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EXTENSION OF THE STROOP INTERFERENCE EFFECT

TO PICTURES AND WORDS

by

Gary Lynn Lassen

A Dissertation Submitted to the Faculty of the

DEPARTMENT OF PSYCHOLOGY

In Partial Fulfillment of the Requirements
For the Degree of

DOCTOR OF PHILOSOPHY

In the Graduate College

THE UNIVERSITY OF ARIZONA

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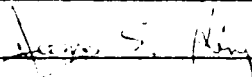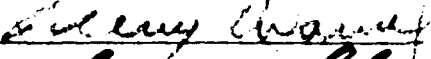
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GRADUATE COLLEGE

I hereby recommend that this dissertation prepared under my

direction by _____Gary Lynn Lassen_____.____

entitled Extension of the Stroop Interference Effect___

_____To Pictures and Words_____

be accepted as fulfilling the dissertation requirement of the

degree of _____Doctor of Philosophy_____

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ABSTRACT

Three experiments were conducted investigating picture-word processing using adaptations of the Stroop interference paradigm. In the first experiment the Stroop paradigm was adapted for use with outline drawing-word pairings. Incongruent words interfered significantly with the task of naming pictures. Incongruency existed when the words were dissimilar to the pictures. In the second experiment, onset of the irrelevant stimulus was varied. Maximum interference of picture naming occurred when incongruent words were exposed 100 milliseconds prior to the picture. Interference of incongruent pictures with word reading was approximately the same across the various exposure conditions. In the third experiment, the Stroop arrangement was extended to a manual same-different reaction time task. Same responses were made faster than different responses and congruent picture matches were faster than congruent word matches, regardless of whether the initial target was a picture or a word. The results are discussed in terms of an information processing model of naming, reading, and comparison, with applications to the Stroop effect.

INTRODUCTION

In the Stroop color-word test (Stroop, 1935), a
large delay occurs in naming the color of a word printed in
colored ink when the word is the name of a different color.
For example, if the word red is printed in green ink, the
subject's response, "green," will be delayed. The reverse
of the Stroop test, which is to read the words printed in
incongruent colors, produced only six per cent slower read-
ing than that for the words written in black ink. This
interference was quite small when compared with delays of
50-100 per cent found for naming the color of an incongruent
word.

Dyer (1971, 1972) and Dyer and Severance (1973) in-
vestigated the effect of preexposing words for various
intervals prior to exposure of the color to be named, pre-
sumably advancing word processing relative to color process-
ing. Dyer (1971), in a study that included ten different
preexposure intervals presented in blocks, found that maxi-
mum interference occurred at forty milliseconds preexposure
with little interference for preexposures greater than
sixty milliseconds. Dyer (1972), in a comparison of block-
ing and randomization of preexposure duration, found longer
response latencies for the shorter preexposure durations

(0-2 seconds) than the condition where all stimuli within a sequence were presented with the same preexposure duration. Dyer and Severance (1973) found that color patch naming was delayed by a fifty millisecond flash of a color name in black ink. This delay, however, was only about half that obtained with simultaneous presentation of word and color. Intervals of 0, 25, 50, and 100 milliseconds between the word and color did not change the amount of interference.

In 1886 Cattell introduced the classical finding (Cattell, 1947) that pictures are named slower than their corresponding object names are read. Stroop (1938) compared naming five common objects to reading the printed names of these same objects. These were compared to color naming and color-name reading. The difference in average time between naming pictures and reading words was greater than between naming colors and reading color-names, with reading being faster in each case.

Dyer (1973) investigated same and different judgments using the Stroop stimuli. It was found that incongruent as well as congruent irrelevant stimuli delayed responses. Congruent stimuli speeded same judgments but not different judgments, and an irrelevant word caused a greater delay than an irrelevant color. It was concluded that there is a greater tendency to encode colors in the form of words than to encode words in the form of colors. The results are contrasted to those of Seymour (1970) who concluded that in

comparisons of words and shapes, words are converted to shape codes for the central match. According to Dyer (1973), a basic difference may exist between the processing of color and shape.

The research thus indicates that words are read faster than either pictures or colors are named, and that incongruent words cause considerable interference with the task of color naming. The present series of experiments investigated picture naming and word reading using an extension of the Stroop paradigm. Of principal interest was whether incongruent words cause more interference with the task of naming pictures than incongruent pictures do with the task of reading words. The temporal locus of the interference in the information processing system was sought by varying the onset of the irrelevant stimulus relative to the stimulus to be named or read. Finally, a manual task was conducted to determine whether output mode had any influence upon the interference effects.

EXPERIMENT ONE

Introduction

The first task was to determine whether the finding
of Stroop interference demonstrated for colors and color-
names could extend to outline drawings representing common
objects and their corresponding names. The typical finding
is of a greater amount of interference caused by incongruent
words in the task of color naming to that caused by incon-
gruent colors in the task of reading color-names. Would this
be true also for picture-word combinations? In this experi-
ment the stimulus conditions for pictures and words were
made as equivalent as possible in order to permit a direct
comparison between the two tasks as to amount of interference
produced.

