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ABSTRACT

Second and fifth graders were presented with a discrimination learning task in which each of four displays were to be paired with a response button. For one group two of the displays shared a common feature and were paired with the other response button. This common feature condition required a subject to learn only two associations if he perceived and used the two as a collative principle. For another group, the four displays shared no common feature and the four associations had to be learned. Following the original learning task, both groups were given four new displays, with common features for each of two pairs. The displays for half the subjects were printed words having a common feature of rhyme and spelling pattern. For the other half, the displays were pictures representing the words, so the rhyming names of the pictures were the common features. When the displays were words, the fifth graders performed better than second graders. When there was no common feature, fifth graders did not excel second graders. When displays were pictures, fifth graders showed a significant transfer effect. It was concluded that ability to use a common feature economically increases with age and that common spelling patterns have little saliency for second graders. (See CS 000 176.) (Author/WR)

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THE RELATIONSHIP BETWEEN PERCEPTUAL DEVELOPMENT AND THE ACQUISITION OF READING SKILL

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PREFACE AND ACKNOWLEDGMENTS

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One of the papers (Gibson, Poag, & Rader) was a follow-up of an experiment written up in the Final Report. The thesis summary (Zaslow) also followed up an experiment in that report. One of them (Gibson, Barron, & Garber) is entirely new and will form the basis of a program of research on development of meaning in words (especially written words) about to be undertaken.

None of the participants in the work reported received remuneration for their time from the grant, but the work would not have been possible without grant support for apparatus, supplies, technical services, and computer time.

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TABLE OF CONTENTS

The Effect of Redundant Rhyme and Spelling
Patterns on a Verbal Discrimination Task

Eleanor J. Gibson, Mary K. Poag and Nancy Rader

Summary

Children from second and fifth grades were presented with a discrimination learning task in which each of four displays were to be paired with a response button, either on S's left or his right. For one group two of the displays shared a common feature and were paired with the same response button. The other two also shared a common feature and were paired with the other response button. Thus, Ss in this condition had only two associations to learn if they perceived and used the common feature as a collative principle. For another group, the four displays shared no common feature and thus four associations had to be learned. In a transfer stage following the original learning task, both groups were given four new displays, with common features for each of two pairs. The displays for half the Ss were printed words, the common feature being rhyme and spelling pattern (e.g. king and ring). For the other half, the displays were pictures representing the words, so the rhyming names of the pictures were the common features.

Fifth graders were better able to take advantage of the collative principle than second graders when displays were words, in both first learning and transfer stages. There was no improvement from original learning to the transfer stage, so the first stage did not train S to induce and use the collative principle. When there was no common feature, fifth graders did not exc ell second graders, so their superiority was entirely ascribable to ability to use the collative principle.

When displays were pictures, the common rhyming name was seldom used economically by Ss of either grade in the first learning task. In the transfer stage, however, fifth graders did show a significant transfer effect. A number of them perceived and used the rhyme eventually to reach the economical solution. It was concluded that ability to use a common feature economically increases with age and that common spelling patterns have as yet little saliency for second graders.

The Effect of Redundant Rhyme and Spelling Patterns on a Verbal Discrimination Task

Eleanor Gibson, Mary Poag, and Nancy Rader
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The discovery of recurrent spelling patterns in words and the efficient use of these common patterns allows a reader to process information in larger structural units. A spelling pattern can be defined as a cluster of letters in a given environment (such as position within the word) which has an invariant pronunciation according to the rules of English. This pattern has the effect of organizing units of perception to produce an economy of processing in reading. Evidence for the effect of such structure can be traced as far back as Cattell (1885) who demonstrated that a word, if not too long or complicated, could be read with as short an exposure as a single letter. It is not simply the familiarity of the word that controls this facilitation, since artificial words that follow rules of English orthography and thus incorporate within them common English spelling patterns are also perceived with significant facilitation (Gibson, Pick, Osser, & Hammond, 1962; Gibson, Shurcliff, & Yonas, 1970).

However, the economy of this perceptual strategy is not automatically available to the reader. Developmental changes in young children's ability to make use of internal orthographic structure have been observed (Gibson, Osser, & Pick, 1963; Rosinski & Wheeler, 1971). Although it is known that most children make increasing use of orthographic regularities as they improve in reading skill, it would be of great interest to know how they learn to abstract spelling patterns.

Several developmental studies have asked this question. Gibson, Farber, & Shepela (1967) set up a sorting task in which words with distinctive letter clusters in several invariant positions and different contexts were presented to kindergarten and first grade children to sort according to their common features (e.g., TEAM and SEAL would belong to a set because of their common inner 'ea' whereas TAME utilizes the same four letters but would not belong to the set). The experimenters were interested in seeing whether over a period of five days a learning set to abstract and use structure would be formed. Although only one out of twelve kindergarteners clearly picked up the strategy, half of the first graders eventually did. Another study (Lowenstein, 1969), looked at the effect that type of training procedure had on later transfer to new cases of using the structure in words. She found that a general training instruction to attend to something common in words provided more help to first graders in a transfer task than did specific training instruction to look for a particular letter pair. It seems that a child must go through an active search for and discovery of invariant pattern in words in order to be able to transfer this skill.

Reasoning that a child must develop the ability to extract a collative principle in order to search successfully for spelling patterns, Gibson and Rader (1971) presented children from second and third grade with a simple verbal discrimination task which could be learned in either of two ways, made possible by presenting alternative sets of cues. By selecting one set, the child had four unrelated choices to learn; by selecting the other set he had only a two-choice problem to solve if he took advantage of a dual collative principle, common spelling pattern and rhyme. We thought the reduction of the number of displays to four, and the obvious economy of using the common features would help the child to induce the principle for himself. A control group had four choices to learn, with no collative principle present. Following learning of the first task, both groups were given a transfer task which was immediately solvable if the economical solution had been discovered in the first stage of learning. Both rhyme and common spelling patterns were present. A further variable in the display was a contour surrounding each word, different for each one. The contour was irrelevant to the collative principle, but could be used instead of the words themselves for the uneconomical solution.

Results of this experiment showed that third graders made fewer errors in learning than second graders when the collative principle was available, but the same number when it was not. However, the difference between the two conditions (control vs. experimental) was not great. In the transfer stage, there were no significant differences, and Ss in grade 3 used the collative principle equally well whether they had had the opportunity to discover it before or not. Only 50% of the Ss showed evidence of using spelling pattern or rhyme. Apparently, if an S was able to do so, he used it, but the learning in stage I did not appear to provide training for extraction of a rule.

The present experiment was undertaken to correct what we felt had been some faults of design and procedure in the previous one, and to ask a further question about the relative usefulness of the two types of redundant information, rhyme and spelling pattern. When the common sound of the words (rhyme) is the only collative principle, is it just as effective as the spelling pattern which has both rhyme and visual similarity potentially available? This question has received considerable attention recently, since so-called "linguistic" methods of teaching reading emphasize rhyme and tracking the sound-stream.

