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PICTORIAL REPRESENTATIONS IN ADULTS AND CHILDREN

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Reaction time to make same-object judgements was measured for pairs of identical pictures, picture synonyms, identical words, word synonyms, and picture-word combinations in adults and children. At all ages, synonym comparisons took longer than identical comparisons. Adults, but not children responded no faster to picture-word pairs than to picture synonym pairs. This is taken as evidence for the use of abstract pictorial information by adults but not by children. Children seem to compare two different exemplars of the same object verbally in the absence of well-integrated abstract pictorial representations.

Introduction

By now, considerable evidence has been amassed attesting to the visual or pictorial content of some internal representations. Much of this evidence is inferred from the time taken to make various judgements. Earlier studies attempted to demonstrate the generality of pictorial representations of various types of stimuli. Thus, Posner and his collaborators (Posner, Boies, Eichelman and Taylor, 1969) showed that the time to decide if two letters have the same name is facilitated when the letters are visually identical. The time required to compare a stimulus in memory to a presented schematic face is reduced when the stimulus in memory is encoded pictorially, regardless of its modality of presentation (Tversky, 1969). Pictorially-encoded geometric figures are also matched faster to presented figures even when the codes are constructed from verbal descriptions of the figures (Seymour, 1974; Tversky, 1974). Even sentences appear to be pictorially represented under certain circumstances (Tversky, 1975); namely, when the sentences are to be compared a short time later to schematic pictures.

Other research has explored the nature of pictorial as opposed to verbal representations, to reveal the physical properties of the visual world that are preserved in pictorial representations. General information about shape is retained. Shape similarity judgements made to the names of states bear a high resemblance to

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judgements made on actual outline drawings of States (Shepard and Chipman, 1970). Moreover, information about shape can apparently be mentally transformed in two and three dimensions. Shepard and his collaborators (Cooper and Shepard, 1973; Metzler and Shepard, 1974) found that the reaction time to compare two figures increases linearly with the angle of rotation between them, as if subjects were mentally rotating the stimuli into correspondence in order to test for a match between them. Size is another aspect of the visual world reflected in comparison reaction times, even without visual presentation of the stimuli. The time taken to compare the sizes of two named animals decreases with increases in the real size difference between them (Moyer, 1973). When subjects are asked to form images of animals, verification time of large features is faster than that of small features; however, linguistic relatedness determines verification time when imagery is not used (Kosslyn, 1976). Finally, distance between parts of an imagined object is reflected in verification time (Kosslyn, Ball and Reiser, 1978).

One goal of the present research is to extend the investigation of the nature of pictorial representations. This research reverses the usual strategy of demonstrating the psychological reality of specific features of the visual world. Instead, we ask, what is the most general judgement that can be based on pictorial content, without recourse to some other content in the representation? Setting an upper bound is evidence that judgements about membership in a particular category (e.g. clothing) are based on the same abstract, non-pictorial information in comparing picture–picture, word–word and picture–word pairs (Pellegrino, Rosinski, Chiesi and Siegel, 1977). In addition, Rosch, Mervis, Gray, Johnson and Boyes-Braem (1976) have presented evidence that category names carry essentially no common perceptual information. On the other hand, evidence cited earlier indicates that identical and rotated objects can be compared on the basis of pictorial content. In the present experiments, we measure reaction time to judge whether two stimuli, pictures or words, refer to the same object. It is of particular interest to note how judgements are made on pairs composed of two entirely different exemplars of the same object, for example, two scissors or two telephones, which may differ in general outline, internal detail, perspective, or all of the above. Are they compared on the basis of pictorial information or is that information recoded to verbal information? Two non-identical pictures cannot be compared directly in the way that two identical pictures can presumably be compared, by checking for an overall or feature-by-feature match, as such a process would not recognize the synonymity of the pictures. One way of comparing two non-identical pictures would be to transform the pictorial information to verbal information—in this case, the name of the object—and to check the names for identity. If non-identical pictures are compared in this manner, RT should be slower for pairs of non-identical pictures than for picture–word pairs because for non-identical picture pairs, two pictures must be named but for picture–word pairs, only one picture must be named and naming time is longer for pictures than for words (Fraisse, 1968). Thus, finding that non-identical pictures of the same object are compared *no slower than* picture–word pairs is evidence against the hypothesis that non-identical pictures are verbally represented for comparison.

