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3 Mundane Symbolism: The Relations Among Objects, Names, and Ideas

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Symbolization is the representing of an object or event by something other than itself. Three aspects of symbol comprehension will be discussed: (1) *recognition* that a given symbol refers to a particular object; (2) *discrimination* between the symbol and the object itself; and (3) *interpretation* of the similarities and differences between the symbol and the object. The first of these aspects is the most central and is the one on which we focus in this chapter. Brief consideration of the other two aspects will follow.

Two theories of symbol recognition that stem from different theories of mental representation can be contrasted. According to the *dual coding* theory, symbols such as the names of objects succeed in referring by eliciting verbal associations and by activating the appearance or image of those objects. According to the *conceptual* theory, names refer by activating amodal concepts (ideas) that are neither perceptual nor verbal. The importance of distinguishing between these two theories, for the study of symbolization, is that the theories disagree on the status of verbal symbols. The dual coding theory allots a special abstract status to words and their associations, distinct from the concrete nature of perception. Because abstract classes such as *furniture* or *democracy* have names but do not have a single perceptual equivalent, verbal thinking is given a power denied to imagery. In contrast, the conceptual theory of representation puts perception and imagery more nearly on a par with verbal comprehension, because all knowledge (apart from names and appearances) is considered part of a single system. Since each view has profound implications for intellectual functioning and development, including the development of symbolization, the two theories are reviewed in detail. To anticipate, we conclude that the conceptual theory is supported by the preponderance of evidence.

One implication of the conceptual theory is that comprehension of symbols such as words parallels perceptual comprehension, since both processes depend on the activation of the same abstract ideas. The similarity between the two processes of perception and symbol comprehension is evident not only for recognition, but also for the second and third aspects of symbolization: discrimination and interpretation. The development of perceptual competence, it is argued later in the chapter, parallels and foreshadows all three aspects of the development of symbol comprehension. The parallel suggests that percepts can be regarded as mundane symbols of object concepts, symbols whose mastery leads to comprehension of both the iconic symbols of art and the conventional symbols of language.

RECOGNITION OF A SYMBOL

How are symbols such as words and pictures understood? The first step is recognition that a particular symbol—say, the spoken word *chair* or a sketch such as

—refers to an already familiar entity, a chair. In representational art and in the use of spoken or written names, the problem of figuring out what object is being symbolized may seem trivial to an adult, but of course it is not. To discover what a word names, children have to divide the world of experience into a set of objects and events that correspond to the names in the language they are learning; how such a division is made is not always obvious (Quine, 1960). Only then can they learn name-object associations in spoken and finally in written language.

Symbol recognition is apparently less difficult for drawings or photographs than for words and least difficult for realistic sculpture and theatrical performance. The more closely the symbol resembles the referent, the easier the recognition process, at least during learning. Goodman (1968) has argued that pictures do not resemble visual appearances very precisely, but clearly there are similarities of contour and color or relative brightness between pictures and perceived objects. To recognize the referent, however, the viewer must overlook the patent differences, such as the flatness of a painting or picture. Even a young child seems to be capable of disregarding these differences and recognizing photographs and drawing of objects, as Hochberg and Brooks' (1962) dramatic experiment with a 19-month-old child who had never seen pictures demonstrates.[1]

[1]When pictures are deliberately made difficult to understand, for example, by blurring a photograph, there is a marked improvement with age in the ability to recognize what is pictured (Potter, 1966). In such conditions, however, problem-solving skill interacts with ordinary perceptual recognition.

In an unpublished study with eight children about 3 years of age Potter and Faulconer (1973) compared children's ability to name real objects and line drawings of the objects. The children had little difficulty recognizing simple line drawings of objects and in fact were able to name them about as rapidly as they named the real objects. The same is evidently true for brain-injured patients with some degree of aphasia—if they can name at all, they do about as well with drawings as with the objects themselves (Corlew & Nation, 1975). Although there have been some reports to the contrary, most studies show that adults and children who have not seen pictures before have surprisingly little difficulty in recognizing what is depicted in a photograph or realistic line drawing (see Hagen, 1974, for a review of this issue and a discussion of ways in which pictures may resemble what they depict).

Although a piece of representational art may correspond with what it symbolizes in contour, color, and the like, any picture still has many conventions that have to be learned. The most obvious of these stem from the two-dimensional representation of three-dimensional objects and spatial layouts. The mimicking of perspective as it would appear if viewed with one eye from a fixed point, disregarding the true distance of the picture surface, is only one way in which the idea of the third dimension might be represented. In another convention, more distant objects are placed higher in the picture without shrinking their size. What looks realistic in one era or culture, in consequence, may look mannered or artificial in another.

The one nonphotographic form with which young children may be most familiar is the cartoon and its static equivalent, the comic strip. Curiously, these forms have numerous conventions, and yet children seem to have little difficulty comprehending them. Studies of Brooks (1977) and Friedman and Stevenson (1975) suggest, however, that action lines and other cartoon conventions are not fully used by children until as late as the ninth grade. Eventually they appear to be understood as automatically and directly as the iconic aspects of the cartoon; their arbitrariness becomes invisible.

Thus, symbols may be recognized either by their resemblance to their referents or (as in the case of words and the conventions of art) by learning. Just what mental events underlie each type of recognition? Consider the simplest case, recognition of symbols for concrete objects. In the chair example already mentioned, one sees the word *chair* or a sketch of a chair and thinks of a chair. But what is "thinking of a chair" in each case? Two different accounts follow.

Two Theories of Mental Representation

Dual Coding Theory

According to dual coding theory there are two distinct systems or codes of mental representation, one verbal and the other pictorial or image-like (Paivio, 1971, 1975a). One system represents knowledge about the

appearance, feel, or sound (if any) of objects such as chairs. Thinking of a chair, in this knowledge system, is activating stored images based on previous perceptions of chairs. These memory images may be somewhat schematic, but they share the spatial characteristics and other sensory qualities of perception. The other system of knowledge, according to dual coding theory, is language-based knowledge, consisting of associations among words. The word *chair* may activate associated words such as *table*, superordinate words such as *furniture*, functions such as *sitting*, and so on.

The two systems of knowledge are linked by learned associations between images and names: A chair image is associated with the word *chair* and vice versa. Understanding the symbol *chair* thus includes activation of two sorts of knowledge: verbal associations and images. Similarly, understanding a sketch of a chair consists of classifying it (by similarity) into the appropriate image category which in turn activates its name and other associations in the verbal system.

Because the word *chair* first enters the verbal system, an extra step is required to evoke the corresponding image. That step takes time and does not invariably occur when we read or hear *chair*. Conversely, when we see a chair or a picture of a chair the image representation is first activated, and an extra step is needed to evoke the chair's verbal representation, that is, its lexical entry or name.[2] Again, the step takes time. An asymmetry between verbal and image codes is hypothesized, however. When one looks at an object or a drawing of it, its name is automatically activated (given sufficient time), whereas when one reads or hears a word naming a concrete object, the corresponding image is not necessarily activated. The dual coding theory is diagrammed in Fig. 3.1.