The method of introducing rhyme without accompanying spelling was to present pictures of objects whose names rhymed (e.g., king and ring) as opposed to presenting the spelled-out words. We expected that Ss would spontaneously generate the names of the pictures and probably perceive the phonetic relationship, since Locke (1971a, b) found that four-year-old children recalled more pictures whose names rhymed than nonrhyming control pictures. If second graders can use a collative principle, but do not yet perceive the redundancy in spelling patterns, the picture condition might excell the word condition when redundancy is available.

The experiment also differed from the previous one in comparing children of more contrasting age groups (second and fifth grade), and in omitting the contours surrounding the printed words.

Method

Design

There were eight groups in all, four from second grade and four from fifth grade. In each grade half the groups were given picture displays and half word displays. One of the word groups in each grade was the experimental group and the other the control group. The picture groups were similarly divided.

Summary of Groups

Grade	Condition	Type of Display
2	experimental	words
2	control	words
2	experimental	pictures
2	control	pictures
5	experimental	words
5	control	words
5	experimental	pictures
5	control	pictures

In all eight conditions, there were two stages of learning. Stage I was the training condition and differed for the experimental and control groups. In the experimental groups there were two pairs of rhyming words printed in lower case or two pictures whose names rhymed. The pictures (color photographs) were designed to be clear representations of the words used. In the control groups, Stage I, four words or four pictures were displayed that had no common spelling patterns or rhyming names. Stage II was the transfer test. It was the same for both experimental and control conditions, with two pairs of rhyming words or two pairs of pictures that rhymed (different from those employed in Stage I). Its purpose was to permit a comparison of Groups E and C to see whether previous exposure to a collative principle (common spelling pattern or rhyme) would result in more immediate pick-up of structure useful for an economical solution. Would this task help the child induce a principle which he could immediately apply when a new but similar case presented itself?

The words (the same as the names for the corresponding pictures) are presented in Table 1.

Procedure

The S was seated before a screen on which slides of the words or pictures were rear-projected. His task was to choose for each of

Table 1
Words and Names for Pictures for
Groups E and C, Stages I and II

	Stage I		Stage II	
Group E	king ring	yarn barn	boat coat	cake rake
Group C	nose king	bell yarn	boat coat	cake rake

the four successively presented words or pictures the appropriate one of two buttons on a small console in front of him. There was also a light on the console which flashed, accompanied by a sound, when S pressed the correct button for a given slide.

For Group E, Stage I, the rhyming pair of words or the pictures with rhyming names always had the same button correct for both members of the pair. For Group C, Stage I, the buttons were assigned arbitrarily to the four slides. The same button was always the correct one for a given slide. In Stage II (as in Group E, Stage I), the redundant pairs of slides always shared the same correct button so that in both cases S had only two choices to learn if he noticed and used the simple rule of common spelling or rhyme. In Group C, Stage I, S of necessity had to learn four separate choices.

S was first shown the set of four words or pictures which would be presented in that stage of the experiment. The words were printed individually on 3 x 5 index cards which E showed to S and had S read. If S read a word incorrectly E pronounced it correctly for him. For the picture conditions, E showed each of the four slides to S on the screen and had him name them. There were generally no incorrect responses here, since the pictures were chosen to be unambiguous. However, if S did grope for a name or, in one particular instance, called a "BOAT" a "SHIP," E told S the appropriate name. E would say, "Let's call it a 'BOAT'." (It had to rhyme with COAT.)

The instructions to S were as follows: "These words/pictures (the ones just shown) are going to appear on the screen and what you will have to do is figure out which of these buttons goes with the word/picture on the screen. The same button will always go with the same word/picture: You will know if you picked the correct button because this light will flash on. If you picked the wrong one the light won't go on. At first you will have to guess which button to press, but soon you'll be able to figure out which button is the correct one for each word/picture."

The S had as long as he wanted to make a response on each slide. His latencies were recorded by E. The display remained on the screen for 2.5 seconds after S had made the correct choice. After an intertrial interval of approximately four seconds, the next slide appeared on the screen. The slides were in random order with the constraint that no two slides appeared more than twice consecutively and no position (right or left button) was correct more than three times consecutively. Trials continued until S responded correctly on ten consecutive trials (criterion) or had completed 60 trials.

When Stage I was completed, E changed the slide tray and told S that he would be presented with new words/pictures, but that his task would be the same as before. That is, he was to figure out the correct button for each word/picture. This constituted Stage II, the transfer stage. S was again run to 10 consecutive correct trials or to 60 trials if criterion was not met.

E then asked S how he had figured out which button to press and which task (Stage I or Stage II) he thought was easier. This interview was recorded on tape.

Subjects

The Ss were 60 second grade and 60 fifth grade children from an Ithaca school.[1] Fifteen Ss were run in each of the eight groups described above. The school population included primarily middle class children of above average socio-economic background, many from academic families. They were taken to a mobile laboratory on the school grounds for the experiment.

Results

It was considered that S could readily use the collative principle in learning the discrimination if he began his criterion run (10 consecutive correct choices) by the fifth word or picture presented. This number was chosen because by trial five S had been presented with all four words or pictures in the set. This measure was applied in both Stage I (training task) and Stage II (transfer task) and effectively gave us a pre-test and a post-test measure of S's ability to use the economical structure and to transfer the principle. This measure was selected in preference to a comparison of total number of errors since a simple comparison of the number of errors confounded training trials with an assessment of S's ability to use the principle. It would not tell us whether Ss could use rhyme or spelling pattern immediately in Stage II because they had learned the collative principle in the training stage, since some Ss might have been able to use it immediately in Stage I. It also did not permit us to analyze interactions because of a ceiling effect in grade five (some of these Ss made zero errors and thus the limits of their abilities were not measured). The measure we chose, the number (percent) of Ss solving (starting the criterion run) by trial five was not amenable to analysis of variance but nevertheless was preferable because of its validity.

1. The authors wish to thank the principal, teachers, and children of the Northeast School, Ithaca, for their enthusiastic cooperation.

Role of Structure with Word Stimuli

The principal question we asked was whether or not our Ss could take increased advantage of the collative principle present for the experimental group as age increased. In other words, does economy of information processing develop from grade 2 to grade 5? Compare first the control groups for the two grades in Stage I with words as stimuli (see Table 2). No Ss in grade 2 started a criterion run by trial 5,

Table 2
Number and Percent of Ss Solving the Word Tasks by Trial Five

Grade	Condition	Stage	
		Stage I	Stage II
2	E	3 or 20%	4 or 26.6%
	C	0 or 0%	2 or 13%
5	E	8 or 53%	9 or 60%
	C	1 or 6.6%	8 or 53%

and only one did in grade 5. When there was no structure present to reduce the information and four separate choices had to be learned, the two grades did not differ. By Fisher's exact test, the proportions are not significantly different.

On the other hand, when the two grades are compared on condition E, Stage I, where there was useful structure, 54% of the Ss in grade 5 started a criterion run by trial 5, but only 20% of the Ss in grade 2 did. This difference is significant at $<$ .025 by chi-square (one-tailed test). Thus, the ability to use an economical strategy increases with age. The fifth graders are also superior to the second graders in the transfer task (Stage II), where 60% of the older group began the criterion run by trial 5, but only 26.6 of the younger group did.

