

The Concreteness Effect in Implicit and Explicit Memory Tests

Maryellen Hamilton

Baruch College, City University of New York

and

Suparna Rajaram

State University of New York at Stony Brook

Four experiments were conducted to examine the concreteness effect in implicit and explicit memory measures. Experiment 1 replicated prior reports of an imagery effect on an implicit conceptual memory test. In Experiment 2, we confirmed our prediction of conceptual sensitivity of free recall, explicit general knowledge, explicit word fragment completion, and the implicit general knowledge tests with a levels of processing manipulation. Furthermore, although we obtained the concreteness effect (better memory for concrete than abstract nouns) in free recall and the explicit general knowledge test, we failed to find this effect in the implicit general knowledge test. Experiment 3 revealed that the failure to find the concreteness effect on the implicit general knowledge test was not attributable to combining two encoding manipulations in Experiment 2. In Experiment 4, we ruled out the possibility that the failure to find the concreteness effect in conceptual implicit memory may be related to the number of meaningful associates for targets. We discuss the implications of these findings within the context of the transfer appropriate processing framework (Roediger, Weldon, & Challis, 1989) and the dual-code hypothesis (Paivio, 1971, 1991) of memory. © 2001

Academic Press

In this article, we focus on the nature of priming in conceptual memory tests. The experiments we report were motivated by the theo-

We thank Richard Delaney, Kevin Felker, William Gartland, Mana Heydarpour, Laurance Lemmerling, Kathy Le, Ellen Martin, Tara Price, Maura Rzeznikiewicz, Amanda Salomon, Jennifer Sanders, Sandra Siegel, Christine Verdino, and Carmine Vozzolo for their help in creating materials and testing participants. We are grateful to Larry Jacoby, Roddy Roediger, Mary Susan Weldon, and an anonymous reviewer for providing helpful comments on an earlier version of this article. Parts of the research reported in this article were presented at the annual meeting of the Eastern Psychological Association in Philadelphia, PA, 1996; Washington, DC, 1997; and at the annual meeting of the Psychonomic Society in Philadelphia, PA, 1997. This research was supported by NIH Grant R29MH57345-01 to Suparna Rajaram.

Address correspondence and reprint requests to Suparna Rajaram, Department of Psychology, SUNY at Stony Brook, Stony Brook, NY 11794-2500. Fax: (631) 632-7876. E-mail: srajaram@psych1.psy.sunysb.edu, or to Maryellen Hamilton, Department of Psychology, Saint Peter's College, 2641 Kennedy Blvd., Jersey City, NJ 07306. E-mail: hamilton_m@spcvxa.spc.edu.

retical conceptualization of three well-known variables that are presumed to engender conceptual or meaning-based processing. These three variables are encoding pictures versus words, imaging an item's referent versus reading words, and encoding concrete versus abstract nouns. These variables are assumed to share a common mechanism in Paivio's (1971, 1991) dual-code hypothesis. We considered the effects of these variables on conceptual forms of explicit and implicit memory with an empirical focus on the effects of concrete versus abstract nouns.

Explicit and implicit memory tasks differ in the test instructions given to the participants (Graf & Schacter, 1985). Explicit memory tasks such as recall and recognition require participants to think back to the prior study episode and perform the memory task at hand. In contrast, implicit memory tasks make no reference to the study episode and participants are required to complete the task at hand with the first

answer that comes to mind. According to the transfer appropriate processing framework postulated by Roediger and colleagues (Roediger, Weldon, & Challis, 1989), explicit memory tasks typically entail considerable use of conceptual processing for retrieving the study episode (but also see Blaxton, 1989). As a result, these tasks benefit from experimental manipulations which enhance conceptual processing of information (see Roediger & McDermott, 1993 for a review). Implicit memory tasks can either rely predominantly on perceptual processes or on conceptual processes. For instance, implicit tasks such as word fragment completion (_ l e _ h _ n _; solution: "elephant") or word stem completion (ele_____) require participants to complete the word puzzle with the first solution that comes to mind and preferentially rely on perceptual processing of information (see Roediger & McDermott, 1993 for a review). Here, we focus on a different class of implicit memory tests that rely on conceptual processes. In these tests, no mention is made of the study episode but implicit memory is aided by the conceptual overlap between study and test items. For instance, in the implicit category production test, participants are provided with a conceptual cue at test that bears no physical resemblance to the study item (e.g., for the studied item "elephant," the category label "animal" is provided at test) and are asked to write down the exemplars of that category that come to mind. The increase in the generation of studied exemplars over nonstudied exemplars, or priming, provides the measure of memory on these implicit tests. Experimental manipulations that enhance conceptual processing improve priming on these conceptual implicit tasks (Blaxton, 1989, Srinivas & Roediger, 1990).