Although concrete objects such as chairs are represented both in the verbal and in the imaginal system, the meanings of many words that refer to abstract entities (such as *liberty* or *infinity*) are represented almost entirely in the verbal system. The verbal system develops as a symbol system of words mapped onto objects—tables and cars and dogs—but through intraverbal connections it becomes autonomous, capable of representing functions, relations, and structures that are abstract rather than perceptible. Thus the verbal system is specialized for representing abstract knowledge whereas the image system represents perceptual properties of objects such as their shapes, colors, and sizes. Since speech is temporally ordered, the verbal system is specialized for the representation of serial order, whereas the image system is specialized for the representation of simultaneous spatial position.

[2]The lexical entry of a word includes information about its sound, spelling, and articulation; that is what is meant here by *name*. Whether the lexical entry is a necessary route to knowledge about a *pictured* object (such as its semantic category) is the theoretical point at issue.

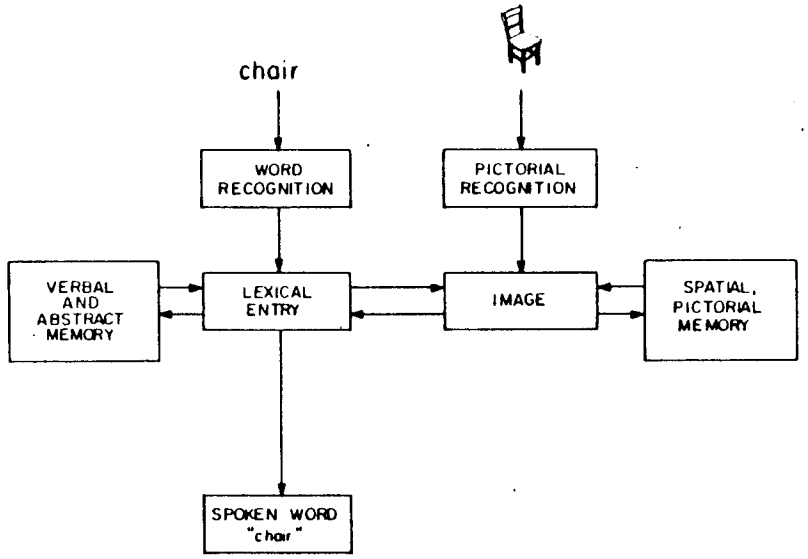

FIG. 3.1. Dual coding model of picture and word representation.

Evidence for Dual Coding Theory. There are many experimental results that have been cited in support of the dual coding theory, of which I will mention only the major findings.

1. *Naming time.* It has been known for a century or so that people take longer to name objects (or drawings) than to name (i.e., read aloud) words. That is exactly what the theory would predict, since an extra step, between systems, is required to get from the image to the name of an object.

2. *Recall.* Drawings are recalled more often than words in experiments in which a list of unrelated words or drawings is learned. Since a drawing rather automatically activates its name, according to the theory, drawings are dually encoded. Words are less likely to activate images spontaneously, and so they are not dually encoded during learning. On the reasonable assumption that two memory representations are better than one, the advantage of drawings in later recall is explained by the theory. In further confirmation of the theory, deliberate imaging of words greatly enhances their recall. In addition, abstract words (which are difficult or impossible to picture) are more difficult to remember than concrete words, just as expected.

3. *Rapid serial presentation.* When a sequence of unrelated words or drawings is presented for immediate recall drawings are, if anything, worse than words. Why does a dual coding theory make this prediction? A drawing

takes time to name, so a sufficiently rapid presentation will result in only a single code, the image code. For immediate recall, especially when the subject is required to recall in the same order as in presentation, the verbal system (specialized for representing temporal order) has an advantage.

4. *Hemispheric specialization.* The accumulating evidence for hemispheric specialization of function is consistent with dual coding theory. Language functions are found predominantly and almost exclusively in one hemisphere (usually the left), and certain spatial abilities such as face recognition, map-using capacities, and the like seem to be localized in the right hemisphere (Milner, 1971, has a useful review).

Conceptual Coding Theory

The conceptual theory of mental representation claims that in addition to images and words there are conceptual representations, that is, representations of the idea of an object. The mental concept *chair*, in this view, is common to the word *chair* and a picture of a chair and is directly accessible from either the word or the object. A diagram of this theory is shown in Fig. 3.2. As in the dual coding theory, there is a structural distinction between one's memory for the appearance of an object and one's memory for the word

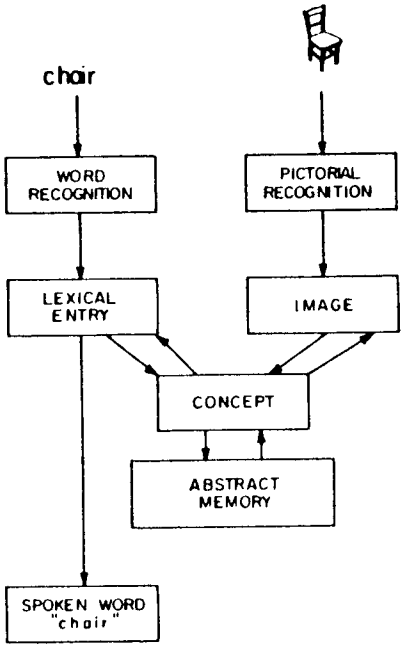

FIG. 3.2. Conceptual model of picture and word representation.

naming the object, but the conceptual theory claims that there is in addition a more abstract conceptual representation common to both.

The conceptual theory proposes that "thinking of a chair" consists of the activation of a concept or idea that is neither verbal nor perceptual. Except for stock phrases and idioms, words are not associated with each other; rather, concepts are associated. When we understand a word, we must first locate it in a lexical "dictionary," but its meaning and associations are not found there. According to this theory, the lexical entry is only a route to the conceptual system in which ideas that correspond to words are stored. When we understand a sketch of a chair, that same chair concept is activated, this time via stored information about the appearances of objects. In this case, the name of the object plays no role in understanding. Instead of two functionally distinct systems of knowledge, one concretely perceptual and the other verbal and hence inherently symbolic and abstract, the conceptual theory proposes that words and appearances are simply way stations on the route to a conceptual representation. Words, pictures, and perceived objects are all equivalent in that they converge on a single concept.[3]

Accounting for the Evidence. The conceptual theory can also account for most of the evidence just cited for the dual coding theory.

1. *Naming time.* The slower naming of a drawing than a word is predicted by this model also, as inspection of Fig. 3.2 will show.

2. *Recall.* The relative advantage of drawings over words in recall experiments may be attributed to greater depth of processing of drawings. The recognition of a written word could stop at the level of the lexical entry without evoking the concept; for example, one could read a word aloud without necessarily becoming aware of its meaning first. Rehearsal of a word might involve only the lexical representation, not the concept. A drawing or perceived object, however, seems invariably and automatically to continue past the pattern-recognition process to the level of conceptual meaning. If the viewer adopts the strategy of naming drawings and rehearsing the names, he will still be obliged to activate the drawing's concept in order to retrieve its name.

