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SANDERS, ELIZABETH BAUER-NILSEN

THE EFFECT OF VERBAL ABILITY ON THE EFFICIENCY OF INTERPRETING VERBAL AND PICTORIAL STIMULI

The Ohio State University
Ph.D. 1981

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THE EFFECT OF VERBAL ABILITY ON THE EFFICIENCY
OF INTERPRETING VERBAL AND PICTORIAL STIMULI

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By
Elizabeth Bauer-Nilsen Sanders, B.A., M.A.

* * * * *

The Ohio State University
1981

Reading Committee:
Harvey G. Shulman, Adviser
Neal F. Johnson
Lester E. Krueger

Approved By

Harvey G. Shulman
Adviser

Department of Psychology
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VITA

March 18, 1953 ........ Born - Cincinnati, Ohio

1975 ............... B.A., Miami University, Oxford, Ohio

1975-1979 ........ University Fellowship, The Ohio State University, Columbus, Ohio

1975-1980 ........ Research Assistant, Human Performance Center, The Ohio State University, Columbus, Ohio

1977-1980 ........ Teaching Associate, Department of Psychology, The Ohio State University, Columbus, Ohio

1977 ............... M.A., The Ohio State University, Columbus, Ohio

PUBLICATIONS


FIELDS OF STUDY

Major Field: Human Experimental Psychology
Minor Field: Quantitative Psychology


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CHAPTER I

INTRODUCTION

The Skilled Reader's Decoding Advantage

Verbally skilled individuals access memory faster from visually presented stimuli than do less verbally skilled individuals. Known as a decoding advantage, this effect has been demonstrated both by Hunt (1978), using a comparison of high-verbal and low-verbal college students, and by Jackson and McClelland (1979) who compared fast and average readers from a university population. Converging evidence comes from studies of grade-school children. Perfetti and Hogaboam (1975) and Hogaboam and Perfetti (1979) found a decoding advantage for skilled readers in the third, fourth and fifth grades.

Verbal or nonverbal decoding advantage? The purpose of the present research was to explore the generality of the skilled reader's decoding advantage. Is the effect strictly limited to verbal stimuli or does it appear for all meaningful visual stimuli, such as pictures? The answer to this question has important implications with regard to models of individual differences in intelligence, models of picture and word encoding, as well as to methods of reading instruction.

Data from normal adult subjects. Data from studies supporting a skilled reader's verbal decoding advantage typically come from a comparison of skilled and less-skilled readers' performances on the Posner matching task. In the Posner letter-matching task (i.e., Posner
(Mitchell, 1967) it takes the average university student about 75 msec longer to indicate that the letters in the mixed-case pair (Aa) have the same name than it does to indicate that the letters in the same-case pair (AA) have the same name. These data show that it takes longer to make a name match when the stimuli first must be transformed into their name codes than it does when the stimuli can be matched, without naming them, on the basis of physical identity. Thus, the reaction time (RT) difference between name matches and physical matches (i.e., the NM-PM difference) can be thought of as reflecting the extra time needed in the decoding process.

Hunt, Lunneborg and Lewis (1975) reported that university students with high verbal aptitude scores showed a smaller NM-PM difference (64 msec) in the letter-matching task than did those with low verbal aptitude scores (89 msec). This effect was interpreted as indicating that high-verbal subjects have faster decoding processes than do low-verbal subjects. The effect has been replicated by Hunt and his colleagues, and also has been found to generalize beyond the university population (Hunt, 1978). For example, young adults not enrolled in a university show a larger NM-PM difference (110 msec) than do low-verbal university students, whereas 10-year-old children show quite a large NM-PM difference (190 msec) in comparison with the performance of young adults.

Although Hunt's (1978) data are sufficient to conclude that high-verbal subjects can decode verbal stimuli faster than can low-verbal subjects, the data do not indicate whether high-verbal subjects are more efficient decoders per se, or whether their decoding superiority applies only to verbal stimuli. Some data from a category-matching
task with word and picture stimuli suggest that the latter may be the case. In a test of Paivio's (1971) dual-coding hypothesis, Pellegrino, Rosinski, Chiesi and Siegel (1977) had subjects judge the semantic category identity (i.e., same versus different category) of pairs of items that were presented pictorially and verbally. They found that word-word latencies were 185 msec slower than the corresponding picture-picture response times, whereas word-picture and picture-word latencies equalled the mean of the two extremes. Pellegrino et al. (1977) interpreted their data as support for a single rather than a dual memory model. Rader (Note 3) used graduate students with very high verbal aptitude scores as subjects in a similar task and found no significant difference for word-word as opposed to picture-picture response times. These results suggest that the relative efficiency of decoding verbal, but not pictorial, information is a function of verbal ability. Rosinski, Pellegrino and Siegel (1977) have, in fact, shown that the word-word versus picture-picture difference in the category-matching task is about 240 and 400 msec for fifth and second graders, respectively.

The above data suggest that the skilled reader's decoding advantage applies to verbal decoding alone rather than to decoding in general. To test whether the decoding advantage of the skilled reader is a verbal (as opposed to both verbal and nonverbal) phenomenon, one could conduct a decoding experiment and look for picture-word differences as a function of verbal ability. If the skilled reader's decoding advantage is strictly a verbal phenomenon, one should find the usual skilled reader RT advantage for the verbal stimuli but not for the nonverbal or pictorial stimuli. On the other hand, if the skilled reader's decoding
advantage applies to decoding in general, one should find a skilled reader RT advantage for both the verbal and pictorial stimuli. This hypothesis has been tested twice with contradictory outcomes.

Hogaboam and Pellegrino (1978) grouped university students according to their scores on the Scholastic Aptitude Test (SAT). The 10 subjects in the high-verbal group had an average percentile rank of 93, whereas the 10 low-verbal subjects had an average percentile rank of 39. They made semantic category decisions about single picture and word stimuli. On each trial, one of 11 category names was spoken by the experimenter, followed by either a word or a picture. The subject's task was to indicate, with a button press response, whether the visually presented stimulus was or was not an instance of the category. The results showed no effect whatsoever for the verbal ability factor.

Thus, Hogaboam and Pellegrino (1978) failed to replicate the skilled reader's verbal decoding advantage reported by Hunt, Lunneborg and Lewis (1975), and later replicated by Hunt (1978) and by Jackson and McClelland (1979). Therefore, the fact that no verbal ability differences were found for semantic category decisions about pictures, either, must be interpreted with caution. Hogaboam and Pellegrino (1978) could offer only a post hoc explanation of their failure to find any effect of verbal ability on the speed of semantically processing words and pictures. They argued that their categorization task was a reflection of the normal manner of processing picture and word stimuli in everyday activity, while the letter-matching task used by Hunt et al. (1975) did not reflect the normal manner of letter processing. Thus, verbal ability differences only showed up in the latter task where high-verbal subjects supposedly adapted better to the unnatural task demands.
On the basis of their results, Hogaboam and Pellegrino (1978, p. 193) chose to "emphasize the difficulty of concluding that verbal ability is unambiguously associated with the speed of accessing long-term memory codes for a variety of verbal and nonverbal stimuli."

A second attempt to determine whether the skilled reader's decoding advantage applies to more than verbal stimuli was reported by Jackson (1980). Since Jackson and McClelland (1979) had already found a skilled reader's decoding advantage for verbal stimuli, Jackson (1980) compared picture decoding times for skilled and less-skilled readers with a picture category matching task. The stimuli included pictures of common objects from six categories. On each trial, a pair of pictures was shown and the subject's task was to indicate whether the pictured objects belonged to the same or different categories. Jackson assumed that RT in this task would primarily reflect the speed of accessing the memory representations for the pictured objects. The results showed a 104 msec difference in favor of the skilled readers on the picture category matching task. Thus, Jackson (1980) concluded that skilled readers have a general decoding advantage over less-skilled readers for meaningful visual patterns.

It is possible, however, that RT in Jackson's experiment reflected not only the speed of accessing memory but also the speed of retrieving and comparing category names. The skilled reader advantage might have been caused by this later verbal process. Some support for this notion can be found in an experiment reported by Perfetti and Lesgold (1977) using fourth-grade subjects varying in reading skill (as defined by their scores on a reading comprehension test). In a matching task, subjects had to decide whether a visually presented word or picture
matched an orally presented target. In a categorization task, the same subjects were to decide whether a visually presented word or picture matched an orally presented target category. In both tasks, a timed button press response was used. The result of interest to the present discussion was that no RT difference between the reading groups was observed for picture stimuli in the matching task, whereas a 103 msec difference in favor of the skilled reading group was observed for picture stimuli in the categorization task. Thus, Perfetti and Lesgold (1977) found an effect of verbal skill in a picture categorization task but not in a picture matching task. Perhaps picture categorization entails two operations—memory access for the pictured object and retrieval of the category name. The verbal ability differences in picture categorization reported both by Jackson (1980) and by Perfetti and Lesgold (1977) may have been caused by differences in the speed with which subjects retrieved the category names of the pictured objects.

In summary, attempts made to discover whether the skilled reader's decoding advantage is strictly a verbal phenomenon permit no clear conclusion. Neither Hogaboam and Pellegrino nor Jackson found an interaction between verbal ability and type of stimulus (pictures versus words). However, each of their studies can be faulted on either empirical or methodological grounds.

Data from dyslexic children and adults. There exists a large body of literature, usually considered separately from basic research on normal cognitive processes, which is nonetheless relevant to a discussion of the skilled reader's decoding advantage. Dyslexia, both developmental and acquired, has been studied for years. Not until recently, however, have cognitive information-processing paradigms been
used to study dyslexic individuals. Caution must be exercised in coming
to conclusions about skilled versus less-skilled normal readers on the
basis of data collected from normal versus dyslexic children. Low-
verbal college students clearly need not have been dyslexic children,
yet it is still possible that consideration of dyslexia will reveal the
existence of cognitive processes responsible for variability in verbal
skill among normal readers. A second reason for considering dyslexia
research in a study of adult verbal ability differences is that any
model of verbal ability differences will be more useful if it can say
something about the causes of verbal ability disorders.

