# Perceptual priming is obtained in a semantic classification task: Comment on E. Vriezen, M. Moscovitch, and S.A. Bellos (1995).

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running head: perceptual priming

## Abstract

E. Vriezen, M. Moscovitch and S. Bellos (1995) assessed priming in a semantic categorization task in which words were visually displayed at study and test. Robust priming was obtained when the same categorizations were repeated, and no priming when two different categorizations were performed. This finding poses a challenge for various perceptual theories of priming according to which priming is obtained as long as the same perceptual representations of words are accessed at study and test. In three experiments, it is demonstrated that this failure to observe priming was the product of the authors including high-frequency words, because when low-frequency words were included in the present experiments, priming was obtained. Furthermore, this priming is reduced following a study-to-test modality shift under some conditions, indicating that perceptual priming can be obtained in semantic categorization task, consistent with standard perceptual accounts of priming.

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Long-term priming refers to a facilitation in processing a stimulus as a consequence of encoding a related stimulus in an earlier episode. For example, participants are generally faster and more accurate in making lexical decisions to words studied a few minutes earlier, at least for low-frequency words (e.g., Bowers, submitted a; Duchek & Neely, 1989; Forster & Davis, 1984). This facilitation can occur when participants are unaware that words are repeated at study and test, leading to the view that priming is an unaware or “implicit” form of memory (Graf & Schacter, 1985). Long-term priming can last hours, and sometimes longer, distinguishing it from semantic and masked priming that typically last a few seconds (Forster & Davis, 1984; Meyer, & Schvaneveldt, 1971; but see Becker, Moscovitch, Behrmann, & Joordens, 1997; Joordens & Becker, 1997).

Long-term priming itself is divided into two types -- <u>perceptual</u> and <u>conceptual</u> (Blaxton, 1989). Perceptual priming occurs when study items are reinstated in whole or in part at test and the perceptual identification of the target or some aspect of it is required, as in the perceptual identification, stem-completion, and lexical decision tasks. Perceptual priming is largely modality specific and insensitive to level-of-processing manipulations (Jacoby & Dallas, 1981), consistent with the view that perceptual representations support the effects (for different characterizations of these perceptual codes, see Bowers & Michita, 1998; Roediger, 1990; Schacter, 1990). Conceptual priming, by contrast, occurs when participants produce studied items in response to test cues that are meaningfully related to a study item but provide no perceptual information about it. For example, in the category generation task, participants are asked to generate instances of a category at test, and priming is observed when previously studied exemplars are more frequently generated compared to non-studied exemplars (Graf, Shimamura & Squire, 1985). In contrast with perceptual priming, conceptual priming is insensitive to study-to-test modality changes (Srinivas & Roediger, 1990), and is sensitive to levels-of-processing manipulations (Hamann, 1990; Srinivas & Roediger, 1990), consistent with the view that conceptual codes mediate these effects.

Recently, Vriezen, Moscovitch, and Bellos (1995) assessed priming in a task that combined characteristics of both perceptual and conceptual tests; namely, a semantic categorization task in which words were presented visually at study and test. For example, in one condition, participants categorized the referents of written words as man-made or natural during the study phase, and at test, in terms of their size. One the one hand, this task can be considered perceptual given that the perceptual attributes of the words were repeated at study and test. On the other hand, given that the meaning of the words was accessed at study and test in order to respond, the task also might also be considered conceptual. The key question was whether perceptual codes support priming in a task that focused on semantic attributes of words.

The straightforward prediction of most perceptual theories is that priming should be obtained under these conditions. Priming should be expected because perceptual representations of words need to be accessed in order to contact the corresponding semantic codes -- and repeated access to the perceptual codes should be sufficient to support priming. The fact that semantic codes are also contacted, and that decisions are based on these conceptual codes should be irrelevant to the perceptual component of priming.