Thus, images may be automatically understood, but words—especially in a list-learning experiment—may not be. This assumption is a modification of

[3]A concept is regarded here as a point or node in mental and neural processing which, when active, makes information about an object or entity available to thought. Just what kinds of information are included in a concept and whether the information becomes available as a packet or piecemeal are theoretically important questions that remain to be answered. In computer models of mental representation such as that of Lindsay, Norman, and Rumelhart (Norman & Rumelhart, 1975), a concept is represented as a node in a network. The "meaning" of the concept is the position of that node in relation to other nodes and ultimately its connection with the inputs ("perceptions") and outputs ("productions") of the whole system.

the assumption of the dual coding theory that images are automatically named but words are not automatically imaged. The modified assumption explains why drawings are more readily recalled than words: They are more likely to have been processed at the conceptual level (Craik & Tulving, 1975). Further, asking a subject to image a word would ensure that it, too, was processed conceptually, since the only way to retrieve the image corresponding to a word would be to retrieve its concept. That would account for the finding that instructions to image increase the probability of recalling words. (A residual advantage of pictures over imaged words may reflect the novel detail present in a picture, detail that may not appear in a self-produced image; cf. Nelson, Reed, & Walling, 1976, and Potter, Valian, & Faulconer, 1977.)

There remains the question of why abstract words are harder to remember than concrete words. One possibility is that abstract words have a less focussed conceptual representation, a less clear-cut meaning, than concrete words. Consistent with that possibility, people produce fewer word associations to abstract than to concrete words (Paivio, 1971) and they rate sentences containing abstract nouns as more difficult and less meaningful than those with concrete, imageable nouns (Johnson, Bransford, Nyberg, & Cleary, 1972). The memory disadvantage may not be in the lack of an image corresponding to an abstract word but in the relative diffuseness of the representation in the conceptual system.

3. *Rapid serial presentation.* The third class of evidence cited above for the dual coding theory concerns the rapid presentation of a series of items. When drawings are presented rapidly there may only be time for activation of the image schema and concept, not the name. With rapid presentation of words, however, the lexical entry is quickly activated, and it includes a representation of the sound and articulation of the word. These sound (or motor) codes can be entered into an acoustic-phonemic short-term memory (e.g., Baddeley, 1976; Crowder, 1976; Penney, 1975) where they can be rehearsed in order, as the dual coding theory also claims.

No corresponding short-term memory appears to exist for *sequences* of visual images (Potter & Levy, 1969). (It is not clear whether a serial short-term memory exists for concepts apart from their names.) Thus either for immediate ordered recall or for recall after very rapid serial presentation, words may be equal to or superior to pictures. At slower rates or when recall in serial order is not required, drawings will be equal or superior. That is just what investigators have found (Nelson, Reed, & McEvoy, 1977; Paivio & Csapo, 1969, 1971; Paivio, Philipchalk, & Rowe, 1975). Moreover, a recent experiment obtained no support for the dual coding prediction that at a high rate of presentation a picture's naming latency would be negatively correlated with the likelihood that it would be retained (Intraub, 1979).

4. *Hemispheric specialization.* As for the evidence that the two hemispheres are specialized in the way that the dual coding theory predicts, the conceptual theory also claims that images and names are represented in distinct systems and might therefore be analyzed in different hemispheres. Since there are large parts of the cortex that are not known to be specialized for language, spatial functions, perception, or motor activity, it is entirely possible that amodal conceptual representation is subsumed by those areas.

Tests of the Two Theories

Both theories can account for most of the evidence so far described. Is there a critical test of the theories, or are they impossible to distinguish? The key difference between them is that the dual coding theory identifies abstract knowledge with the verbal system, whereas the conceptual theory separates abstract knowledge from both the verbal and the image systems. The dual coding theory claims that to retrieve from memory abstract information about an object—for example, its superordinate category—one has to enter the verbal system. Since it takes longer to name an object or drawing than to name aloud a written word, it should also take longer to *categorize* an object abstractly than to categorize the object's written name, according to the dual coding theory.

In contrast, the conceptual theory claims that abstract information is part of the conceptual system and can therefore be retrieved directly when an object or drawing is perceived, without first naming the object. Thus, although it takes longer to name an object than to name a word, it will not necessarily take any longer to categorize the object.

Naming Versus Categorizing Pictures and Words. An experimental test of the two theories was carried out by Potter and Faulconer (1975), who contrasted two tasks: naming and categorizing. The method used was the following. We started with a large set of line drawings of objects and their written names. The first step was to make sure that the drawings and words to be used in the experiments were equally easy to see as visual patterns. We measured the minimum time that each item had to be in view in order to be seen correctly, using a masking procedure. For the group of 96 items that were used in the subsequent experiments, the average times were very close: 44 msec for the drawings and 46 msec for the words. Thus, the pattern-recognition stage (see Fig. 3.1 and 3.2) was roughly equal for the two types of material. The next step was to obtain naming times. A group of eight college students named each item in one or the other form, and the time to start pronouncing the name was measured using a voice key. Just as earlier

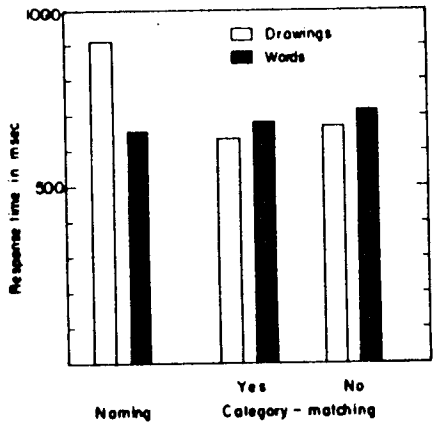

FIG. 3.3. Mean response times to name a word or drawing and to decide whether it is a member of a previously named category (from Potter & Faulconer, 1975).

investigators had found, it took almost 40% longer to name the drawings than it did to read the words aloud.[4]

Finally, in the critical experiment a new group of 16 students categorized the items. The 96 items fell into 18 superordinate categories such as food, furniture, clothing, and tools. Just before each item was shown to the subject, the experimenter named a category. The task of the subject was to say *yes* if the drawing or word matched the category that had just been named and *no* if it did not. (Half the time the category and item did not match). Again response time was measured. The results for both the naming and category-matching experiments are shown in Fig. 3.3. Even though drawings took 260 msec longer to name than words, it took subjects about 50 msec *less* time to decide on the category of a drawing than a word, contrary to the prediction of the dual coding theory.

It might be argued in support of the dual coding theory that the superordinate category of a concrete object such as a cow or shoe—that is, animal or clothing—is itself a concrete, imageable idea. If so, a drawing could

[4]It has been suggested that pronunciation of a word might not require prior activation of the lexical entry for that word, because orthographic-phonemic rules can be used to map the spelling onto sound. That is, a word provides a map for pronunciation, and that alone might explain the difference in naming time of words and pictures, making the latencies an invalid measure of time to activate the lexical entry (the verbal code). Indeed, adults can pronounce regularly spelled nonwords such as *tavon* almost as quickly as real words (Forster & Chambers, 1973; Frederiksen & Kroll, 1976). Chinese characters have no equivalent orthographic-phonemic rules, and so naming requires lexical retrieval. Hence the relative naming times for Chinese characters and pictures provide a test of the orthographic-phonemic explanation of the naming time difference found in English. Using native Chinese speakers, Potter, So, Ng, and Friedman (1978) found that characters are named much faster than pictures, exactly as in English. Since lexical retrieval is markedly faster for Chinese words than pictures, there is no reason to attribute the difference between English words and pictures solely to the use of spelling-sound rules.

be matched in the image system and a word in the verbal system, processes which might take similar times. A little reflection, however, will make clear that a category such as *animal* or *clothing* cannot be imaged except by thinking of a particular exemplar. Although cows look enough alike that an image of any particular cow may resemble most other cows, an image of any particular animal certainly does not resemble all other animals. To take another example, all shoes may look somewhat alike, but shoes and hats and coats do not look alike. This point has been established clearly by Rosch, Mervis, Gray, Johnson, and Boyes-Braem (1976), who use the term "basic level object" to describe the level of classification at which exemplars resemble each other.