Vellutino (1977) reviewed and evaluated research on developmental
dyslexia with regard to the four most prevalent explanations: visual
perception, intersensory integration, temporal-order perception and
verbal functioning. According to the visual perception explanation,
reading disability is caused by visual-spatial confusion operating at a
perceptual level (e.g., Orton, 1925). Vellutino (1977) presents evi-
dence supporting the idea that it is visual-verbal rather than visual-
spatial relationships that are confused in the dyslexic reader.
According to the intersensory integration explanation, reading
disability results from a failure to integrate information from
different sensory systems (Birch, 1962). This theory, however, fails
to account for the fact that associative learning of pairs of nonverbal
stimuli from different sensory modalities is equally efficient in normal
and dyslexic readers (e.g., Vellutino, Harding, Phillips, & Steger,
1975). The third explanation of dyslexia attributes reading disability
to a problem in the perception of temporal order (e.g., Bakker, 1972).
Bakker's view is that temporal-order perception is a left or language-
dominant hemisphere function and that dyslexia is caused by a dys-
function in that hemisphere, resulting in sequencing problems for verbal
stimuli. More recently, Holmes and McKeever (1979) compared adolescent
dyslexic and normal readers on four tasks defined by the factorial
combination of serial versus general memory and verbal versus nonverbal
stimuli. The groups differed on only the task requiring serial memory
of verbal stimuli. Vellutino (1977) favors the fourth theory of dyslexia
which attributes the reading disability to deficiencies in verbal
processing. In support of the verbal-deficit explanation, he reviews
data showing impaired performance by poor readers on tasks requiring
semantic, syntactic, as well as phonological processing.

In summary, much data exists which supports a verbal-deficit expla-
nation of dyslexia. Very little data exists which suggests that the
deficit may apply also to nonverbal stimuli and/or tasks. Consequently,
an extrapolation of the data collected about developmental dyslexia indi-
cates that the skilled reader's decoding advantage may be a verbal
rather than a general decoding advantage.

Vellutino's (1977) verbal-deficit hypothesis has little to say
about the cause of this. Others have suggested that dyslexic children
may be trying to read with a cognitive style characteristic of the
right, non-language hemisphere (Witelson, 1977; Guyer and Friedman,
1975; Kershner, 1977). Studies of acquired dyslexia are relevant to
this issue because they show what happens when the left hemisphere
becomes impaired. Striking similarities between the verbal behavior
of adults with acquired dyslexia and children with reading disabilities
have been recently reported. For example, Shallice and Warrington
(1975) and Patterson and Marcel (1977) have shown that patients with
one type of acquired dyslexia, phonemic dyslexia, are specifically
impaired in their ability to use grapheme-phoneme correspondence rules.
Snowling (1980) has shown that dyslexic children also have a specific
difficulty in the grapheme-phoneme conversion. She also showed that
the improvement in reading performance with age results from different
factors in normal and dyslexic subjects. In normal readers, the use
of grapheme-phoneme correspondences increases with age, whereas in
dyslexic readers it does not. Snowling (1980) suggested that dyslexic
subjects improve in reading performance by increasing the number of
words they can read by sight (i.e., via a direct semantic route).

Richardson (1975a, 1975b) has shown that word imageability and
frequency affect the reading performance of adults with acquired
dyslexia. He suggested that the patients were "making up a mental image
corresponding to the presented word, and naming the object imaged"
(1975a, p. 281). Jorm (1977) found that although word frequency had
an effect on both good and poor young readers, word imageability
affected the reading performance of only the poor readers. He inter-
preted these results as showing that good readers rely on a strategy of
phonics (i.e., grapheme-phoneme conversion) whereas poor readers read
by the whole word method (i.e., direct grapheme-semantic pathway).
Jorm (1977) also reported no performance differences between his good
and poor readers when both groups were forced to use direct grapheme-
semantic encoding.

Thus, studies of developmental dyslexia suggest that the disorder
is specific to verbal-encoding processes. There is evidence supporting
the idea that dyslexic children may be reading in a cognitive style
characteristic of the non-dominant hemisphere. These data suggest
that the skilled reader's decoding advantage is a verbal phenomenon that may be linked to the use of different cognitive styles by individuals of varying verbal skill.

A Test of the Skilled Reader's Decoding Advantage

The present experiments were designed to test the hypothesis that the decoding speed advantage commonly observed for verbally-skilled individuals is restricted to verbal rather than general encoding processes. The experimental paradigms were chosen in the hope that the resulting data might reveal where in the encoding process it is that high-verbal and low-verbal subjects differ.

The tasks. The first experiment can be described as a name-matching task with verbal and pictorial stimuli. The task is analogous to Posner's (e.g., Posner and Mitchell, 1967) letter-matching task, with pictures and their verbal labels being substituted for upper- and lowercase letters. The verbal and pictorial stimuli used can be seen in Figure 1. The second experiment can be called a format-matching task with verbal and pictorial stimuli. Here subjects responded "same" to stimulus pairs consisting of either two words or two pictures and "different" to pairs composed of a word and a picture. Both tasks were performed by both high-verbal (HV) and low-verbal (LV) subjects.

Posner's theory of isolable processing codes. Information can be thought of as being represented internally by various codes or formats. Posner has shown that the internal codes arising from the same stimulus event are functionally independent and, hence, can be experimentally isolated and manipulated (Posner, 1978, Chapter 2). Any given stimulus event can be described as having at least the following three stimulus codes. First is the trace of the particular stimulus, second is the
physical code and third the name code (Posner and Warren, 1972). Each stimulus event gives rise to a unique trace. The ensuing physical code is determined by the form and modality of the trace. For example, the word DOG presented auditorily, the word DOG presented visually, and a picture of a dog will all result in different physical codes. These three physical codes will, however, be associated with the same name code for the concept DOG. Decoding is defined as the process by which the stimulus trace activates its name code.

In the Posner letter-matching task, subjects are faster in responding "same" to two physically identical letters than to two letters having only a common name (e.g., Posner and Mitchell, 1967). The 70 to 100 msec RT difference between physical match (PM) and name match (NM) pairs is typically referred to as the NM-PM difference. Posner has offered two explanations of the NM-PM difference. He first attributed the effect to a difference in the levels of processing reached for PM and NM pairs. Presumably, physical matches were made on the basis of physical codes whereas name matches were made using name codes. More recently, Posner and Snyder (1975) have explained the NM-PM difference in terms of an effect of pathway facilitation. According to the pathway facilitation explanation, physical matches are faster than name matches because "... two identical letters will share more of the same pathways than letters that agree only in name" (Posner and Snyder, 1975, p. 72). The advantage due to pathway facilitation is typically in the range of 30-50 msec. Thus, Posner and Snyder (1975) have suggested that both components, levels of processing and pathway facilitation, contribute to the 70-100 msec NM-PM difference.
According to Posner's (e.g., 1978) theory of codes, independent processing systems operate in parallel to extract physical and name codes from a given stimulus event. Posner (1970) has suggested also that the operations of stimulus naming and classification work in parallel. For example, Posner (1970) showed that naming precedes classification when a vowel/consonant classification is made whereas classification either precedes or proceeds in parallel with naming when a letter/digit classification is made. More recent evidence suggests that the naming operation may be automatic in the sense that it "... may occur without intention, without giving rise to conscious awareness, and without producing interference with other ongoing mental activity" (Posner, 1978, p. 91). Thus, when subjects are asked to classify stimuli, they automatically decode these stimuli at the same time. In some cases (e.g., vowel/consonant classification) stimuli are decoded before they are classified. In other cases (e.g., letter/digit classification), decoding may not be complete until after the stimuli have been classified.

Predictions. In the name-matching task with verbal and pictorial stimuli, a larger NM-PM difference is expected for LV than for HV subjects. If physical matches are made on the basis of physical codes, there should be no effect of verbal ability on the speed of making physical match decisions for either words or pictures. In the picture-word version of the Posner matching task, name match pairs consist of a word and picture denoting the same object. LV subjects are expected to be slower in making name matches than HV subjects because of the verbal decoding involved. Thus, the larger NM-PM difference predicted
for LV subjects is expected to be caused primarily by longer NM decision times for these subjects.

The verbal decoding hypothesis makes several predictions about the different-name data in the picture-word version of the Posner matching task. If verbal ability differences in decoding speed are found for verbal, but not nonverbal, stimuli, there should be no effect of verbal ability on the time it takes to decide that two pictures differ. However, it is expected that LV and HV subjects will differ in the speed of deciding that two words name different objects and that a word and picture refer to different objects.

The format-matching task was designed to reveal a Stroop-like interference effect. Hunt, Lunneborg and Lewis (1975) suggested, but did not test, the idea that HV subjects, being faster verbal decoders, should show more interference than LV subjects in a Stroop color naming test. In the format-matching task, subjects must classify each stimulus (i.e., picture or word?) and then compare classifications (i.e., same or different?) before responding. According to Posner (1970), stimulus decoding occurs in parallel with stimulus classification. Interference could result if the decoding operation is at least as fast as the classification operation and if the two processes come up with conflicting information. For example, interference could result when a word and a picture (i.e., different format) have the same name or when two words or two pictures (i.e., same format) have different names. According to the verbal decoding hypothesis, HV subjects decode verbal stimuli more quickly than do LV subjects. Therefore, greater interference effects are predicted for HV than for LV subjects on those potentially interfering stimulus pairs having at least one verbal member.
Posner and Mitchell (1967) showed that the physical match strategy seems to operate whenever identical stimuli are presented, regardless of the dimension on which the stimuli are matched. Assuming this to be true in the format task, there should be no effect of verbal ability on the speed of making format-match decisions for physically identical word or picture pairs. If responses to identical stimulus pairs are made at the physical code level in both tasks, then RT to the identical pairs are not expected to differ between the name-matching and format-matching tasks.
CHAPTER II

METHOD

Subjects

Since scores for the Scholastic Aptitude Test (SAT) were not available for many of the potential subjects, a sample test from an SAT Study Guide (Turner, 1977) was administered to a group (n = 156) of introductory psychology students at The Ohio State University. All students obtained course credit for their participation in the test of verbal ability. They were informed that a select group would be contacted concerning their performance in a second phase of the study. Students were specifically told that this select group would not include only the top performers and that they should do their best. One student was omitted from the sample for sleeping.