Thus, it is interesting that Vriezen et al. failed to observe priming when different semantic categorizations were made at study and test (-15 ms), whereas robust priming (100 ms) was obtained when the same categorizations were repeated (Experiment 1). This striking result appears to compromise the standard perceptual theories of priming. Interestingly, they also found robust cross-modal priming when the same categorizations were repeated at study and test, supporting the view that this priming was mediated by conceptual rather than perceptual codes (Experiment 2). Based on these and related results, the authors supported a particular version of the component processing theory of priming (Moscovitch & Umilta, 1990, 1991), and argued against the more standard accounts of priming, such as the multiple-memory (Schacter, 1990) and the transfer-appropriate-processing (Roediger, 1990) accounts.

Although the results reported by Vriezen et al. (1995) are clear, there is reason to question their generality. The authors assessed priming with relatively high-frequency words, ranging from 4 to 521 per million, with a mean of 80.5 (Francis & Kucera, 1982), and priming tends to be reduced for high- compared to low-frequency words. In fact, in the lexical decision task, priming effects are often eliminated for high-frequency words when different tasks are performed at study and test (Bowers, submitted a; Forster & Davis, 1984; Rajaram & Roediger, 1993). Accordingly, the null effects they reported may not support the general conclusion that perceptual codes do not contribute to priming in a semantic categorization task, but rather, only indicate that perceptual codes for high-frequency words do not support such priming. If indeed this is the case, the theoretical conclusions the authors put forward do not follow.

In order to determine whether perceptual codes can support priming for low-frequency words in a semantic categorization task, three experiments were carried out. Experiments 1a-b demonstrate that priming can be obtained for low-frequency words when different semantic categorizations are performed on written items at study and test. Thus, Vriezen et al.'s (1995) failure to obtain priming in this condition does not reflect a general constraint that is incompatible with perceptual theories of priming. Furthermore, Experiments 3 demonstrates that this priming can be reduced following a study-to-test modality shift, providing direct evidence that perceptual codes can support priming in the semantic categorization task. However, Experiments 2a-b show that the conditions that support modality specific priming in a semantic task are limited.

## Experiments 1a-b

### Method

Participants. Forty-eight students from Rice University participated in return for course credit in Experiment 1a, and an additional 48 Rice students participated in Experiment 1b for credit.

Design and Materials. The experiments included frequency (high vs. low) and study-test condition (same categorization at study-test vs. different categorization at study-test vs. categorization only at test) as within-subjects variables. Categorizations during the study phase were blocked, and for half of the participants, words were first categorized as man-made or natural followed by a size judgment task, and for the other half, the order was reversed. In Experiment 1a, all test words were categorized as man-made or natural, and in Experiment 1b, all test words were categorized according to size. Six test forms were created for each experiment so that each word was included in the various conditions equally often, yielding completely counter-balanced designs.

Both experiments included the same set of 48 high-frequency words (mean frequency = 166 occurrences per million, range from 76-591) and 48 low-frequency words (mean frequency = 2 occurrences per million, range from 1-7) selected from the Kucera and Francis (1967) norms. All words were highly imaginable so that the size judgment task could be easily completed. The low-frequency words ranged from 3-9 letters in length, with a mean length of 5.8 letters and 1.8 syllables, and the high-frequency words ranged from 3-9 letters, with a mean of length 4.6 letters and 1.2 syllables. In the study phase of each experiment, 32 words were categorized as man-made or natural (16 high-frequency and 16 low-frequency) and 32 were categorized in terms of size (16 high-frequency and 16-low frequency), and at test, all 96 words categorized. An additional a set of 10 filler items were presented at the beginning of each study block to familiarize participants with both categorization tasks. All 20 filler items were different from the critical items.

<u>Procedure</u>. The two experiments were conducted under conditions of incidental encoding: Participants were not informed that any of the words were repeated. The experiments were run using the DMASTER software program developed at the University of Arizona by K.I. Forster and J.C. Forster that synchronizes the timing of the display with the video raster. Standard IBM text font was used. On each trial, a fixation mark of a "+" was presented for 500 ms, which was replaced by a word. Categorizations were performed by pressing the left or right shift key as quickly as possible, with the right shift

key corresponding to natural objects and objects larger than a computer monitor, and the left shift key corresponding to man-made objects and objects smaller than a computer monitor (depending on the condition). Written feedback in terms of reaction times and accuracy was presented after each response. The type of categorization to be made in each block was presented on the computer monitor prior to the first item in each block.