The items used in Potter and Faulconer's experiments were basic level objects, in Rosch's sense. The superordinate categories, however, were at a level too abstract to permit category matching on the basis of perceptual features common to all members of the category. Instead, each item would have to be recognized at the basic level (e.g., as a shoe) before it could be compared with the category *clothing*. The theoretical issue, to repeat, is whether associations such as that between *shoe* and the abstract category *clothing* are part of a verbal system or are part of an amodal, conceptual system. The results we obtained support the latter hypothesis.

Other Picture-Word Tasks. In a series of subsequent experiments (Potter, 1978; Potter & Elliot, 1978; Potter, Klein, Faulconer, Feldman, So, & Garrett, 1978; Potter, So, Ng, & Friedman, 1978; Potter, Valian, & Faulconer, 1977) we verified the conclusion that both drawings and words have rather direct access to a wide range of conceptual knowledge about the object, including not only its superordinate category but also its value, associations, and even its name in another language. Only the sound characteristics (such as what a word rhymes with), the articulation, and the orthography of a word seem to be represented as part of the verbal system. Even when one is reading a sentence serially at a high rate, a picture can replace a word without disrupting comprehension (Potter, Kroll, & Harris, 1979; Potter, Kroll, Yachzel, & Cohen, 1978).

As for the image system, apart from features such as the shape of an object that are obviously more available in a drawing than in a word, there is as yet no clear evidence that knowledge about nonpictured sensory attributes (such as familiar size) are more directly available when one looks at a picture than when one looks at a word. Rather, there appears to be a small but consistent advantage of drawings over words in getting at abstract information such as an object's category as well as at quasi-perceptual information such as usual size (Banks & Flora, 1977; Paivio, 1975b; Pellegrino, Rosinski, Chiesi, & Siegel, 1977; Potter, 1978).

The findings just described support the conceptual theory's claim that in addition to a lexical system and a perceptual or imagery system adults have a

third memory system in which concepts are represented amodally. We can now raise briefly a question about the development of these three systems of representation before turning again to the main issue of symbol recognition.

Development of Representational Systems

Since the apparatus of object perception is largely innate whereas a language has to be learned, it might seem reasonable to suppose that a child first represents knowledge in a form close to perception. Further, since words (other than proper names) categorize experience by referring to classes of objects whereas perceptions are necessarily of single instances, it might also seem reasonable to suppose that the growth of abstract concepts is precipitated by and closely tied to the acquisition of language. This view is more consistent with the dual coding theory just rejected than with the conceptual theory, since it gives language a special function in the organizing (and hence probably in the retrieval) of concepts.

Dual Coding in Childhood? Is it possible, then, that dual coding occurs early in development, to be replaced later by conceptual coding? That is, early in the acquisition of concepts, are they bound separately to words and to percepts? That idea was tested in a number of studies carried out by E. J. Gibson and her students. Gibson, Barron, and Garber (1972) hypothesized that if young children have two somewhat independent systems of representation for objects and for words, then they should experience greater difficulty in comparing a word and a drawing than in comparing two words or two drawings. Rader (1975) had children decide whether two objects—either two written words, two pictures, or a word and a picture—belonged to the same or different categories. Although second graders were much slower on words than drawings, the mixed pairs took no longer than the average of word pairs and drawing pairs, contrary to the dual coding prediction. Rosinski, Pellegrino, and Siegel (1977) used the same task and obtained a similar result: Children of grades 2 and 6, like adults, can deal about as well with a mixture of pictures and written words as they can with words alone or pictures alone.

The task of comparing superordinate categories, however, requires an abstraction that cannot be represented in a perceptual-imaginal system, I have argued. Therefore, the paradigm used by Rader and by Rosinski et al. may be unsuitable for testing Gibson's idea that dual coding precedes conceptual coding in development. What other evidence have we that young children do or do not have a single concept for objects and their names? In experiments with adults, Bransford and Franks (1971) presented a set of sentences about a single event or scene. The subjects spontaneously integrated the information into a single representation, making whatever inferences

were necessary to do so. In consequence, they later had difficulty distinguishing between the exact sentences they had been presented and new sentences that were consistent with an integrated conceptual representation. Paris and Mahoney (1974) asked whether children (in grades 2 and 4) integrate sentence information as adults do and in addition asked whether a set of pictures containing information like that in the sentence sets would lead to the same kind of integration. They found that children did integrate both sentence sets and picture sets. Further, they found that picture-set integration transferred almost completely to test sentences. A child who saw two pictures, one showing a box to the right of a tree and the other a chair on top of the box (but no tree), was quite likely to report falsely that the sentence "The chair is to the right of the tree" corresponded with a picture.

Interference Tasks. Another sort of evidence for a single conceptual system common to words and objects has been obtained, for adults, in Stroop-type interference experiments. For example, naming a page of drawings of objects takes longer when names of other objects are printed in the center of the drawing. That is, an adult cannot help processing the written words even when he is trying to attend only to the drawings (Ehri, 1976; Rosinski, Golinkoff, & Kukish, 1975). Would children show less interference, as though they can process in each mode independently? The same experimenters tested children in grades 2 and up. At all ages, the incongruous words slowed naming; the only exception was a group of slow readers in grade 2 who were not affected by the incongruous words (Ehri, 1976). At least when the task is to produce a name, words are processed automatically even when a child is attending to a picture. The converse is also true, as Willows (1975) and Rosinski et al. (1975) found when children read words superimposed on drawings. The automatic merging of verbal and pictorial information, at all ages, is more consistent with a conceptual than a dual coding account.

Conceptual Representation in Infants? The experiments just described were carried out with children who could read. What about younger children? K. Nelson (1974) argues for a single conceptual basis of knowledge in children from the earliest age. She suggests that the core of an object concept is normally a functional, sensory-motor scheme, to which are attached other attributes such as an object's name and appearance. This view is consistent with the conceptual hypothesis, but the empirical evidence for it remains somewhat elusive. How we should characterize the system or sytems of mental representation of a child as young as 2 or 3 continues to be problematical.

Development of Memory for Pictures and Words. Another approach to the dual-systems question is to look for possible age changes in memory for

pictures and words. For adults a word list is harder to remember than an equivalent list of pictures. Are words even more disadvantaged for children? The answer appears to be no: The relative advantage of pictures remains roughly constant. For example, Perlmutter and Myers (1976) gave children of 37 and 53 months lists of objects in the form of drawings or spoken names or both drawings and their names. The drawings were easier to remember than their names (in a yes-no recognition task), but the effect did not interact with age. Equally interesting is the lack of an interaction between the form of the item in learning and in the test. It was harder to learn words than pictures and harder to recognize a named item than a pictured one, but there was no *additional* disadvantage to being tested in a different format from that of learning. The implication is that names and pictures had the same core conceptual representation.