Method

Apparatus

The $\underline{S}$s were seated at a three-channel tachistoscope
(Scientific Prototype Model GB). The $\underline{S}$ controlled a floor
switch which caused the stimuli to appear after a brief ran-
dom foreperiod. The presentation of the relevant stimulus
initiated an electronic timer-printer. The $\underline{S}$'s verbal

naming or reading response activated an Astatic Voice oper-
ated Relay that terminated the printer-timer.

Subjects and Stimuli

The five Ss were all volunteers from introductory
psychology courses at The University of Arizona. Subjects
were initially tested for visual acuity by means of a Bausch
and Lomb Orthorater, and all had normal uncorrected vision.
The stimuli were five printed words and their corresponding
pictures (line drawings) that were chosen for high frequency
of occurrence, easy identifiability, and consistent pronun-
ciability. All Ss were familiarized with the stimuli before
the experiment. The words and pictures were centered at one
degree of visual angle either above or below fixation.

Design

Two within-S factors determined the design of the
experiment. These were relevant response (naming the picture
or reading the word) and congruency of relevant and irrele-
vant stimuli. On any one trial S was presented with both a
picture and a word. If the task was to name the picture
then the word was the irrelevant stimulus and vice versa.
Half of the irrelevant stimuli within each block of either
naming or reading were congruent (the picture and word were
the same) and half were incongruent (picture-word different).

Procedure

The $\underline{S}$s first participated in 100 practice trials in
order to familiarize the $\underline{S}$s with the procedure and to pro-
duce stabilized responding. $\underline{S}$s participated in experimental
sessions for four days, for a total of 400 trials. Each day
consisted of a block of 100 trials in which $\underline{S}$s either named
pictures or read words. On a single trial the $\underline{S}$ was pre-
sented with both a picture and a word stimulus. In naming,
the $\underline{S}$ responded vocally as rapidly as possible naming the
picture and ignoring the word. In reading, the picture was
similarly ignored. The order of events for one trial were:
1) $\underline{E}$ pressing a buzzer, 2) $\underline{S}$ pressing a foot pedal to ini-
tiate the trial, 3) a short variable delay, 4) presentation
of the stimuli, 5) $\underline{S}$'s response, 6) repeat whole sequence.
The inter-trial interval was from fifteen to twenty-five
seconds.

Results and Discussion

The five items differed in naming and reading
latencies, $F (4, 28) = 6.18$ $p < .01$. The objects used as
stimuli represented a bird, drum, kite, nail, and tree. Post
hoc testing (Tukey HSD, Kirk, 1968) revealed that kite and
tree were named and read slower than the item bird. As
found by Cattell (1947) and Stroop (1938), reading words
was generally faster than naming pictures, but the difference
was not significant.

The Stroop interference effect was demonstrated using pictures and words. Incongruent words interfered with the task of naming pictures considerably more than incongruent pictures did with word reading as evidenced graphically in Figure 1. This graph represents the significant effect of Congruency X Response Type, $F_{(1, 3)} = 19.06$ $p < .025$. The notable difference was for incongruent words in the task of naming, which was significantly slower than all other conditions.
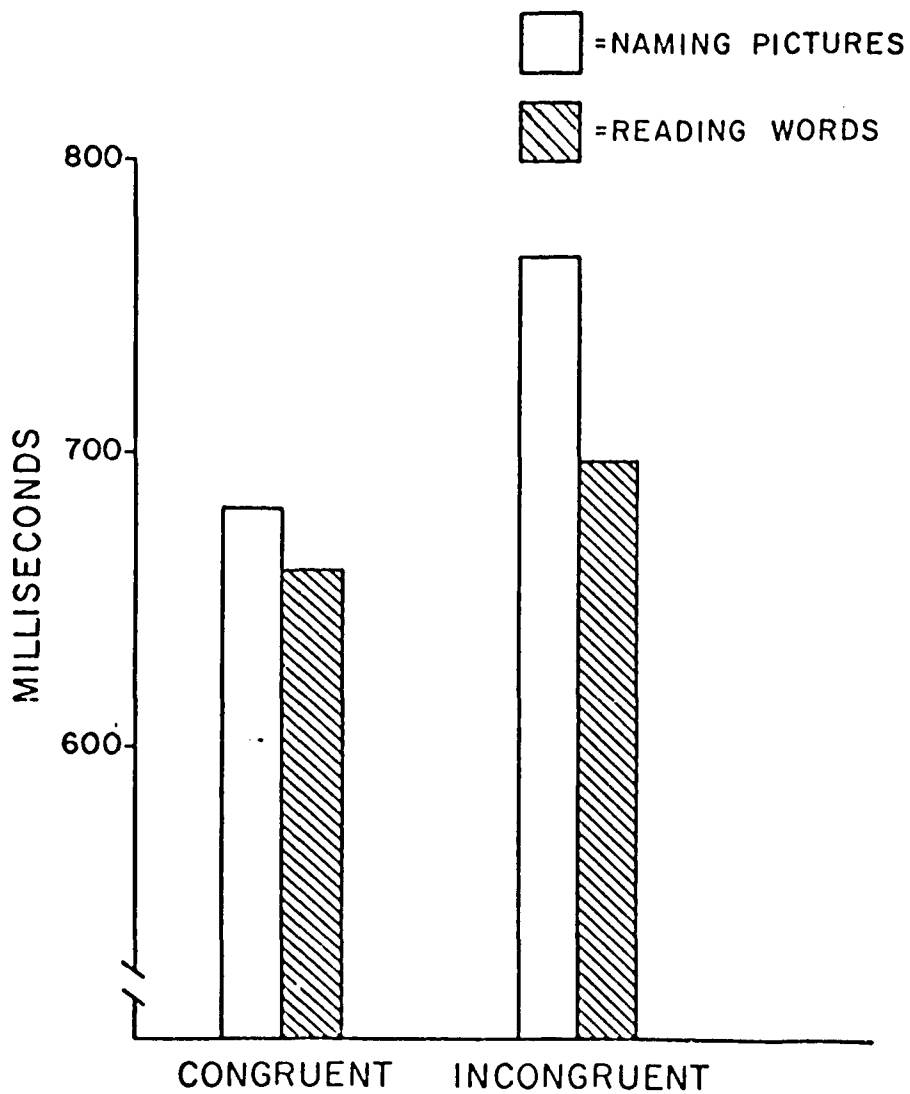
Figure 1.   Reaction Time in Milliseconds for Congruent and
Incongruent Naming and Reading Responses.