The effects of the three variables of present interest, picture versus word processing, imaging the referent versus reading words, and studying concrete versus abstract nouns, have been well established on measures of conceptual explicit memory and are straightforward (see Paivio, 1971, 1983 for reviews). Specifically, pictures are recalled or recognized better than words (picture superiority effect) on ex-

PLICIT memory tests such as free recall (Paivio, Rogers, & Smythe, 1968) and recognition (Shepard, 1967; see also Madigan, 1983). Imaging the referent of a word produces better retention than nonimaged words (imagery effect), and concrete nouns are better remembered than abstract nouns (concreteness effect) on explicit memory measures including free recall, recognition, and paired associate learning (see Paivio, 1971, 1983, for reviews).

In contrast to these outcomes, the effects of these variables on conceptual implicit tasks appear to be less clear and sometimes discrepant (Blaxton, 1989; McDermott & Roediger, 1996; Nyberg & Nilsson, 1995; Weldon & Coyote, 1996; Wippich & Mecklenbrauker, 1995). Specifically, some researchers have failed to find a picture superiority effect on conceptual implicit memory tests (McDermott & Roediger, 1996; Weldon & Coyote, 1996), and yet, others have reported a positive imagery effect on this same class of tasks (Blaxton, 1989; Nyberg & Nilsson, 1995; Wippich & Mecklenbrauker, 1995). Our aim in this article is to empirically address these discrepancies in the results with conceptual implicit tests and provide a coherent theoretical description of these effects on explicit tasks as well as conceptual implicit memory tasks.

As mentioned earlier, the picture superiority effect, the imagery effect, and the concreteness effect are assumed to be related effects in Paivio's (1971, 1991) dual-code hypothesis. According to the simplest interpretation of this hypothesis, there are two possible codes which can be activated when an item is presented at study, verbal (logogens) or imaginal (imagens) (Paivio, 1978). These two codes are assumed to be additive in nature. It is postulated that pictures, items studied with imagery instructions, and concrete words activate both the verbal and the imaginal code, whereas simply reading a word only activates one code (verbal). Therefore, the superior memory for pictures, items studied with imagery instructions, and concrete items is the result of the additive contributions of two codes to memory.

Under this possibility, the activation of two codes requires cross-system, or referential, pro-

cessing (Paivio, 1971, 1991). Specifically, it is assumed that if the encoding of a picture is accompanied with invoking its name, both the verbal and imaginal systems become engaged through referential processing. Similarly, when participants are required to image the pictorial representation of a word (e.g., sailboat), it is assumed that referential processing enables the activation of both codes. Finally, in the dual-code hypothesis, it is also assumed that concrete words facilitate the activation of logogens and imagens, whereas abstract words can only access logogens, and thus, referential processing is likely for the former and not the latter set of items (see Paivio, 1983, for a review).

Thus, all three effects of interest are presumed to be guided by cross-system, or referential, processing. Because referential processing is assumed to be conceptual in nature (Paivio, 1991, pp. 280–281), the activation of dual codes implies one type of conceptual processing of information. It should be noted that referential processing represents only one type of conceptual processing and that conceptual processes during encoding and retrieval could be of different types depending on the experimental manipulation employed to engender conceptual processing. Within the context of the research reported here, our definition of conceptual processes at encoding will be restricted to referential processing across the verbal and imaginal codes. Based on this assumed role of referential processing in the dual-code hypothesis, the picture superiority effect, the imagery effect and the concreteness effect may be considered as conceptually driven effects on memory. As such, these three effects should emerge on memory tests that are classified as conceptual tests, both explicit and implicit, within the transfer appropriate processing framework.

To examine this idea, Blaxton (1989, Experiment 3) examined the imagery effect in five memory tasks. In this experiment, participants were asked to form mental images of the item's referent for half the items presented during study. No specific study instructions were given for the remaining items. Blaxton constructed five different memory tests by combining different test instructions (explicit and implicit)

and types of processing (perceptual and conceptual) so as to test the predictions of the transfer appropriate processing framework (Roediger et al., 1989). Of these five tests, two conceptual tests, free recall and semantic cued recall (i.e., target is cued with a semantically related word, e.g., study: universe; test: cosmos____), were explicit memory tests. The third test, graphemic cued recall, was an explicit perceptual test where the target was cued with a perceptually similar word (e.g., unversed_____). The fourth test, word fragment completion, was an implicit perceptual test where participants were provided with a perceptually degraded version of the target (_ _ i v _ _ s e) and were asked to provide the first solution that came to mind. The fifth test, general knowledge, was an implicit conceptual test. Participants were provided with conceptually related test questions ("What was the Big Bang said to have created?) which bore no physical resemblance to the studied words (universe) and were asked to answer with the first solution they could think of to solve these questions.