Alternatively, non-identical pictures could be compared on the basis of abstract

visual or pictorial information. The information is pictorial in the sense that it refers to visible properties of objects, yet abstract in that the particular properties or features need not be identical. Klatzky and Stoy (1974) have presented evidence for the use of abstract pictorial information in a memory task requiring comparison between successively presented pictures. The use of abstract pictorial information in direct comparison would be indicated by finding that comparison between non-identical pictures is no slower than comparison between picture–word pairs.

Another way of testing the boundaries of a phenomenon is to trace its development. To the extent that we have abstract pictorial representations that allow comparison and recognition of pictures, these must be dependent on knowledge about the way objects in the world look. It is quite possible that small children are lacking in this more abstract pictorial knowledge. Numerous experimenters have demonstrated that children, like adults, excel in remembering pictures (e.g. Brown, 1973). However, only a very literal representation of a picture is needed to pass such tests. Evidence that more abstract pictorial information, knowledge about the essential features of visual objects, and their interrelationships and invariances, is gradually acquired by school-age children, has been presented by Carey and Diamond (1977), Diamond and Carey (1977), Piaget and Inhelder (1971), and Tversky and Bassok (unpublished). A second goal of the present experiment is to determine how different exemplars of the same object are compared in children.

A third goal of the present research is to obtain further evidence that higher levels of processing or longer comparison times, are entailed by more abstract judgements. Thus, identical word pairs should be compared faster than word synonyms and identical picture pairs should be compared faster than two different exemplars of the same object. This result has been obtained by many investigators (e.g. Bartram, 1976; Friedman and Bourne, 1976; Posner *et al.*, 1969), but is herein extended to children.

Experiment I

Method

Subjects

Subjects were 20 native Hebrew-speaking students at the Hebrew University who were either paid or given course credit for their participation.

Stimuli

The stimuli were Hebrew words, typed directly onto slides, or pictures, dictionary-type drawings, photographed and reproduced as black-on-white slides. Five lists of twenty stimulus pairs each were prepared. Half the pairs of each lists were "same", that is, had the same object name, and half were "different". The order of pairs in each list was randomized with the constraint that no more than three same or different pairs occurred in succession.

The five lists were: word–word (WW), where same pairs were always identical words; word–word* (WW*), where same pairs were word synonyms (e.g. *carpet–rug; palace–castle*); picture–picture (PP) where same pairs were identical drawings; picture–picture* (PP*), where same pairs were two different drawings of the same object; and picture–word (PW) pairs, where same pairs consisted of a drawing of an object and its name. Both words and

pictures referred to familiar household objects, clothing, food, animals, plants, vehicles, buildings, and the like. Word synonym pairs were chosen so that they were unequivocally synonyms and so that members of the pairs were about equally familiar. Picture synonyms were not constructed in any systematic fashion. The two members of a pair could differ on shape, decoration, parts, perspective, position, or some combination of the above. In most if not all cases, it was immediately evident that the two members of a same pair were two different exemplars of the same type of object, rather than transformations of the very same object (e.g. two televisions with different pictures, dials and antennae). The picture–word pairs were also selected to be unequivocal. In all five lists, the different pairs were clearly unrelated objects (e.g. *tractor–cake; camera–truck*). Each word and each picture appeared only once over all the lists.

Ten different orders of the lists were chosen so that each type appeared equally often in each position, thereby counterbalancing practice effects. A pair of subjects received each order; for one of the subjects, the right index finger responded "same", and for the other, the left index finger responded "same".