To summarize, these studies of children agree with those of adults in suggesting that words, pictures, and perceived objects all have direct access to a single underlying conceptual system. Entrance to that system does not require naming, and conversely reading a word aloud does not necessarily require prior access to that word's concept. The dual coding model is correct in claiming that word names are stored separately from the images or appearances of objects, but in addition to the imaginal and verbal systems of representation there is a third more abstract system present in children at least as young as 6. Even in children, then, much of thought may be conceptual rather than specifically linguistic or imagistic.

Percepts as Symbols

The evidence that has been presented on timed responses to pictures and words shows that when we retrieve knowledge about an object it matters little whether we are cued by a picture or by a word. What about perception of a real object? Is it a fundamentally different process from perception of arbitrary symbols such as words and iconic symbols such as pictures? Evidence already discussed suggests that pictures can be understood with little or no learning, which suggests in turn that recognition of pictures makes use of some of the same processes that lead to recognition of real objects. It seems, then, that word, picture, and object comprehension are closely related.

Images as Representations of Meaning? Since we already rejected the notion that the relation among an object, its name, and its picture consists of convergence on the name or verbal code, could we say instead that they all converge on a perception-like representation, that is, an image? The answer is no, both on logical and on experimental grounds. On logical grounds, the image theory of mental representation is unworkable. There is no single

perceptual experience that is necessary for me to know that this object is a pencil, and in fact an entirely new perceptual experience (such as feeling it under a rug with my toes) could inform me of its identity. A prototypical image cannot be the core representation of an object, since surely I do not constantly refer to such an image to understand atypical exemplars. If I encounter a mechanical pencil that looks like a pen, I know it is a pencil despite its appearance, not by imaging a typical pencil in its stead. A prototypical image may help me to identify a new instance of a pencil, but the product of identification is a pencil concept that unites information not only about typical appearance but also about function, material, cost, places in which it is likely to be found, and an indefinite amount of other information.[5]

On experimental grounds, Potter and Faulconer's evidence against a verbal basis for concepts also allows rejection of an imaginal basis. Although pictures of objects are understood somewhat faster than written words, the difference of about 50 msec is too small to permit a word to be imaged. Tasks that do require imaging (such as recalling whether given lowercase letters have risers or descenders) take 500 msec or more per image (Weber & Castleman, 1970).

Conceptual Representation of Perceived Objects

Word, picture, and object comprehension are thus fundamentally similar in that all depend on the activation of a conceptual representation of the object. One recognizes an object when the sensory array leads to the activation of a mental representation that includes knowledge retained from previous experience with that object or similar objects. The same conceptual representation is activated when the object's name or picture is understood.[6] In an important sense, then, the appearance or percept of an object can be regarded as a *symbol* for the object's concept. Unlike words, of course, the perceptual "symbol system" is for the most part innately determined, so that people who share the same five senses share much the same perceptual language.

Even though the capacity to acquire concepts on the basis of perceptual experience is innately programmed, it takes time to mature. Piaget's work is an outstanding guide to the stages of development of the capacity to represent

[5]A discussion of the issue of images as representations of meaning is found in Fodor, Bever, and Garrett (1974) and Fodor (1975) and a debate about the nature of imagery in Pylyshyn (1973), Kosslyn and Pomerantz (1977), and Anderson (1978).

[6]There is an important conceptual distinction between a definite object such as this pencil and an indefinite class of objects such as pencils. Introduction of the distinction complicates the theory but does not change the main conclusions reached here.

a permanent object, one that persists even when it is out of sight or has altered in appearance. Just as an arbitrary symbol such as a word is understood when the appropriate concept is activated, so a child comes to understand a particular percept when he has built up a concept that abstracts away from fluctuating sensory experience. The concept achieves stability by correlating perceptual information from several senses and joining with it conceptual information acquired through language, pictures, and other symbol systems. Concepts, not appearances or names, are the enduring mental representations of reality.

The apparently innate ability to correct for changes in illumination, distance, angle of view, and the like and to perceive the same object despite such differences in sensation, called perceptual constancy, is the forerunner of a more general ability to use a variety of symbols as direct routes to a single concept. That is, whether the association between a particular set of perceptual experiences and a mental concept was programmed during evolution or whether it is acquired through learning, the relation is that between a symbol and a concept.

Summary: Symbol Recognition

The first stage of symbol comprehension is to recognize what object or entity a symbol represents, that is, what mental concept the symbol refers to.[7] In the perception of objects the first, protracted step in development is to set up those mental concepts. Initially an infant does not have the cognitive capacity to develop an enduring concept of any object. Once object concepts have been established, then perceptual constancy, generalization to new but similar perceived objects, and activation of the concept by pictures and by spoken words or gestures all become possible. The evidence strongly suggests that words and simple drawings of objects activate the relevant concept rapidly and directly, even in young children. The ready responses of 1- and 2-year-old children to spoken language and pictures does not appear to be discontinuous with their ability to recognize and understand real objects. In this account, perception of objects itself requires a semiotic capacity; the ability to recognize symbols such as words and pictures grows directly out of that capacity.

[7]Note that in this case a symbol such as a word is considered to refer to or represent a mental *concept* of an object, rather than the real-world object. The processes under discussion do not have information about real-world objects except via percepts of the objects, perceived symbols, and mental concepts. Within this system, percepts and perceived symbols refer to (represent) object concepts. From the point of view of an outside observer, however, one can talk about the relation between real physical objects and their representation in a person's percepts and concepts. Which usage of "represent" is intended should be clear in context.

DISCRIMINATION BETWEEN SYMBOLS AND PERCEIVED OBJECTS

Once a symbol such as a word or drawing becomes capable of activating the appropriate underlying concept, a second problem may arise. Since on other occasions the same concept may be activated perceptually by the real object, how does the perceiver distinguish between the presence of the object and a symbolic mention of it? How is it that symbols such as words and pictures *represent* real objects, whereas real objects don't represent anything—they simply *are* objects? The appearance or feeling or sound of a real object is not the object itself (if we speak carefully); rather, a percept is a mental event that innately and through learning is able to activate the concept of the object.[8] Since the percept coexists with the concept, however, the total mental event is different when a real object is perceived than when it is mentioned. A word does not look or sound (ordinarily) like the thing it symbolizes. Hence an adult knows that a perceived pencil can be used to write and can break, whereas the word *pencil* cannot. Conversely, the word can be loud or soft, whereas a perceived pencil cannot be. Similarly, pictures are flat and static, so they fool the eye only under special circumstances.

Since the same concept is part of the mental representation in all cases, however, one might expect occasional failures to discriminate between symbols and object perceptions. Although an infant soon learns not to eat the picture of an apple, he may remain reluctant to touch the picture of a spider or snake. In adults as well as children, the impact of a play or television drama depends in part on such failures to distinguish between symbol and reality; only by suspending disbelief can we participate in the events and feelings portrayed. As we know, children are fascinated by play acting and as-if situations as long as a proper tension between the symbolic and the real is maintained. When the balance tips too far, a child or even an adult may be terrified or shaken with sorrow.