As predicted by the transfer appropriate processing framework (Roediger, Weldon, Stadler, & Riegler, 1989), Blaxton found a typical imagery effect on all conceptual tests, explicit (free recall and semantic cued recall) or implicit (general knowledge). More items were recalled or questions answered with words studied with the imagery instructions than with words studied without the imagery instructions. In addition, she found no imagery effect in either the explicit perceptual task (graphemic cued recall) or the implicit perceptual task (word fragment completion; see also Durgunoglu & Roediger, 1987, for converging evidence). This finding of a positive imagery effect on a conceptual implicit test has been subsequently replicated with a category association task (Nyberg & Nilsson, 1995) and a verb association task¹ (Wippich &

¹ In the verb association task, participants studied action phrases (i.e., holding the tire) within a text. During test they were provided with verbs (half of which were from early action phrases) and asked to fill in the first associations that came to mind (e.g., holding _____). Note that there is perceptual overlap between the study item and the test cue and therefore this task does not meet the criterion suggested

Mecklenbrauker, 1995). Together, these findings support the notion that imagery entails conceptual processing (Paivio, 1991) and that this conceptual manipulation enhances performance on conceptual implicit memory tests.

With respect to the picture superiority effect, the reported findings are quite different from those found with the imagery effect. In a recent study, Weldon and Coyote (1996) consistently failed to find a picture superiority effect on two implicit conceptual tests (category production and word association) such that pictures and words produced equivalent amounts of priming. At the same time, a significant levels of processing effect (Craik & Lockhart, 1972) was found on both tests, indicating that the tests were indeed conceptual in nature. Furthermore, when the same two tests were given with explicit instructions, recall was better for items studied as pictures than for items studied as words. Similarly, McDermott and Roediger (1996) failed to find a picture superiority effect on the implicit conceptual test of category production. In fact, only one study (Nicolas, 1995) has reported a picture superiority effect on an implicit conceptual test (category production). It is not clear why Nicolas (1995) has obtained a picture superiority effect on an implicit conceptual test while Weldon and Coyote (1996) and McDermott and Roediger (1996) failed to find one. Weldon and Coyote have suggested that one possibility may be that he used intentional study instructions, which may have led to explicit contamination on the implicit memory test. However, Weldon and Coyote and McDermott and Roediger's failure to find the picture superiority effect is the focus of the current research since this finding seems to contradict the predictions of the transfer appropriate processing framework.

Thus, if we assume that imaging and picture processing both entail activation of two codes through referential processing (Paivio, 1991), then the imagery effect on the conceptual implicit tasks (Blaxton, 1989; Nyberg & Nilsson,

1995; Wippich & Mecklenbrauker, 1995) supports both the dual-code hypothesis and the transfer appropriate processing framework. But on this view, the absence of a picture superiority effect on conceptual implicit tasks (McDermott & Roediger, 1996; Weldon & Coyote, 1996) is problematic for both accounts.

To our knowledge, there are no published studies that have examined the effects of studying concrete versus abstract nouns on conceptual implicit memory. This lacuna in the literature becomes particularly striking in light of the discrepancy we have just discussed. Specifically, positive imagery effects have been found on implicit conceptual memory tests (Blaxton, 1989; Nyberg & Nilsson, 1995; Wippich & Mecklenbrauker, 1995) but no picture superiority effect has been found on these tasks (McDermott & Roediger, 1996; Weldon & Coyote, 1996). Therefore, in order to explore the reasons for this discrepancy it is essential to examine whether a theoretically related effect (i.e., the concreteness effect) would be obtained on these tasks. Based on the dual-code hypothesis, it is reasonable to assume that superior memory for concrete nouns relative to abstract nouns likely arises from the conceptual processing advantage (arising from the cross-system or referential processing) for concrete nouns. Thus, according to the transfer appropriate processing framework, an advantage for concrete over abstract nouns should be obtained not only on explicit tasks such as free recall, recognition, and paired associate learning (see Paivio, 1983, for a review), but also on conceptual implicit tasks. We set out to test this prediction.

We selected the implicit general knowledge task as our conceptual implicit task to examine the effects of the concrete/abstract variable. Our selection of this task was guided by the studies that have tested the effects of theoretically related variables. In particular, we selected the implicit general knowledge test as our conceptual implicit task because Blaxton (1989, Experiment 3) reported a robust imagery effect on this task. Having selected this task, we first sought to replicate the positive imagery effect (Blaxton, 1989) in our laboratory and with our subject pool. To this end, we used Blaxton's

earlier for conceptual implicit tests (i.e., no perceptual overlap between study and test cues). However, we include it here since the authors classify it a conceptual implicit task.

(1989) general knowledge task as our implicit conceptual test. It was expected that we would find a typical imagery effect; i.e., more questions answered with items studied under imagery instructions than items studied without imagery instructions.

EXPERIMENT 1

Method

Participants. Eighty-three undergraduates from SUNY at Stony Brook participated for credit as partial requirement for course work. The undergraduates were recruited from the Psychology Department human subject pool and informed consent to participate in the study was obtained. Of these 83 participants, 35 took part in a norming study and 48 took part in the experiment.

