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Abstract

This paper examined conceptual vs. perceptual priming in identification of incomplete pictures by using a short-term priming paradigm, in which information that may be useful in identifying a fragmented target is presented just prior to the target's presentation. The target was a picture that slowly and continuously became complete and the participants were required to press a key as soon as they knew what it was. Each target was preceded by a visual prime. The nature of this prime varied from very conceptual (e.g., the name of the picture's category) to very perceptual (e.g., a similar-shaped pictorial prime from a different category). Primes also included those that combined perceptual and conceptual information (e.g., names or images of the target picture). Across three experiments, conceptual primes were effective while the purely perceptual primes were not. Accordingly, we conclude that pictures in this type of task are identified primarily by conceptual processing, with perceptual processing contributing relatively little.

Key words: Incomplete Picture, Conceptual Prime, Short-Term Priming, Picture Identification, Perceptual Prime

Conceptual vs. Perceptual Priming in Incomplete Picture Identification

Results from picture identification and naming have often been considered in terms of three-stage models-- accessing the visual features of the item or its stored structural description; accessing the item's meaning or its semantic representation; and accessing its pronunciation or phonological representation (Humphreys, Riddoch, & Quinlan, 1988; Lachman, 1973; Levelt, Schriefers, Vorberg, Meyer, Pechmann, & Havinga, 1991; Riddoch & Humphreys, 1987; Snodgrass, 1984; Wheeldon & Monsell, 1992). In the first, structural stage, a three-dimensional description of the object is retrieved without retrieving either its name or its meaning (Marr, 1982). In the second, semantic stage, the object's meaning is accessed in terms of its semantic features and associations (Chertkow, Bub, & Caplan, 1992; Riddoch & Humphreys, 1987). In the third, lexical access stage, the picture's name is retrieved. The lexical access stage is sometimes divided into two substages: a lemma access substage in which the to-be-lexicalized concept accesses a lemma (an abstract symbol representing the selected word as a syntactic-semantic entity) followed by a phonological access substage in which the lemma is translated into its phonological form (Dell, 1986; Dell & O'Seaghdha, 1991; Levelt, 1989). Thus the picture-naming process may be conceptualized as a series of three or four stages.

In the present study, the picture identification process is terminated by the participant's key press indicating that he or she knows the identity of the picture. We therefore conceptualize this identification process as relying primarily on Stages 1 and 2. Stage 3, lexical retrieval, may be carried out at the participant's leisure in this study.

Whether these stages occur in strict serial order has been an issue of recent debate. Humphreys et al. (1988) considered a three-stage model (in which stages 3 and 4 are combined) and reported evidence that these three stages occur in cascade (that is, information from a prior stage is fed into a succeeding stage before the prior stage finishes). Humphreys, et al. looked at two variables that they argued should logically affect two separate stages. The first variable was whether the exemplars within a category were structurally distinct or structurally similar and the second variable was name frequency. They found that structurally distinct exemplars were named faster than structurally similar exemplars, and argued that this effect must occur in the first, structural stage. In addition, they found that name frequency affected naming times, but only for pictures from structurally distinct categories. They argued that name frequency must affect the third, lexical access stage, and so they take this interaction as evidence that information from a first, structural stage is being continuously transferred to subsequent stages.

A completely interactive account of picture naming would permit both forward cascading and backward cascading, so that semantic factors could affect the perceptual stage and phonological factors could affect the semantic stage. Rapp and Goldrick (2000) reviewed five models of picture naming (called in their paper "spoken word production") that varied in their degree of interactivity. They showed that limited interactivity is required to explain the literature on speech errors from normal and brain-damaged individuals. Similarly, Cutting and Ferreira (1999) found evidence for interactivity between the semantic and phonological stages. However, all of these models of naming have focused on the relationship between the semantic and phonological stages, with little attention to the relationship between the semantic and the perceptual stages, the focus of the present paper.

A position contrary to the interactive hypothesis is Fodor's (1983,1985) modularity hypothesis. Fodor has argued that perceptual processing is modular in the sense that it is unaffected by conceptual information. One way to explore this issue is to determine whether both stages are affected by conceptual priming. This issue has been examined by Farah (1989). On the basis of a review of the literature, Farah supported the modularity hypothesis by showing that perceptual priming affected sensitivity whereas semantic priming affected only bias. She reviewed the literature on perceptual priming of location and semantic priming of lexical decision and concluded, based upon those studies for which both discriminability and bias indices were available, that perceptual priming affected true discriminability whereas semantic priming affected only bias. However, Rhodes, Parkin, and Tremewan (1993) demonstrated that semantic priming can increase sensitivity in visual word recognition, and Norris (1995) demonstrated that increases in sensitivity measured by increases in *d'* can be exhibited by a modular criterion-bias model of priming in which priming has no effect on perceptual encoding.

In previous picture naming studies using a short-term priming paradigm, the most commonly used type of prime is a categorically related picture or word. Sperber, McCauley, Ragain, and Weil (1979) presented either a series of to-be-named pictures (Study 1) or a series of to-be-named words (Study 2), and considered the item named on trial n-1 as the prime for the item named on trial n. Items on adjacent trials were either semantically (categorically) related or not. In both studies, Sperber et al. observed facilitation when the item on trial n-1 was categorically related to the item on trial n, although the priming effect was larger for picture-

picture pairs than for word-word pairs. In Study 3, both pictures and words were preceded by picture and word primes. Here picture targets were primed better by picture primes than by word primes, although word targets were primed equally by either form. Similar findings were obtained by Carr, McCauley, Sperber, and Parmelee in 1982. They showed that the effects persisted even when the prime was not consciously identified.