The failure to distinguish between a symbol and the real object is ordinarily unidirectional: The symbol is treated as a real object, not vice versa. It has been suggested, however, that the opposite can happen. The reality of an event may become thin and insubstantial when it is experienced only through perceptions that are removed in time and space from their real objects (such as

[8]In the history of perception that goes back to the ancient Greeks, explanations of how we see objects have only slowly moved away from the misconception that percepts convey knowledge of objects because they resemble them to the realization that systematic correspondence between physical stimuli and neural patterning is the basis of veridical representation (Held, 1965). In Held's words, "the identity and continuity of objects can be regarded as the outcome of this [perceptual] processing rather than as its cause. The establishment of correspondence then becomes tantamount to discovering the laws of operation of the perceptive mechanism" (p. 54).

television news films of a war). Or a symbolized experience becomes bigger than life; one owner of a wall-sized television screen said that it had become uninteresting to meet celebrities in person.

Vygotsky (1962) points out still another kind of confusion that may arise during development. To quote,

> for a long time the word is to the child a property, rather than the symbol, of the object... the child grasps the external structure [i.e., the association] word-object earlier than the inner symbolic structure.... (p. 50)

> [Hence] preschool children "explain" the names of objects by their attributes. According to them, an animal is called "cow" because it has horns, "calf" because its horns are still small.... When asked whether one could interchange the names of objects, for instance call a cow "ink," and ink "cow," children will answer no, "because ink is used for writing, and the cow gives milk." An exchange of names would mean an exchange of characteristic features, so inseparable is the connection between them in the child's mind. (p. 129)

In the present formulation, the children studied by Vygotsky (and those described more recently by Osherson and Markman, 1974–1975) did not confuse words and real objects: They failed to distinguish words from their concepts. That is, they acted as though the question being asked was why the concept of a cow (not the name *cow*) is connected with perceived cows, and quite correctly they argued that the concept includes the information that cows have horns and give milk but cannot be used for writing. The problem was that they had difficulty considering a word as an entity in its own right.

Although the first step in symbol learning is to connect the symbol with the appropriate concept, the acquisition of this link has a cost: It becomes difficult to think of the symbol as separate from the concept. Similarly, the achievement of perceptual constancy has a cost: It becomes difficult to treat a percept as an experience separate from the concept it compellingly activates. Even adults have difficulty in treating a scene as a two-dimensional retinal array in order to paint it or in registering the perceived rather than the known color of objects or in adjusting to lenses that shift the usual correlation between visual and tactile space. And even adults may doubt that a rose by the name *pig* would smell sweet.

INTERPRETATION OF THE RELATION BETWEEN A SYMBOL AND A CONCEPT

The comprehension of a symbol might stop at the point when a person had recognized the conceptual referent and also realized that the symbol is not identical to the concept. That is, the symbol could be transparent to the level of meaning (Foss & Swinney, 1973; McNeill & Lindig, 1973) so that the

concept would be activated along with a representation of the word or percept that enables the viewer to discriminate between a symbol and perception of the real object. A symbol, however, is a kind of metaphor. It is an object in its own right and yet it maps onto another object, its referent. As in the case of metaphors, interpretation may be possible on at least two levels. A painting of a person, for example, may convey by its style a comment on the person, but appreciation of this comment requires simultaneous awareness of the person depicted and the painting as an object with its own stylistic properties.

Its style or poetic aspect are what distinguish a symbol that one would call a work of art from the pedestrian symbols that tell us how to get to the subway or what happened on the stock market today. Functional symbols such as public signs, news reports, passport photographs, and the like are deliberately self-effacing; one reads the message and ignores the medium. When the purpose is to communicate a message, there is an advantage in using as symbols things uninteresting in themselves. In Langer's example, "a succulent, ripe, real peach" would be a poor symbol for plenty because "peaches are too good to act as words; we are too much interested in peaches themselves. But little noises [or little black marks] are ideal conveyors of concepts, for they give us nothing but their meaning" (1942, p. 61).

A work of art, in contrast, juxtaposes the characteristics of the symbol and those of the concept to make an indirect comment on the concept. If that were all, however, a political cartoon would be the epitome of art. A work of art as an object in its own right has properties that are amusing, pleasing, or evocative, arising from the pattern it makes on the canvas, its harmonious or discordant colors, its alliteration and rhythm (in poetry), and the other attributes that make up style.

In the greatest works of art, the style of the symbol as an object and the comment made about the conceptual topic produce a combined structure that transcends both topic and style. Consider Michelangelo's sculpture *David* as a familiar example. To understand its higher-order structure requires the simultaneous awareness of the topic (this is a representation of the biblical David), the comment (perhaps his nobility and youthful sweetness), and the sculptor's style (the marble, the slight distortions of proportion, the choice of scale, the stylization of details, and so on). What is required is a metaperception similar to the metalinguistic awareness discussed elsewhere in this volume. That awareness at several levels simultaneously is what constitutes full experience of a work of art. Taken separately, there is only a reminder of the historic David, or a nice-looking man, or an enormous hunk of sculptured stone.

Again, as in symbol recognition and discrimination, there is a parallel between the interpretation of a symbol and the interpretation of a percept. Like a symbol, a perceptual experience has particular qualities that may be appreciated apart from recognition of the identity of the objects seen or

heard. And just as a symbol makes a comment on its topic, so a given perceptual encounter provides a particular subset of information about the object, showing it from a particular angle, making visible some details rather than others and the like. Since nature is not an artist, such perceptual comments on the object are haphazard; we ourselves decide which moments to frame. A landscape in the evening light is not simply identified but relished as a perceptual experience in much the way that one may enjoy a painting. The interesting sense in which nature imitates art is not in literal resemblance but in the role art may play in enabling us to look *at* our perceptions, not just through them to the concepts they symbolize.

Development of Symbol Interpretation

The ability to interpret all three facets of meaning of a symbol—its conceptual referent, its own qualities as an object, and the relation between the two—is initially absent in a child. The appreciation of the symbol as an object in its own right detaches it from its representational character. That is most obvious in production, when a young child may start a painting or sculpture or sentence with the intent of representing an idea and then get absorbed by the properties of the paint on paper or the tactile qualities of clay or the repetition of a word.

A child's limited ability to hold two or more things in mind simultaneously may prevent him from realizing the relation between the properties of the symbol and those of the referent. Either he focusses on the conceptual referent, or he looks at the symbol as an object: The sculpture is a big stone. The development of the ability to apprehend the identity of the symbolic medium at the same time as the identity of the referent has been studied by Elkind and his colleagues (e.g., Elkind, 1969) using pictures in which an object such as a man is constructed of other objects such as fruits. The development of the ability is related, in Elkind's account, to Piaget's theory of the development of logic-like perceptual regulations.

Similarly, a young child seems to be a *perceptual* literalist, not always able to recognize the conceptual equivalence among different views of a given object and not fully aware of the distinction between the conceptual object and the particularities of a momentary percept. The development of conservation of quantity, which requires a child to distinguish between the unchanging conceptual object and a misleading perceptual change, is closely allied to the ability to distinguish between symbolic play and reality, according to a study by Golumb and Cornelius (1977). They found that a measurable increase in the number of conservers occurred after three sessions of "pretend" games during which the experimenter led the child to confront the difference between pretense and reality.