Materials and norming. We used 35 participants to norm 132 general knowledge questions selected from Blaxton's (1989) materials for our subject population. Blaxton's materials were used because these materials had previously produced a positive imagery effect on an implicit conceptual test. From the 132 general knowledge questions, a pool of 80 items were selected based on the results of our norming study. The overall mean base-rate performance for these items was 19%.

Design. We used a 2×2 within-subject design. A given participant saw 40 words at study and the other 40 words served as new items at test. For each list of 40 words, half of the items were studied under imagery instructions and the other half of the items were simply read (nonimaged). The imaged and nonimaged conditions were presented in a blocked fashion. Counterbalancing was done for item type (old/new), study instructions (imaged/nonimaged), and the presentation order of study blocks (imaged followed by nonimaged vs nonimaged followed by imaged), thereby creating eight study lists.

Procedure. Participants were tested in groups of one to three. Items were presented on Zeos 486 computers using Schneider's (1990) Micro-Experimental Laboratory (MEL; Version 1.0). Participants took part in both a study and a test

phase. All participants were presented with 40 words during study for 5 s each. Twenty of the words were presented with imagery instructions. Specifically, participants were instructed to form a mental image of the item's referent. The participants were asked to hit a specially marked "Y" key as soon as they had formed a mental representation of the item. They were told that the word may still remain on the screen for a predetermined amount of time and that during this time they should keep the image in their mind. The remaining 20 items were presented with nonimaged instructions. Participants were told to simply read the words. Again they were instructed to hit the specially marked "Y" key as soon as they had read the word. Participants were asked to read no slower or faster than they normally do. Once again they were instructed that the word would remain on the screen for a predetermined amount of time during which they should continue to read the word. Participants in conditions where imagery instructions were given first were told to make sure they did not image in the "read" condition as this would slow down their reading times.

The test phase was presented as a different experiment to help ensure that the participants did not associate the study and test phase. Participants were told that for the second experiment they would have to answer trivia questions. They were instructed that the majority of the questions had multiple solutions, and therefore, there were no right or wrong answers. Participants were instructed to answer the questions with the first word that comes to mind that answers the question appropriately. No mention of the prior study episode was made. All participants took part in a practice session prior to the test. Test instructions and practice lasted approximately 10 min.

During the test phase the participants were presented with 80 general knowledge questions, one question at a time. Half of the questions had target answers from the earlier study list (half from the imaged condition and half from non-imaged condition). The other half of the questions had nonstudied target answers. Each question appeared on the computer screen, with the prompt, "If you have a solution, Press the Y

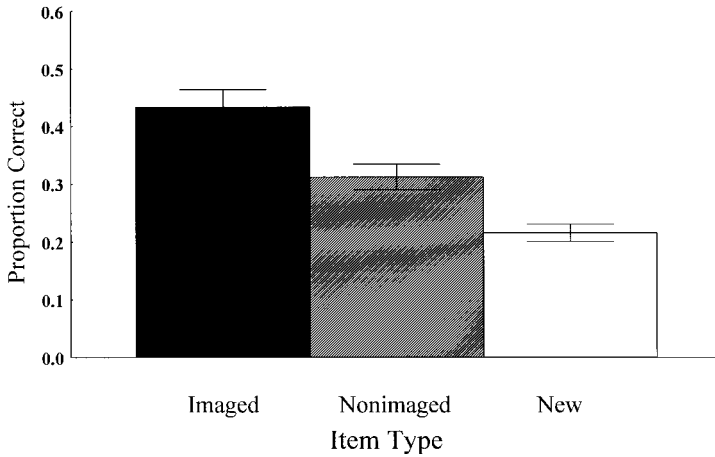


FIG. 1. Mean proportion of questions answered (and standard errors) with studied imaged, studied nonimaged, and new items in Experiment 1.

Key.” Participants were instructed to hit the specially marked “Y” key as soon as they thought of a one word solution. Once they hit the “Y” key, participants were instructed to type in their response. After typing in the response, or if the participants did not hit the “Y” key in the allotted time (20 s), the next question appeared automatically.

At the end of the testing phase, each participant was debriefed and questioned about their awareness of any relationship between the study and test phase.