EXPERIMENT TWO

Introduction

In this experiment the time of onset of irrelevant stimulus relative to the stimulus to be named was manipulated. Preexposures of printed color names have been found to interfere with the task of color naming (Dyer, 1971, 1972; Dyer and Severance, 1973). There may be different preexposures or postexposures for pictures and words that would lead to corresponding amounts of interference. This finding would support a processing rate difference interpretation of the Stroop effect for these stimuli.

In this experiment the effect of asynchronous stimulus onset on the Stroop interference task was tested using pictures and words. An equivalent number of trials were run in which only a blank channel came on asynchronously, instead of the irrelevant stimulus to insure that the effects observed were due to the interference of word or picture stimuli and not simply onset of illumination.

Method

The apparatus and general procedure were identical to those used in Experiment One.

Subjects

The eight Ss were volunteers from introductory psy-
chology courses at The University of Arizona.

Stimuli

The stimuli were the same as those used in Experi-
ment One. In order to make the amount of interference
equivalent for pictures and words, the pictures were placed
in the middle of the visual field surrounding the fixation
point, so that they could not be avoided. Words appeared
either above or below, to prevent Ss from adopting an ori-
enting strategy to avoid the irrelevant stimulus.

Design

Three within-S factors determined the design of the
experiment. These were: 1) relevant response (naming or
reading), 2) congruency of relevant and irrelevant stimuli,
and 3) onset of irrelevant stimulus. Half of the irrelevant
stimuli within each block of either naming or reading were
congruent (picture-word same) and half were incongruent
(picture-word different). The irrelevant stimulus items
were presented at 100 msec. preexposure, 50 msec. preexpo-
sure, simultaneously, 50 msec. postexposure, or 100 msec.
postexposure to the relevant stimulus. Presentation se-
quence for congruency-incongruency and the onset of irrele-
vant stimulus conditions were randomized within each
experimental session for each S. In addition to the

interference conditions, an equal number of control trials were run when only the relevant stimulus was presented with a light coming on in the other channel in the same temporal arrangement as the irrelevant stimuli.

Results and Discussion

As in the previous experiment, the stimulus items differed in their naming latencies, $F (4, 28) = 3.70$ $p < .005$. Bird again produced the fastest vocal reaction times, while kite yielded the slowest. The only significant pairwise comparison (Tukey HSD) was between the items bird and kite. In this study pictures were named faster than words were read, $F (1, 7) = 30.99$ $p < .001$. This is contrary to the findings of previous investigators. The principal factor which may have contributed to this result was that words appeared in one of two positions, either above or below the picture, while pictures always occurred in the center of the visual field. The reasoning behind this arrangement was to produce comparable amounts of interference for pictures and words, and this goal was achieved.

Interference was found to be caused by both incongruent and irrelevant pictures as well as words when the task was to respond to the opposite mode. This is represented in the effect of congruency-incongruency, $F (1, 7) = 56.39$ $p < .001$. The mean vocal reaction time (VRT) for congruent pairings across all other conditions was 640

milliseconds while that for incongruent pairings was 697
milliseconds. Presence of an incongruent stimulus produced
substantially more interference than a congruent stimulus.
Congruent stimuli did not lead to faster VRTs than the pre-
sentation of the relevant stimulus alone. The mean VRT for
relevant stimuli presented alone was 607 milliseconds. Thus,
even a congruent stimulus presented in the irrelevant mode
caused some interference. (The reading and naming control
presentations across the different onset conditions are pre-
sented in Figure 2. These can be compared with the experi-
mental treatments for the different onset conditions
presented in Figure 3.)