The verbal ability test was made up of six subtests: two vocabulary, two reading comprehension, one English usage and one sentence correction test. Four- and five-choice questions were used. The guessing rate corresponds to 21% correct answers. The mean score corresponded to 53% correct answers with a range of 26% to 77% correct. No subjects were excluded from the sample for guessing performance.

Subjects selected for the second phase of the experiment were chosen from those scoring in the top 20% (the high-verbal or HV group) and those scoring in the bottom 20% (the low-verbal or LV group). Sixteen subjects in each group participated in Experiments I
and II. They received either course credit or cash for their participation in the second part. Subjects were informed neither of their performance on the verbal ability test nor why they were selected for the second phase until after they had participated in both experimental tasks.

Each verbal ability group was made up of eight male and eight female subjects. All 16 high-verbal subjects claimed to be right-handed. In the low-verbal group there were three left-handed males, one left-handed female and one ambidextrous female.

Materials

The nine picture-word pairs used in both the name and format tasks are displayed in Figure 1. Eight stimulus pair types resulted from the crossing of three factors: picture versus word, same versus different name, and same versus different format. Examples of each pair type are shown in Figure 2. The three letter names for each pair type are to be interpreted as follows. The first letter refers to whether the upper stimulus is a picture (P) or a word (V) and the second letter gives the same information for the lower stimulus. The third letter tells whether the pair of stimuli have the same (S) or different (D) names. Thus, VPS refers to a stimulus pair having a word above a picture where the word names the picture.

Stimulus lists were constructed in the following manner. With nine picture-word pairs, 36 unique same name pairs can be constructed, i.e., nine each of types PPS, VVS, PVS and VPS. Each of the four stimulus lists contained these 36 same name pairs. Note that half of the same name pairs have the same format and half have different formats. With nine picture-word pairs, 288 unique different name
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**Figure 1**: The picture and word stimuli used in the name and format tasks.
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<td>5. VPS</td>
<td>triangle</td>
</tr>
<tr>
<td>2. PPD</td>
<td>□</td>
<td>6. VPD</td>
<td>square</td>
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<tr>
<td>3. PVS</td>
<td>△</td>
<td>7. VVS</td>
<td>triangle</td>
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<tr>
<td>4. PVD</td>
<td>□</td>
<td>8. VVD</td>
<td>square</td>
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*Figure 2:* The stimulus pair types for the name and format tasks.
pairs can be constructed. Four sets of 36 different name pairs were used, one set per stimulus list, with each set containing nine each of types PPD, VVD, PVD, and VPD. As was true of the same name pairs, half of the different name pairs have the same format and half have different formats. Four stimulus lists resulted from combining the 36 same name pairs in turn with each of the four sets of 36 different name pairs.

Each list contained 72 pairs, half with the same format and half with different format. Any given subject saw only one stimulus list for each of the five blocks per experiment, ensuring that same and different name pairs would receive equal practice. Each subject saw the same stimulus list in each task, also, to ensure that intra-task comparisons could be made. Figure 3 shows how the same stimulus pairs were responded to in the name and format tasks.

**Design**

In order to minimize any potential effects of one task upon the other, subjects came for two sessions one week apart. The order in which they received the tasks was counterbalanced and treated as a factor (day). Thus, Day 1 refers to the first experimental session and Day 2 to the second session one week later. Subjects were nested under a crossing of the verbal ability and day factors. That is, half of the HV subjects performed the name task first and the format task a week later whereas the other half of the HV subjects performed the format task followed by the name task. The same was true for the LV subjects. All other factors were crossed with subjects and with every other factor. The design of both experimental tasks was the same. The three stimulus factors included name (same vs. different), format
**Figure 3:** Response assignments for each type of stimulus pair in the name and format tasks.
(same vs. different) and type, where Type 1 refers to those stimulus pairs having a picture in the top display position and either a picture or word in the bottom position and Type 2 to those pairs having a word in the top display position and either a word or picture in the bottom position. Since subjects saw the same stimulus list for five blocks of trials, the effect of practice could be ascertained, as well. Two dependent variables, RT and error rate, were analyzed using this experimental design.

Before each experimental session, subjects were instructed about the response rule for the task to be performed. Subjects in the name task were told to make a positive response whenever the stimuli in the pair had the same name and a negative response for different name pairs. Half of the subjects within each verbal ability by day group used the index finger of their preferred hand for a positive response. The other half used their nonpreferred index finger. Subjects in the format task were told to make a positive response whenever two words or two pictures appeared together and a negative response when the stimulus pair was made up of a word and a picture. Those subjects who used their preferred hand for a positive response in one task also used that hand for a positive response in the other task. A chart similar to Figure 1 was shown to each subject to familiarize him or her with the stimuli to be seen in the experiment. Following the instructions and stimulus familiarization, each subject participated in nine practice trials of the current task. One of each of the nine stimulus pair types was shown on flash cards and subjects responded verbally in the practice set.
For each task subjects participated in five blocks of 72 trials apiece. The order in which the stimulus pairs were presented was randomized anew for each block. The stimuli were presented on a cathode ray tube (CRT) display controlled by a NOVA computer. The sequence of events that took place on each trial was as follows. A warning signal (+++++) was presented for 500 msec, followed by a 500 msec blank interval. A stimulus pair was then displayed for two seconds. The members of each stimulus pair were centered and presented one above the other. Subjects had two seconds in which to make a button-press response. If they exceeded the time limit or responded incorrectly, an error message (E) was presented. No feedback was given for correct responses. The warning signal appeared again 500 msec after the offset of the preceding stimulus display, initiating a new trial. At the end of each block of trials, subjects were given a short rest and were informed of their mean correct RT and number of errors. They were urged in both tasks to respond as quickly as possible while keeping errors at a minimum. Each experimental session lasted about 45 minutes. Following each session, if time permitted, subjects were asked the following questions: Did you have a strategy for performing this task? If so, can you briefly describe it? Any other comments?
CHAPTER III

RESULTS

Name Task

The mean of median RT data and percent error data averaged over day and practice are shown in Table 1. The upper panel shows the name task data for the HV subjects and the lower panel shows the data for the LV subjects.

A reliable main effect of same vs. different format was evident in both the RT and error data. Some format pairs were responded to 160 msec faster than different format pairs, $F(1,28) = 458.26$, $\overline{MS_e} = 17864.95$, $p < .001$, and fewer errors were made on same format (1.3%) than on different format (5.8%) pairs, $F(1,28) = 88.46$, $\overline{MS_e} = 0.5788$, $p < .001$. This large effect of format on name matching will be referred to as the recoding effect. Presumably, the slower, less accurate responses to different format pairs reflect the operation of recoding picture-word pairs into a common format. Four first-order interactions involving the recoding effect were significant in the RT data. The interaction between the same-different format and name factors, $F(1,28) = 9.64$, $\overline{MS_e} = 12234.02$, $p < .01$, shows a larger recoding effect for same name (179 msec) than for different name pairs (141 msec). The larger recoding effect for same name pairs includes within it an effect of pathway facilitation since same-name, same-format pairs are physically identical. The 141 msec recoding effect for
Table 1: RT in msec and percent error data (in parentheses) for the eight stimulus pair types in the name-matching task. Data for high- verbal subjects are shown in the upper chart. Data for low-verbal subjects are shown in the lower chart.

### HIGH-VERBAL SUBJECTS

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<th>Different Format</th>
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### LOW-VERBAL SUBJECTS

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<td>Different Name</td>
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<td>770 (1.7)</td>
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different-name different-format pairs, however, represents a more direct estimate of recoding time. Subtracting the different name recoding time estimate from the same name estimate gives a difference of 38 msec for the pathway facilitation effect. A second two-way interaction occurred between the format and type factors, $F(1,28) = 22.93$, $MS_e = 3496.02$, $p < .001$. Here it is shown that stimulus type (i.e., picture vs. word in the top display position) had no effect on recoded (i.e., different format) pairs, but that pairs of pictures were responded to more quickly than pairs of words. There was also an interaction between format and verbal ability, $F(1,28) = 7.37$, $MS_e = 17864.95$, $p < .05$. This important interaction shows that LV subjects took longer to recode than did HV subjects. Since recoding involves a translation between a verbal and a pictorial code, this finding indicates that HV subjects had a verbal recoding advantage. The final interaction, involving format and days, $F(1,28) = 5.25$, $MS_e = 17864.95$, $p < .05$, shows that recoding took longer for subjects who performed the name task in the second session than it did for subjects who performed the name task first. Perhaps prior format task performance interfered with name task performance because subjects persisted in attending to the irrelevant format dimension (Krueger, Note 1).