Results and Discussion

None of the participants noticed a connection between the study phase and the test phase. Figure 1 illustrates the mean proportion of questions answered with target items for the studied imaged items, the studied nonimaged items, and for new items. For all results reported, the alpha level was set at $p < .05$. Unless otherwise noted, the first statistical value (e.g., the F value or the t value) represents the subject analysis, whereas the second statistical value represents the item analysis. A significant difference was found among the means [$F(2,141) = 18.84$, $MS_e = .03$; $F(2,237) = 18.93$, $MS_e = .04$]. To determine if priming occurred, planned comparison t tests were performed between the proportion of questions answered with target studied

items and the proportion of questions answered with target nonstudied items, for each encoding condition. Significant priming was obtained in both the imaged condition [$t(47) = 8.37$, $SE = .02$; $t(79) = 9.36$, $SE = .02$] and the nonimaged condition [$t(47) = 5.52$, $SE = .02$; $t(79) = 4.66$, $SE = .02$]. In order to determine if there was an imagery effect, a within subject t test was performed between the priming (studied–nonstudied) proportions of imaged items ($M = .21$) and nonimaged items ($M = .09$). This comparison revealed a significant imagery effect [$t(47) = 4.65$, $SE = .02$; $t(79) = 4.81$, $SE = .02$]. Thus, we replicated Blaxton’s (1989) findings. Specifically, we found both significant priming and a significant imagery effect on our implicit conceptual memory test of general knowledge.

Having replicated the imagery effect on the implicit conceptual test of general knowledge, we proceeded to examine our central question of interest, i.e., the effect of studying concrete versus abstract nouns on conceptual implicit memory. In Experiment 2, we included five memory tasks to examine the concreteness effect on memory. We included a free recall task in order to replicate the well-established concreteness effect on an explicit memory task (Paivio & Csapo, 1969; see Paivio, 1983 for a review). Our critical measure was the concep-

tual implicit task of general knowledge and its selection was based on the findings from previous studies (Blaxton, 1989) and the results of our Experiment 1. We also included an explicit version of this task in order to examine the concreteness effect on a conceptual explicit task that met the retrieval intentionality criterion (Schacter, Bowers, & Booker, 1989). That is, we sought to confirm the presence of a concreteness effect in an explicit task that was identical to the conceptual implicit task in all respects except for the retrieval instructions. To our knowledge, there is no published report of an explicit version of the general knowledge task. Finally, we also included two widely used perceptual tasks, the implicit word fragment completion task and its explicit version of fragment cued recall. The effect of encoding concrete and abstract items has not been previously examined for this category of tasks. We did not expect any effect on the implicit version of this task because this task is at the perceptual end of the processing continuum. While we included an explicit version of the word fragment completion task we did not have a strong prediction for this task (we return to this issue shortly).

In Experiment 2, we also included the levels of processing (Craik & Lockhart, 1972) manipulation in our experiment to confirm the typical assumptions regarding the processing nature of these five tasks. Past research has documented a levels of processing effect on conceptual tasks but not on tasks that are predominantly perceptual in nature (Challis & Sidhu, 1993; Hamann, 1990; Srinivas & Roediger, 1990). However, based on past research (Roediger, et al., 1992; Weldon, Roediger, Beitel, & Johnston, 1995), we also predicted a levels of processing effect for fragment cued recall (i.e., the explicit perceptual task). A levels of processing effect is believed to occur on this test, even though the cue is perceptual (word fragment), because explicit retrieval in itself demands conceptual processing (the participant needs to make a judgment about whether an item has been seen earlier). Therefore, this contamination of the perceptual test with conceptual processing was expected to aid performance for semantically encoded words. On this logic, a small concrete-

ness effect may also be expected on the explicit word fragment completion task. However, if concreteness of words is not as strong a conceptual manipulation as levels of processing, the concreteness effect may not occur on this predominately perceptual task (we return to this issue under General Discussion).

EXPERIMENT 2

Method

Participants. A total of 324 undergraduates from SUNY at Stony Brook participated in this experiment for credit needed for partial fulfillment of a course requirement. Of these, 108 participants took part in the norming study and 216 in one of the five experimental test conditions. Of these 216 participants, 40 each took part in four different tasks, free recall, question cued recall, implicit word fragment completion, and fragment cued recall. In the implicit general knowledge task, 56 participants were tested.

Design. In this experiment a $2 \times 2 \times 2 \times 5$ mixed-factorial design was used. Studied status (old vs new), item type (concrete vs abstract), and levels of processing (deep vs shallow) were manipulated as within-subject variables. Test type (free recall, question cued recall, fragment cued recall, implicit word fragment, or implicit general knowledge) was manipulated as a between-subject variable.

From the pool of 80 critical items, we created two lists of 40 items (20 abstract and 20 concrete). Each list was further divided so that half the items (10 abstract and 10 concrete) were shown with semantic encoding instructions and the remaining half of the items were shown with graphemic encoding instructions. The presentation of items was blocked with respect to semantic and graphemic encoding. Altogether, eight possible study lists were created to achieve appropriate counterbalancing. Thus, across participants each item appeared as a studied or nonstudied item and for semantic and graphemic encoding. In addition, the order for these two encoding conditions was also balanced across participants.