Procedure

Subjects performed individually. At the start of the session, the experimenter explained the entire experiment and gave the subject practice operating the apparatus. Subjects were told they would see pairs of stimuli, pictures or words, and to respond "same" by pressing the appropriate lever when the pairs referred to the same type of object, and to respond "different" by pressing the other lever when pair members represented different objects. Before every block of trials (list type), the subject was informed of the nature of the same pairs of that block, i.e. identical words, word synonyms, identical pictures, picture synonyms, or picture–word pairs. In picture–word pairs, the word always appeared on the right, since reading in Hebrew starts at the right of the page. Subjects were instructed to respond as quickly as possible without making errors.

The subject initiated each trial by pressing a foot pedal, which caused the pair of stimuli to be projected simultaneously on the screen and started the timer, accurate to milliseconds. By pressing one of the levers, the subject caused the stimuli to disappear and the timer to stop. The experimenter's feedback was the signal to initiate the next trial. Sessions took about half an hour.

Results

The error rates for subjects were all below 3% and erroneous responses were omitted from all analyses. Mean RTs for "same" and "different" responses for each list type are displayed in Figure 1. On the whole, "different" responses were 30 ms slower than "same" responses, as is typically found in such experiments. However, this interacted with list type so that in picture synonym pairs, "different" responses were actually faster than "same" responses. An analysis of variance was performed on the reaction time data, yielding significant effects for list type ($F(4,76)=17{\cdot}00$, $P<0{\cdot}001$, MSe$=0{\cdot}521$), for "same"–"different" ($F(1,19)=11{\cdot}20$, $P<0{\cdot}01$, MSe$=0{\cdot}068$) and for their interaction ($F(4,76)=11{\cdot}64$, $P<0{\cdot}001$, MSe$=0{\cdot}066$).

Planned comparisons were made on the various conditions to test the hypotheses that higher levels of processing are required for synonymous pairs than identical pairs and that picture synonym comparison is not verbally mediated. PP* judgements were significantly slower than PP judgements ($t=5{\cdot}96$, $P<0{\cdot}001$) and WW* judgements were significantly slower than WW judgements ($t=12{\cdot}99$, $P<0{\cdot}001$) supporting the hypothesis that higher levels of processing are required

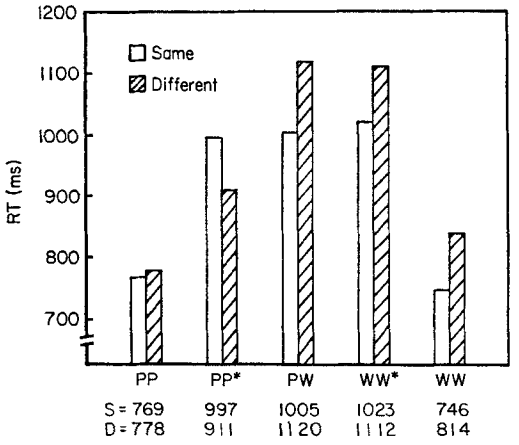

FIGURE 1. Mean RTs of same and different responses for comparison type in adults.

for synonymity judgements than for identity judgements. PW judgements were not faster than PP*, the comparison critical for support of the hypothesis that PP* judgements are not verbally mediated. In fact, PP* was significantly faster than PW ($t=3{\cdot}37$, $P<0{\cdot}001$), though this is primarily due to "different" trials.

Discussion

Support was obtained for the two main hypotheses, that higher levels of processing are entailed by more abstract comparisons and that picture synonym comparison is not based on verbal representations but rather on abstract pictorial information. Thus, judgements of synonym pairs took longer than judgements of identical pairs for both words and pictures. Picture synonym comparison was no slower than picture–word comparison, precluding the possibility of retrieval and comparison of names in the case of picture synonyms. How are the picture synonyms compared, if not through a common verbal code? Since each picture differs from its mate in different ways, no simple transformation or set of transformations can be applied to all of the pairs to get from one to the other. The pairs could be compared by comparing each to some "prototypical" example of the object (Posner and Keele, 1968; Rosch, 1978) to determine if each is similar enough to the prototype to be an instance of the object category. The analogous verbal process would be checking to see if two word synonyms have the same referent. Alternatively, picture synonyms might be compared directly, to determine if they share the same essential features. In either case, the comparison relies on perceptual properties of the objects, yet properties that are abstract in the sense that they are not literally the same in both stimuli. Both cows, for instance, must have a body, legs, tail, head, and so forth, though some of the parts may not be visible from certain angles. The actual positions and shapes of these parts may vary, but in a lawful fashion. On the other hand, patterns of coloration and background scenery are not essential to the identity of the cow, and may vary considerably.