What about the effect of training? Did practice on a discrimination task containing the higher-order structure (relevant pretraining) facilitate using the economical strategy on a second similar task? To answer this question we applied the binomial test to scores of Ss in Group E to determine whether there was a significant change from Stage I to Stage II. Did children who did not start a criterion run by trial 5 in Stage I (when structure was present) have a greater probability because of practice when the opportunity was given a second time in the transfer task? The test was non-significant for both grades. So, although the children who did not perceive the economical strategy by trial 5, Stage I, had further opportunity to do so (up to 60 trials), there was no trend toward benefiting from this practice in the transfer task. Considering this as a pretest-posttest comparison, no transfer was observed.

Conceivably, a poor strategy begun on the first task might interfere with discovery of the economical principle on the second task. This possibility might have occurred accidentally for some children in Group E (one cannot tell), but it surely existed for Ss in Group C, where no superior strategy was possible. To see whether inability to use structure in Stage I had a negative effect on Stage II, the proportion of children solving by trial 5 in the control group, Stage II, was compared with the number solving by trial 5 in the experimental group, Stage I. In neither grade was there a significant difference by chi-square test. Since it was the first exposure for both groups to the problem that could be solved economically, there was no evidence of interference by an earlier poor strategy carrying over. The percent of Ss solving by trial 5 (53%) for Group C, Stage II, fifth grade, was in fact identical with the percent solving in Group E, Stage I.

Role of structure with pictures. Were the age differences found with words replicated when pictures were substituted as stimulus material? We conjectured that the second graders might be able to use a collative strategy, but found it hard to extract the principle from printed words. On the other hand, it might be that ability to induce the economical strategy had not developed yet. Looking at the data for Stage I (see Table 3), there is remarkably little difference between the two age groups in either condition. In condition E, Stage I, where fifth graders had excelled with words, the difference between

Table 3
Numbers and Percent of Ss Solving the Picture Tasks by Trial Five

Grade	Condition	Stage	
		Stage I	Stage II
2	E	1 or 6.6%	2 or 13%
	C	0 or 0%	2 or 13%
5	E	3 or 20%	8 or 53%
	C	2 or 13%	6 or 50%

the two grades with pictures was non-significant by Fisher's Exact test. It was also non-significant for Group C. Thus, neither the older or younger children were able to make immediate use of rhyming names as an information-reducing strategy. Only three children in grade 5 did so, and one in grade 2.

However, when we look at the change from Stage I to Stage II it turns out that for fifth graders a significant change occurred (contrary to the results with words). Applying the binomial test, fifth graders showed improvement over Stage I ($p < .05$), but the second graders did not. The impact of the rhyming names may have built up in the course of Stage I training and helped some of the fifth grade children perceive the presence of rhyme and use it in Stage II. It is possible that this effect was generated by a hint given some Ss. One of the pictures in Stage II was a boat. Several Ss called it a "ship" when asked to name it and were corrected by E. The correction might have called their attention to the rhyme with "coat." However, the control group, who had the same Stage II, did not show a similar improvement ($p > .05$). In any case, rhyming names alone were more apt to go unnoticed by Ss of both grades than printed words having common spelling patterns.

Again, there was no evidence of interference from using a poor strategy in the first task. When Group C, Stage II was compared with Group E, Stage I by a chi-square test, the difference was non-significant for both grades.

Pictures vs. words. It is a fairly general finding that children, at least in recognition tasks, remember pictures better than words (e.g., Fraisse, 1970). One might guess, therefore, that pictures should make easier cues for a discrimination task. This is not the case, however. Nine of the second grade children (experimental and control groups combined) solved the task by our criterion with words as cues, but only five with pictures. Twenty-six fifth graders solved with words and only 19 with pictures. There was thus no advantage in pictures even for the younger children in this task.

Latencies. Although latencies were recorded, there was so much variability between Ss that analysis of the pooled data revealed nothing interesting.

Interviews. Most of the children were able to give quite informative accounts of how they "figured out" the task, the fifth graders of course better than second graders. There was a nearly perfect correlation between solving by our criterion and commenting on the rhyme or spelling pattern. All but one of the second graders who met the criterion with words in Stage II remarked on the rhyme. One S who started the criterion run on trial 6 said the "words ended the same." One who started the criterion run on trial 19 mentioned the words having the "same letters." All but one fifth grade S who met the criterion in Stage II with words remarked on either rhyme or common spelling. Spelling was mentioned more frequently by fifth, than by second graders. Two Ss spoke of "similar vowels"; one said he solved the problem "alphabetically." About half the second graders simply said they "remembered." Only two fifth graders said this.

For pictures, nearly all second graders said they just "remembered." The four who mentioned rhyme all began a criterion run in time to complete 10 correct trials before the experiment was ended. Fourteen fifth graders mentioned rhyme. All of them completed the experiment.

No tests of significance were performed on these data, because some of the tapes were not interpretable. But it was obvious that awareness of a collative principle and meeting the criterion went together.

Discussion

Our concern in this experiment was how knowledge of the component relationships within words---in particular abstraction of common recurrent relationships--develops. Such knowledge has utility for transfer in reading new words and is an important factor in economical processing by the skilled reader. Previous experiments showed that children do not acquire this knowledge easily in the early stages of reading. Common spelling patterns seem to have little saliency for the beginning reader. Whether this is due to unfamiliarity of the component letters, difficulty in handling order information in combinations of letters, or immaturity of the ability to abstract a common factor and generalize a simple rule, we still do not know. Lowenstein's (1969) experiment showed that some children in the latter part of first grade were able to profit by hints about searching for common features for making a classification, but discovering the features for themselves (rather than being told them) was important.

The discrimination task used here seemed to be about the simplest possible vehicle for forcing an induction of a rule on the part of the child. We hoped the children would do so and then be capable of instant transfer to a new problem. The expectation was essentially not confirmed. More than half of the fifth graders did find and use the rule, but they either did so immediately, or not at all. The training task, in other words, did not train them to generalize if they could not already do it. Since they did not excell second graders when there was no rule available, their superiority depended on ability to use the rule.

The second graders were significantly less able to make use of the collative principle and also did not profit by the first task as a training method. The difficulty was not one of material--of words being "hard" for them--for they were even less successful with pictures. It is possible, despite Locke's (1971a, b) finding, that they did not name the pictures to themselves and thus did not discover the rhyming principle, but pictures rather than words did not make the task easier in the control condition either.

Lowenstein's first graders actually succeeded better in using common spelling patterns than did our second graders, despite the apparent simplicity of the present task. The sorting task she used has the advantage of letting S see two examples of the common feature simultaneously. We think now that even the small memory load put on the child in the successive discrimination task may be a disadvantage. Of course, it is an essential requirement in actual reading, if common patterns are to be utilized successfully, but greater maturity is evidently necessary for inducing the principle under these conditions. Direct simultaneous comparison would seem to be a better training procedure.

We conclude that there is very definitely an increasing economy of information processing as age increases, but factors in the method of presenting a task may enhance or hinder development of the ability. How to enhance it in the reading situation is a major and important problem.