Materials and norming. All items, both at study and at test, were presented and data were

collected on Zeos 486 computers by using Schneider's (1990) Micro-Experimental Laboratory (MEL; Version 1.0) software system. Because our manipulation of interest (concreteness) was inherent in our items, we needed to select a new set of materials for Experiment 2. A set of 80 nouns was selected from the Paivio, Yuille, and Madigan (1968) norms. Forty of these items were chosen to be highly concrete (scores above 6 on the 7-point concreteness scale, $M = 6.74$) and 40 items were chosen to be abstract (scores between 1.5 and 4.5 on the concreteness scale, $M = 2.69$) in nature. Paivio et al. also normed items on two additional scales; imageability and meaningfulness. The imageability scale is a 7-point scale, whereas the meaningfulness scale reflects the number of meaningful associates a participant generates for a given word. Since the imageability and meaningfulness scales are highly correlated with the concreteness scale, concrete items were accompanied with high scores on both the imageability ($M = 6.39$) and the meaningfulness ($M = 6.44$) scales, and the abstract items were accompanied with low scores on the imageability ($M = 3.62$) and the meaningfulness ($M = 5.42$) scales. All items were between 5 to 10 letters in length and of medium frequency ranging from 10 to 49 ($M = 25$) occurrences per million words in print according to Thorndike and Lorge (1944). There was a significant difference between concrete and abstract items on the concreteness scale, $t(78) = 26.50$, $SE = .15$, the imageability scale, $t(78) = 31.21$, $SE = .09$, and the meaningfulness scale, $t(78) = 8.28$, $SE = .12$. No significant differences were observed between concrete and abstract items on both word length, $t(78) = 1.77$, and word frequency, $t(78) = 1.03$.

For each item, both a word fragment and a general knowledge question were created (e.g., target—strawberry; word fragment—s t _ a _ _ e _ _ y; general knowledge question—What fruit wears its seeds inside its skin?). These word fragments and general knowledge questions were normed to establish an acceptable baseline rate of accuracy. One hundred eight participants took part in one of four norming studies. Based on the four norming studies,

we ensured that the nonstudied baseline hit rate for both the word fragments and the general knowledge questions was, on average, 26%. Furthermore, we ensured that our two critical sets of items (abstract and concrete nouns) did not statistically differ on their baseline performance on word fragment completion, $t(78) < 1$, or general knowledge questions, $t(78) = 1.32$.

Our levels of processing manipulation was based on a method used by Challis and Sidhu (1993). For the graphemic (shallow) encoding condition, participants were asked if a certain letter was in the word (e.g., Does this word contain a "c"?). Participants were never asked about the same letter twice within a given list. Approximately half of the answers were "yes" and the other half were "no" responses. For the semantic (deep) encoding condition, participants were asked about the meaning of an item (e.g., Can you buy this?). A pool of 77 questions was created. Normative data showed that 38 of the questions focused on concrete ideas (e.g., Is this a person?), whereas 39 questions focused on abstract ideas (e.g., Is this desired?). Concrete questions were used for concrete items while abstract questions were used for abstract items. Each question appeared only once per study list and half of the questions required a "yes" response, whereas the other half required a "no" response.

Our pilot data showed that single presentation yielded weak priming on the implicit conceptual test. Therefore, the encoding procedure was slightly different for the participants in the implicit general knowledge test. Following the precedence established in previous investigations (Challis & Sidhu, 1993; Weldon & Coyote, 1996), we used massed repetition during encoding in the implicit conceptual tests. Based on Challis and Sidhu's (1993) parameters, each item appeared four times consecutively and four separate questions were asked in each encoding condition. For example, in the semantic encoding condition the word "strawberry" was presented four times consecutively, and each time this word was followed by a different question (i.e., Is this made of wood?; Can this be found in a garden?; Does this involve music?; Can this grow?). An encoding question was used from

one to four times per study list. However, no question was used more than once for the same word. For each word, two of the questions had "yes" responses, whereas two of the questions had "no" responses.

During retrieval, for all tests but free recall, participants were presented with the cues for the original 80 items. For a given participant, 40 items were studied, whereas the remaining 40 were new (nonstudied) items. In the implicit word fragment completion test and the explicit fragment cued recall test, participants were presented with 80 word fragments. Similarly, for the implicit general knowledge test and the explicit question cued recall test, participants were presented with 80 general knowledge questions. The implicit and explicit tests differed only in the instructions given.

Procedure. Participants were tested in groups of one to three. A given participant took part in only one of five test conditions. In the free recall, explicit question cued recall, implicit word fragment completion, or the explicit word fragment cued recall test conditions, participants saw single presentations of items in the study phase. During the single presentation, each word appeared on the computer screen for 3 s. Following the word, a question that required a yes/no response appeared on the screen for 2 s. Participants were asked to respond by hitting the specially marked "Y" or "N" keys (which were adjacent to each other on the keyboard). In the shallow processing condition, participants were instructed to read the word carefully, pay attention to the letters, and answer the graphemic question. In the deep processing condition, participants were instructed to read the word carefully, pay attention to the meaning of the word, and answer the semantic question.