Comparisons between picture–word pairs took longer than identical word comparisons, suggesting that naming a picture in order to compare it to a presented name does increase RT.* Picture–word and word synonym comparisons took essentially the same time, an intriguing finding, since both comparisons entail either transformation of one of the stimuli, or else reference to some higher shared level of meaning. "Same" responses were shorter than "different" responses except in the case of picture synonyms. Shorter "same" times are usually interpreted as a difference in strategy, where an additional operation, such as double-checking, is performed on "different" pairs (Bamber, 1969; Bindra, Donderi and Nishisato, 1968; Tversky, 1969). It appears as though this strategy was reversed in the case of picture synonymity, and that the subjects double-checked to ascertain that two visually-different stimuli in fact referred to the same object.

Experiment II

The first experiment presented evidence that different exemplars of the same object are pictorially compared and that higher levels of comparison took more time than lower. The present experiment sought to determine if these effects can be found in children. Because many important cognitive and perceptual changes occur between the ages of 4 and 7 (White, 1965), one group of children in that age group was chosen and one older group of children. Since the younger children did not yet read, words were spoken rather than printed. This alteration of procedure necessitated another one, successive rather than simultaneous presentation of stimuli. Recall that Klatzky and Stoy (1974) presented evidence for the use of abstract pictorial representation by adults in a successive comparison task. A more comprehensive experiment, using a procedure identical to that of the study on adults, i.e. printed words, simultaneous presentation by automated slide projectors, was run on children in second, fourth and sixth grade. The pattern of findings was exactly like those to be reported. However, reading time, even in the oldest children, was so slow that it obscured some of the findings. Therefore, qualitiative differences in performance between children and adults cannot be attributed to changes in procedure.

Method

Subjects

Subjects were 40 middle-class native Hebrew speaking children attending the Hebrew University summer day camp. The 20 kindergarten children had an average age of 6 years exactly and the 20 third grade children had an average age of 9 years exactly. Each age group had an equal number of boys and girls. Two children from the younger group and four from the older group were eliminated because of language or equipment difficulties, and were replaced.

*There is, of course, the logical possibility that a picture is generated by the name for purposes of comparison, instead of vice versa, but this does seem unlikely given the large number of pictures that can be generated by the same name, and the time taken to generate a pictorial representation. For a comprehensive discussion of how pictures and names might be compared, see Smith, Balzano and Walker (1978).

Stimuli

The stimuli and the lists were of the same type as in Experiment I, with the following changes. Picture stimuli were printed on 3×5 cards and word stimuli were spoken out loud. Both words and pictures were pre-tested on children for comprehension and agreement. The latter was particularly important for word synonym pairs.

Procedure

Subjects performed individually. At the start of each session, the experimenter carefully explained the procedure and the entire experiment, with many examples and six practice trials. Prior to every list type block were further instructions and another four practice trials, half same, half different, corresponding to that list type.

The procedure varied slightly from the previous experiment. Words were spoken by the experimenter because the younger children were non-readers. This necessitated successive presentation of the stimuli. The experimenter practiced extensively with a metronome to insure uniform presentation conditions. The first stimulus was enunciated if a word or turned over if a picture. One second after initiation of the first stimulus, the second stimulus occurred; simultaneous with that, the experimenter started the timer, accurate to milliseconds. When the first stimulus was a picture, it was not removed until completion of the trial, so that both pictures were in view simultaneously. On word–picture trials, the word always preceded the picture. Thus RT was measured from the onset of the picture in these cases, making them as comparable as possible to picture–picture pairs.

