showed that the processing of incongruent shape names can interfere substantially with the speeded classification of shapes, provided that the classification rule requires the grouping of shapes which do not share an obvious common visual attribute. This interference effect is thus very similar to that obtained for visual scanning and speeded classification of ink colors (Flowers & Dutch, 1976). Experiment 2, however, demonstrated that, given four sessions of exclusive practice with a single shape-classification rule, the interference effect disappeared, whereas interference in an analogous color-classification task was maintained with equivalent practice.

The elimination of the interference with practice seems to be largely the result of spatially focused visual attention, since a similar elimination of interference occurred in a color-classification task (Experiment 3) in which the ink colors were spatially separated from the words. Such spatially focused attention does not, however, appear to be an effective means of reducing interference from words in the standard Stroop paradigm of orally naming stimuli, as Experiment 4 demonstrates, even when the same stimulus materials were used.

Had the interference effect vanished with practice in all the classification tasks, it would seem reasonable to attribute the initial interference to a temporary covert verbal encoding strategy which is discarded as task performance becomes highly practiced (Kahneman, 1973, pp. 106-107). However, the persistence of the interference with classification of the color-compounded stimuli, together with the rather strong subjective impressions of a number of subjects, suggests that learning to avoid interference in the other classification tasks is largely an input selection phenomenon, rather than a fundamental change in stimulus encoding. Thus, while printed color words may have the power to automatically activate pathways relevant to manual color classification, spatial segregation of the word from the color is apparently sufficient, with practice, to either delay such activation or reduce its "depth" or "intensity" below some critical level.

The same amount of spatial separation which eliminated interference in the classification tasks did not, however, prevent the unwanted word processing

Table 4
Amount of Interference With Naming 30 Consecutive Stimuli as a Function of Days of Practice in Experiment 4

	Days of Practice			
	1	2	3	4
Shape Stimuli	3.35	3.07	1.84	2.66
SE	.37	.82	.28	.49
Color Stimuli	4.22	3.75	3.02	2.75
SE	.75	.47	.77	.54

Note–*Main cell entries are mean differences between naming times for the word and control decks. SE = standard errors of these differences.*

in the naming tasks. Clearly, then, it is not proper to describe the present findings in terms of a model postulating a single physical region or "beam" of attention within which detailed processing is devoted to all elements of a display, and outside of which such processing may be suppressed. The present findings illustrate that the spatial breadth of attention when processing visual displays is, like many parameters of both auditory and visual attention, strongly influenced by the response requirements of the task.

The relative sensitivity of naming tasks vs classification tasks to interference from words other than color names provides an interesting parallel with the present results. Words other than color names can be shown to cause slower color-naming times than nonsense syllables or forms (Klein, 1964). Keele (1972), however, found that the presence of "neutral" words (e.g., "bird") produced no slower response times than nonsense Gibson forms, in a manual color-classification task requiring a keypress response, even though substantial interference resulted from the presence of actual color names. As Keele noted, the relative pertinence of words as a class of stimuli is greater to the act of naming than to manual sorting. While Keele's (1972) study thus illustrates the influence of response pertinence on semantic selectivity, the present data suggest a similar influence on spatial selectivity. While one should be cautious about generalizing across perceptual modalities, it is interesting to note that the influence of task-defined pertinence on the spatial selectivity of auditory attention is a rather well known phenomenon. The classic shadowing experiments of Treisman (e.g., 1964) and more recent studies by Lewis (1970) and McKay (1973) provide examples of how performance decrements can result when "irrelevant" verbal material which bears a semantic relationship with that being processed in a primary task is presented in a spatially distinct and "unattended" channel.

Attributing differences in spatial selectivity to the relative task pertinence of words does not, in itself, specify the source or locus of interference in sorting and oral naming tasks. Since the present findings, together with those of Keele (1972), show how manipulations of stimulus variables differentially affect interference from words in naming and classification tasks, it seems reasonable that the interference loci in the two types of tasks are indeed different. Quite possibly, interference with classification results from pathways which are both distinct and more "weakly" activated than those which generate the "response competition" in the naming tasks. Preattentive "unit formation" processes (Kahneman, 1973) may be sufficient to suppress the weakly activated pathways, yet be less effective in preventing the generation of an articulatory response tendency.

Regardless of the precise locus of the interference effects in these tasks, the present findings strongly emphasize the importance of task variables other than stimulus properties on the efficiency of selective attention. It is becoming increasingly apparent, from research as diverse as the present study and the multiple stimulation experiments by Greenwald (1970), that ability to ignore irrelevant information in a display can be critically influenced by response requirements. Models of visual selective attention which take into account only the physical properties of the stimulus display may thus prove to have limited generality.

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NOTES

1. Technically, it was an ellipse; the word "oval" is more familiar and more easily pronounced.

2. Observed error rates were less than a single error per deck

for every subject in all experiments in this study, and many subjects exhibited errorless performance. Thus, no further analysis will be undertaken.

3. An overall analysis of variance was performed on these sorting times (deck type by rule by trials by subjects), which revealed main effects for rule [$F(3,21) = 10.15$, $p < .01$, $MSe = 62.0$], deck type [$F(1,7) = 16.05$, $p < .01$, $MSe = 11.3$], and an interaction of Deck Type by Rule [$F(3,21) = 8.36$, $p < .01$, $MSe = 39.4$]. Since the overall pattern of results is apparent from the descriptive data presented in Table 1, we concur with an anonymous reviewer that the use of individual planned comparison is, for our purposes, a more appropriate means of data analysis and description.

4. Approximate Munsell values for the six hues were 5R 4/12, 2.5YR 6/14, 5Y 8/12, 5G 5/8, 10B 3/8, and 5P 3/10 for the color-compounded stimuli, compared with 2.5R 4/12, 10R 6/12, 5Y 8/12, 5G 5/8, 7.5B 4/8, and 10PB 3/10 for the color-separated stimuli.

(Received for publication September 26, 1976;
revision accepted January 25, 1977.)