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The Developmental Convergence of Meaning for Words and Pictures

Eleanor J. Gibson, Roderick W. Barron, and Ellen E. Garber

Summary

This experiment compared latencies for same and different judgments for pairs of pictures (PP), pairs of words (WW), and a pair composed of a word and a picture (WP). Word pairs were presented in two type faces, and pictures in two aspects of the same object so S could not make a physical match. The Ss were second, fourth, and sixth graders and college students. All Ss took part in all three display conditions. The question was whether a semantic match for the mixed representation (WP pairs) was reached relatively faster as development progressed, on the hypothesis that meaning progresses developmentally toward an abstract, non-imagistic, non-linguistic representation.

All latencies decreased with age. Display condition was a significant variable. The WP condition was slowest for all age groups. Display conditions PP and WW did not differ for the intermediate grades, but PP was faster for second graders whereas WW was faster for adults. Overall, latencies for type of judgment (same or different) did not vary. There was a significant age by grade interaction with WP dropping relative to PP and WW with age. But this decrease did not appear consistently for same judgments. A triple interaction of grade by display condition by type of judgment suggested that second graders and adults were using different decision-making processes in the WP condition. Second graders apparently got the meaning and a name for the picture first and matched it with the word, making their same judgments faster. Adults, on the other hand, read the word first and matched its meaning to the meaning of the picture. Since meaning probably precedes naming, different judgments were arrived at without naming and were shorter than same judgments, where a name had to be reached to match to the word. It was concluded that the hypothesis was supported, but that task variables cause differential processing developmentally. Experiments were suggested to check the interpretation offered.

The Developmental Convergence of Meaning for Words and Pictures

Students of semantic development have suggested that the basic semantic system continues to develop until rather late (McNeill, 1970; Moorehead, 1971). Comprehension of semantic features of speech continues to improve up to eight years (Gallagher, 1969; McNeill, 1970, pp. 117 ff.) and probably beyond. If this is the case with speech, we might expect that ability to extract meaning from written language will reach its peak still later. A skilled adult reader picks up semantic features of words as he reads automatically, swiftly, and in fact, almost obligatorily. It requires a conscious effort to prevent meaning from "surfacing," as the Stroop test (1935) and related laboratory tasks have shown.

Meaning is not extracted in such an immediate and involuntary fashion in early stages of a child's reading, for a number of rather obvious reasons. He is taken up with "cracking the code," for one thing; and he is dependent on extracting the meaning secondarily from the sound system, rather than directly as he might in a logographic or pictographic writing system. The question is, how does he arrive at what appears to be the adult's more direct and automatic processing of meaning in a writing system which is based on sound mapping?

Children begin to comprehend meanings of events and objects in the world at a very early age. Even pictures of objects are recognized and respond d to appropriately very early (Hochberg and Brooks, 1962). Is the representation of meaning for concrete objects separate from that for words? Or is there a course of development which brings the two closer together as verbal skill (reading skill especially) increases? Both the proponents of imageless thought (see, for instance, Moore, 1919) and Morton (1969) in his logogens theory, suggested that verbal meani g is represented abstractly. Could one add to this the hypothesis that meaning of real things and events and the verbal symbols for them converge during development toward the same abstract representation? The implication is that semantic features of speech and writing are derived from perceived meanings of real events and things, and that, in the end, there are not two or three meaning systems--one for concrete events, one for speech, and one for writing--but only one.

There is a small amount of indirect evidence to support the above hypothesis. An experiment by Shepela (1971) compared the effect of bimodal interference at two grade levels (kindergarten and second grade). Visual material (line drawings of familiar objects) was displayed on a small screen at the rate of two pictures per second. At random intervals during the presentation, a target picture of a bird appeared. In the first unimodal condition, the child was instructed to press a key every time he saw the bird. Auditory material (words heard over earphones) was presented in the second unimodal condition and the child pressed the key when he heard "bird." In the bimodal condition, both the pictorial and verbal material was displayed and the child was instructed to press the key when he saw the picture of the bird and when he heard the word "bird." The kindergarten group showed significant interference in the bimodal condition, but the second graders did not. Control conditions showed that the age difference was not due to an increased number of targets, and that the superiority of the second grade was due to improved detection of the verbal targets. Shepela reasoned that the older children were getting meaning more directly from the words and that the bimodal condition was therefore approaching a unimodal one such that the meaning of the pictorial and verbal targets was converging toward the same representation for the older group.

An experiment by Fraisse (1970) suggested to us a more direct method of studying the development of semantic perception of words and pictures and the possible convergence of processing for meaning in the two modes. In Fraisse's experiment, adult Ss were presented with three types of display and their reaction times recorded for a same-different judgment. Two pictures were displayed in one condition; two words in the second condition; and a word and a picture were displayed in the third condition. Half of the pairs were sames and half were differents. In the case of word-picture pairs, a same pair consisted of a picture with its corresponding name. Fraisse predicted that the third condition would require a longer time for judgment, because semantic processing, rather than mere "physical" processing would be required. "Elle exige l'intervention d'un processus de comparaison sémantique stocké dans la mémoire à long terme qui permette de décider que l'objet chaise, par exemple, peut se categorizer par le mot chaise (Fraisse, p. 80)." Fraisse's hypothesis was confirmed, since the judgments for picture-word pairs were significantly longer than those for the other two conditions, which did not differ from one another.

One might be tempted to conclude from these results with adult Ss that our hypothesis regarding the convergence of meanings in some abstract relation common to objects and words must be incorrect. But the fact is that physical matches (processed for graphic information only) were possible in the two non-mixed conditions, since the word pairs and picture pairs for a same judgment were physically identical (Posner & Mitchell, 1967). No semantic processing was necessary in either case, so the experiment does not afford a test of our hypothesis.

Consequently, we modified Fraisse's method so that same pairs for pictures and for words were not physically identical. Picture pairs, although belonging to the same conceptual category and having the same name, differed in superficial graphic features. A picture of a dog, for instance, would be presented in two different aspects, or from different angles. The judgment to be made was whether they were pictures of the same object, not whether they were physically identical. A pair of words was presented in different type faces, one member in upper case and the other in lower. We hoped that this arrangement would force the S to use the semantic features of the word or picture.

Since our hypothesis was a developmental one, four age groups were chosen for comparison--second, fourth, and sixth graders, and college students. We made the following predictions:

1. Latencies should decrease with age for all types of judgment.

2. For the youngest age group, picture-picture pairs, the most concrete material and thus presumably the most salient to a young child, should yield the shortest latencies; word-word pairs next; and picture-word longest.

3. As age increases, the latency should become relatively shorter for the picture-word condition as compared to the other two. In other words, we expected an age by conditions interaction with a significant component of the variance due to lowered latencies for the picture-word condition.

Method

Design

The experiment, as explained above, had three display conditions, four age groups and two types of response judgments. A Picture-Picture (PP) display was used in the first condition, a Word-Word (WW) display was used in the second condition and a Word-Picture (WP) display was used in the third condition. The four age groups (32 Ss per group) were drawn from the second, fourth, and sixth grades of a local elementary school and from Cornell University (the college students were paid two dollars for their participation). One-half of the Ss in each group were males and one-half were females.