Lupker (1988) used primes that were names of objects from the same (related condition) category or from a different (unrelated condition) category. Prime-target pairs were chosen to be unrelated phonetically, orthographically, or through verbal association. A small yet significant priming effect of approximately 25 ms was obtained in the same category priming condition. In another experiment both picture and word primes were used. Significant facilitation was observed for both prime types in the same category priming condition but, in contrast to the results of Sperber et al. (1979), there was no priming advantage for pictures over words.

In contrast, La Heij, Dirkx, and Kramer (1990) found that semantically related word primes were effective only when the word prime and picture targets were associatively related. They defined semantically related primes as being to be from the same category as the target whereas associatively related pairs were defined as being from the same category and eliciting the target in a verbal word association test (e.g., the prime"dog" elicits the target "cat" but not the target "lion" as an associate). When prime and target were only semantically related, no significant facilitation was observed, whereas significant facilitation was observed in the semantically and associatively related condition. This led them to conclude that studies which report semantic priming effects have confounded association with categorical relatedness, and that categorical relatedness alone does not produce a semantic priming effect in picture naming. Their results contradict Lupker's (1988) finding of a small yet significant facilitation from semantically related primes when level of association was controlled.

It is clear that different types of primes provide participants with different information about the target stimulus. The information provided depends on what features - visual, semantic, or lexical - are shared by the prime and target. The target picture itself, for example, provides helpful visual, semantic, and lexical information, thereby presumably affecting all three processes involved in naming. The target's name, on the other hand, provides helpful semantic and lexical information but no helpful visual information, because pictures and their names do not share common visual features (of course, if participants imaged the word's referent, then the imaginal version of the word would share common visual features with the target). A word or picture from the target's category has also been shown to prime picture naming (although not always consistently, as described above). It is not clear how such a prime exerts its effects. A categorically related picture prime shares semantic features with the target but may also share visual features (Humphreys et al., 1988; Rosch, Mervis, Gray, Johnson, & Boyes-Bream, 1976; Sperber et al., 1979). Rosch et al. (1976) found that two objects from the same basic level (what they defined as the level at which the object is named – e.g., “cat”) showed more visual overlap than two objects from supeordinate categories (e.g., “mammal”).

In contrast, a categorically related word prime shares only semantic features with the target, but also may have an associative relationship, in which case what is being primed is not only semantic information (i.e., Stage 2) but also lexical information about the target's name through associative processes (i.e., Stage 3).

The picture priming literature does not directly address whether the structural stage can be primed because no published picture priming studies, to our knowledge, have used a priming condition in which only perceptual features were primed. The present study attempts to remedy this deficit.

In order to maximize the possible effect of a perceptual prime, we used as a target a slowly completing picture in which the measured response is a key press indicating that the participant knows what the picture is (although s/he may or may not know at that instant what its name is). Accordingly, we assume that either the first (structural description) or second (access to meaning) stages are most important for this process, and that the third stage, access to the picture's name, plays little or no role in the process.

To disentangle the contributions of perceptual and conceptual information, we compared the efficacy of primes that are purely perceptual in nature, those that are purely conceptual, and those that are a combination of both. In Experiment 1, we compared two types of word primes: picture names and category names. For each type of prime, there were three degrees of semantic relatedness to the target picture -- identical, related, and unrelated. In Experiment 2, we used two forms of primes, pictures and words, with two degrees of semantic relatedness -- identical and unrelated. In Experiment 3, we used two forms of primes, pictures and words, and five kinds of semantic and perceptual relatedness -- identical, related by both category and shape, related by category but not by shape, related by shape but not by category, and unrelated by both category and shape. In each experiment, we also used a baseline condition (a series of X's) so we could evaluate interference as well as facilitation from each type of prime.

General Method

Apparatus, Materials, and Procedure

The targets were pictures taken from Snodgrass and Vanderwart (1980). The primes were either the names of the pictures, the pictures themselves, or the names of the categories to which a picture might belong according to the Battig and Montague (1969) category norms. The experiments were conducted on Macintosh Classic computers.

Each trial began with the words "get ready" which appeared in the center of the screen for 500 ms. After a 500 ms blank interval, the prime appeared for 500 ms. After a 1500 ms blank interval following the prime, the target picture appeared as an apparently continuously completing image. This was accomplished in the following way. Pictures were stored as 200 x 200 pixel bit-mapped images. In Microsoft QuickBasic (the programming language used here) each bit-mapped image consists of approximately 1300 elements. These elements are horizontally aligned so that within the 200 x 200 pixel image, each row contains about 6 elements consisting of 33 pixels each. At each epoch of time during the picture completion process, an additional element is added to the picture. An epoch of time corresponds to 1/60 of a second (i.e., 16.67 ms.) so it would take approximately 22 seconds for the entire image to be displayed if the initial image were completely blank. However, the pictures were initialized with some minimum number of elements displayed (for Experiment 1 it was 200 elements, and for Experiments 2 and 3 it was 100 elements). Thus the maximum number of time epochs for Experiment 1 was 1100 (i.e., approximately 18 seconds) and for Experiments 2 and 3 it was 1200 (i.e., approximately 20 seconds). In contrast to other fragmenting algorithms we have used which have deleted only the informative blocks (i.e., those containing black pixels, see Snodgrass, Smith, Feenan, & Corwin, 1987), in this algorithm there is no distinction made between white areas and those which contain pixels defining the target picture. Thus a very simple picture with few contours could take longer to identify than a very complex picture with many contours.

The major dependent variable in each experiment was the number of time epochs (NTEs) needed to correctly identify the picture. Because participants did not always identify the picture correctly (despite instructions and rewards to the contrary), a second dependent variable was the proportion of pictures correctly identified.