The main effects of both the same vs. different name, $F(1,28) = 166.04$, $MS_e = 10573.91$, $p < .001$, and verbal ability factors, $F(1,28) = 6.34$, $MS_e = 305969.10$, $p < .05$, as well as the interaction between these factors, $F(1,28) = 7.67$, $MS_e = 10573.91$, $p < .01$, were reliable in the name task RT data. This pattern of effects shows that HV subjects took 60 msec longer in responding to different name than to same name pairs, but LV subjects took as long in responding to same name
pairs as the HV subjects took for different name pairs. LV subjects needed an additional 90 msec to respond to different name pairs. Overall, HV subjects responded about 80 msec faster than LV subjects.

In the RT data the reliable main effect of stimulus type, $F(1,28) = 14.88$, $MS_e = 3669.28$, $p < .001$, and the significant interaction between the type and same-different name factors, $F(1,28) = 7.75$, $MS_e = 3792.51$, $p < .01$, are by-products of the reliable three-way interaction between the type, name and format factors $F(1,28) = 12.87$, $MS_e = 3779.88$, $p < .01$. This interaction shows that stimulus type (i.e., picture or word in the top display position) affected response times only for same format stimuli with different names, and here type PPD pairs (two different pictures) were responded to more quickly than type VVD pairs (two different words). Thus, pair types PPS (identical pictures) and VVS (identical words) were responded to equally fast, RTs to pair types PVS and VPS (picture and word with the same name) were identical, and pair types PVD and VPD (picture and word with different names) were responded to in the same amount of time. Apparently, stimulus type had no effect on different format pairs where recoding took place, or on same format pairs with the same name where some operation unique to physically identical stimuli occurred. In the RT data, the type and format factors interacted also with verbal ability, $F(1,28) = 15.30$, $MS_e = 3496.02$, $p < .001$. This interaction shows that stimulus type had no effect on RT to different format (i.e., recoded) pairs for either HV or LV subjects, whereas stimulus type did have an effect on same format pairs, but only for the LV subjects, who responded more slowly to two words than to two pictures. This finding provides support for the verbal decoding hypothesis in showing a less-skilled
reader's verbal decoding speed disadvantage. In the error data there was only one effect involving the type factor. The reliable interaction between the type and verbal ability factors, $F_{(28)} = 4.37, \text{MS}_e = 0.1833, p < .05$, showed that LV subjects were more accurate on those stimulus pairs having a word in the top display position, whereas HV subjects did not differ in accuracy between pairs with a word and pairs with a picture in the top display position.

In both the RT and error data, reliable main effects of practice were found. The speed of making name-match responses improved on each succeeding block of trials, $F(4, 112) = 38.01, \text{MS}_e = 14763.75, p < .001$. Error rates decreased over blocks, as well, with the exception of a slight increase in error rate on the fourth out of five blocks, $F(4, 112) = 8.06, \text{MS}_e = 0.3607, p < .001$. An interaction between the practice and name factors was evident in both the RT, $F(4, 112) = 2.92, \text{MS}_e = 2514.83, p < .05$, and error data, $F(4, 112) = 3.56, \text{MS}_e = 0.2157, p < .01$. The RT interaction revealed that responses to the slower different-name pairs improved more with practice than did responses to same-name pairs. The error rate interaction revealed that the spuriously high error rate on the fourth block of trials was caused by erroneous responses to same name, and not to different name, stimulus pairs. Two other first-order interactions involving the practice factor were significant in the name task RT data. The practice by verbal ability interaction, $F(4, 112) = 4.17, \text{MS}_e = 14763.75, p < .01$, showed that LV subjects showed more RT improvement over blocks than did HV subjects, although LV subjects were still slower than HV subjects by the final block of trials. The day by practice interaction, $F(4, 112) = 12.05, \text{MS}_e = 14763.75, p < .001$, revealed that subjects who
performed the name task first started out slower but ended up faster in making name match responses than subjects who performed the name task second.

In the RT data there were also three reliable second-order and one significant third-order interactions involving the practice and same vs. different name factors. Each of these higher-order interactions represented a slight variation on the overall practice by name interaction (i.e., different name pairs improved more with practice than did same-name pairs). In the error data two third-order interactions involving the practice factor were significant. These interactions did not change the direction of any of the lower-order error rate effects. No other main effects or interactions were reliable in the name task RT and error data.

**Summary.** The following three predictions were made about the name task data: The HV and LV subjects were not expected to differ in the speed of responding to physically identical pairs. The LV subjects were predicted to show a larger NM-PM difference than the HV subjects. An effect of verbal ability was not predicted for type PPD pairs (two different pictures), but was predicted for the different name pairs having at least one verbal member (i.e., pair types VVD, PVD and VPD). The first prediction was made also in connection with the format-matching task. Responses to physically identical pairs from both tasks were entered into a separate analysis. This physical match analysis will be discussed later, following a presentation of the format task data. The second prediction, i.e., a larger NM-PM difference for LV subjects, was confirmed. The NM estimate was obtained by averaging over pair types PVS and VPS (picture and word with the same name) whereas the PM
estimate represents an average of types PPS (identical pictures) and
VVS (identical words). The resulting NM–PM differences were 160 msec
for HV subjects and 198 msec for LV subjects. By the Tukey test,
this difference is reliable, q crit (.01,8,28) = 5.54, q obs (28) =
9.22. The third prediction of verbal ability differences on pair
types VVD, PVD and VPD, but not type PPD pairs, was partially confirmed.
The data showed that HV subjects were 54 msec faster than LV subjects
on PPD pairs (two different pictures), 91 msec faster on VVD pairs
(two different words), 119 msec faster on PVD pairs (picture and
word with different names), and 112 msec faster on VPD pairs (word and
picture with different names). The Tukey test shows that the 54 msec
difference on type PPD pairs was, contrary to expectation, reliable,
q crit (.01,16,28) = 6.14, q obs (28) = 16.67. However, the verbal
ability difference on type PPD pairs was also reliably smaller than any
of the other pair type differences between HV and LV subjects, q crit
(.01,16,28) = 6.14, q obs (28) = 11.42.

Stronger support for the verbal decoding hypothesis can be found
in the reliable interaction between the type, format and verbal ability
factors. This interaction showed that although stimulus type had no
effect on responses to recoded (i.e., different format) pairs, stimulus
type was a factor on RTs to same format pairs— but only for the LV
subjects, who responded more slowly to pairs composed of two words than
to pairs made up of two pictures.

More important, however, than the confirmation of predictions was
the large effect of recoding in the name task analysis. The recoding
operation implies a preceding format decision (e.g., Swanson, Johnsen
and Briggs, 1972). One must know whether a pair of stimuli are of the
same or different formats in order to decide whether or not to recode. A second finding of theoretical interest was the same-different format by verbal ability interaction that showed LV subjects were slower recoders than HV subjects. A larger NM-PM difference was observed for LV than for HV subjects, also. As mentioned earlier, the same name recoding effect or the NM-PM difference in the picture-word name-matching task is made up of two components—a recoding effect and an effect of pathway facilitation. Thus, the above findings suggest that verbal ability differences arise primarily in the recoding component of the NM-PM difference. An estimate of the pathway facilitation effect can be obtained by subtracting the different name recoding time estimate from the same name recoding time estimate or the NM-PM difference. Using this method, similar pathway facilitation estimates are obtained for the HV (160 - 119 = 41 msec) and the LV (198 - 162 = 36 msec) subjects. Thus, the larger NM-PM difference found for LV subjects can be attributed primarily to longer recoding times for these subjects in the picture-word name-matching task.

The format-matching task was designed under the assumption that the operations of naming and classifying pictures and words are independent and parallel processes. The existence of a recoding effect in the name task, however, raises doubts about this most basic assumption. The recoding operation implies that pictures and words are classified by format before they are decoded, i.e., a serial model. If classification by format precedes decoding for picture and word stimuli, responses in the format-matching task ought to be much faster than responses in the name-matching task since the format response is based on a comparison of classifications and the name response is based on a comparison of
name codes. If picture-word classification and decoding are serial processes, it is not clear whether any of the predicted interference effects due to conflicting name and format information will be found.

**Format Task**

The mean of median RT data and percent error data averaged over day and practice are shown in Table 2 for the format-matching task. The top chart shows the data for the HV subjects and the lower chart contains the data for the LV subjects. A comparison of Tables 1 and 2 reveals that subjects were much faster and more accurate at making format task than name task decisions. The average RT in the format task was 535 msec (with 2.1% errors), nearly 200 msec faster than the average RT in the name task, which was 732 msec (with 3.5% errors). The RT difference between tasks was in the same direction for every subject. The mean RT difference between tasks was larger for LV (230 msec) than for HV (165 msec) subjects, t(30) = 2.30, p < .05.

The format task data were analyzed in two ways: same and different responses were analyzed separately and all responses were analyzed together. Results of the separate analyses will be reported because they isolate several interesting effects not readily apparent in the overall analysis. There were no reliable main effects or interactions in the overall analysis that were not also reliable in the separate analyses. Results of the overall analysis are shown in the Appendix.

**Same Format Data**

In the same format analysis a main effect of same vs. different name was reliable in both the RT, F(1,28) = 79.10, MSe = 3303.44, p < .001, and the error data, F(1,28) = 17.30, MSe = 0.2442, p < .001. Responses to same format pairs with the same name were 40 msec faster
Table 2: RT in msec and percent error data (in parentheses) for the eight stimulus pair types in the format-matching task. The upper chart shows the data for high-verbal subjects. The lower chart shows the data for low-verbal subjects.

### HIGH-VERBAL SUBJECTS

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and more accurate (1.3% errors) than responses to pairs with different names (3.1% errors). "Same" responses to physically identical pairs were 40 msec faster than "same" responses to nonidentical pairs. Thus, the same-different name effect can be attributed to pathway facilitation.