Results

The mean categorization latencies and error rates in the various conditions of Experiments 1a-b are shown in Tables 1a-1b, respectively. As can be seen in the tables, the same pattern of priming was obtained in the two versions of the experiment, and accordingly, the data were collapsed and analyzed.

Consistent with the results of Vriezen et al., no priming was obtained for the high-frequency words when different categorizations were made (5 ms), and significant priming was obtained for these items when the same categorizations were performed (40 ms). However, in contrast with their results, robust priming was obtained for low-frequency words when the categorizations were different at study and test (31 ms) as well as when they were the same (61 ms). An overall ANOVA carried out on the reaction time (RT) data revealed a main effect of priming, $F(2,180) = 61.71$, $MSe = 2039$, $p < .01$, and a main effect of frequency, $F(1,90) = 5.36$, $MSe = 2027$, $p < .05$. The interaction between priming and frequency was also significant, $F(2,180) = 5.43$, $MSe = 1803$, $p < .01$, reflecting the larger priming for low- compared to high-frequency words. Most critically, a simple contrast revealed significant priming for low-frequency words when different categorizations were made, $F(1,90) = 19,40$, $MSe = 2434$, $p < .01$. The analysis of errors also revealed a main effect of priming, $F(2,180) = 23.02$, $MSe = 85.61$, $p < .01$, while the effect of frequency only approached significance, $F(1,90) = 2.76$, $MSe = 81.07$, $p = .10$. Priming for errors did not interact with frequency, $F(2,180) < 1$.

## Discussion

These results clearly show that priming can be obtained in the semantic categorization task when different categorizations are made at study and test, but these effects are restricted to low-frequency words. Thus, Vriezen et al.'s (1995) failure to obtain priming in this condition can be attributed to the set of high-frequency words the authors used, rather than to a general principle of priming. This challenges the theoretical conclusions the authors advance.

However, this priming is not necessarily the product of visual perceptual representations. It is possible, for example, that conceptual priming is greater for low- compared to high-frequency words, and accordingly, conceptual representations mediated these effects. Alternatively, this priming may be mediated by phonological codes, given that phonological codes are often activated during the course of contacting semantic codes from print, particularly for low frequency words (e.g., Coltheart, Patterson, & Leahy, 1994). Neither of these latter conclusions are consistent with the Vriezen et al. (1995) analysis given that the authors specifically argued that priming only occurs in a semantic decision task when the same decisions are repeated at study and task or when the decisions require access to information in the same semantic domain -- which is not the case for the size judgment vs. man-made judgment tasks. Still, if it turns out that the preserved priming is completely mediated by phonological or semantic representations, then these findings would also challenge standard perceptual accounts of priming that should predict a visual component to priming for repeated low-frequency written words, regardless of the nature of the semantic decisions required at study and test.

## Experiments 2a-b

Experiment 2 was carried out in an attempt to determine the nature of the representations that support priming for low-frequency words when different categorizations are made at study and test. The same set of low-frequency words was used in this experiment, but in this case, half of the studied words were spoken rather than written. The critical question is whether the within-modal priming is eliminated following a study-to-test modality shift.

### Method

Participants. Forty-eight persons from the Bristol area participated in return for £3.00, 24 in Experiment 2a and 24 in Experiment 2b. The participants were a mixture of students and non-students, ranging in age from approximately 20 to 50.

Design and Materials. The experiments included study-test condition (words studied and tested in written format vs. words spoken at study and written at test, vs. nonstudied words and written test words) as a within-subjects variable. Different categorizations were made at study and test, with participants in Experiment 2a categorizing words as man-made or natural at study followed by a size judgment task at test, and participants in Experiment 2b performing the tasks in the opposite order. Six test forms were created so that each word was included in the various conditions equally often, yielding completely counter-balanced designs. The 48 low-frequency words used in Experiment 1 and 10 filler items were used in this experiment.