Participants were told that their task was to identify a slowly completing picture and that they should press the space bar as soon as they knew what the picture was. Participants had unlimited time to produce and type the name of the picture. They were also told that prior to each picture they might be presented with a possible clue in the form of the name of the target picture, its category, or a replica of the picture itself, and that this information could help them to identify the target picture. They were also instructed that they would earn points for being fast and correct, they would earn no points for being slow and correct, and that they would lose points for incorrectly identifying the picture. They were given feedback after every trial, and were also shown the running total of their points. They were informed that the participant earning the most points would win $25.00. Correctness in naming the target picture was determined by consulting a list of possible correct names (including misspellings), and by consensus of two experimenters. All participants gave their consent to be in the experiment and were debriefed after the experiment as to its purpose.

Statistical Analysis

Because of the complexity of some of the designs, we analyzed the data in the following ways. First, we compared proportion correct and NTEs for each priming condition against the baseline condition to determine whether there was facilitation or inhibition from each prime type. Next, we carried out factorial ANOVAs on the conditions other than baseline to determine differences among the remaining priming conditions. Finally, we carried out planned comparisons for those differences that were predicted.

To deal with outlying values of NTEs, we identified those NTEs that were greater than two standard deviations from each participant's mean, and replaced those outliers with the 2 SD value (see Snodgrass & Yuditsky, 1996, for a justification for this truncation procedure compared to other possible ways of dealing with outliers).

Because all of the experiments included a condition in which the prime was identical to the target, there was always the possibility that a participant would choose the prime as his or her response in cases of uncertainty (despite instructions and rewards to the contrary). Incorrectly naming the target with the name of the nonidentical prime for that target was defined as a false alarm. Thus if the participant saw the target picture 'apple' preceded by the related prime 'orange' or the unrelated prime 'hammer' and identified the target 'apple' as 'orange' in the first case or 'hammer' in the second, this was defined as a false alarm for the identical prime-target condition. Although an incorrect response identical to the prime was expected to be the most common false alarm, in some cases, the prime and target were categorically related, perceptually related, or both. Accordingly, we defined false alarms for the remaining conditions as any response that was identical to the counterbalanced prime for that target for that condition. Thus, if the target picture 'apple' had as its related prime 'orange', a response of 'orange' to the identical prime-target pair 'apple'-'apple' was defined as a false alarm for the related prime condition.

These false alarm rates were subtracted from their corresponding hit rates to obtain an unbiased measure of target identification, Pr (see Snodgrass & Corwin, 1988, for justification of this measure).

Experiment 1

Experiment 1 sought to determine whether providing a correct picture name or a correct category name as a prime for the target picture would facilitate target identification, and conversely whether providing an incorrect picture name or an incorrect category name would inhibit target identification, compared to a baseline condition in which no information was provided by the prime. Lloyd and Humphreys (1997) and Humphreys et al. (1988) showed that natural and man-made objects share commonalities of features such as irregular contours in the case of natural objects and edges and joints in the case of man-made objects. Accordingly, we assumed that primes from the superordinate categories natural and man-made would facilitate picture identification because of shape similarity.

Method

Participants

Thirty-five New York University undergraduate students participated as part of a course requirement for an Introductory Psychology class. Data from two participants were excluded from the analysis because of poor performance, leaving a total of 33 participants.

Materials and Design

Target stimuli were 80 pictures of common objects, 40 from the natural categories fruit, vegetables, animals, and human body parts and 40 from the man-made categories clothing, furniture, vehicles, and musical instruments. The superordinate categories natural and man-made will be referred to as classes. Each category contained 10 pictures.

Word primes were either picture names or category names. Two category names were abbreviated when they served as primes ("body" for human body parts, and "music" for musical instruments). Picture name primes were identical to the picture ("apple" for the picture APPLE), related to the picture (the prime was from a different category but the same class -- "eye" for the picture APPLE), or unrelated to the picture (the prime was from a different category and class -- "piano" for the picture APPLE). Category name primes were identical to the picture's category ("fruit" for the picture APPLE), related (from the same class) to the picture's category ("body" for the picture APPLE), or unrelated (from the other class) to the picture's category ("music" for the picture APPLE). On baseline trials, "XXXXXX" was displayed instead of a word prime. Each condition contained 10 trials except for the baseline condition, which contained 20 trials.

All participants saw the same set of 80 pictures in one of eight counterbalanced orders (the baseline condition was divided into two conditions for this purpose). Thus across participants each picture had an almost equal chance of appearing in each condition.[i] Ten practice trials preceded the 80 experimental trials. The 90 trials were divided into three, 30-trial blocks. Participants were instructed to take a break between blocks and to continue when they were ready.

Results

Insert Table 1 about here

The false alarm rate for the identical picture name condition was 2% (6 out of a possible 350 responses) and there were no other false alarms. Accordingly, proportion of correct responses (hit rates) for the identical picture name condition were corrected by subtracting the false alarm rate from the hit rate before analyses were conducted. Table 1 shows corrected hit rates for each condition. A one way ANOVA on corrected hit rates yielded a significant main effect of condition, F (6, 192) = 5.43, MSe = .007, p < .001. Planned comparisons between each condition and baseline showed that the hit rate for the identical picture name condition was significantly higher than baseline, F (1, 32) = 24.57, MSe = .003, p < .001, but there were no differences between any other condition and baseline. Thus only the identical picture name prime facilitated identification of the target picture when measured by proportion of correct responses.

Table 1 also shows mean correct NTEs for each condition (1.7% were truncated according to the criterion described above). A one way ANOVA on NTEs yielded a significant main effect of condition, F (6, 192) = 11.00, MSe = 2,572, p < .0001. Planned comparisons between each condition and baseline showed that both identical picture name and identical category name conditions were significantly faster than baseline, F (1,32) = 46.80, MSe = 1,493, p < .0001, F (1, 32) = 7.24, MSe = 1,396, p < .01, respectively, but there were no differences between any other conditions and baseline. A planned comparison between the identical picture name and identical category name conditions showed that identical picture primes produced faster identification responses, F (1,32) = 13.35, MSe = 2,011, $p < .001$.