Figure 4 represents a subtraction of the control VRT
for each of the onset conditions from the corresponding ex-
perimental treatments at each onset condition. This was
done to provide the best index of amount of interference
produced by the irrelevant stimuli. Generally, preexposures
of irrelevant stimuli lead to the fastest VRTs which is con-
sistent with the results of the control conditions suggest-
ing a signaling effect of irrelevant preexposures. This is
true except for a preexposure of an incongruent word when
the task is picture naming. Here, the maximum interference
to the task of picture naming is found. Conversely, maxi-
mum interference of an incongruent irrelevant picture oc-
curred with postexposures. There appears to be little
difference dependent upon congruency, when words serve as
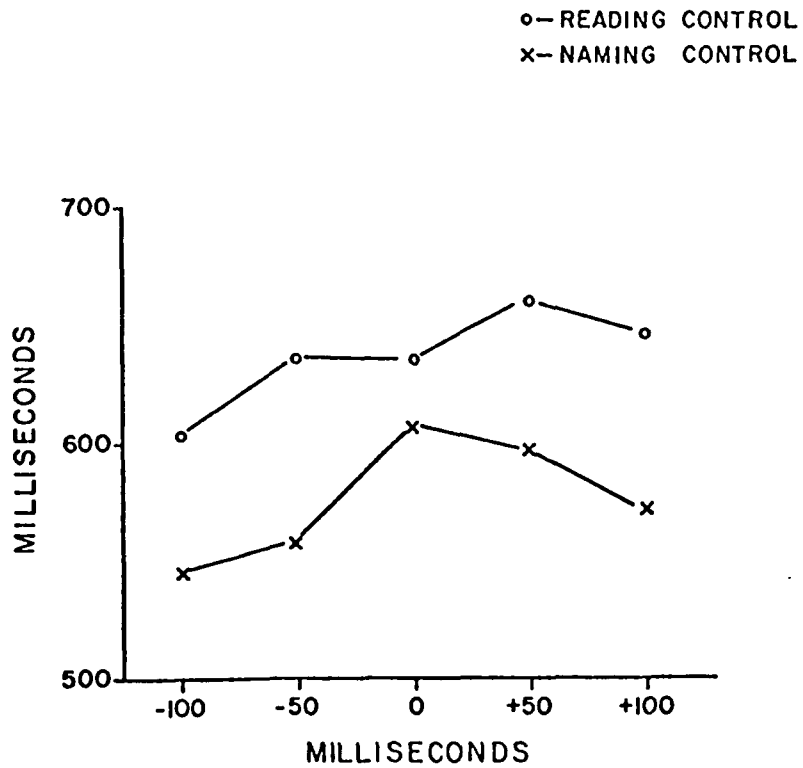
Figure 2. Mean Vocal Reaction Time in Milliseconds for the
Reading and Naming Control Trials at Each of the
Five Onset Channel Conditions. -- Minuses indi-
cate preexposures of control channel and plusses
indicate postexposures of control channel.

Figure 3. Mean Vocal Reaction Time for Congruency X Type
of Response X Presentation Interval Inter-
action. -- Minuses indicate preexposures of
irrelevant stimulus, and plusses indicate
postexposures of irrelevant stimulus.
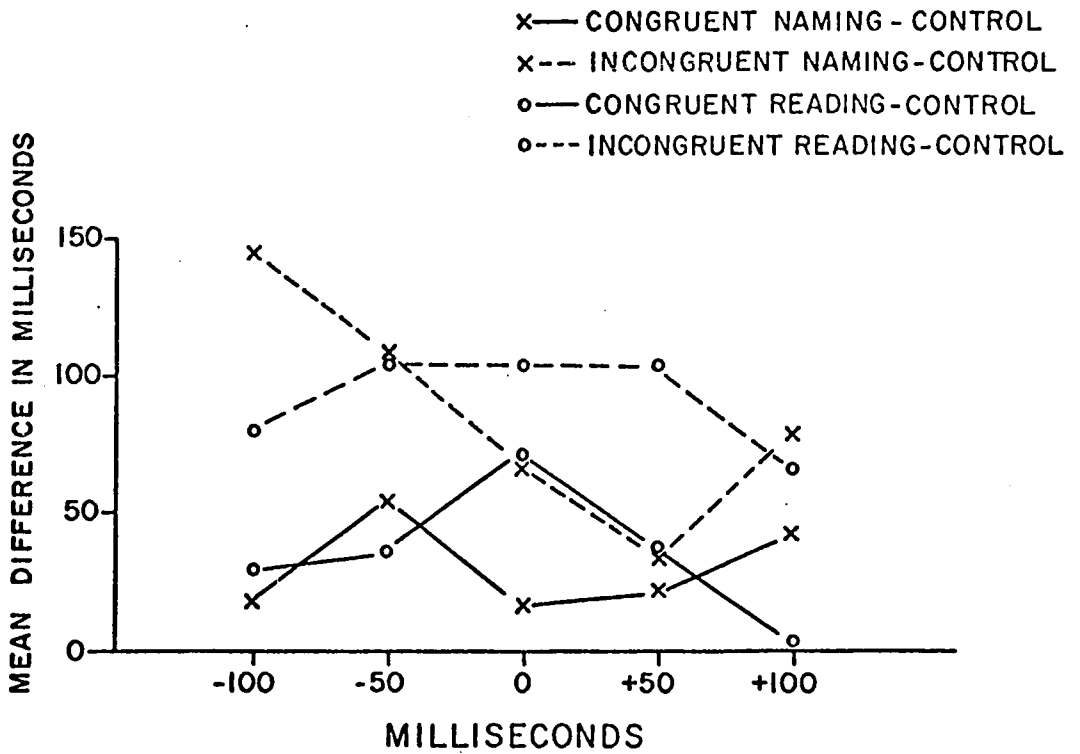
Figure 4. Subtraction of the Control Latencies from the
Individual Treatment Condition Vocal Reaction
Times in Milliseconds for the Five Onset
Conditions.