A sign of development is a child's fascination with ambiguities that come almost within his grasp, such as a picture with hidden objects, Escher

graphics, and verbal puns. The play acting already mentioned becomes possible as a child develops the ability to see or be two things at once. Still, a child is unlikely to appreciate the "style" of a perception (for example, the beauty of a particular landscape) until much later, just as the understanding of style in art comes late. Noticing style requires a metaconception of which a child is not initially capable.

PRODUCTION OF SYMBOLS

Although the present account has been concerned with the comprehension of symbols, not their production, there are obvious implications for an account of production. The production of an intentional symbol presumably begins with the production of a "real" object or action such as a hand wave. The infant's second step is recognizing that the chance or imitative production is a member of a certain class of actions for which he has already developed a concept. Later, as that event (produced by others) comes to be recognized as a symbol of (say) going away—that is, activates the concept of going away—the child may become able to produce that symbolic action when thinking of going away, just as he can take the "real" action of going away. At that point, he may have the same difficulty distinguishing between the real and symbolic productions that he sometimes has in symbol comprehension. A young child may be outraged that his bye-bye does not immediately result in going away.

In the production of symbols, as in their comprehension, children seem unable initially to command a symbol's potentiality for commenting on its referent and for exhibiting stylistic characteristics of its own. As already mentioned, a young child may play with clay or paint as an object itself or switch to a literal claim that he has produced the object he wants to symbolize, disregarding the communicative inadequacies of the symbol. He knows what concept his painting activates in him, and so he assumes that you see the same thing. A similar failure in young children to appreciate the communicative value of a given verbal expression has been studied by Glucksberg, Krauss, and Weisberg (1966). Gradually, a child develops a critical appreciation of the attributes of his painting or words or actions and their fit or misfit to other perceptual or symbolic representations of the concept. Thus he is increasingly able to predict what concepts his paintings and words will activate in others.

SUMMARY: THREE ASPECTS OF SYMBOL COMPREHENSION

I have suggested that the comprehension of a symbol has three aspects: *recognition* of the symbol's conceptual referent, *discrimination* of the symbol from the concept it evokes and from perception of the real object, and *interpretation* of what the symbol says about the concept and about itself.

Symbol recognition occurs when the symbol activates the appropriate mental concept. In the case of concrete objects, the same concept may also be activated by perception of the object itself. Discrimination between the symbol and concept may not occur unless the symbol's distinctive properties are also identified. A full appreciation of the comment a symbol makes about its concept requires a simultaneous awareness of properties of the symbol and the remembered object embodied in the concept.

MUNDANE SYMBOLISM

The perceptual process leading to the recognition of real objects is not different in principle, I have argued, from symbol recognition. Each requires a process of inference, of going from sensory experience to the appropriate concept. Activation of the concept of a given object or event does not depend on any particular sense experience but abstracts away from perception just as it abstracts away from words and drawings in the experiments described earlier. We see objects rather than "mere dissolving sensa" (in Langer's phrase) because Gestalt-like principles organize our perceptions into wholes and because at a further level of abstraction percepts activate concepts.

Of course, a symbol differs from an object percept in being both a percept and a symbol—a written word is both a collection of black marks (one concept) and a symbol for something else (a second concept). We cannot stop seeing a word as black marks because the perceptual apparatus does not know how to turn off (and we would be in trouble if it did). Thus, the black-marks concept is activated along with the concept that the word symbolizes, even though we are hardly aware of the former.

Still, the basis of both perceptual and symbolic comprehension is activation of a mental concept. Mental concepts, not percepts or words or images, are the primary elements of thought. In acquiring the ability to activate an appropriate concept from a wide range of percepts, an infant is preparing the ground for activation of that concept through some other experience such as a word or picture. In learning to discriminate between the qualities of the momentary sensory experience and those of the enduring (conceptual) object, a child is readied for understanding that symbols are not the same as their referents. Finally, in becoming able to enjoy the conflict between conceptual knowledge and contradictory sensory experiences, as when seeing the room still spinning around after a twirling game, a child is learning to interpret the relation between the qualities of a symbol and its conceptual referent.

In a sense, then, a particular perception is a "mundane symbol" for an object. The abstract notion we have of the object is brought to mind by a glimpse or a touch, just as it can be brought to mind by words and other

symbols. So the symbolization process is foreshadowed by the development of perception. The growth of a child's ability to understand and produce the cultural symbols of speech, written language, and the representational arts is part of his increasing understanding of the natural symbols of mundane perceptual experience.

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REFERENCES

Anderson, J. R. Arguments concerning representations for mental imagery. *Psychological Review*, 1978, *85*, 249-277.

Baddeley, A. D. *The psychology of memory*. New York: Basic Books, 1976.

Banks, W. P., & Flora, J. Semantic and perceptual processes in symbolic comparisons. *Journal of Experimental Psychology: Human Perception and Performance*, 1977, *3*, 278-290.

Bransford, J. D., & Franks, J. J. The abstraction of linguistic ideas. *Cognitive Psychology*, 1971, *2*, 331-350.

Brooks, P. H. The role of action lines in children's memory for pictures. *Journal of Experimental Child Psychology*, 1977, *23*, 98-107.

Corlew, M. M., & Nation, J. E. Characteristics of visual stimuli and naming performance in aphasic adults. *Cortex*, 1975, *11*, 186-191.

Craik, F. I. M., & Tulving, E. Depth of processing and the retention of words in episodic memory. *Journal of Experimental Psychology: General*, 1975, *104*, 268-294.

Crowder, R. G. *Principles of learning and memory*. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1976.

Ehri, L. C. Do words really interfere in naming pictures? *Child Development*, 1976, *47*, 502-505.

Elkind, D. Developmental studies of figurative perception. In L. Lipsitt & H. W. Reese (Eds.), *Advances in child development and behavior* (Vol. 4). New York: Academic Press, 1969.

Fodor, J. A. *The language of thought*. New York: Crowell, 1975.

Fodor, J. A., Bever, T. G., & Garrett, M. F. *The psychology of language*. New York: McGraw-Hill, 1974.

Forster, K. I., & Chambers, S. M. Lexical access and naming time. *Journal of Verbal Learning and Verbal Behavior*, 1973, *12*, 627-635.

Foss, D. J., & Swinney, D. A. On the psychological reality of the phoneme. *Journal of Verbal Learning and Verbal Behavior*, 1973, *12*, 246-257.

Frederiksen, J. R., & Kroll, J. F. Spelling and sound: Approaches to the internal lexicon. *Journal of Experimental Psychology: Human Perception and Performance*, 1976, *2*, 361-379.

Friedman, S. L., & Stevenson, M. B. Developmental changes in the understanding of implied motion in two-dimensional pictures. *Child Development*, 1975, *46*, 773-778.

Gibson, E. J., Barron, R. W., & Garber, E. E. The developmental convergence of meaning for words and pictures. Appendix to final report, *The relationship between perceptual development and the acquisition of reading skill*. Project No. 90046, Grant No. OEG-2-9-420446-1071 (010) between Cornell University and the U. S. Office of Education, 1972.

Glucksberg, S., Krauss, R. M., & Weisberg, R. Referential communication in nursery school children: Method and some preliminary findings. *Journal of Experimental Child Psychology*, 1966, *3*, 333-342.