In addition, we evaluated priming scores computed by subtracting baseline NTEs from NTEs for each of the other conditions. We carried out a 2 (picture name, category name) X 3 (identical, related, unrelated) within-subjects ANOVA on the priming NTEs. The results of this analysis indicated that picture names primed significantly better than category names, F (1, 32) = 9.84, MSe = 3,574, $p < .01$; there was a significant effect of semantic relatedness, F (2, 64) = 24.23, MSe = 2,617, $p < .0001$; and there was no interaction. Despite the lack of a significant interaction, simple effects analyses revealed that only the difference between the identical name and identical category was significant.

There were no significant differences between the related and unrelated priming conditions. This is not too surprising as the related priming condition for name primes was defined as a name from a different category within the same class and for the category primes as the name of a different category from the same class (e.g. natural category if the target was natural and man-made category if the target was man-made).

Discussion

Experiment 1 clearly showed the effectiveness of priming picture identification with either the name of the picture or its category. In addition, it showed that priming with the name of the picture is more effective than priming with its category. Although these results are not surprising, we hoped to learn from the present study whether priming from the broader categories -- natural and man-made --would also facilitate picture identification. The hypothesis that these related primes would facilitate picture identification is based upon previous research showing that natural and man-made objects share commonalties of features such as irregular contours in the case of natural objects and edges and joints in the case of man-made objects (Lloyd, & Humphreys, 1997, Humphreys et al. ,1988). However, we found no hint of greater facilitation from "related" than from "unrelated" primes so, at least for this task, broader categories or exemplars from them did not facilitate picture identification. More surprisingly, perhaps, we found no hint of interference from unrelated picture or category names. We attribute this lack of interference to the ability of participants to quickly disregard an incorrect "clue" on the basis of the visual features of the emerging picture.

How, one might ask, does a participant use the correct name or category of the target picture to identify it more quickly? In the case of the correct name, does s/he form a mental image of the prime and then compare it with the emerging features of the picture, or is there a more conceptual/analytic process that takes place? In the case of a correct category name, does the participant form a mental image of the category? We know that pictures within the same category tend to have similar shapes while pictures from different categories tend to have different shapes. This suggests that a correct category prime could produce a mental image of the shape of the exemplar, thereby facilitating detection of the object's shape. Alternatively, a correct category prime could narrow the field of possible candidates for the target picture in a more conceptual/analytic process.

In order to investigate the relative contributions of perceptual and conceptual processing in priming, in Experiment 2 we manipulated the form of the prime -- picture or word -- in order to vary the degree to which participants had conceptual information (available from both picture and word primes) and perceptual information (available initially only from the picture primes although, as we noted above, imaginal processing of word primes could provide perceptual information as well). We assumed that an identical picture prime would provide additional facilitation over an identical word prime because it provided additional perceptual information.

Experiment 2

Method

Participants

Twenty-five New York University undergraduate students and Stuyvesant High School students participated as part of a course requirement for an Introductory Psychology class or voluntarily. Data from one participant was excluded from the analysis because of poor performance, leaving a total of 24 participants.

Materials and Design

Target stimuli were 48 pictures of common objects. Prime stimuli were 96 picture primes and their 96 corresponding names. The target pictures came from the eight categories fruit, vegetables, animals, human body parts, tools, furniture, musical instruments, and vehicles. There were two types of picture and word primes: identical and unrelated. Unrelated primes came from different categories than the target[ii]. There were eight trials for each of the four prime conditions, and 16 trials for the baseline condition. In order to eliminate the possibility of direct physical matching between the prime and the target, the picture prime was presented in a smaller size than the target (100 x 100 pixels, i.e. one-quarter the area of the target). All participants saw the same set of 48 target pictures in one of six counterbalancing conditions (the baseline condition was divided into two conditions for this purpose) so that across participants each target picture appeared an equal number of times in each prime condition (there were four participants assigned to each of the six counterbalancing conditions). The 48 experimental trials were divided into two 24-trial blocks. Participants were told to take a break between blocks and to continue when they were ready.

Results

Insert Table 2 about here

There were approximately 5% false alarms (9 of 192 incorrect responses), all of which occurred in the unrelated word prime condition. Accordingly, the hit rates for the identical word prime condition were corrected by subtracting those false alarms that occurred in the unrelated word prime condition. Table 2 shows these corrected hit rates for each condition. A one-way five-level within subjects ANOVA yielded a significant main effect of condition, F (4, 92) = 7.14, *MSe* = .009, $p < .0001$. Planned comparisons between each condition and baseline showed that both identical picture and word conditions were significantly more accurate than the baseline condition, F(1, 23) = 10.81, *MSe* = .005, $p < .01$, F (1,23) = 4.56, *MSe* = .008, $p < .05$, respectively. There were no other differences between the remaining two conditions and baseline. A planned comparison between identical picture and word conditions showed no significant difference, $p > .10$. Thus only identical picture and word primes facilitated accurate identification of the target picture, and the two forms were equally facilitatory.

The percentage of truncated NTEs was 5%. Table 2 also shows mean NTEs for correct responses for each condition. A one-way ANOVA on these NTEs yielded a significant main effect of condition, F (4, 92) = 36.55, *MSe* = 3,219, $p < .0001$.Planned comparisons between each condition and baseline showed that both identical picture and word conditions were significantly faster than baseline, F (1,23) = 81.96, *MSe* = 2,803, $p < .0001$, F (1, 23) = 47.01, *MSe* = 2,325, $p < .001$, respectively. There were no other differences between the remaining two conditions and baseline. A planned comparison between the identical picture and word conditions showed that identical picture primes had a stronger facilitating effect than identical word primes, F (1,23) = 11.25, *MSe* = 1,953, $p < .01$.