Each S saw each display condition 24 times for a total of 72 trials. Within each display condition, one-half of the displays required a same response judgment and one-half a different response judgment. The same response was on the left for one-half of the Ss in each group and on the right for the other one-half.

The three display conditions were presented in random order, with the constraint that no display condition, and no response judgment occurred more than four times in succession. The two members of each display were presented simultaneously, and the position of the members of the display was counterbalanced so that an individual picture or word appeared equally often on the left and right.

Materials. One-half of the Ss from each age group were given the following words and corresponding pictures: fish, bird, dog, cup, sock, boat. The other one-half of the Ss were given: frog, lamb, cat, key, iron, and plane. The pictures were simple outline drawings taken from children's coloring books and photographed for slide presentation. For the same response judgments, as explained above, two pictures were chosen to represent each object. Hence for a single display in the PP Condition, one aspect of the object was given by one picture (e.g., the profile of a dog), and another aspect of the object was given by the second picture (e.g., a three-quarter view of a dog). In the case of the WW display condition, the same word was given in two type faces (i.e., DOG dog). Finally, in the WP display condition, the two members of the display consisted of the printed word "dog" and a picture of a dog. The two type faces and aspects of the pictured objects were equally represented.

Procedure

The S was seated 90 cm. from a 30 x 30 cm. ground-glass screen. When the S was ready, he pressed a foot pedal which started a Hunter Klockcounter and simultaneously opened two Gerbrand G1166 electronic shutters in front of the lenses of two GAF ESP2000 random access slide projectors. The opening of the shutters allowed a 15 x 21 cm display to be back projected onto the screen in front of the S. When the S had decided that the two members of the display were the same or different, he indicated his response judgment by pressing one of the two appropriately labeled buttons on the response panel in front of him. An orange light appeared on the panel if the S was correct.

Before the experiment began, each S was shown all of the slides and asked to read the words (in both type cases) and to identify the pictures (in both aspects). If after two presentations of the word, the S was still unable to identify the word, he was not used in the study. In the instructions which follow, the S was shown two examples (one same and one different) of each of the three display conditions.

"I am going to show you pictures of some words and some objects. When I say go, I want you to press the foot pedal that is on the floor. Are these two pictures the same? They are both pictures of cats, so they are the same. They are not exactly the same cat, but they are both cats so they are the same. O.K.? I want you to press the button marked same. Press the foot pedal again. Here is a picture of a cat and the word cat. Are they the same? Yes, because they both mean cat. So you press the same button. Press the foot pedal again. What is that a picture of? A lamb--right. Is it the same as the other picture? No. One is a cat and the other is a lamb, so we say they are different. So you press the different button. Press the foot pedal again. Can you read that word (pointing to lamb)? That's right. And the other word? Are they the same? No. So you would press the different button if you saw them together. Press the pedal again. Here is a picture of a lamb and the word cat. What do you say? Right. Remember, press the right (left) button if they are the same and the left (right) button if they are different. Press the button just as quickly as you can. If you are right the light will go on. If you are wrong, it won't. All set? O.K. Press the foot pedal when I say O.K."

All of the age groups received essentially the same instructions. The younger children had no difficulty in following the instructions. All of the Ss were urged to be as accurate as possible, but this was particularly emphasized with the two older groups because pilot studies had indicated that they were more likely to sacrifice accuracy in order to increase their speed.

Results

The error frequency data are presented in Table 1 for each grade as a function of display condition and response judgment. Since the mean error rate for each grade was always less than five percent, we feel justified in analyzing the latencies as the dependent variable of main interest. Before leaving the error data, a few trends should be noted. Second graders made the fewest errors overall. They were very deliberate in the performance of the task. They made significantly more errors ($p < .01$ by a Wilcoxon Matched Pairs Signed Ranks Test)

Table 1
Frequency of Errors for each Grade as a Function of Display Condition, and Type of Response

Grade	Picture-Picture Display		Word-Word Display		Word-Picture Display		Mean percent error rate
	Same	Different	Same	Different	Same	Different	
Second	2	7	19	8	15	14	2.8%
Fourth	17	9	12	19	23	14	3.9%
Sixth	11	13	12	24	29	21	4.8%
College	10	11	9	9	25	8	3.1%

on the W-W displays than on the PP display, undoubtedly because of their as yet undeveloped reading skill. This finding is also reflected in the latencies, as will be seen. The sixth graders made the most errors; these older children seemed more concerned with speed than the younger children. One S was dropped from the experiment because he made more than ten errors.

An interesting trend was the tendency for the college Ss to make three times as many errors on the same judgments as on the different judgments in the W-P condition ($p < .01$ by the Wilcoxon test). The differences were not significant in the other conditions. We shall return to this result after considering the latency data.

The basic data for each S were medians calculated from the 12 latencies observed under each level of display condition and response judgment. Error latencies were not included in the computation of the medians. The means of the median latencies for each grade as a function of display condition and type of response judgment are presented in Table 2. The results were subjected to an analysis of variance which is presented in Table 3. As expected, the grade variable was highly significant ($p < .001$) and responsible for a large share of the variance. The range of mean RTs was from 1957 milliseconds for the

Table 2
Mean Latencies for each Grade as a Function of Display Condition and Type of Response

Grade	Picture-Picture Display		Word-Word Display		Word-Picture Display	
	Same	Different	Same	Different	Same	Different
Second	1957	1987	2044	2133	2141	2281
Fourth	1364	1343	1318	1330	1479	1418
Sixth	1114	1194	1132	1162	1224	1221
College	821	856	793	842	939	893

Table 3
Analysis of Variance for Median Latencies

Source	df	SS	MS	F
Between Squares	127	207,243,988.67		
Grade (G)	3	157,402,495.87	52,467,498.62	130.533**
S/G	124	49,841,493.13	401,947.53	
Within Squares	640	27,882,915.00		
Display Condition (D)	2	2,194,318.81	1,097,159.41	21.583**
GXD	6	752,965.27	125,494.21	2.469*
SD/G	248	12,606,708.92	50,833.50	
Response (R)	1	147,297.52	147,297.52	.199
GXR	3	303,557.15	101,185.72	.137
SR/G	124	9,178,678.33	740,215.99	
DXR	2	44,315.15	22,157.58	2.61
GDR	6	545,592.21	90,932.04	10.69**
SDR/G	248	2,109,481.64	8,505.97	
Total		235,126,903.67		

**$p < .001$
*$p < .025$

P-P "same" response judgments in the second grade to 793 milliseconds for the W-W "same" judgments in the college students.

Display condition was also a highly significant variable ($p < .001$). Overall, the P-P condition had the shortest latency, the W-W condition was intermediate, and the W-P condition was the longest. The biggest difference was between the WP condition and the other two conditions, as we had expected. The response judgment main effect ("same" or "different"), taken by itself, was not significant.