postexposed irrelevant stimuli to the task of picture naming.
This Congruency X Type of Response X Presentation Interval
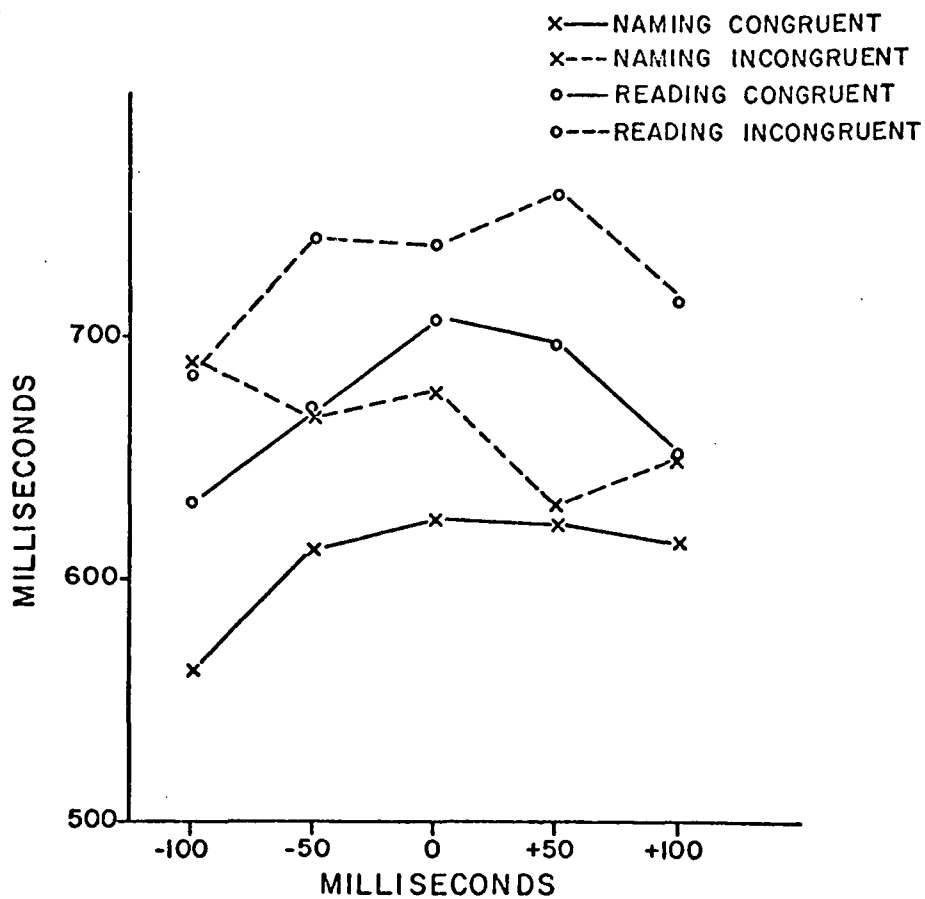Interaction yielded significant differences, $F_{(4, 28)} =$
3.84 $p < .025$. A post hoc analysis (Tukey HSD) revealed
the following pairwise effects. The 100 msec. preexposure
congruent naming condition was significantly faster than
any other treatment condition. The 50 msec. congruent con-
dition for naming was faster than all incongruent conditions
and all reading conditions but the 100 msec. congruent pre-
exposure. The slowest responses were obtained in the read-
ing condition with either a 50 msec. preexposure or
postexposure of irrelevant picture. These conditions led
to significantly slower times than all other conditions.

EXPERIMENT THREE

Introduction

Dyer (1973) used Stroop color-word stimuli in a
same-different reaction time task. He found a greater delay
in reaction time caused by an irrelevant incongruous word
when the task was to match on the basis of color than by an
irrelevant incongruous color when the task was to match
according to the words. This result was interpreted by
Dyer as showing a greater tendency of colors to be encoded
as words than words to be encoded as colors. These results
were contrasted to findings of Seymour (1970), who found a
shape code to mediate matching better than did a word code.
These conflicting findings, which bear on the nature of the
central comparison of pictures and words, suggest the use of
shape stimuli with Dyer's technique. An important variation
of Dyer's experimental procedure is warranted. Manual re-
action time was substituted in this experiment for vocal
reaction time, to test the proposition that the Stroop
interference effect is task dependent.