In addition, we carried out a 2 (identical, unrelated) X 2 (picture, word) ANOVA on the priming scores computed by subtracting baseline NTEs from NTEs for the other conditions. The results of this analysis indicated that identical primes facilitated identification significantly better than different primes, F (1, 23) = 77.32, MSe = 4,826, $p < .0001$, and that pictures facilitated identification significantly better than words, F (1, 23) = 11.54, MSe = 3,464, $p < .005$. However, there was no interaction between prime form and semantic relatedness, $F < 1$. Simple effects analyses revealed that pictures primed better than words both in the identical and unrelated conditions (both p's < .05). The lack of a significant interaction suggests that the extra facilitative effect of identical picture primes over identical word primes stems from a general facilitative effect of picture primes, not the specific information that the picture provides.

Discussion

Although this experiment shows that providing an image of the target, rather than its name, facilitates target identification, it also shows that providing an image of a different object also facilitates target identification. Thus, contrary to our prediction, identical pictures do not provide any additional facilitation over identical words. Rather, it appears that picture primes in and of themselves facilitate target identification, and the apparent advantage of identical picture over word primes comes from this general facilitative effect. This general facilitative effect may be attributable to the engagement of the pictorial processor by a picture prime, which speeds up processing of pictures. Similar within-form facilitation effects have been reported previously in the literature (e.g., Kroll & Potter, 1984; Vanderwart, 1984). The fact that the additional perceptual information provided by an identical picture does not facilitate picture identification suggests that the priming effects observed in Experiment 1 for identical target names were conceptual rather than perceptual in nature. In fact, Experiment 2 does not provide any evidence that the extra perceptual information available from the picture itself facilitates picture identification. In terms of the stages, then, Experiment 2 provides no evidence that Stage 1 -- structural processing -- can be facilitated by providing the extra perceptual information available in the picture itself.

There are studies that contradict this conclusion. For example, Warren and Morton (1982) showed that pictures which had been named in a study phase primed identification of a picture regardless whether it was identical or a different drawing of the same concept, whereas naming identical words had no priming effect. This finding suggests the importance of the shape of a picture for picture identification. Biederman (1987) in his model of picture identification stressed the importance of shapes for object identification, claiming that objects are recognized as spatial arrangements of basic component parts or "geons."

In order to test the hypothesis that Stage 1 cannot be primed, we manipulated what is undoubtedly the most important aspect of a picture -- its shape -- in the next experiment. Experiment 3 varied both the shape and category of a prime that was presented either as a picture or a word. If perceptual information alone can facilitate target identification, we would predict that similar shaped primes, regardless of their category, would facilitate picture fragment identification, and that this effect would be particularly strong for picture primes. We know from Experiment 1 that semantic information, in the form of a same category prime, should facilitate picture identification. By orthogonally manipulating perceptual and conceptual similarity of the prime to the target, we can better evaluate the effect of each separately, and of their combination.

Because of the difficulty of finding shape-mates for targets from a different category, we were only able to use 36 picture targets for which there were shape-mates both from the category to which the target belonged and from another unrelated category. Because there were few trials and many conditions, we increased the number of participants in Experiment 3 so as to increase the total number of trials of each type across participants.

Experiment 3

Method

Participants

Sixty-five New York University undergraduate students participated in Experiment 3 as part of a course requirement for an Introductory Psychology class. Data from two participants were excluded due to failure to follow instructions, leaving a total of 63 participants.

Materials and Design

Stimuli were 36 target pictures of common objects and 144 picture primes and 144 corresponding names. The target pictures were drawn from the categories fruit, vegetables, animals (mammals), birds, insects, human body parts, clothing, furniture, kitchen utensils, architecture, carpenter tools, stationery, vehicles, and musical instruments.

Primes used were of two forms: picture and word. There were five priming conditions for each prime form (Picture or Word): Identical (ID), Same Category/ Similar Shape (SC/SS), Same Category/Different Shape (SC/DS), Different Category/ Similar Shape (DC/SS), and Different Category/Different Shape (DC/DS). The baseline priming condition was, as before, a series of XXXX's. The targets and their primes are shown in the appendix. Because the total number of priming conditions was 12 (the baseline represented twice as many trials as each priming condition), each priming condition consisted of only three trials. As for Experiment 2, the area of the prime picture was only one-quarter that of the target picture (i.e., 100 x 100 pixels).

Because there were 12 conditions (five prime types by two prime forms plus two identical baseline conditions), a total of 12 counterbalancing conditions was constructed. Approximately equal numbers of participants were assigned to the 12 counterbalancing conditions. Six practice trials preceded the 36 experimental trials. The 42 trials were divided into two, 21-trial blocks. Participants were told to take a break between blocks and to continue when they were ready.

Results

Insert Table 3 about here

False alarm rates were 5% each for identical word and picture primes, and 1% each for same category/similar shape picture and word primes. Table 3 shows corrected hit rates for each condition. A 2 (prime form) x 5 (prime type) within-subjects ANOVA on priming scores for corrected hit rates yielded a significant main effect of prime type, F (4, 248) = 5.32, MSe = .043, p < .001. There were no effects of prime form and no interaction between prime form and prime type. Planned comparisons showed that identical primes produced significantly more accurate performance than the average of the remaining four conditions, p < .001.

Table 3 also shows mean correct NTEs. The percentage of trancated NTEs was 5.3%. A one way ANOVA on correct NTEs yielded a significant main effect of prime type, F (10, 620) = 10.19, MSe = 11,926, p < .0001. Planned comparisons between each prime type and the baseline showed that NTEs for the ID and SC/SS conditions for word and picture primes were significantly faster than baseline, F(1, 62) = 24.39, MSe = 8,074, p < .001, F (1,62) = 6.23, MSe = 11,397, p <.05 for words, F(1, 62) = 34.19, MSe = 9,628, p < .001, F (1,62) = 37.54, MSe =5,430, p <.001 for pictures, for identical and SC/SS conditions respectively. There were no differences between any other condition and baseline. Thus only the identical and same category/similar shaped primes speeded picture identification.