The grade by display condition interaction was of greatest interest to us, and it was significant ($p < .025$). The r ason for this interaction was chiefly due to a decline with age in the difference between the WP condition and the other two conditions (i.e., PP and WW), as we had predicted. The overall explanation of these results, however, turned out to be considerably more complicated than we had anticipated. For one thing, the difference between the WP condition and the other two conditions decreased steadily through the sixth grade, but this trend was not continued with the college Ss. This decrease in latency with grade is shown in Figure 1 by means of a difference score which was computed by subtracting the latency of the WP condition from the mean of the WW and PP conditions ($WP-\frac{WW+PP}{2}$). The curve for the different response judgments in Figure 1 drops very consistently across the three grades and levels off, but the curve for the same response judgments drops until the sixth grade, and then rises for the adult Ss.

The very significant ($p < .001$) triple interaction of grade by display condition by response judgment bears out this difference between the same and different response judgments. This triple interaction is plotted in Figure 2 with grade and type of response judgment as parameters. For the second grade, latency increases steadily from PP to WW to WP, and the same judgments are consistently faster than the different judgments. This is not the case for the other three grades. The WW condition does not take longer than the PP condition; and the same judgments tend to be slower than the different judgments in the WP condition, especially for the college Ss.

Consider first the PP condition compared to the WW condition. The PP latencies were significantly shorter than the WW latencies for the second graders, $t(30) = 2.55$, $p < .02$, presumably because the second graders do not yet read very competently, and thus do not get the meanings from the words as easily as from the pictures (their error rate for words accords with this interpretation). The fourth and sixth graders do not differ significantly on the two types of display condition, but the college students do, $t(30) = 2.07$, $p < .05$. The order, furthermore, is reversed. They have shorter latencies for the WW condition suggesting that it is easier for them to extract meaning from the words than from the pictures.

Now consider the same and different response judgments. As mentioned above, type of response judgment overall was not a significant variable. In addition, the type of response judgment did not interact significantly with either the grade or display condition variables. But when the response judgment variable is considered together with both the grade and display condition variables, it is clear that the same and different judgments have differential effects. The condition of interest is WP. The same judgments are significantly

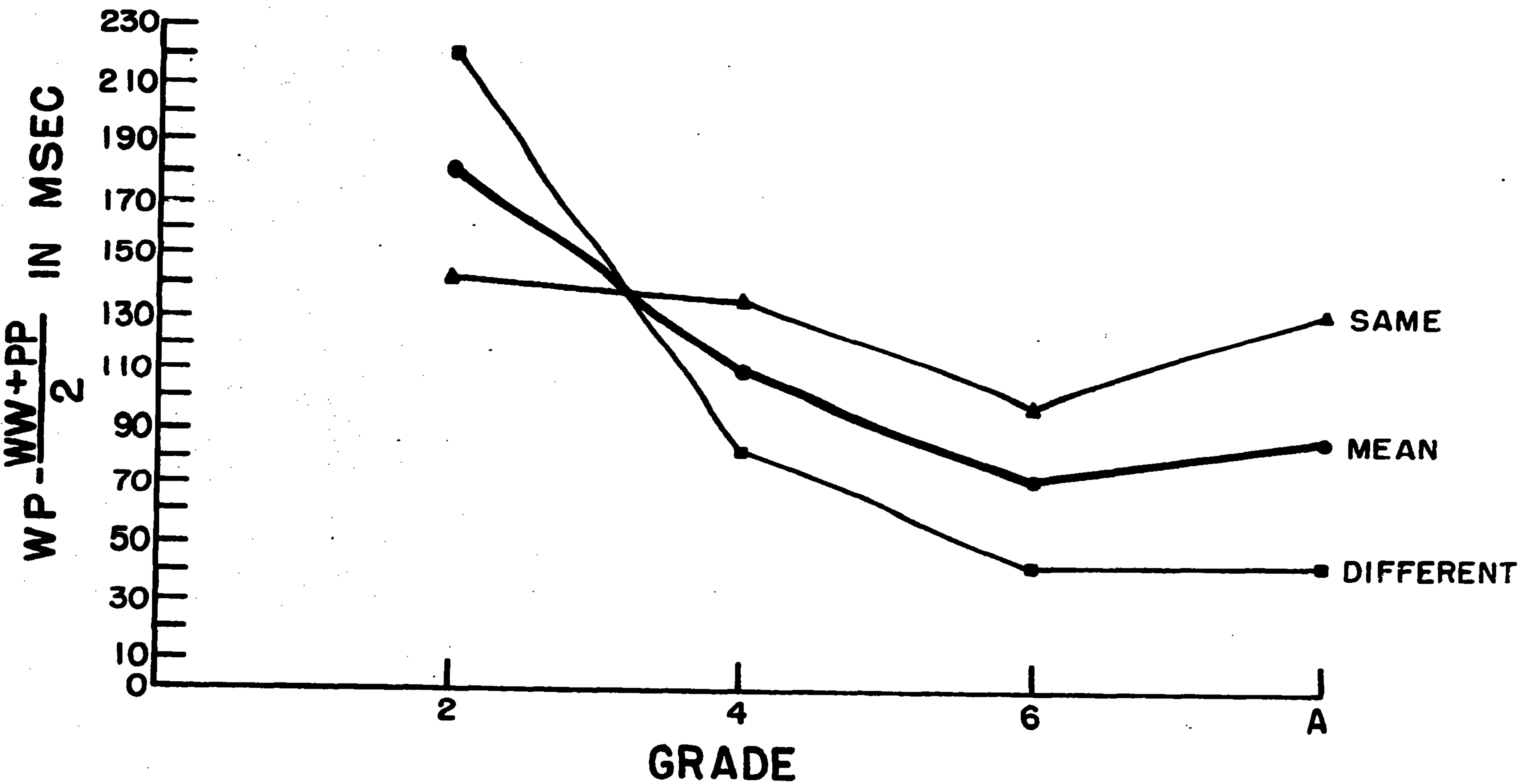

Figure 1. Difference in latency between the W-P condition and the mean of the W-W and P-P condition across grades.