The stimulus type and verbal ability factors interacted significantly in the same format RT data, $F(1,28) = 6.45$, $MS_e = 3348.16$, $p < .05$. This interaction revealed that HV and LV subjects took exactly the same amount of time in responding to two pictures, but that LV subjects were slower than HV subjects in responding to two words. The type and verbal ability factors did not interact with the name factor ($F < 1.0$), showing that this pattern held for both same and different name pairs. These findings show that although both groups of subjects were equally fast in deciding that a visual stimulus represents a picture, LV subjects were slower in deciding that a visual stimulus represents a word. The error data showed a reliable main effect of verbal ability, $F(1,28) = 12.05$, $MS_e = 0.4067$, $p < .01$. Although the two groups did not differ in speed, LV subjects responded to same format pairs more accurately than did HV subjects.

The same format RT analysis showed a significant main effect of day, $F(1,28) = 11.02$, $MS_e = 115784.60$, $p < .01$. Subjects performing the format task in the first experimental session responded more slowly than those who performed the format task second. A reliable main effect of practice was evident in the RT data, as well, $F(4,112) = 35.05$, $MS_e = 6542.81$, $p < .001$. Same format responses improved in speed on each successive block of trials. The practice factor interacted in the RT data with name, $F(4,112) = 3.30$, $MS_e = 1218.55$, $p < .05$, with verbal ability, $F(4,112) = 5.36$, $MS_e = 6542.81$, $p < .001$, and with day,
$F(4,112) = 6.23, MS_e = 6542.81, p < .001$. The interaction between the practice and name factors showed that RTs to different name pairs improved more with practice than did RTs to same name pairs. The practice x verbal ability interaction revealed that LV subjects improved more with practice than did HV subjects. The interaction between the practice and day factors showed that subjects who performed the format task in the first session showed more improvement in their response times (than subjects who performed the format task second) as a function of practice. By the final block of trials, however, day one subjects still responded more slowly than did day two subjects.

The only other reliable effect in the RT and error data of the same format data analysis was an interaction in the error data between the name, type and practice factors, $F(4,112) = 2.72, MS_e = 0.1902, p < .05$. This interaction was caused by a preponderance of errors on type PPD pairs (two different pictures), but only on the first three blocks of trials. This effect may have been caused by interference between name and format information since subjects responded "same" (i.e., same format) to a pair of different objects on type PPD pairs. The interaction suggests that subjects learned with practice to ignore this source of interference. In fact, several subjects described their strategy in the format task as one of trying to ignore the meanings of the words and pictures.

**Summary.** Two predictions were made about the same format data. The prediction that verbal ability would have no effect on RTs to physically identical pairs will be discussed following the later presentation of the physical match analysis. The second prediction described a larger interference effect for HV than LV subjects on
type VVD pairs (two different words). This prediction was made under the assumption that picture-word classification and decoding were parallel processes, and that name processing for HV subjects might sometimes be completed before format processing. The predicted interference pattern did not materialize. This is consistent with the name task results which supported the idea that picture-word classification and decoding are serial, not parallel, operations.

Several theoretically interesting effects did occur in the analysis of same format responses. The stimulus type x verbal ability interaction revealed that HV and LV subjects were equally fast in deciding that a visual stimulus was a picture, but LV subjects were slower than HV subjects in deciding that a visual stimulus was a word. Apparently, verbal ability differences arise at a very early stage of verbal processing, as well as at later stages such as recoding. "Same" responses to physically identical pairs were 40 msec faster than to nonidentical pairs. This effect can be interpreted in terms of pathway facilitation. A third effect of interest in the same format analysis was the large proportion of errors on type PPD pairs (two different pictures). This finding suggests that two pictures can be decoded quickly enough to cause interference with an ongoing format-match response.

**Different Format Data**

In the different format analysis a reliable main effect of the same vs. different name factor was found for the RT data, $F(1,28) = 8.63, MS_e = 254342, p < .01$. "Different" responses to picture-word pairs having the same name were 11 msec faster than to pairs with different names. The direction of this numerically small yet highly
reliable effect was the opposite of that predicted. The effect of the name factor was in the predicted direction for the error data, with 2.3% errors on same name and 1.7% errors on different name pairs, but was not reliable ($p < .20$).

As was true of the same format data, the two groups of subjects responded equally fast on the different format pairs, but the HV subjects made more errors than the LV subjects, $F(1,28) = 5.83$, $MS_e = 0.2746$, $p < .05$. In the error data the same vs. different name and stimulus type factors interacted, $F(1,28) = 4.53$, $MS_e = 0.1987$, $p < .05$, showing a large number of errors on type VPS pairs (word and picture with the same name) in comparison to the other three different format pair types (i.e., PVS, PVD and VPD).

In the RT data there was a significant main effect of practice, $F(4,112) = 53.58$, $MS_e = 7562.91$, $p < .001$, as well as interactions between practice and verbal ability, $F(4,112) = 3.94$, $MS_e = 7562.91$, $p < .001$, and between practice and day, $F(4,112) = 3.09$, $MS_e = 7562.91$, $p < .01$. These effects in the different format analysis are described just as they were in the same format analysis.

A main effect of day was present in the different format analysis for both the RT, $F(1,28) = 9.11$, $MS_e = 145888.60$, $p < .01$, and error data, $F(1,28) = 5.12$, $MS_e = 0.2746$, $p < .05$. These effects showed that subjects who performed the format task in the first experimental session were slower and made more errors than did subjects who performed the format task second.

The only other reliable main effect or interaction in the different format RT and error analyses was a three-way interaction in the RT data for the type, verbal ability, and day factors,
F(1,28) = 4.70, MS_e = 3166.79, p < .05. This interaction shows that
the slower responses by day one subjects were primarily due to the LV
subjects, who were particularly slow on pairs having the word shown
above the picture.

Summary. In the different format data, an interference effect
was predicted for same name pairs due to conflicting format and name
identity information. The interference was expected to be larger for
HV than LV subjects. These predictions were not confirmed. The
opposite effect, in fact, was observed in the RT data. Subjects
responded "different" (i.e., format) more quickly to same name than
to different name pairs. This 11 msec priming effect appeared to be
larger for HV (16 msec) than for LV (7 msec) subjects. The relevant
name x verbal ability interaction did not, however, even approach
significance (F(1,28) = 1.08).

Physical Match Analysis

The RT and error data for the physically identical pair types
PPS and VVS from both the name and format tasks were analyzed in the
physical match analysis. These data were from the same subjects giving
the same overt response ("same") in both tasks.

In the RT data a large main effect of name versus format task
was reliable, F(1,28) = 104.35, MS_e = 18579.25, p < .001. Responses to
identical pairs in the name task were 110 msec slower than responses to
the same pairs in the format task. This finding does not support the
prediction that a match of physical codes is used in responding to
identical pairs in both tasks. In the error data there was a significant
main effect of verbal ability, F(1,28) = 11.20, MS_e = 0.1808, p < .01,
as well as an interaction between verbal ability and the task factor,
$F(1, 28) = 6.05, \text{MS}_e = 0.1487, p < .05$. These effects showed that although HV subjects made more errors overall than did LV subjects, the HV subjects were more accurate on identical pairs in the name task whereas the LV subjects were more accurate in the format task.

In the RT data a reliable interaction between stimulus type and verbal ability was found, $F(1, 28) = 7.58, \text{MS}_e = 1810.88, p < .05$. This interaction revealed that both name and format task responses made by HV subjects were equal for same-picture pairs and same-word pairs, but that responses made by LV subjects were faster for same-picture pairs than for same-word pairs. This pattern was identical across tasks, as shown by the absence of an interaction between stimulus type, verbal ability and task ($F(1,28) = 0.00$).

The RT data in the physical match analysis showed a reliable main effect of day, $F(1, 28) = 4.40, \text{MS}_e = 95651.56, p < .05$, and a day x task interaction, $F(1, 28) = 10.30, \text{MS}_e = 18579.25, p < .01$. These effects showed that subjects who performed the name task followed by the format task responded more quickly to physically identical pairs than did the other group of subjects. The faster group of subjects was especially quick in responding to identical pairs in the format-matching task. The day and task factors also entered into significant four-way interactions with the type and verbal ability factors for both the RT, $F(1, 28) = 4.58, \text{MS}_e = 1284.00, p < .05$, and error data, $F(1, 28) = 4.22, \text{MS}_e = 0.1201, p < .05$. The third-order interaction in the RT data represents a more detailed version of the day x task interaction. The third-order error data interaction represents a variation on the lower order task x verbal ability interaction.
A reliable main effect of practice, \( F(4,112) = 34.42, MSe = 4972.37, p < .001 \), and an interaction between the practice, task and day factors, \( F(4,112) = 17.50, MSe = 3364.15, p < .001 \), were evident in the RT data of the physical match analysis. These effects showed that those subjects who performed the format task followed by the name task showed more RT improvement in the format than in the name task as a function of practice. Alternatively, those subjects who performed the name task first showed more improvement in RT in the name than the format task as a function of practice. No other main effects or interactions were significant in the physical match analysis for either the RT or error data.