In addition, a 2 (form) X 5 (prime type) within-subjects ANOVA on priming scores showed that the main effect of prime form was not significant (F(1, 62) = .36, MSe = 12,800, p

> .5), the main effect of prime type was highly significant, F (4, 248) = 19.59, MSe = 13,953, p < .0001, and there was no interaction. Planned comparisons showed that the ID condition primed significantly better than the SC/SS condition, $p < .05$, that both the ID and SC/SS conditions primed significantly better than the remaining conditions (all p's < .01), and that the SC/DS condition primed significantly better than either the DC/SS or DC/DS conditions, both p's < .05. However, the DC/SS and DC/DS conditions were statistically equivalent. Unlike Experiment 2, there was no significant effect of form -- that is, pictures were not more effective primes than words.

Because of the importance of the two preceding analyses to our hypotheses, they were repeated using items as the units of analysis. We considered only priming scores for NTE in these analyses as it is our major dependent variable. A 2 (prime form) x 5 (prime type) ANOVA on the NTE priming scores revealed that, similar to the analysis based on subjects, the main effect of prime form was not significant, the main effect of prime type was highly significant, F (4, 140) = 21.47, MSe = 7,364, $p < .0001$, and there was no interaction. Also similar to the analysis based on subjects, planned comparisons showed that the ID condition primed significantly better than the SC/SS condition, $p < .01$, that both the ID and SC/SS conditions primed significantly better than the remaining conditions (all p's < .01), and that the SC/DS condition primed significantly better than either the DC/SS or DC/DS conditions, both p's < .05. However, the DC/SS and DC/DS conditions were statistically equivalent.

Discussion

The most important result of Experiment 3 is that similar shaped objects from different categories did not facilitate picture identification even though similar shaped objects from the same category did. This seems to show that perceptual information (the target's shape) is not effective in the absence of semantic information (the target's category). This is the first evidence we have obtained that perceptual information can help in identification, albeit only with accompanying semantic information.

Within the context of the stage model, the fact that similar shape items only facilitate priming when they are in the same category as the target but not when they are in a different category suggests an interaction activation process in picture naming (Rapp & Goldrick, 2000), which also suggests, as we noted in the Introduction, that Stage 1 is cognitively penetrable. That is, the present result would appear to support the notion of backward cascading, in which semantic relatedness between the prime and target facilitates the use by the structural stage of structural relatedness. This conclusion, however, is predicated on the assumption that the degree of semantic relatedness of the SC/SS primes to the target is equal to the degree of semantic relatedness of the SC/DS primes, and that the degree of shape similarity of the SC/SS primes to the target is equal to the degree of shape similarity of the DC/SS.

In constructing our lists, we focused upon obtaining good shape matches between the DC/SS prime/target pairs, and poor shape matches between the SC/DS prime/target pairs. We did not attempt to equate items within a category as to their semantic relationship (that is, we did not attempt to equate SC/SS and SC/DS primes in semantic relatedness). We assumed, as many investigators do, that items within a category are all equally semantically related. However, when we examined our list more closely (see the appendix) we observed that some SC/SS primes appeared to be more semantically related to the target than their SC/DS category mates. Shape is an important determinant of category membership, so it would not be surprising to find that pairs of items within a category sharing the similar shape are more semantically related than pairs of category items which differ in shape (Matsukawa, 1995; Snodgrass & McCullough, 1986). The same thing may hold for shape similarity; shape similarity across categories may not be equal to shape similarity within categories

Accordingly, we carried out two additional experiments, in which participants were asked to rate the degree of shape similarity between target and their primes in SC/SS, SC/DS, DC/SS, and DC/DS conditions in one experiment (Experiment 4-1) and the degree of semantic relationship between the Same Category items for both the Similar Shape and the Different Shape conditions in the other experiment (Experiment 4-2). Ratings were collected for both picture and word forms of the primes in Experiment 4-2.

<u>Experiment 4-1</u>

Experiment 4-1 was carried out to determine whether the set of prime-target pairs used in Experiment 3 had been adequately equated by experimenter selection both by shape and by conceptual similarity. That is, was shape similarity equal between SC/SS and DC/SS pairs, and was conceptual similarity equal between SC/SS and SC/DS pairs.

Method

Participants

Thirty-five Kanazawa University undergraduate and graduate students participated in Experiment 4-1 as volunteers.

Materials and Design

Stimuli were 36 target pictures of common objects and 144 picture primes used in Experiment 3.

Each participants rated the degree of shape similarity between picture targets and picture primes for the four kind of categories SC/SS, SC/DS, DC/SS, DC/DS on a scale from 1 (very dissimilar) to 5 (very similar). The rating task was a paper and pencil test and shape similarity was defined as the degree of overlap between the shapes of each target-prime pair. Each target was presented four times paired with each of the four kinds of prime, for a total of 144 trials. In order to minimize carry-over effects from the first rating of a particular target-prime pair, four series of trials were constructed subject to the condition that a particular target would not be repeated within three trials.

Procedure

Participants were informed that they would be shown pairs of objects shown as pictures on sheets of paper, eight pairs per page, and that they would be asked to rate the degree of shape similarity of each pair by marking on a scale from 1 (very dissimilar) to 5 (very similar) on the sheets. Participants were informed that shape similarity was defined as the degree of overlap between the shapes of each target-prime pair.