Procedure. The same general procedure was used as above. In this case, however, participants were instructed to make semantic judgments to written or spoken words at study, and at test, make semantic judgments to written words.

Results

The mean categorization latencies and error rates in the various conditions of Experiments 2a-b are shown in Tables 2a-2b, respectively. Once again, the same pattern of priming was obtained in the two versions of the experiment, and accordingly the data were collapsed and analyzed.

The critical findings is that a similar amount of priming was obtained within (26 ms) and between (27 ms) modalities, suggesting that none of the priming for low-frequency words was mediated by perceptual representations. The overall priming was significant, $F(2,84) = 5.44$, $MSe = 2056$, $p < .01$, but clearly, there was no difference in the amount of priming in the two conditions. Accordingly, the results do not provide any support for the conclusion that visual perceptual codes mediate priming when participants make semantic categorizations to written words at study and test.

Discussion.

The absence of modality specific priming for repeated low-frequency words appears to challenge the standard view that visual perceptual codes support priming when low-frequency written words are repeated at study and test. However, before this conclusion is accepted, a stronger test of this hypothesis seems warranted. Indeed, there are at least two reasons why the above pattern of results could be obtained without contradicting standard perceptual theories. First it should be noted that size of the priming obtained in experiments 1-2 were relatively small when different categorizations were made at study and test (an average of 29 ms across experiments), and accordingly, the absence of modality specific priming may been the consequence of a functional floor effect. The small size of the priming effects may be related to finding that the frequency effects in this task were also relatively small (in the baseline conditions in Experiments 1a-b, there was only a small advantage of 24 ms for high- compared to low-frequency words averaging across experiments).

Interestingly, previous studies have also reported small (even null) frequency effects in the semantic categorization tasks, which contrast with the much larger frequency effects in lexical decision (e.g., Balota & Chumbley, 1985). Initially, these findings were taken to indicate that frequency effects reflect decision processes rather than perceptual processes involved in identifying words. However, more recent work suggests that the reduced frequency effects were due to the relatively complex nature of the semantic decisions that were required in these experiments, resulting in a great deal of variability in response times. As a consequence, effects of word frequency tended to be swamped by the variability of the RTs contributed by the semantic decision stage (Monsell, 1991). Indeed, the greater the duration and variability of the decision process the greater the likelihood that any effects of frequency on transcoding time would not propagate through to the measured RTs. Monsell (1991), however, did find large and robust frequency effects in a semantic categorization task when the decision process was as simple as possible. Given these considerations, it might be expected that including a simple semantic categorization task at test would reduce noise in the present tasks, increasing the likelihood of obtaining modality specific component of priming if perceptual codes do contribute to priming in the semantic task. Indeed, the magnitude of modality specific priming and word frequency interact (Bowers, submitted a), and it is often argued that priming and frequency effects are the product of the same underlying representations, with primed low-frequency words acting as temporary high-frequency items (e.g., Morton, 1979). If this is the case, it is not surprising that small priming effects were obtained in a task that was relatively insensitive to frequency.

Second, and perhaps more crucially, participants may have accessed the semantic codes of study-test words via phonological representations, consistent with the evidence that phonology plays an important role in accessing meaning for low-frequency words (Coltheart et al., 1994). If participants tended to access phonological codes using a sub-lexical grapheme-phoneme conversion strategy (e.g., Lukatela, Frost, & Turvey, 1998), then the lexical-orthographic codes that are presumed to mediate modality-specific word priming may not have been contacted fully. What may be needed are conditions that encourage participants to access lexical-orthographic codes during the process of contacting semantic information.

The final experiment was constructed in light of these considerations. If modality specific priming fails to be observed under conditions in which variability in response latencies is minimized, and where lexical-orthographic codes are contacted, the results would provide a stronger challenge to perceptual theories.