Summary. The same predictions were made about the physically identical pair types PPS and VVS in both the name-matching and format-matching tasks. Specifically, it was predicted that if physical codes were used in matching pairs of identical words or pictures, there should be no effect of verbal ability on the speed of making physical match decisions for either words or pictures. Furthermore, no overall RT difference between tasks should be observed for identical pairs if a match of physical codes was used. The results of the physical match analysis failed to confirm either prediction. Although HV subjects responded as quickly to identical word pairs as to identical picture pairs, LV subjects responded more slowly to word pairs than to picture pairs in both tasks. A large RT difference (110 msec) between the tasks was observed, as well.
CHAPTER IV

DISCUSSION

Review of the Experimental Findings

In the name-matching task, HV and LV subjects decided whether paired picture and word stimuli had the same or different names. In the format-matching task, the same subjects decided whether these stimuli matched in format (i.e., both pictures or both words) or not (i.e., one picture and one word). The experimental design also allowed a comparison across tasks. Every subject made faster format than name task responses. In the format task, both groups of subjects were equally fast, although the LV subjects responded more accurately. In the name task, on the other hand, both groups were equally accurate, but the HV subjects made faster responses than the LV subjects. In spite of the very large RT difference (almost 200 msec) between tasks, similar patterns of RT data were observed. In both tasks the name and format factors interacted reliably. In the name task stimulus format had a large (141 msec) effect on name-matching responses. In the format task, stimulus name had a small (11 msec) effect on format-matches. The name x format interaction did not interact with verbal ability in either task, suggesting that similar processing strategies were used by both groups of subjects.¹

In the name task a large effect of format was observed. Name-match responses to stimulus pairs consisting of a word and a picture were 160 msec slower overall than responses to pairs consisting
of two words or two pictures. This implies a recoding of mixed format pairs which must have been preceded by a comparison of formats. The name task data revealed that recoding took longer for LV than for HV subjects, since a larger NM-PM difference was observed for LV than HV subjects. The data showed that verbal ability differences in recoding speed contributed largely to this difference. Estimates of a pathway facilitation effect due to physically identical pairs were obtained for both groups of subjects, and were similar.

In the name task analysis more support for the verbal decoding hypothesis was found in the form of an interaction between the stimulus type, format, and verbal ability factors. This effect showed that stimulus type (i.e., picture or word in the top display position) had no effect on responses to recoded (i.e., different format) pairs. Stimulus type did affect responses to same format pairs, but only for LV subjects who responded more slowly to two words than to two pictures.

The format task analyses contained two major unexpected findings. First, the same format analysis revealed a verbal ability difference in RT arising at a very early stage of processing. When two pictures were presented, it took the HV and LV subjects the same amount of time to respond, whereas when two words were presented, the HV subjects made faster format responses than did the LV subjects. This effect can be interpreted as showing that HV subjects were equally efficient in deciding whether a visual stimulus was a word or a picture but that LV subjects took longer to decide that a visual stimulus was a word than they took to decide it was a picture. The second unexpected finding showed up in the different format analysis. Here it was shown that "different" responses were 11 msec faster to
same name than to different name picture-word pairs. This small yet reliable effect is puzzling since it implies that the recoding operation may be bypassed in making picture-word identity comparisons. The 11 msec priming effect can be interpreted as evidence in support of the automatic nature of the decoding operation. The high proportion of errors on type PPD pairs (two different pictures) in the different format analysis also supports the decoding operation's automaticity.

In the physical match analysis, data from identical picture pairs and word pairs in the name and format tasks were analyzed together. Here it was shown that responses to physically identical pairs were 110 msec slower in the name task than in the format task. Furthermore, HV and LV subjects responded differently to the identical picture and word pairs. The reliable interaction between stimulus type and verbal ability showed that HV subjects responded as quickly to word pairs as to picture pairs, but LV subjects responded more slowly to word pairs than to picture pairs. These data do not support the hypothesis that a match of physical codes was used in responding to physically identical stimulus pairs in the name and format tasks. The fact that the same pattern of data was observed in each task suggests that an initial picture-word classification decision may be a common component of both tasks.

Implications for the Parallel Processing Model

Posner's theory postulates the existence of independent processing systems that operate in parallel to extract physical codes and name codes from a given stimulus event. Posner and Snyder (1975) presented evidence to support the automaticity of the decoding operation, i.e., the process by which the stimulus trace activates its name code is
automatic. Posner (1970) has suggested that stimulus classification and naming (decoding) are parallel operations, as well. His suggestion was based on studies of letter-digit and vowel-consonant classification. The present data showed that classification and naming are not parallel processes in the case of picture-word classification. The large recoding effect observed in the name-matching task is incompatible with the parallel model of classification and naming. Since the existence of recoding implies a prior format comparison, the results of the name task are better described in terms of a serial model of classification and naming. According to the serial model, the first step in stimulus decoding is stimulus classification, i.e., is it a picture or a word?

The present data show that with picture and word stimuli, the operations of stimulus classification and naming are serial, rather than parallel, processes. This is the only place where the data fail to support Posner's views. His newer ideas about independent and parallel physical and name codes as well as automatic encoding are not challenged by the data.

A Serial Processing Model

There were four major influences, besides Posner (1978), in the development of the serial model of picture and word encoding that is shown in Figure 5. First and most important is the sensory-semantic model of picture and word encoding proposed by Nelson, Reed, and McEvoy (1977) and further detailed by Nelson (1979). This model is shown in Figure 4. A primary assumption of the model is that simple pictures and their corresponding verbal labels have functionally identical meaning codes. The sensory-semantic model assumes that both sensory and
Figure 4: The sensory-semantic model of picture and word encoding (Nelson, Reed & McEvoy, 1977).
Figure 5: A serial model of picture and word encoding.
semantic codes can be activated for both modes of representation.

Access to phonological information, e.g., name codes, however, differs for pictures and words. Name code access or access to phonological information is direct for words in that no prior semantic processing is required. Access to phonological information is indirect for pictures since name codes are assumed to be accessible only after semantic processing has taken place. The second influence behind the new serial model comes from a general consensus of the growing body of literature concerned with picture versus word encoding. Most of these studies either show or are consistent with the viewpoint that pictures and words have access to the same semantically based memory system (e.g., Rosch, 1975; Friedman and Bourne, 1976; Banks and Flora, 1977; Smith and Magee, 1980).

The third influence behind the proposed model is the lexical-semantic system introduced by Loftus and Cole (1974) and later incorporated into the Collins and Loftus (1975) model. Specifically, two memory systems are said to exist. The lexical system contains information about names, e.g. how the names sound and are spelled. The semantic system contains information about meanings and their relations to other concepts. Thus, the lexical system stores labels and the semantic system stores meanings. Finally, the proposed model of picture and word encoding was influenced by Lupker, Katz and Cartman's (Note 2) suggestion that although pictures and words access the same memory files, they access the relevant files from different directions.

The new model of picture and word encoding that incorporates the serial nature of picture-word classification and decoding operations is
shown in Figure 5. The first step in encoding both pictures and words is stimulus classification, i.e., is the visual stimulus a word or a picture? Perhaps picture-word classification is performed by the two cerebral hemispheres, i.e., the right hemisphere admits pictorial stimuli for processing whereas the left hemisphere admits verbal stimuli for processing. In the model, verbal processes are shown on the left and nonverbal processes are shown on the right as a way of representing hemispheric specialization. Once the initial classification has been made, pictures and words are processed by independent and parallel operating systems. The pictorial operating system is the nonverbal analogue of Posner's (1978) verbal processing system.

In both the pictorial and verbal operating systems, physical and memory codes are simultaneously extracted from visual stimuli. The serial model of picture and word encoding differentiates between verbal and nonverbal encoding processes and so must the model's terminology. Table 3 provides a summary of the mnemonics used in discussing the new model and its relationship to the present data.

In the verbal processing system, the physical code will be referred to as the physical word-code and the memory code will be called the lexical code since information about the names of words are stored in the lexicon. A verbal stimulus is said to have been decoded when its lexical code has been activated. In the pictorial processing system, on the other hand, the physical code will be called the physical picture-code and the memory code within the semantic system will be called the semantic code. A pictorial stimulus is said to have been decoded when its semantic code has been activated. Thus, the decoding operation activates a different set of memorial information
Table 3: Definition of the variables and concepts referred to by the serial model of picture and word encoding.

ENCODING VARIABLES

VERBAL ENCODING

WC = time to form a physical word-code
LC = time to form a lexical code

NONVERBAL ENCODING

PC = time to form a physical picture-code
SC = time to form a semantic code

VERBAL–NONVERBAL RECODING

R = time to recode between the lexical and semantic systems

MATCHING VARIABLES

PHYSICAL CODE MATCHES

PLM = time to make a location match of physical codes
PIM = time to match physical codes

MEMORY CODE MATCHES

LMM = time to match lexical codes in lexical memory
SMM = time to match semantic codes in semantic memory

DEFINITIONS

Word decoding = lexical code formation
Picture decoding = semantic code formation
Interpretation = semantic code formation for pictures and words
for words as opposed to pictures. A visual stimulus, word or picture, is said to have been interpreted or understood when its semantic code has been activated. The model assumes that stimulus processing proceeds automatically to the formation of the semantic code. Pictures are, therefore, directly understood. Words may be interpreted via two different routes. Words may be indirectly understood, i.e., the lexical code is translated into the semantic code through a verbal process referred to as recoding. Words also may be understood directly, i.e., without going through the lexical system. As Figure 5 shows, a path leads directly from the verbal stimulus to the semantic system. The code used in this operation has been described as an abstract orthographic code (Sanders and Shulman, Note 4).

Name task and format task processing. Table 4 shows, for each stimulus pair type, the set of operations involved in making name task and format task responses. The variable names are defined in Table 3. Since a simpler set of operations is involved in format-matching than in name-matching, the format task will be discussed first.

All responses in the format task are made on the basis of a physical code location match (PLM). The PLM is to be distinguished from the physical code identity match (PIM). Both comparison processes require the prior establishment of physical codes, but the PLM can be conducted more quickly than the PIM because the PLM compares the general locations of the codes involved whereas the PIM compares the actual codes. For example, if both stimuli in the pair activate physical codes in the picture processing system (right hemisphere), the PLM produces a match. Such would be the case for pair types PPS (identical pictures) and PPD (two different pictures). If both stimuli activate physical codes
Table 4: Processing sequences for each stimulus pair type in the name-matching and format-matching tasks. The variables are defined in Table 3.