Method

Apparatus

The apparatus was identical to that in the previous
experiments except that the voice operated relay was

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replaced in the system by a manual reaction time (RT) system
consisting of a panel at the end of S's arm rest with two
buttons whose depression triggered a relay which terminated
the printer-timer. Button position corresponding to same
or different judgment was balanced across Ss.

Design

Three different factors were of principal interest
in this experiment. They are type of target (picture or
word), blocking or randomized presentation of target, and
five different types of stimulus congruency. The target
(first stimulus in a successive same-different match) was
either a picture or a word. The S either received blocks of
all pictures or all words as target items or randomized
orders of blocks consisting of half pictures and half words
as target items. Five Ss received two days of blocked pre-
sentations (100 trials each day; pictures were the target
item one day and words the other) followed by two days of
mixed trials (both pictures and words). The other Ss re-
ceived just the reverse order.

There were five different types of stimulus con-
gruency relationship for each target mode. These are de-
picted schematically in Figure 5. The first three required
a same judgment, and the last two required a different
judgment. The first (top) is double congruency. Both com-
ponents (picture and word) of the second, or test, stimulus

CATEGORY	TARGET	STROOP PAIR
DOUBLE CONGRUENT SAME		NAIL
PICTURE CONGRUENT SAME		KITE
WORD CONGRUENT SAME		NAIL
CONGRUENT DIFFERENT		KITE
INCONGRUENT DIFFERENT		TREE

Figure 5. Schematic Representation of Five Stimulus Congruency Relationships Using Pictures as Targets. -- The target was the first stimulus in a sequential same-different reaction time task. The Stroop pair was the second stimulus.

(Stroop pair) were the same as the target stimulus. The
other two congruent conditions existed when one of the two
components (either in the same mode as the target stimulus
or in the opposite mode) was the same as the target stimulus
and the other component of the test was different than the
target stimulus. Two conditions (the bottom two) of incon-
gruency existed which required a different response. In
one the Stroop pair represented the same object and were
different from the target, and the second was when the
Stroop pair represented different objects, both different
from the target stimulus.

Procedure

On the first day Ss received a practice session con-
sisting of 100 trials analogous to their first experimental
day's target conditions. For the next four days they re-
ceived 100 trials each day, with either the blocked or the
randomized trials occurring before the other.

The sequence for one experimental trial was as
follows: 1) E pressed a buzzer, 2) S initiated trial by
pressing a foot switch, 3) fixed delay of three seconds,
4) onset of target stimulus for one second duration, 5) vari-
able delay which consisted of a rectangular distribution of
delays from one to three seconds with approximately ten per
cent catch trials in which no second stimulus pair appeared,

6) onset of Stroop pair terminated by 7) S's manual same-different response.

Results and Discussion

An analysis of variance conducted on correct same responses revealed the following effects. There was a significant effect of trials, $F (3, 24) = 12.91$ $p < .01$. Post hoc testing (Tukey HSD) showed that the significant differences due to trials occurred when the manual RT data from trial one was compared with that of the other trials. There was a significant effect of stimulus congruency upon manual RT, $F (2, 16) = 58.01$ $p < .01$. The fastest RT occurred when both components of the Stroop pair test stimulus were equivalent to the target stimulus (461 msec.). This result is not surprising. No interference by a second stimulus should be expected to yield the fastest RTs. Picture congruency to the target stimulus yielded the next fastest RTs (505 msec.), while the slowest RTs were obtained for word congruency (582 msec.). These times were all found to be significantly different from each other at the $p < .05$ level (Tukey HSD). Picture matching was found to be superior to word test matching, even when the target was a word. This clearly indicates a superiority of a match based on an internal code more closely related to pictures than to words. These data are contrary to the evidence favoring the word code presented by Dyer (1973) when he used colors and

color-names and vocal responses. This finding is consistent with Seymour's (1970) evidence favoring a shape code. The crucial factor appears to be whether or not the response is a vocal or a manual one. In Experiment One, words were found to be the most potent sources of interference when the response was naming. In this experiment, with a manual same-different response, but with the same stimuli, the pictures were found to be the preferred stimuli.

Figure 6 depicts the interaction of the three types of same congruency and the target mode. Whereas both picture and word targets yielded the same order of congruency effects, the same matching superiority for picture matches and the decrement caused by word matching were not as pronounced when words were the targets. These differences are reflected in the Congruency X Target Mode Interaction, F (2, 16) = 7.34 p<.01. The significant differences in all cases existed among different congruency conditions and were never due to target alone (Tukey HSD). In addition, neither picture nor word double congruent conditions were faster than the picture target picture congruent condition. This indicates that an incongruent word is not as potent an interference producer as has been found in previous Stroop experiments, in which vocal responses were used.