Golomb, C., & Cornelius, C. B. Symbolic play and its cognitive significance. *Developmental Psychology*, 1977, *13*, 246-252.

Goodman, N. *Languages of art*. New York: Bobbs-Merrill, 1968.

Hagen, M. A. Picture perception: Toward a theoretical model. *Psychological Bulletin*, 1974, *81*, 471-497.

Held, R. Object and effigy. In G. Kepes (Ed.), *Structure in art and science*. New York: Braziller, 1965.

Hochberg, J., & Brooks, V. Pictorial recognition as an unlearned ability: A study of one child's performance. *American Journal of Psychology*, 1962, *75*, 624-628.

Intraub, H. The role of implicit naming in pictorial encoding. *Journal of Experimental Psychology: Human Learning and Memory*, 1979, in press.

Johnson, M. K., Bransford, J. D., Nyberg, S. E., & Cleary, J. J. Comprehension factors in interpreting memory for abstract and concrete sentences. *Journal of Verbal Learning and Verbal Behavior*, 1972, *11*, 451-454.

Kosslyn, S. M., & Pomerantz, J. R. Imagery, propositions, and the form of internal representations. *Cognitive Psychology*, 1977, *9*, 52-76.

Langer, S. K. *Philosophy in a new key*. Cambridge, Mass.: Harvard University Press, 1942.

McNeill, D., & Lindig, K. The perceptual reality of phonemes, syllables, words, and sentences. *Journal of Verbal Learning and Verbal Behavior*, 1973, *12*, 419-430.

Milner, B. Interhemispheric differences in the localization of psychological processes in man. *British Medical Bulletin*, 1971, *27*, 272-277.

Nelson, D. L., Reed, V. S., & McEvoy, C. L. Learning to order pictures and words: A model of sensory and semantic encoding. *Journal of Experimental Psychology: Human Learning and Memory*, 1977, *3*, 485-497.

Nelson, D. L., Reed, V. S., & Walling, J. R. Pictorial superiority effect. *Journal of Experimental Psychology: Human Learning and Memory*, 1976, *2*, 523-528.

Nelson, K. Concept, word, and sentence: Interrelations in acquisition and development. *Psychological Review*, 1974, *81*, 267-285.

Norman, D. A., & Rumelhart, D. E. *Explorations in cognition*. San Francisco: W. H. Freeman, 1975.

Osherson, D. N., & Markman, E. Language and the ability to evaluate contradictions and tautologies. *Cognition*, 1974-75, *3*, 213-226.

Paivio, A. *Imagery and verbal processes*. New York: Holt, Rinehart & Winston, 1971.

Paivio, A. Neomentalism. *Canadian Journal of Psychology*, 1975, *29*, 263-291. (a)

Paivio, A. Perceptual comparisons through the mind's eye. *Memory and Cognition*, 1975, *3*, 635-647. (b)

Paivio, A., & Csapo, K. Concrete-image and verbal memory codes. *Journal of Experimental Psychology*, 1969, *80*, 279-285.

Paivio, A., & Csapo, K. Short-term sequential memory for pictures and words. *Psychonomic Science*, 1971, *24*, 50-51.

Paivio, A., Philipchalk, R., & Rowe, E. J. Free and serial recall of pictures, sounds, and words. *Memory and Cognition*, 1975, *3*, 586-590.

Paris, S. G., & Mahoney, G. J. Cognitive integration in children's memory for sentences and pictures. *Child Development*, 1974, *45*, 633-642.

Pellegrino, J. W., Rosinski, R. R., Chiesi, H. L., & Siegel, A. Picture-word differences in decision latency: An analysis of single and dual memory models. *Memory and Cognition*, 1977, *5*, 383-396.

Penney, C. G. Modality effects in short-term verbal memory. *Psychological Bulletin*, 1975, *82*, 68-84.

Perlmutter, M., & Myers, N. A. Recognition memory in preschool children. *Developmental Psychology*, 1976, *12*, 271-272.

Potter, M. C. On perceptual recognition. In J. S. Bruner, R. A. Olver, & P. M. Greenfield (Eds.), *Studies in cognitive growth*. New York: Wiley, 1966.

Potter, M. C. Mental comparison: Images and meanings. Article in preparation, 1978.

Potter, M. C., & Elliot, B. *Probing the meaning of scenes*. Article in preparation, 1978.

Potter, M. C., & Faulconer, B. A. *The ability of 3-year-olds to name pictures and objects*. Unpublished experiment, 1973.

Potter, M. C., & Faulconer, B. A. Time to understand pictures and words. *Nature*, 1975, *253*, 437-438.

Potter, M. C., Klein, B. V. E., Faulconer, B. A., Feldman, L., So, K.-F., & Garrett, M. G. Lexicon and concept in first and second language. Article in preparation, 1978.

Potter, M. C., Kroll, J. F., & Harris, C. Comprehension and memory in rapid sequential reading. In R. S. Nickerson (Ed.), *Attention and performance VIII*. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1979, in press.

Potter, M. C., Kroll, J. F., Yachzel, B. R., & Cohen, J. S. *Pictures in sentences: Conceptual and lexical representation in language comprehension*. Article in preparation, 1978.

Potter, M. C., & Levy, E. I. Recognition memory for a rapid sequence of pictures. *Journal of Experimental Psychology*, 1969, *81*, 10-15.

Potter, M. C., So, K.-F., Ng, K.-F., & Friedman, R. Reading in Chinese and English: *Naming versus understanding*. Article in preparation, 1978.

Potter, M. C., Valian, V. V., & Faulconer, B. A. Representation of a sentence and its pragmatic implications: Verbal, imagistic, or abstract? *Journal of Verbal Learning and Verbal Behavior*, 1977, *16*, 1-12.

Pylyshyn, Z. W. What the mind's eye tells the mind's brain: A critique of mental imagery. *Psychological Bulletin*, 1973, *80*, 1-24.

Quine, W. V. *Word and object*. Cambridge, Mass.: The M.I.T. Press, 1960.

Rader, N. L. Developmental changes in getting meaning from written words. In R. W. Barron (Chair), *Getting to the meaning of written words: Implications for the development of the reading process*. Symposium presented at the meeting of the Society for Research in Child Development, Denver, 1975.

Rosch, E., Mervis, C. B., Gray, W. D., Johnson, D. M., & Boyes-Braem, P. B. Basic objects in natural categories. *Cognitive Psychology*, 1976, *8*, 382-439.

Rosinski, R. R., Golinkoff, R. M., & Kukish, K. S. Automatic semantic processing in a picture-word interference task. *Child Development*, 1975, *46*, 247-253.

Rosinski, R. R., Pellegrino, J. W., & Siegel, A. W. Developmental changes in the semantic processing of pictures and words. *Journal of Experimental Child Psychology*, 1977, *23*, 282-291.

Vygotsky, L. *Thought and language*. Cambridge, Mass.: The M.I.T. Press, 1962.

Weber, R. J., & Castleman, J. The time it takes to imagine. *Perception and Psychophysics*, 1970, *8*, 165-168.

Willows, D. M. Influences of background pictures on children's decoding of words. In R. W. Barron (Chair), *Getting to the meaning of written words: Implications for the development of the reading process*. Symposium presented at the meeting of the Society for Research in Child Development, Denver, 1975.