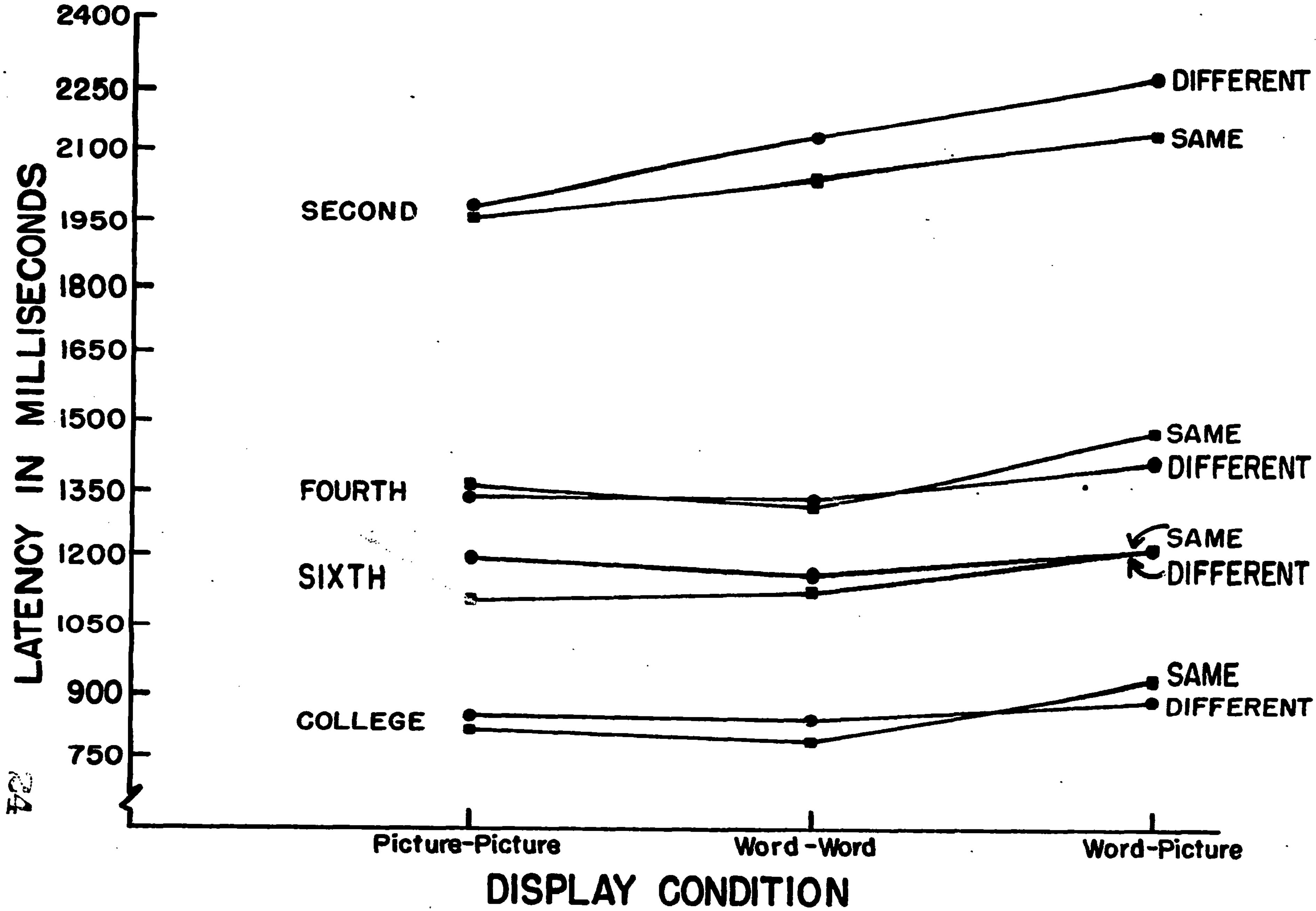

Figure 2. Plot illustrating the triple interaction between grade, display condition and type of response, with grade and type of response as parameters.

faster than the different judgments for the second graders when the display is a word and a picture, $t(30) = 2.22$, p .05. For the fourth and the sixth graders this difference is not significant, but for the college students the order is reversed. Now the different judgments are significantly faster than the same judgments, $t(30) = 2.52$, $p < .02$. This reversal of the same and different judgments for the college students is shown dramatically in Figure 1 where the difference in latency between the WP condition and the mean of the WW and PP conditions is plotted. There is only a 44 millisecond difference between the WP condition and the other two conditions when the different judgments are considered by themselves. But the difference is three times as great (132 milliseconds) for the same judgments, suggesting that a convergent representation of meaning is not reached as readily when a same response judgment is required. This group's significantly higher error rate for same judgments in condition W-P is in accord.

It seems to us that these results indicate a radical difference between the second graders and adults in processing WP displays. The age difference in ease of processing in the PP and WW display conditions suggests that the explanation must take into account the facility with which meaning is extracted from pictures as contrasted with words. A hypothesis regarding this difference will be offered in the Discussion.

Discussion

In recent years, there has been much research and lively debate as to how meaning is stored in memory, with the debate centering around a dichotomy between imagistic and linguistic preferences for how meaning is "coded" (e.g., Bower, in press; Paivio, 1971; Reese, 1970; Rowher, 1970). Both positions, as well as an ecumenical compromise accepting them as parallel systems, imply that a distinction between modes is retained in processing for meaning when remembering something. On the other hand, there are those who argue that rather than several parallel "mnemonic coding systems," there may be only one abstract semantic system in which meaning is neither embodied in linguistic form nor as any kind of concrete imagery, but in some abstract deep structure (Bransford, Barclay, & Franks, 1972; Ehri & Richardson, 1972). What that structure is like we cannot say, but we have revived, it seems, the concept of imageless thought.[1] As Shepard and Chipman (1970) remarked, "Ss do indeed seem unable to tell us anything significant about the structure of an individual mental image as such. What they can however tell us about, is the relation between that internal representation and other internal representations (p. 17)."

The latter sentence is particularly relevant to the approach taken in the present study. We did not put the question directly to

1. T. V. Moore's (1919) monograph, "Image and Meaning in Memory and Perception," begun with Külpe at Munich in 1913, is an excellent reminder of the power of this concept.

the Ss, but we compared directness of access to meaning within and between modes of display. The question differs from that of most recent experiments because we are asking about access--extraction of meaning--rather than how meanings are "stored."

The hypothesis we were concerned with is closest to the unicameral, abstract, amodal position; that is, that there is only one meaning system, neither specifically iconic nor specifically linguistic. This is the same position, essentially, as that so eloquently advocated by Moore more than 50 years ago. We thought it likely that there would have to be a developmental road to this ideal, economical conceptual system. Since it would necessarily be unavailable to introspection, we chose to study it by comparing modes of representation that we could manipulate, using the S's latency in judging whether two members of a display had a same or different meaning as the dependent variable. Time to make the decision would tell us, we thought, just how similar the internal representations of meaning were: and whether, with different modes to compare, there is eventually convergence toward the latency for the within-mode comparisons.

A superficial look at the results suggests that this hypothesis has been, at best, only partially confirmed. The results plotted in Figure 1 show a nicely declining latency, as predicted, from grade two through six, when same and different judgments are averaged. But the college students do not continue the trend. If only the different judgments are considered, the overall picture is very satisfactory. But the same judgments do not show a consistent downward trend, and there is even an upturn for the adults. We must look further for an explanation than the simple hypothesis of an advance with maturity to a single amodal representation of meaning.

Are the Ss truly reaching a semantic level in making their judgments in this experiment, or are they perhaps only matching words? Do they read the two words in the W-W condition and merely match acoustic representations of them? Do they name the two pictures in the P-P condition and match names, without going through a semantic system? Do they read the word, name the picture, and then match the two words by some acoustic, but non-semantic representation in condition WP? This notion in the PP and WP display conditions, at least, seems thoroughly untenable. Moore (1919) showed Ss pictures and measured the time between presentation and the experience of meaning and likewise between presentation and occurrence of a name. Latency for meaning was always shorter for all pictures and all Ss. Moore said (p. 90), "When the meaning experience comes the name is not yet present. My Ss often spoke of the priority of the meaning to the naming." Again (p. 180), "A meaning cannot be lacking if the subject names the picture--no matter what the task.". In other words, the semantic category must be found before a name can be produced. Brown (1958) seems to have come to a similar conclusion.