The subject indicated his response by pressing one lever, which stopped the timer, and saying out loud "yes" if the pair was same and "no" if it was different. It was felt that two levers would be confusing at that age. The children had no difficulty synchronizing their verbal and manual responses. These procedures had been used in previous RT studies with small children with success (e.g. Tversky, 1973). Children were told to respond as quickly as possible without making errors.

Results

Error rates were below 3% for all subjects and erroneous responses were omitted from all analyses. Error rates were highest in the WW* condition, and in some strict sense were disagreements and not errors. An analysis of variance was performed on the RT data, followed by planned comparisons amongst the list types. Mean RTs for "same" and "different" responses in each list type for each age group are displayed in Figures 2 and 3. Note that these RTs are not directly comparable to adult RTs because of the change in procedure. Children's RTs were measured from presentation of the second stimulus, while adult RTs were obtained from simultaneous presentation of the two stimuli. Older children performed faster than younger children ($F(1,38)=34{\cdot}81$, $P<0{\cdot}001$, $\mathrm{MSe}=18{\cdot}95$). The effect of list type was significant ($F(4,152)=18{\cdot}58$, $P<0{\cdot}001$, $\mathrm{MSe}=1{\cdot}76$) and "different" responses were significantly longer than "same" responses ($F(1,38)=9{\cdot}69$, $P<0{\cdot}01$, $\mathrm{MSe}=0{\cdot}51$). These two factors interacted significantly ($F(4,152)=3{\cdot}87$, $P<0{\cdot}01$, $\mathrm{MSe}=0{\cdot}62$), primarily due to a reversal of the typical rapidity of "same" responses in the picture synonym condition in the older children, where "different" responses were faster than "same". This interaction had the same form in the adult data, supporting generality of the phenomenon. List type also interacted significantly with age ($F(4,152)=3{\cdot}23$, $P<0{\cdot}05$, $\mathrm{MSe}=1{\cdot}76$). The only reversal of order of list types occurred between PW and PP. At kindergarten, PW responses are slightly faster than PP, and at third grade PP is faster than PW, but

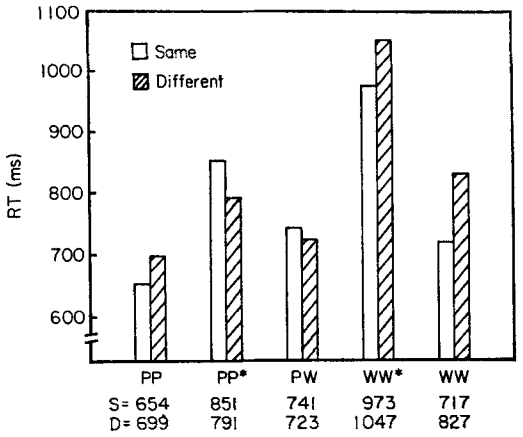

FIGURE 2. Mean RTs of same and different responses for comparison type in third graders.

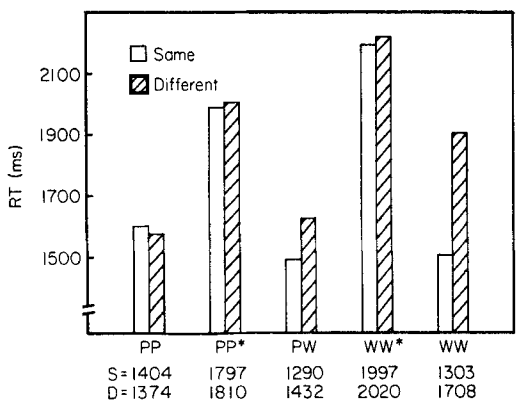

FIGURE 3. Mean RTs of same and different responses for comparison type in kindergartners.

neither of these differences is significant. Thus, the pattern of data in the older children is more like the adult pattern.