In the encoding procedure for the implicit general knowledge test, the same manipulation was used except that each word was presented four times consecutively on the computer screen with each presentation lasting 1 s followed by a question presented for 2 s. Participants were given the same instructions as the single presentation groups except that they were informed that the same item may appear more

than once and that each time an item was presented a new question would be asked.

After the study condition, participants had a 10-min retention interval where they played a game of cards on the computer for 6 min and were given test instructions and practice items for the remaining 4 min.²

Following the retention interval, participants in the free recall condition were instructed to write down in any order all the words they could recall from the earlier study lists. They were informed that the words could come from either of the two lists that they saw earlier. Participants were given 7 min for the task.

For the remaining four tests, test items appeared on the computer screen one at a time with the prompt, "If you have a solution, press 'Y.'" When the participants pressed the "Y" key, they were asked to type in the solution and press the enter key. If the participant failed to press the "Y" key, the item remained on the screen for 20 s and then timed out.

For the explicit tests (i.e., word fragment cued recall and question cued recall), participants were instructed to try to solve the items presented in the allotted time. Participants were also informed that some of the cues could be solved with words that they had previously seen in either of the two encoding conditions. Participants were urged to solve only those cues for which their solution was a word from the earlier studied lists. For the implicit tests participants were instructed to solve the items presented in the allotted time with the first word that came to mind. In the general knowledge tasks participants were urged to give one word solutions. For all five groups, the entire procedure took less than 1 h.

Results

In Fig. 2, we have collapsed the results across the concrete/abstract variable to present the priming and the levels of processing effects first. Figure 2 illustrates the mean proportion of items retrieved for the nonstudied (new) condition and both levels of processing encoding

² Participants in the free recall condition played the card game for 7 min because there was no practice phase.

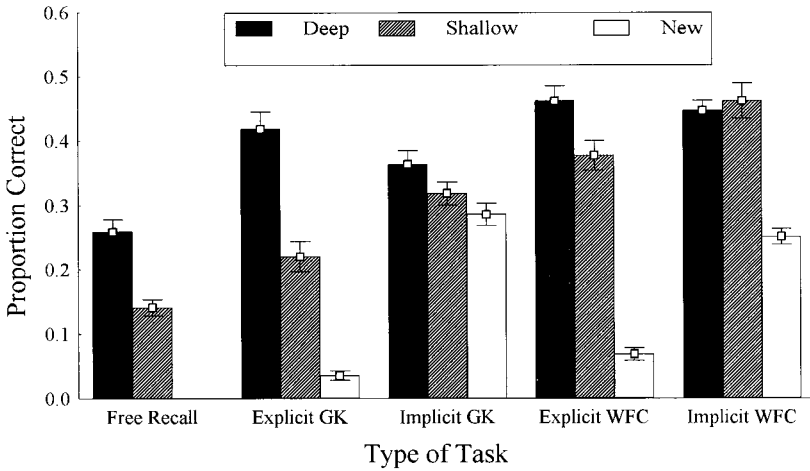


FIG. 2. Mean proportion of correct responses (and standard errors) for each item type for each of the five tasks used in Experiment 2. GK = general knowledge task; WFC = word fragment completion task.

conditions for each of the five memory tests. The levels of processing analyses and planned comparison *t* tests were performed on the corrected measures of studied minus nonstudied items.

A typical levels of processing effect (i.e., greater retention for items studied under semantic processing when compared to items studied under graphemic instructions) was observed for all our conceptual tests [free recall, $t_1(39) = 5.95, SE = .02, t_2(79) = 4.95, SE = .02$; explicit general knowledge test, $t_1(39) = 7.6, SE = .03, t_2(79) = 8.66, SE = .02$; and implicit general knowledge test, $t_1(55) = 2.2, SE = .02, t_2(79) = 2.40, SE = .02$]. A significant level of

processing effect was also observed on the explicit word fragment completion test [$t_1(39) = 2.75, SE = .03, t_2(79) = 3.06, SE = .03$]. As expected, no levels of processing effect was observed for the implicit word fragment completion task [$t_1(39) < 1, t_2(79) < 1$].

Table 1 presents the studied, nonstudied, and corrected scores for both concrete and abstract nouns on each of the five tests. Figure 3 illustrates the corrected recall and priming proportions for both concrete and abstract nouns for each of the five memory tests. For every test but free recall, a 2×2 ANOVA was performed with study status (old vs new) and item type (concrete vs abstract) as factors. In addition, per

TABLE 1

Mean Proportion of Studied and Nonstudied Items Retrieved and Standard Deviations for Each Item Type in All Five Tasks in Experiment 2

Task	Concrete			Abstract		
	Studied	Nonstudied	St.-Nst.	Studied	Nonstudied	St.-Nst.
Free Recall	.23 (.12)	0	.23 (.12)	.17 (.10)	0	.17 (.10)
Explicit GK	.35 (.17)	.03 (.05)	.32 (.18)	.29 (.15)	.04 (.06)	.25 (.17)
Explicit WFC	.42 (.13)	.06 (.07)	.36 (.15)	.41 (.16)	.08 (.08)	.33 (.18)
Implicit WFC	.48 (.13)	.26 (.09)	.22 (.14)	.41 (.14)	.24 (.12)	.17 (.17)
Implicit GK	.32 (.15)	.27 (.15)	.05 (.16)	.37 (.15)	.30 (.14)	.07 (.15)

Note. GK = general knowledge task; WFC = word fragment completion task.