Dr. Elizabeth Warrington (personal communication) showed two photographs of the same object, each photographed from a different angle, and asked S to say whether or not they were the same object. Patients with right parietal lesions showed a significant deficit in this task. Since their speech and language functions were intact, she reasoned that "verbal hypotheses" play a minimal role in the task.

The precedence of meaning over naming is important in interpreting our results. The results suggest that second graders process the meaning in words and pictures differently than college students. We obtained two reversals in latency between the second grade and the college Ss. The second graders were faster in the PP condition than in the WW condition, but this trend was reversed for the college students, who were faster in the WW condition. There was no difference between the two display conditions for the intermediate grades. The same judgments were faster than the different judgments for the second graders in the WP condition, but for the college students the different judgments were faster. The same and different judgments did not differ for the intermediate grades. What do these reversals tell us?

We suggest that the same judgments are shorter in the WP condition (but not in the other conditions) for second graders, because the meaning of the picture, and hence its name, is more readily accessible to them than the meaning of the word. We suggest that the second graders' strategy is to get the meaning first from the picture, then name the picture (get a word for it), and then match that word to the written word. If a match is obtained, they will have been facilitated by knowing the meaning of the picture, but if the word does not match, knowing the meaning of the picture cannot help them. Since matches lead to same judgments, the same judgments are faster than the different judgments in the WP condition.

The college students, on the other hand, use a very different strategy. The different judgments are shorter in the WP display condition (though not in the other conditions) because words are more salient to them than pictures. We suggest that the college students first get the meaning from the word and then match it to the meaning of the picture before going on to a naming stage, since meaning precedes naming (cf. reference to Moore, above). A different judgment can be made without naming when the meanings for the words and pictures do not match. When the meanings do match, however, the college student goes on to the naming stage and checks the name of the picture with the word. This extra step inevitably takes longer. The different judgments are shorter, in other words, because the name is not processed at all, or only after the judgment has been made and the key pressed.

Why would the college S go on go check the name of the picture before making a same judgment when the word has already provided a meaning? Words have multiple meanings, especially for adults, and the meaning given by the word might not be the one represented by the picture. Multiple meanings for words and names for objects, most characteristic of adults, will affect same judgments, but not different judgments. They make the same judgments longer and, as shown in Table 1, result in more errors.

If this explanation is correct, errors for same judgments (that is, deciding different when same was the correct judgment) should have shorter latencies than the correct same judgments, because S made his judgment before checking the name. This is, indeed, the case. The mean latency for correct same judgments was 939 msec; but for erroneous ones (a total of 25 errors) it was 792 msec.

This admittedly speculative explanation can fortunately be checked. It is planned to run the P-W condition again with second graders and adults, with sequential presentation of the material. If the above hypotheses are correct, the children should have faster reaction times when pictures are presented first; but the adults should be faster when words are presented first.

It will also be of interest to conduct the experiment with acoustic, rather than written presentation of the words. Since the above interpretation depends partially on the difference in salience of written words for children and adults, the condition by grade by response interaction might be reduced for Ss in the age range used in this experiment. We would, however, still expect an age by condition interaction for children of the age range tested by Shepela.

Does the proposed explanation disconfirm the hypothesis we were investigating? It seems to us to be perfectly consistent with it. The downward trend in Figure 1 for different judgments bears it out and the data suggest no other explanation for that trend. The nature of the task draws differentially on the competences of second grade children and college students and causes them to perform in ways which are most economical for each.

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The Effect of Orthographic Structure on Letter Search: A Reexamination*

Martha Zaslow

In an experiment done by Gibson, Tenney, Barron and Zaslow (1972), no difference was found in scanning rates between Ss who scanned through lists that were composed of orthographically structured pseudo-words to locate a target letter N, and Ss who scanned through lists that were not orthographically structured. Though a scanning procedure had never been used before to test for the effect of orthographic structure, the results were inconsistent with previous experiments on orthographic structure using tachistoscopic presentations. In these experiments, pseudo-words that were pronounceable and orthographically well structured were consistently more accurately and rapidly perceived than control items. It is proposed that the results of the Gibson et al. experiment could be accounted for in terms of the particular procedure used, and predicted that with a limited number of changes, the facilitating effect of orthographic structure could be demonstrated in a scanning experiment very similar to the original one.

The following changes in procedure were proposed, and for the following reasons: (1) Instead of using a single target throughout the experiment, Ss scanned for a different target on each of the 20 experimental trials. Previous research (Ulric Neisser, 1964) had indicated that the scanning procedure tended to favor, as a strategy of search, the use of graphic information. Using a single target throughout might encourage processing for the graphic features of this letter, and make such information as orthographic structure irrelevant to the task. Changing the target on each trial would decrease S's tendency to rely merely on graphic information.

(2) Orthographic structure, or rules governing the spelling patterns of English, have two components: permissible (probable) combinations or groupings of letters, and positions permissible for them to occur in. While other theories of word perception make statements about sequentially probable combinations of letters, a theory of orthographic structure based on spelling-to-sound correspondences as proposed by E. J. Gibson is further concerned with the importance of constrained position of letters and letter clusters. It was decided to examine the importance of position, as a means of separating theories of orthographic structure and theories based on sequential probability. Accordingly, the second change was to select a set of letter-clusters that fit both requirements in a very specific way. Two-letter consonant clusters were selected that were constrained to appear only at the beginning or at the end of monosyllabic English words. BL, for example, can only begin such a word in

*A summary of a Senior Honors Thesis, Cornell, 1972. A full-length paper will be submitted for publication.

English, and ND can only end one. Working with such constrained forms enabled E to devise lists of pseudo-words that were well structured and pronounceable when the clusters were in the proper position, but the reverse when the clusters were put at the "wrong" ends of monosyllabic pseudo-words. One could thereby test the importance of agreement in both position and letter sequence with the rules of orthographic structure in contrast with a given sequence (target cluster) alone. (3) As noted above, the earlier experiment apparently had not made the structure of the context items relevant information for the scanning procedure used. In this experiment, a cluster rather than a single letter was always the target. It was felt that the targets selected (consonant clusters of high probability in English) would make pick-up of information about structure task-relevant in the well-structured condition where the cluster was correctly placed in both target and context items. In the non-structured condition, the target being scanned for was the same cluster but appeared in the wrong location.

The results of the revised experiment indicate that Ss in the well structured condition scanned significantly more rapidly ($p < .05$) than Ss in the non-structured condition. The structure thus did become task-relevant, and facilitated search. Taken together with the earlier experiment, the results indicate that a facilitation effect occurred only when both requirements of orthographic structure were met. The scanning task itself tends to encourage the use of the most economical procedure for scanning. The present experiment indicates that once the option of processing for graphic structure alone is eliminated, processing for orthographic structure becomes a highly economical search approach. This in turn, attests to the extent to which adult readers have, and can readily utilize, their abstracted knowledge of orthographic structure in words.

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