## Experiment 3

Two modifications were made to the present experiment. First, the semantic decision was simplified. Rather than asking participants to judge the size of the referent or whether the referent refers to a natural kind or an artifact, participants judged whether it was alive or not. Various evidence suggest that living/non-living distinction is salient in semantic memory (or at least strongly correlated with important divisions in semantic memory, e.g., Farah & McClelland, 1991). By simplifying the semantic judgments, reaction times should be less variable, providing a better opportunity to observe any modality specific priming. Second, a list of low-frequency irregular words were used in the experiment. Irregular words cannot be read on the basis of sub-lexical grapheme-phoneme correspondences, and require access to higher-level orthographic knowledge. If repeated access to lexical-orthographic representations is necessary to support perceptual priming, then this priming should be more likely with these items.

Method.

Participants. Twenty-four undergraduate students from University of Bristol area participated in return for £3.00 or course credit.

Design and Materials. As in Experiment 2, Experiment 3 included study-test condition as a within-subjects variable. Three test forms were created so that each word was included in the within-modal, between-modal, and baseline conditions equally often, yielding a completely counter-balanced design. A set of 48 low-frequency irregular words were included (mean frequency = 9.7 occurrences per million, range 1-43; Kucera & Francis, 1967), half of which referred to living things, half of which did not. The words ranged in length from 4-10 letters, with a mean length of 5.4 letters, and a mean of 1.5 syllables per word. An additional 10 filler irregular words were used in the experiment to give participants practice before completing the critical items. The critical items are listed in the Appendix.

Procedure. Participants performed the size judgment task at study and the living/non-living task at test. Many of the words referred to inanimate things (e.g., chaos), and in these cases, participants were instructed to respond "not larger than a computer monitor" at study, and "non-living" at test.

Results and Discussion

The mean categorization latencies and error rates in the various conditions of Experiment 3 are shown in Tables 3. As can be seen in this table, robust within-modal priming was obtained (43 ms), but in contrast with Experiments 2a-b, the cross-modal priming was dramatically reduced (11 ms). An overall ANOVA revealed a main effect of priming for the RTs, $F(2,42) = 5.96$, $MSe = 1985$, $p < .01$, and a planned contrast showed significantly more within- compared to cross-modal priming, $F(1, 21) = 4.56$, $MSe = 1166$, $p < .01$. The cross-modal priming did not approach significance, $F(1,21) < 1$. No effect of errors was obtained, $F(2,42) < 1$. Accordingly, perceptual priming can be obtained in a semantic decision task.

It should be noted that the living/not-living decisions in Experiment 3 were not faster (nor more accurate) than in the man-made/natural decision task in Experiment 2b, and accordingly, it might appear that this task was not easier than previous tasks. In which case, the critical difference between Experiments 2-3 was the inclusion of irregular words rather than task difficulty. This may well be true, but it is worth pointing out that latencies to respond to low-frequency irregular words tends to be slower than for regular words (e.g., Andrews, 1982). Given that this was not the case in the present experiment, it presumably means that the living/non-living task was somewhat easier than the other tasks. But in any case, the critical point is that perceptual priming can be obtained in the semantic task, as predicted by perceptual theories.

## General Discussion

Two main findings are reported in the present article. First, robust priming is obtained for written low-frequency words in a semantic categorization task when different decisions are made at study and test. Second, this priming is reduced following a study-to-test modality shift when irregular words are tested, and when the decisions required at test are relatively simple. Accordingly, the results provide support for the conclusion that perceptual priming occurs in a semantic task. These findings are compatible with standard views of perceptual priming, but contradict the particular version of the component processing theory of priming that Vriezen et al. (1995) advance.