<table>
<thead>
<tr>
<th>NAME TASK</th>
<th>RT</th>
<th>PAIR TYPE</th>
<th>RT</th>
<th>FORMAT TASK</th>
</tr>
</thead>
<tbody>
<tr>
<td>$PC_1 + PC_1 + PIM$</td>
<td>602</td>
<td>PPS</td>
<td>493</td>
<td>$PC_1 + PC_1 + PLM$</td>
</tr>
<tr>
<td>$WC_1 + WC_1 + PIM$</td>
<td>609</td>
<td>VVS</td>
<td>498</td>
<td>$WC_1 + WC_1 + PLM$</td>
</tr>
<tr>
<td>$SC_1 + SC_2 + SMM$</td>
<td>674</td>
<td>PPD</td>
<td>533</td>
<td>$PC_1 + PC_2 + PLM$</td>
</tr>
<tr>
<td>$LC_1 + LC_2 + LMM$</td>
<td>724</td>
<td>VVD</td>
<td>539</td>
<td>$WC_1 + WC_2 + PLM$</td>
</tr>
<tr>
<td>$SC + LC + R + LMM$ - priming</td>
<td>785</td>
<td>PVS</td>
<td>544</td>
<td>$PC + WC + PLM$ - priming</td>
</tr>
<tr>
<td>$LC + SC + R + LMM$ - priming</td>
<td>785</td>
<td>VPS</td>
<td>551</td>
<td>$WC + PC + PLM$ - priming</td>
</tr>
<tr>
<td>$SC + LC + R + LMM$</td>
<td>843</td>
<td>PVD</td>
<td>555</td>
<td>$PC + WC + PLM$</td>
</tr>
<tr>
<td>$LC + SC + R + LMM$</td>
<td>837</td>
<td>VPD</td>
<td>564</td>
<td>$WC + PC + PLM$</td>
</tr>
</tbody>
</table>
in the verbal processing system (left hemisphere), the PLM produces a match, as in the case of pair types VVS (identical words) and VVD (two different words). A mismatch is produced when both the pictorial and verbal processing systems are activated, as is the case for different format stimulus pairs.

An operation analogous to the physical code location match has been described by Posner and Snyder (1975) to account for performance in digit search tasks. Based on the assumption that the memory system has separate storage areas for letters and digits, Posner and Snyder suggested that when a subject is asked to look for a digit in a field of letters, "... he need simply to check to see whether there is activation in that area of memory that represents digits" (1975, p. 70). The PLM is based on the assumption of separate processing systems for pictures and words. The match or mismatch is based upon activation in one or both of the processing systems.

Table 4 shows that a similar set of operations describes performance on identical pair types PPS and VVS in both tasks. The only difference between tasks is the type of matching operation, i.e., the PIM is used in the name task and the PLM is used in the format task. Thus, the reliable 110 msec difference between name and format task responses to physically identical pairs can be attributed to the different matching operations, i.e., the PLM is 110 msec faster than the PIM. Note that similar estimates of the match time difference are obtained for type PPS pairs (109 msec) and for type VVS pairs (111 msec).

Looking now only at format task operations, Table 4 shows that the only difference between pair types PPS and PPD is whether or not identical picture codes are established. Similarly, the only difference
between pair types VVS and VVD is whether or not identical word codes are established. In each case the effect of pathway facilitation favors the establishment of identical physical codes. Note that similar estimates of the pathway facilitation effect are obtained for pictorial (40 msec) and verbal (41 msec) codes.

The same basic set of operations describes performance on all four different format pair types, i.e., a picture code and a word code are established and the PLM results in a mismatch. The different format analysis showed, however, that responses to same name pairs were a reliable 11 msec faster than responses to different name pairs. This effect is represented in Table 4 as RT facilitation due to priming. The priming effect provides support for the assumed automaticity of stimulus interpretation. Both stimuli in the pair must have been interpreted (i.e., semantic codes activated) in order for there to have been an effect of the name factor upon different format RTs. It is likely that direct semantic access was used to interpret the words in the different format pairs since the very fast format responses showed no evidence of recoding. The automaticity of stimulus interpretation also receives support from the high proportion of errors on type PPD pairs where subjects erred by responding "different" to a pair of different pictures.

In the name-matching task all responses to physically different pairs are made on the basis of memory code matches. Two types of memory code matches are assumed to exist. The lexical memory match (LMM) refers to a comparison of lexical codes in the lexicon and the semantic memory match (SMM) refers to a comparison of semantic codes in semantic memory. The name task recoding effect shows that name-
matches cannot be based upon the comparison of a lexical and a semantic
code. One member of picture-word pairs must be recoded to permit a
comparison of either names or meanings within either the lexical or
the semantic system.

Table 4 shows that the very fast name task responses to physically
identical pairs are based upon a match of physical codes. Averaged
over verbal ability groups, physical word-codes are matched as quickly
as physical picture-codes. Responses to pair types PPD (two different
pictures) and VVD (two different words) are assumed to be based upon
memory matches. For type PPD pairs, a match of semantic codes
results in a mismatch and for type VVD pairs, a match of lexical
codes results in a mismatch. Averaged over verbal ability groups,
responses to type VVD pairs were slower than responses to type PPD
pairs. This effect was, however, due primarily to the LV group. The
longer RTs to type VVD than to type PPD pairs could be due to one of
two or both reasons. It might be that lexical codes take longer to
activate than semantic codes (i.e., LC > SC), or the lexical memory
match might be a slower process than the semantic memory match (i.e.,
LMM > SMM), or both. The present data do not distinguish between
these possibilities.

The same basic set of operations describes name task performance
on all four different format pair types, i.e., a lexical code and a
semantic code are established, followed by the recoding operation and
a memory match. The choice of the lexical memory match shown in
Table 4 was based primarily on introspections of the subjects. With
regard to the location of memory matches for recoded pairs, three
possibilities exist. First, the word may be recoded and a comparison
made in the semantic system. The model supports this alternative since all stimulus processing eventually reaches the semantic system. On the other hand, the picture may be recoded and a comparison made in the lexical system. The name task instructions implied that this was the strategy to use. A third possibility is that the upper stimulus is recoded into the format of the lower stimulus or vice versa.

Several subjects spontaneously described their strategy in the name task as one of recoding different format pairs. Most of these recoders claimed to recode the picture in order to compare the names of the stimuli. For example, "If the stimuli were different (i.e., format) I had to consciously name them to compare them and then respond." One recoder, however, seemed to be recoding the words. For example, "If there is one word, read it first. Then decide whether or not the picture looks like what the word says it is." No subject described his or her strategy as one of recoding the upper stimulus into the format of the lower stimulus or vice versa.

The direction of recoding is an issue worthy of further investigation. For example, are the verbal ability differences found in recoding speed related to the direction of recoding? The use of sequential presentation in the picture-word name-matching paradigm might answer this question.

In the name-matching task, recoded (i.e., different format) pairs with the same name were a reliable 55 msec faster than recoded pairs with different names, \( q \text{ crit (.01,28,4)} = 4.80, q \text{ obs (28)} = 18.87. \) This effect can be attributed to priming between same name pairs, as was the case in the format-matching task. An alternative explanation
of the 55 msec same vs. different name effect upon recoded pairs can be derived by extrapolating Krueger's (1978) noisy-operator theory of perceptual matching to the case of memorial matching. According to Krueger, "... internal noise is more likely to produce spurious featural mismatches than matches and ... rechecking (is) needed to remove these spurious differences" (1978, p. 278). In deciding whether or not two patterns are identical, subjects recheck "different" pairs more often than "same" pairs, resulting in faster "same" than "different" judgments, but with more errors on "same" than on "different" judgments. The present data suggest that internal noise may be affecting higher level memory matches in a similar manner. Responses to recoded same name pairs were faster than responses to recoded different name pairs, with 5.83% errors on same name and 5.66% errors on different name pairs. Although the error rate difference on recoded pairs was not reliable, $q_{crit} (.05,28,4) = 3.84$, $q_{obs} (28) = 0.70$, it was in the direction predicted by the noisy-operator theory.

Comparison to other models of picture and word encoding. The serial model of picture and word encoding shown in Figure 5 is similar to other current models of picture and word encoding. Paivio's (1971) dual coding approach was the impetus behind later models. In Paivio's (1978a) modified dual code model, the verbal and nonverbal systems have come to resemble the lexical and semantic structures described by Loftus and Cole (1974). Paivio (1978b) showed that abstract attributes of concrete objects (i.e., value) are represented in and are processed by the nonverbal system. Thus, Paivio now believes that semantic information or "... information that corresponds to our knowledge of the world..." (1978a, p. 42) is represented in the nonverbal system.
The serial model of picture and word encoding was influenced by Nelson, Reed and McEvoy's (1977) model, described earlier and shown in Figure 4. The Nelson et al. model was designed to explain picture-word differences in recall, recognition and reconstruction tasks (Nelson, 1979). The serial model represents an extension of the Nelson et al. model which was designed to explain picture-word differences in RT tasks.

Snodgrass's (note 5) model of picture and word encoding is more general than the present serial model in that it is capable of explaining the input and output of verbal and pictorial information through both the auditory and visual channels. When stripped to the visual input processes, Snodgrass' model resembles the serial model with an additional memory level which distinguishes between conscious and unconscious memories.

The major difference between the serial model and the other three models of picture and word encoding is that the serial model makes explicit the first step of picture-word classification. That this step is not a trivial addition is attested to by the fact that verbal ability differences were found for the time it takes to decide that a visual stimulus is a word but not for the time it takes to decide that a visual stimulus is a picture. The serial model differs also from the earlier models in suggesting that the initial step of picture-word classification corresponds to a choice between cerebral hemispheres, with the pictorial processing system being located in the right hemisphere and the verbal processing system being located in the left or dominant hemisphere.
**High- and low-verbal processing differences.** The reliable RT differences between the HV and LV subjects for the name and format tasks can readily be represented in terms of the serial model of picture and word encoding. Figure 6 displays these differences graphically. Results of the physical match analysis showed that HV and LV subjects were equally fast in responding to two pictures but that HV subjects responded more quickly to two words than did LV subjects. In terms of the model, verbal ability has an effect upon WC, the time to form a word code, but not upon PC, the time to form a picture code. The name task analysis showed that recoding took longer for LV than for HV subjects. In terms of the model, verbal ability has an effect upon R. The name task analysis also showed that although type VVD pairs (two different words) were responded to more slowly than type PPD pairs (two different pictures), the effect was caused largely by the LV subjects. In terms of the model, verbal ability affects LC, the time to form a lexical code, more than it affects SC, the time to form a semantic code.