Results

Insert Table 4 about here

Average ratings for these items are shown in Table 4. The results of a 2 (Same Category/Different Category) X 2 (Similar Shape/Different Shape) within-items ANOVA revealed that both main effects were significant. For the Category variable, F (1, 35) = 42.40, *Mse* = .306, $p < .001$; for the Shape variable, F (1, 35) = 390.17, *Mse* = .453, $p < .01$. There was also a significant interaction: F (1, 35) = 5.49, *Mse* = .270, $p < .05$. As can be seen, Similar Shape pairs were rated as more similar than Different Shape pairs and Same Category pairs were rated as more similar than Different Category pairs. More importantly, the interaction occurred because Same Category/Similar Shape (SC/SS) pairs were rated as more similar than Different Category/Similar Shape (DS/SS) pairs, indicating that despite our best efforts, we were not able to equate similarity of shape across category relatedness.

<u>Experiment 4-2</u>

Experiment 4-2 was carried out to determine whether the set of Same Category/Different Shape (SC/DS) items used in Experiment 3 were as semantically related as the Same Category/Similar Shape (SC/SS) items. If they were not, then the apparent advantage of priming effectiveness for SC/SS over SC/DS might have been produced by semantic rather than perceptual similarity.

Method

Participants

Forty New York University undergraduate students participated in Experiment 4 as part of a course requirement for an Introductory Psychology class.

Materials and Design

Stimuli were the 36 target pictures used in Experiment 3 paired with the SC/SS prime and the SC/DS prime (we did not have participants rate the Different Category primes because of concern about floor effects on the ratings).

Each participant rated each target twice: once when paired with a SC/SS prime and once when paired with a SC/DS prime, for a total of 72 trials. Each target-prime pair appeared once as a picture and once as a word. Two counterbalancings were used, so that equal numbers of participants rated each pair as both a picture and a word. In order to minimize carry-over effects from the first rating of a particular target-prime pair, four series of trials were constructed subject to the condition that a particular target would not be repeated within three trials. Each series was then converted to picture or word pairs such that equal numbers of each occurred in each series and the each target-prime pair appeared in both its picture and word form.

Procedure

Participants were informed that they would be shown approximately 80 pairs of objects shown as pictures or as words, that each member of the pair would be selected from a particular category so that each pair would be related somewhat by meaning, but that they would be asked to rate the degree of meaning relationship by typing a number from 1 (very unrelated) to 5 (very related). Each pair was presented simultaneously on the screen of an Apple MacIntosh Classic Computer, and remained in view until the participant entered the rating. Participants gave their written consent before the experiment and were given both an oral and written debriefing after the experiment.

Results

Because of an error in programming, the wrong picture was displayed for one of the targets so that target-prime pair and its mate were removed from the analysis, leaving a total of 70 items for which ratings were available.

Insert Table 5 about here

Average ratings for these items are shown in Table 5. As can be seen, Similar Shaped pairs were rated as more semantically related than Different Shaped pairs, and Picture pairs were rated as more semantically related than Word pairs. The results of a 2 (Similar/Different) X 2 (Picture/Word) within-items ANOVA revealed that both main effects were significant. For the shape similarity variable, F (1, 34) = 24.24, *Mse* = .769, $p < .001$; for the picture/word variable, F (1, 34) = 8.31, *Mse* = .145, $p < .01$. However, there was no significant interaction. This means that different-shaped picture pairs from the same category did not appear less semantically related than different-shaped word pairs from the same category. This suggests, as discussed below, that it is a semantic, not a perceptual, effect.

General Discussion

The results of these experiments can be summarized as follows. Experiment 1 showed that both identical and same category name primes are effective in facilitating picture fragment identification, whereas related and unrelated name and category primes neither facilitate nor interfere with picture fragment identification compared to baseline. The category name prime presumably facilitates by providing easier access to the picture's meaning, facilitating Stage 2. The identical word prime presumably facilitates by also providing easier access to the picture's meaning, but it may also have primed by providing a visual image of the target prime. To test this idea, we carried out Experiment 2, which compared identical picture and word primes. In Experiment 2, we found an overall facilitative effect of pictures. However, pictures were facilitative regardless of whether they were identical or unrelated. This suggests that an identical picture does not facilitate picture identification, but rather that having a picture as a prime merely facilitates overall picture processing. Thus, Experiment 2 suggested that both identical words and pictures facilitate conceptual processing, affecting Stage 2 rather than Stage 1.

To more intensively investigate whether Stage 1 can be independently affected by a prime, we carried out Experiment 3 in which we varied both the semantic similarity of the prime to its target (whether it was in the same category or not), and the perceptual similarity of the prime to its target (whether it had a similar shape or not). The question we asked was whether a shape-mate that had no semantic similarity to the target could prime the target. The result of Experiment 3 was that similar shaped objects from different categories did not facilitate picture identification even though similar shaped objects from the same category did. This seems to show that perceptual information can help in identification, but only when accompanied by semantic information. However, we could not conclude that semantic relatedness between the prime and target facilitates the use by the structural stage of structural relatedness, because the rating result of Experiment 4-2 showed that Similar Shaped pairs were rated as more semantically related than Different Shaped pairs.

These results suggest that conceptual processing is paramount in priming of picture fragment identification in which pictures slowly and continuously became complete, and that perceptual processing, at least for this particular task, is ineffective.

We view the first stage -- obtaining a structural description of the picture -- as a perceptual module. The fact that semantic and perceptual factors did not interact, in Experiment 3, would appear to support Fodor's (1983,1985) claim that a perceptual module is cognitively impenetrable. The fact that shape did not prime at all makes the lack of an interaction meaningless, as we would expect a perceptual manipulation like shape to affect a perceptual module. The rating result of Experiment 4-1, however, showed that the shape similarity of Same Category/Similar Shape items was rated higher in shape similarity than Different Category/Similar Shape items. On the other hand, rating tasks are certainly affected by semantic factors, so we cannot rule out the possibility that participants might have been affected by semantic relatedness in their ratings.