Although the results do not directly support one particular perceptual account over another, the finding that modality specific visual word priming was restricted to low-frequency irregular words provides an important constraint for theories. One approach that can accommodate these findings is the view that pre-existing lexical-orthographic codes support priming (Bowers, 1996, in press, submitted b; Bowers & Michita, 1998; Morton, 1979). On this view, orthographic knowledge is coded in a frequency sensitive manner, and accordingly, the interaction between frequency and priming should be expected based on additive factor logic (Sternberg, 1969). For example, it could be argued that the perceptual processing of low-frequency words is facilitated because these orthographic representations continue to be strengthened with practice, whereas for high-frequency words, learning has approached asymptote. Another class of theories assume that priming is mediated by newly acquired perceptual memory codes (e.g., Roediger 1990; Schacter, 1990). Although these theories would not necessarily predict an interaction between priming and frequency, it is certainly possible to develop theories of this sort that would also predict such an effect (e.g., see Logan, 1990).

The additional finding that modality specific priming was restricted to irregular low-frequency words can also be accounted for within an orthographic account of priming. That is, it is often argued that low-frequency regular words are understood by converting sub-lexical orthographic patterns to phonological patterns, which in turn activate the semantic representations (e.g., Lukatela et al., 1998). For these items, then, the lexical-orthographic codes that mediate modality specific word priming would not be fully contacted, reducing the specific component of priming.[1] In the case of irregular words, however, lexical-orthographic codes may be more fully contacted during the process of accessing meaning from print, resulting in more robust modality specific effects. Whether other perceptual accounts of priming could explain a regular-irregular differences remain to be seen.

Although priming was restricted to low-frequency words when different semantic categorizations were performed at study and test, priming did extend to high-frequency items when the same categorizations were performed. It is important to note that this latter priming was also sensitive to frequency, with an average of 62 ms priming for low-frequency words, and 32 ms for the high-frequency words (averaging across Experiments 1a-b). Still, this finding raises the obvious question as to why priming extends to high-frequency items when the same categorizations are performed. One possibility is that conceptual codes support this priming, although it is unclear why conceptual priming would extend to high frequency items while perceptual priming does not. Another possibility, is that this priming is mediated by the connections between conceptual codes and specific responses repeated at study and test. For example, although the conceptual representation for <u>table</u> is high in frequency, the association between this code and the response "bigger than a computer monitor" is low in frequency, and the establishment of this new association may have contributed to the priming when the same responses were repeated. Of course, these two accounts are not incompatible, and priming could reflect a combination of modifying pre-existing conceptual codes as well as establishing new associations between conceptual codes and responses.

In addition to the perceptual and conceptual contributions to priming in the semantic task, phonological codes may have contributed as well. Although there is no direct evidence regarding the role that phonological codes play in priming when semantic categorizations are performed at test, it should be noted that Ziemer and Bowers (submitted) obtained evidence that phonological codes play a key role in priming for visually presented words in the lexical decision task. In this study, twice as much within- (18 ms) compared to cross-modal (9ms) priming was obtained when the distracter nonword foils were pseudowords (e.g., blap), which is a typical proportional reduction following a study-to-test modality shift. The new finding was that the inclusion of pseudohomophone nonword foils at test (e.g., brane, that sounds like brain) eliminated cross-modal priming (-2 ms), but left within-modal priming (16 ms) unchanged. We argued that the inclusion of pseudohomophones foils discouraged participants from using phonology as a basis of making lexical decisions, and given this manipulation also eliminated cross-modal priming, it suggests that phonological codes mediate the cross-modal priming when pseudowords were employed. Bowers (submitted a) also found the within- and cross-modal components of priming to be similarly affected by frequency manipulations, suggesting that the phonological representations that support cross-modal priming in the lexical decision task are lexical in nature. The extent to which lexical-phonological codes contribute to priming in the semantic categorization task remains unclear, however.

In sum, the present results clearly demonstrate that visual perceptual priming can occur in semantic categorization tasks, contrary to the conclusion of Vriezen et al. (1995). This finding provides support for the view that the repeated perceptual processing of low-frequency words is sufficient to support perceptual priming, irrespective of the response that is required by the participants. I would suggest that the modality specific priming obtained in the semantic task is a by-product of strengthening pre-existing lexical-orthographic codes, although other perceptual accounts of priming may explain this findings as well.