In summary, of the five encoding variables used to describe name and format task processing, verbal ability differences were found for all three verbal encoding operations. LV subjects were shown to be slower than HV subjects in forming physical word-codes, lexical codes, and recoding between the lexical and semantic memory systems. No effect of verbal ability was found for the speed of forming physical picture-codes. A small effect of verbal ability, reliable by a post hoc procedure, was found for the speed of forming semantic codes. As a whole, these data do provide support for the original hypothesis,
i.e., that the decoding speed advantage for HV subjects is restricted to verbal rather than general encoding processes.

**Relationship of the serial model to other data.** The serial model of picture and word encoding, along with its verbal ability versions shown in Figure 6, provides a framework in which to view previously established differences between skilled and less skilled readers. For example, on the Posner letter-matching task, HV and LV subjects differ more in the speed of making name matches (NM) than physical matches (PM), resulting in a larger NM-PM difference for the LV subjects (e.g., Hunt, Lunneborg and Lewis, 1975; Hunt, 1978; Jackson and McClelland, 1979). Thus, the verbal decoding advantage for the skilled readers can be attributed primarily to faster lexical code access times for skilled as opposed to less skilled readers.

Both Jackson (1980) and Perfetti and Lesgold (1977) reported faster picture categorization responses from skilled than from less skilled readers. It was suggested earlier that this effect of verbal ability may have taken place in the process of retrieving and comparing category names, a process taking place after the pictures had already been interpreted. In terms of the serial model, category names must be retrieved from lexical memory, i.e., the effect of verbal ability upon picture categorization RTs can be attributed to differences in the speed of recoding between the semantic and lexical memory systems.

Adults with acquired dyslexia and children with developmental dyslexia have been characterized as being specifically impaired in the ability to use grapheme-phoneme correspondence rules (e.g., Patterson and Marcel, 1977; Snowling, 1980), as well as being better able to read imageable than nonimageable words (e.g., Richardson, 1975a and
Figure 6: Models of picture and word encoding for high-verbal (upper) and low-verbal (lower) subjects.
1975b; Jorm, 1977). In terms of the serial model of picture and word encoding, these data suggest that dyslexic individuals lack the ability to directly access the lexical memory system via lexical codes. Instead, they obtain the lexical information needed to name words by directly accessing semantic memory and then recoding. Thus, dyslexic individuals can be said to name both pictures and words in the same manner, i.e., by first establishing semantic codes, followed by recoding into lexical codes.

The serial model of picture and word encoding predicts that verbal ability differences in RT should be found for reading words as well as naming pictures. The model predicts that HV subjects should read words faster than LV subjects since HV subjects need less time to form lexical codes than do LV subjects. Alternatively, HV subjects should be able to name pictures faster than LV subjects because HV subjects are able to recode between the semantic and lexical systems more quickly than LV subjects. The data needed to test this prediction are not available for adult subjects varying in verbal skill, but confirming evidence is found in two experiments that compared normal and dyslexic children in the speed of naming verbal and nonverbal stimuli. Both Denckla and Rudel (1976) and Spring and Capps (1974) reported that dyslexic children were slower than normal children in naming both verbal stimuli (e.g., letters and digits) and nonverbal stimuli (e.g., pictures and colors).

A final study that fits within the context of the serial model of picture and word encoding is Graesser, Hoffman and Clark's (1980) comparison of microstructural and macrostructural reading time components. Microstructure processing includes word level components
whereas macrostructure processing includes sentence level components.

Graesser et al. compared the RT performance of fast and slow readers on microstructural and macrostructural reading components. They found that the slower readers needed more time than the faster readers in microstructure processing, but no verbal ability differences were found in macrostructure processing. Graesser, Hoffman and Clark concluded that "Reading speed is apparently determined by skills involved in performing lexical, syntactic, and propositional analyses within sentences, rather than performing semantic and conceptual analyses which integrate information from different sentences" (1980, pp. 145-146).

Perhaps the lexical system is responsible for microstructure processing while the semantic system is responsible for macrostructural processing. If so, Graesser et al.'s data, like the present data, can be interpreted as showing that the RT advantage characteristic of the skilled reader is limited to the verbal side of interpretation.
APPENDIX A

FORMAT TASK ANALYSIS

In the overall analysis of the format-matching task, responses to same format pairs were reliably faster than responses to different format pairs, $F(1,28) = 62.62, MSe = 7183.63, p < .001$. A reliable main effect of the same versus different name factor was observed both in the RT, $F(1,28) = 72.96, MSe = 2999.21, p < .001$, and the error data, $F(1,28) = 5.16, MSe = 0.2073, p < .05$. These effects showed that responses to stimulus pairs having the same name were faster and more accurate than responses to pairs with different names. The format and name factors also interacted in both the RT, $F(1,28) = 23.14, MSe = 2880.58, p < .001$, and the error data, $F(1,28) = 17.39, MSe = 0.2139, p < .001$. The format x name interaction in the RT data showed that the speed advantage for same name as opposed to different name pairs was larger for same format stimulus pairs (40 msec) than for different format pairs (11 msec). The format x name interaction in the error data supports Krueger's (Note 1) notion of a response interference effect in showing that fewer errors were made when format and name information matched (e.g., same name and same format) than when format and name information did not match (e.g., same name and different format).

In the error data alone, a significant main effect of the verbal ability factor, $F(1,28) = 13.56, MSe = 0.4564, p < .001$, revealed that
more errors were made by HV than by LV subjects. Also reliable only in the error data was an interaction between the name and stimulus type factors, $F(1,28) = 4.23, \text{MS}_e = 0.4804, p < .05$, which showed that more errors were made on same name pairs when a word was in the top display position, whereas more errors were made on different name pairs when a picture was in the top display position.

In the RT data alone, a significant main effect of the day factor, $F(1,28) = 10.25, \text{MS}_e = 254462.90, p < .01$, revealed that subjects who performed the format-matching task in the second experimental session were faster than subjects who made format matches in the first session. The reliable second order interaction in the RT data between the day, verbal ability and stimulus type factors, $F(1,28) = 4.79, \text{MS}_e = 3639.21, p < .05$, showed that of the subjects who made format matches in the first experimental session, only the LV subjects were slowed by pair types having a word in the top display position, whereas both groups of subjects responded equally fast to both stimulus pair types in the second experimental session.

A reliable main effect of practice was observed in the RT data of the overall format task analysis, $F(4,112) = 58.30, \text{MS}_e = 10591.31, p < .001$, showing that format-matching RTs improved on each successive block of trials. The practice factor also interacted reliably in the RT data with the same versus different format factor, $F(4,112) = 4.14, \text{MS}_e = 3559.47, p < .01$, the verbal ability factor, $F(4,112) = 6.11, \text{MS}_e = 10591.31, p < .001$, and the day factor, $F(4,112) = 5.81, \text{MS}_e = 10591.31, p < .001$. The practice x format interaction revealed that the slower different format responses improved more with practice than did the same format responses. The practice x verbal ability
interaction showed that although the HV subjects made faster format-
matching responses than the LV subjects on the first block of trials, the
two groups did not differ in speed on the remaining four blocks. The
practice x day interaction revealed that the slower responses made by
day one subjects showed more improvement with practice than did responses
made by subjects who made format matches in the second experimental
session. The only other reliable effect in the overall format task
analysis was a third order interaction in the error data which involved
the practice factor, $F(4,112) = 2.81$, $MS_e = 0.2296$, $p < .05$. 
An alternative interpretation of the name x format interactions in the RT data for both tasks has been suggested by Krueger (Note 1). Krueger eliminates the need for the concept of pathway facilitation by explaining the data in terms of a response interference effect. Response interference occurs when name and format information do not match (e.g., same name but different format or different name but same format). The name x format interactions reflect the absence of response interference for both types of stimulus pair with matching name and format information (e.g., same name and same format or different name and different format). Thus, in the name-matching task, the 179 msec recoding effect for same name pairs is large due to the lack of interference on the fast same format pairs, whereas the 141 msec recoding effect for different name pairs is small due to the lack of interference on the slow different format pairs. The name x format interactions in the error data support Krueger's interpretation in showing that more errors were made when name and format information did not match than when name and format information did match. The name x format interaction was, however, reliable in the error data only for the format matching task.

FOOTNOTE

1An alternative interpretation of the name x format interactions in the RT data for both tasks has been suggested by Krueger (Note 1). Krueger eliminates the need for the concept of pathway facilitation by explaining the data in terms of a response interference effect. Response interference occurs when name and format information do not match (e.g., same name but different format or different name but same format). The name x format interactions reflect the absence of response interference for both types of stimulus pair with matching name and format information (e.g., same name and same format or different name and different format). Thus, in the name-matching task, the 179 msec recoding effect for same name pairs is large due to the lack of interference on the fast same format pairs, whereas the 141 msec recoding effect for different name pairs is small due to the lack of interference on the slow different format pairs. The name x format interactions in the error data support Krueger's interpretation in showing that more errors were made when name and format information did not match than when name and format information did match. The name x format interaction was, however, reliable in the error data only for the format matching task.
LIST OF REFERENCES

REFERENCE NOTES