The planned comparisons among list type supported the hypothesis that higher levels of processing are necessary for comparing synonym pairs than for identical pairs. PP was faster than PP* at kindergarten ($t=5{\cdot}13$, $P<0{\cdot}001$) and at third grade ($t=3{\cdot}52$, $P<0{\cdot}001$) and WW was faster than WW* at kindergarten ($t=6{\cdot}17$, $P<0{\cdot}001$) and at third grade ($t=6{\cdot}30$, $P<0{\cdot}001$). The major difference between the data of the children and those of the adults is in the reversal of the relation between PW and PP*. In the children, PW was faster than PP* at kindergarten ($t=5{\cdot}54$, $P<0{\cdot}001$) as well as at third grade ($t=2{\cdot}19$, $P<0{\cdot}05$). This is an indication that in children, though not in adults, PP* comparisons are verbally mediated.

Finally, boys performed faster than girls at kindergarten, but not at third grade

($t=2{\cdot}64$, $P<0{\cdot}01$). A closer examination of the data revealed that the boys were faster only on WW and WW*, and that this disappeared at third grade.

Discussion

Like the adults, the children's data show clear evidence for levels of processing; judgements of synonymous pairs took longer than judgements of identical pairs for both words and pictures. Also like the adults, children were faster to respond "same" than "different" except in the case of picture synonym pairs for the older children. This has been interpreted as an effect of strategy, or technique of comparison, and it is typically found that older children use strategies more than younger (Flavell and Wellman, 1977).

The major departure of the children's data from the adult data was in the indication of verbal mediation in the picture synonym condition. In the children, picture–word comparisons were actually faster, by 265 ms, than the picture synonym comparisons, indicating that the children did not compare picture synonyms in a pictorial manner, but resorted to identifying or naming the pictures, and comparing the names. The advantage of picture–word comparisons over picture–picture comparisons decreases with age; thus, the older children seem to respond more like adults than do the younger children.

General discussion

Evidence has been presented for levels of processing of pictures and words in both children and in adults, and for the use of abstract (non-literal) pictorial information in the comparison of picture synonyms by adults but not by children. Underlying the notion of levels of processing is the assumption, supported by much research, that stimuli are processed only to the minimal level efficient for a particular task. Thus, it has been shown that different pictures of the same object can be compared at the object level using abstract pictorial information. Such information is called abstract because it is not literally the same in the two pictures. The same essential elements of the objects appear in both pictures but in different positions, with different ornamentation, and viewed from different angles. Similarly, non-essential parts of one picture do not appear in the other. Judgements on picture synonyms at some higher level, for instance, generic category, require processing pictures to a semantic, non-pictorial level (Pellegrino *et al.*, 1977). Such abstract pictorial representations allow us, for instance, to recognize acquaintances after many years, and many changes, even when we have forgotten their names.

The finding that children compared picture synonyms verbally rather than pictorially is surprising in the light of the widespread belief that early school-age children represent events of the world visually rather than symbolically (e.g. Bruner, 1966) and the common finding that children are quite adept at remembering pictures (Brown, 1973). Children's visual representations seem to be quite literal, quite close to actual perception, and it is this quality that appears to limit their usefulness in more complex tasks. Evidence from other work supports this notion. Saltz and Siegel (1967) found that young children were more likely than older

children to regard two different photographs of the same child as different children. Moreover, small children often do not know which features of an object are essential and which are incidental, and can be easily mislead by features that are perceptually salient yet not definitive (Diamond and Carey, 1977; Tversky and Bassok, unpublished). This is not to say that children do not ever have abstract pictorial representations; Diamond and Carey (1977) found that young children were quite accurate at picking which two of three photographs were the same person when the photographs were of friends, but not when the photographed faces were unfamiliar. Even when abstract pictorial information is available to children, it may nevertheless not be utilized or effective in certain situations. Even the school age children in the present task seemed to rely on verbal information in direct comparison of drawings of familiar objects. Indeed, some of the information underlying abstract pictorial representations of objects would seem to be based on knowledge about how geometric figures appear under spatial transformations, which Piaget and Inhelder (1971) have found develops with the school years. Children's acquisition of word concepts is often described as a process proceeding from the more concrete to the more abstract (e.g. Clark, 1973); it appears that such a process also describes the developmental course of acquisition of pictorial concepts.

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