Both the experimental task of picture identification used in Experiments 1 through 3 and the rating tasks used in Experiment 4 provide ample time for the participant to make decisions. As Yuditsky (1998) has pointed out, if a stage proceeds very quickly, the effects of a prime may not be observable, even though the prime may be an effective one. It may be that the first stage occurs so quickly that it cannot be primed by the shape manipulation we used here, either for picture identification or for ratings.

Summary

In the present paper, we have provided ample evidence for the importance of conceptual influences in fragmented picture identification which, in terms of a stage model of object identification, must occur at Stage 2. In contrast, we have been unable to find any evidence whatsoever for perceptual influences in fragmented picture identification, or priming of Stage 1. We found that neither the additional perceptual information available from identical picture primes compared to identical word primes nor the additional perceptual information available from primes which had similar shapes to the target picture provided additional facilitation in picture identification. Thus we concluded that pictures in this type of task are identified primarily by conceptual processing, with perceptual processing contributing relatively little. This might be because the stage proceeds so quickly and easily that it cannot be further facilitated.

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Table 1

Average Proportion Corrected Responses (Hits - FAs) and Number of Time Epochs (NTEs) for the Seven Priming Conditions of Experiment 1

	Semantic Relatedness			
Prime Type	Identical	Related	Unrelated	Baseline
Hits – FAs: Name				
Category	0.98	0.88	0.89	0.92
	0.93	0.90	0.91	
NTEs:				
Name	295	362	357	361
Category	336	377	382	

<u>Note:</u> Identical = a prime which names the target or the category to which the target belongs; Related = a prime which names an exemplar or a category in the same class as the target; Unrelated = a prime which names an exemplar or a category in a different class from the target; Baseline = a prime consisting of X's. NTE is measured in units of time epochs (~17 ms).

Table 2

Average Proportion Corrected Responses (Hits - FAs) and Number of Time Epochs (NTEs) for the Five Priming Conditions of Experiment 2

	Prime Type		
Prime Form	Identical	Different	Baseline
Hits – FAs			
Picture	.94	.84	.88
Word	.95	.84	
NTEs			
Picture	223	350	362
Word	266	389	

Note: Identical = names or pictures of the target; Different = names or pictures of an exemplar from a different category than the target; Baseline = a prime consisting of X's. NTE is measured in units of time epochs (~17 ms).

Table 3

Average Proportion Corrected Responses (Hits - FAs) and Average Correct Number of Time Epochs (NTEs) of Experiments 3

	Prime Type					
Prime Form	Ident	SC/SS	SC/DS	DC/SS	DC/DS	Base
Hits – FAs						
Picture	0.91	0.81	0.84	0.83	0.84	0.88
Word	0.90	0.81	0.88	0.79	0.81	
NTEs						
Picture	304	325	378	425	430	406
Word	327	358	380	405	418	

Note Ident = names or pictures of the target; SC = same category; DC = different category; SS = similar shape; DS = different shape, Baseline = a prime consisting of X's. NTE is measured in units of time epochs (~17 ms).

Table 4

Average Ratings of the Shape Similarity for the Prime Type of Category and Shape.

	Shape	
Category	SS	DS
Same Category	4.11	1.69
Different Category	3.31	1.29

Note: SS = similar shape; DS = different shape.

Table 5

Average Ratings for the Priming Shape Types of Picture and Word.

	Prime Type	
Prime Form	SS	DS
Picture	3.77	3.52
Word	2.98	2.85

Note: SS = similar shape; DS = different shape.

Appendix

List of Targets With Their Same and Different Category Primes of the Similar and Different Shape

Target	SC/SS	SC/DS	DC/SS	DC/DS
Same Category primes judged to be equally semantically related				
ant	fly	butterfly	roller skate	bow
bear	cow	monkey	frog	spider
bed	couch	chair	toaster	key
bee	beetle	butterfly	roller skate	bow
bus	truck	car	house	candle
carrot	celery	lettuce	saw	ring
corn	celery	mushroom	brush	harp
desk	couch	chair	bread	grapes
guitar	violin	accordion	broom	envelop
lemon	apple	banana	football	arm
lips	eye	ear	watermelon	cherry
motorcycle	bicycle	car	turtle	snake
onion	artichoke	celery	wheel	baseball bat
orange	peach	grapes	ball	ruler
pepper	potato	mushroom	pitcher	baseball bat
pumpkin	tomato	celery	ball	ruler
strawberry	apple	banana	top	car
train	truck	sailboat	iron	glasses

Same Category primes judged to be not equally semantically related				
airplane	helicopter	sailboat	alligator	snake
barrel	garbage can	key	drum	trumpet
belt	watch	bow	sandwich	lobster
boot	sock	comb	foot	wheel
dresser	television	stool	toaster	umbrella
duck	swan	eagle	squirrel	horse
hat	cap	tie	cake	asparagus
knife	fork	kettle	chisel	clock
mitten	glove	tie	pitcher	chain
nail	screw	pliers	pen	box
pencil	paintbrush	scissors	asparagus	pineapple
pot	frying pan	saltshaker	pipe	doll
refrigerator	stove	kettle	book	church
screwdriver	chisel	ladder	toothbrush	football helmet
shirt	jacket	pants	stove	flag
spoon	fork	cup	toothbrush	football helmet
vase	lamp	ashtray	penguin	ostrich
window	door	doorknob	book	cigarette

Note SC = same category; DC = different category; SS = similar shape; DS = different shape

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[i] Because there were eight counterbalancing conditions and only 33 subjects, it was not possible to assign equal numbers of subjects to each counterbalancing.

[ii] Note that the definition of unrelated here differs from that of Experiment 1. In Experiment 2, unrelated means an exemplar from a different category and in Experiment 1, unrelated means an exemplar from a different category in a different class. Because the class of the different category prime in Experiment 1 had no effect whatsoever, we redefined the definition of unrelated for Experiment 2.