There was no significant effect due to target mode. Pictures and words did not differ in their contribution as targets across all other conditions. This explains the
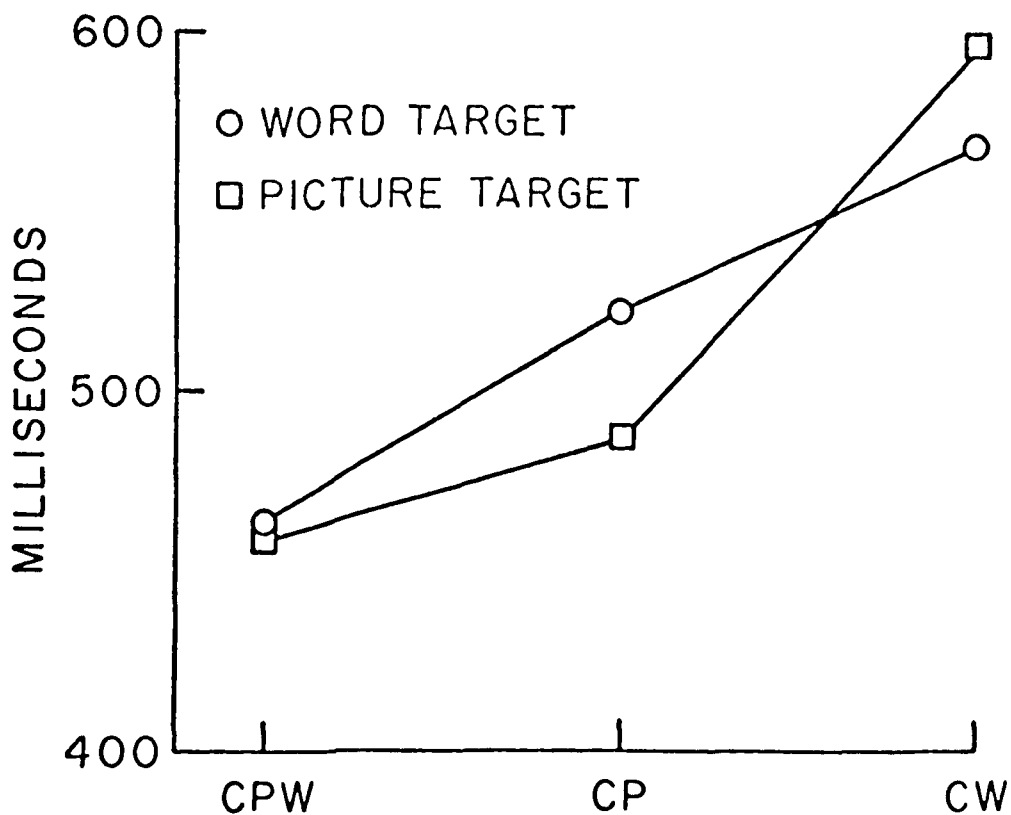
Figure 6. Manual Reaction Time in Milliseconds for
Sequential Responses for Three Congruent Con-
ditions. -- CPW designates both picture and
word congruent to the target, CP represents
picture congruent, and CW represents word
congruent.

lack, also, of an effect for blocking or randomizing pictures and words as targets.

For _different_ responses there was a significant target object effect, $F (4, 32) = 6.90$ $p < .01$. The stimulus target tree yielded slower RTs than any of the other objects (Tukey HSD); the latter did not differ significantly from each other. There was also a significant congruency effect, but the magnitude of the differences between the two conditions which required a _different_ response was small, $F (1, 8) = 6.96$ $p < .05$. The mean RTs were 630 and 640 msec. respectively. _Different_ responses were slower than _same_ responses. And the difference between the two different conditions was slight. These results support the contention that _same_ and _different_ judgments are distinct.

DISCUSSION

The basic Stroop paradigm was used to determine whether the Stroop effect holds for outline drawings and their corresponding word equivalents. The results confirmed this consistent with the findings of Stroop (1938). Words were found to be named slightly faster than pictures and incongruent words caused considerably more interference with picture naming than incongruent pictures did with word reading.

An attempt was made to determine the locus of the Stroop interference effect by varying the onset of the irrelevant stimulus relative to the stimulus to be named or read. It was found that maximal incongruent word interference occurred at preexposures of 100 msec., whereas interference produced by pictures was similar across onset conditions.

Dyer's (1973) finding of a greater delay in same-different matching caused by an irrelevant word than by an irrelevant color when the task was to match according to the opposite attribute is not replicated using pictures and words in a manual task. He interpreted his findings as indicating that colors are more likely to be encoded as words than are words to be encoded as colors. The reverse

appears to be the case for pictures and words in a manual
RT task. Words are more likely to be encoded in a form
more analogous to pictures, in a manual same-different
match, than pictures are to be encoded as words. This re-
sult is consistent with Seymour's (1970) finding where he
found a shape code to mediate matching better than a word
code.

Morton (1969) postulated a single response channel
to account for the Stroop interference effects. The faster
reading response tends to occupy the channel ahead of the
color naming response thus producing the interference.
Seymour (1973) modified Morton's model proposing different
routes for pictorial and verbal stimulus input to account
for the classical finding (Cattell, 1886) that naming ob-
jects is slower than reading the corresponding words.