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## Author note

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# Footnote.

1. If this argument is to hold, it would have to be assumed that the lexical-orthographic codes of regular low-frequency words are contacted during the performance of the lexical decision task, as modality specific priming is obtained for regular items in this task. Indeed, there is various evidence that lexical-orthographic knowledge is contacted for low-frequency words in the lexical decision task (e.g., Bowers, Vigliocco, & Haan, 1998)

Table 1a.

Mean Reaction Times and Error Rates to respond Man-made or Natural in Experiment 1a as a Function of Word Frequency and Study-Test Condition.

| Frequency | Reaction Time | % Errors |
|---|---|---|
| Low | | |
| Same Categorization | 601 (58) | 8.9 (4.6) |
| Different Categorization | 625 (34) | 15.1 (-1.6) |
| Baseline | 659 | 13.5 |
| High | | |
| Same Categorization | 590 (35) | 4.3 (6.3) |
| Different Categorization | 629 (-3) | 10.6 (0) |
| Baseline | 626 | 10.6 |

Table 1b.

Mean Reaction Times and Error Rates to Make Size Judgments in Experiment 1b as a Function of Word Frequency and Study-Test Condition.

| Frequency | | Reaction Time | % Errors |
|---|---|---|---|
| Low | | | |
| | Same Categorization | 603 (65) | 6.9 (4) |
| | Different Categorization | 640 (28) | 12.7 (-1.8) |
| | Baseline | 668 | 10.9 |
| High | | | |
| | Same Categorization | 607 (45) | 7.8 (4) |
| | Different Categorization | 640 (12) | 14.4 (-2.6) |
| | Baseline | 652 | 11.8 |

Table 2.

Mean Reaction Times and Error Rates in Experiment 2a-b as a Function of Study-Test Condition.

| Experiment | Reaction Time | % Errors |
| --- | --- | --- |
| 2a: Man-Made vs. Natural Decisions at Test | | |
| Same Categorization | 743 (33) | 8.7 (-1.1) |
| Different Categorization | 739 (37) | 8.0 (-0.4) |
| Baseline | 776 | 7.6 |
| 2b: Size Decision at Test | | |
| Same Categorization | 723 (19) | 10.1 (-3.5) |
| Different Categorization | 726 (16) | 7.6 (-1.0) |
| Baseline | 742 | 6.6 |

Table 3

Mean Reaction Times and Error Rates to Make Living vs. Non-living Decisions in Experiment 3 as a Function of Study-Test Condition.

| Study-Test Condition | Reaction Time | % Errors |
|---|---|---|
| Same Categorization | 705 (43) | 7.5 (1.1) |
| Different Categorization | 737 (11) | 7.8 (0.8) |
| Baseline | 748 | 8.6 |

Appendix: Forty-eight low-frequency irregular words, 24 of which refer to living things, 24 of which do not. Frequencies listed along with words.

| Living things | Non-living things. |
|---|---|
| lawyer 43 | drought 5 |
| bush 14 | anchor 6 |
| calf 11 | biscuit 2 |
| chauffeur 4 | chaos 4 |
| chef 9 | comb 2 |
| clientele 3 | glove 20 |
| coyote 1 | deaf 13 |
| crook 3 | debt 10 |
| crow 2 | echo 8 |
| earl 12 | guitar 13 |
| heir 7 | height 1 |
| lieutenant 29 | vase 15 |
| mechanic 5 | liquor 17 |
| monk 16 | ninth 7 |
| monkey 9 | ocean 11 |
| pheasant 1 | hood 18 |
| sergeant 28 | rhythm 4 |
| swan 3 | sausage 15 |
| tiger 7 | scent 12 |
| tortoise 3 | subtle 20 |
| tsar 1 | tomb 22 |
| wasp 2 | vague 4 |
| wolf 6 | weird 5 |
| worm 4 | yacht 6 |