A schematic representation of Seymour's (1973) model
appears in Figure 7. In Seymour's model, word input, after
having been graphically analyzed, proceeds directly to an
exit node which makes it available for vocal output. Pic-
ture input, to reach this same node, must first be pictori-
ally analyzed, proceed to the pictorial exit node and then
be interpreted by semantic memory before reaching the vocal
exit node. This added number of processing stages for
pictorial input is proposed to explain the finding that
naming is slower than reading as well as the Stroop inter-
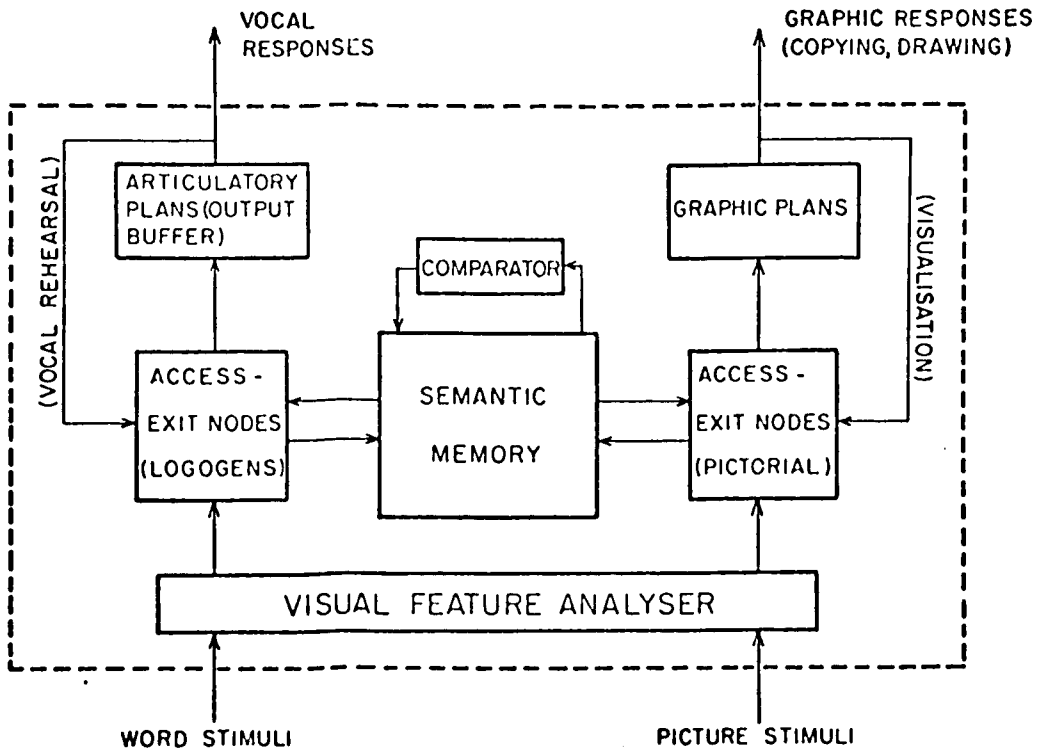ference effect. Simply stated, word input occupies the

Figure 7. Schematic Representation of Seymour's Logogen
Model for Naming, Reading and Comparison.
(After Seymour, 1973)

vocal output node faster than picture input and thus is produced faster.

The results of Experiment Two are consistent with the proposition that words enter the "logogen" vocal system readily and are easily available for vocal output. Entry of an incongruent word into this system before the picture is assured by preexposing the word. This would lead to maxi-, mum interference with the subsequent naming of a picture. Words postexposed do not interfere much, which is consistent with this prediction. Conversely, no such marked interference occurs for the task of word reading preceded by an incongruent picture. The slower times for incongruent pairings in this task are similar across all stimulus onset conditions suggesting an interference that occurs due to distinct initial processing of pictures and words. In short, words interfere maximally because they can enter the "logogen" system and compete with alternative processing. This appears to be an adequate explanation of the Stroop interference effect. Apparently pictures are not necessarily encoded in a form that readily occupies this "logogen" system. If the task is to name pictures, however, they do occupy this system but more slowly than do words.

Using Morton (1969) and Seymour's (1973) "logogen" terminology, encoded versions of incongruent words are incremented easily in "logogen" strength and thus compete for channel space with the not so fast pictures or colors. In

Seymour's model this is due to additional processing stages that pictorial information must undergo before reaching the "logogen" vocal output node. If the output is not vocal, but manual, then pictorially coded information might be similarly advantaged due to more direct incrementation in the corresponding pictorial "logogen" output node. This involves the proposition that the pictorial "logogen" system mediates manual same-different matches more efficiently than the vocal output system predicting faster manual RT based on pictorial coding. This was found here in Experiment Three, and has been found in physical-name match comparisons (Posner and Mitchell, 1967).

In summary, words are capable of producing substantial amounts of interference with processing in another mode, when the output is vocal. The locus of their interference could be a functional system such as the proposed vocal "logogen" output stage. Similarly, pictures are the more efficient stimuli in a manual task.

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