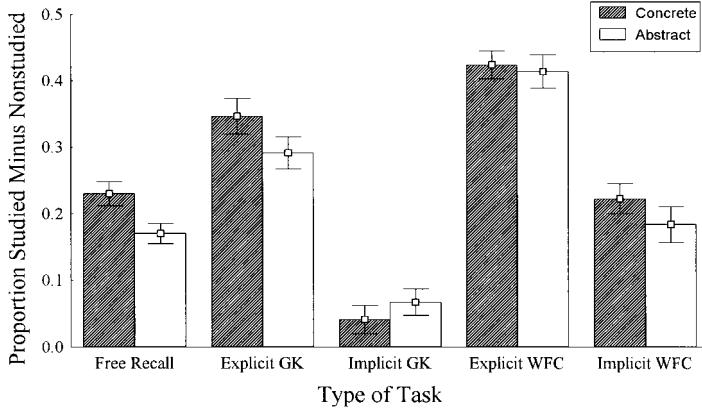


FIG. 3. Recall and priming proportions (and standard errors) for concrete and abstract nouns for each of the five tasks used in Experiment 2. GK = general knowledge task; WFC = word fragment completion task.

our hypothesis, planned comparison t tests were performed to detect priming and the concreteness effect on our two implicit measures.

Since there were no nonstudied items (intrusions) reported in free recall we did not use a 2×2 ANOVA on these data. For the free recall task, significant differences were observed between the proportion of studied concrete items recalled and the proportion of studied abstract items recalled (the concreteness effect) [$t(39) = 2.71$, $SE = .02$, $t(78) = 2.22$, $SE = .03$].

In the general knowledge explicit task, a main effect was found for study status [$F(1,39) = 140.63$, $MS_e = .02$, $F(2,178) = 147.94$, $MS_e = .02$]. No main effect was found for item type [$F(1,39) = 2.27$, $F(2,178) < 1$]. A significant interaction was found by subject [$F(1,39) = 7.01$, $MS_e = .05$], but not by item [$F(2,178) = 1.27$]. Planned comparison t tests revealed that a significant concreteness effect was found on the corrected priming scores of the general knowledge explicit test by subject [$t(39) = 2.64$, $SE = .05$], but not by item [$t(78) = 1.12$], although note that the numerical difference was in the expected direction (concrete $M = .32$; abstract $M = .26$). Thus, as expected, the overall pattern produced a concreteness effect in this task.

For the explicit word fragment completion task, there was a significant main effect of study status [$F(1,39) = 352.36$, $MS_e = .01$; $F(2,178) = 279.50$, $MS_e = .02$] and no main

effect of item type [$F(1,39) < 1$; $F(2,178) < 1$]. No significant interaction was observed [$F(1,39) < 1$; $F(2,178) < 1$]. Therefore, as expected, there was no concreteness effect observed on the corrected priming scores in our explicit word fragment completion task [$t(39) < 1$; $t(78) < 1$].

In the implicit word fragment completion test, there was a main effect of study status [$F(1,39) = 152.71$, $MS_e = .01$; $F(2,178) = 93.35$, $MS_e = .02$] and a main effect of item type by subject [$F(1,39) = 5.23$, $MS_e = .01$], but not by item [$F(2,178) < 1$]. No significant interaction was found [$F(1,39) = 1.08$, $F(2,178) = 1.05$]. Planned comparison t tests revealed significant priming for both the concrete items [$t(39) = 9.89$, $SE = .02$; $t(39) = 6.79$, $SE = .03$] and for abstract items [$t(39) = 6.81$, $SE = .02$; $t(39) = 6.99$, $SE = .03$]. Per our predictions, no concreteness effect was observed on the priming scores for the implicit word fragment completion task [$t(39) = 1.04$; $t(78) = 1.03$]. Note that the small numerical trend for the concreteness effect in this task is unlikely to be real because this trend became even smaller in the explicit version of the task and was not significant, as described above.

In the implicit general knowledge task, we obtained a main effect of study status [$F(1,55) = 14.16$, $MS_e = .01$; $F(2,178) = 14.21$, $MS_e = .01$] and a main effect of item type by subject [$F(1,55) = 10.81$, $MS_e = .01$],

but not by item [$F2(1,78) < 1$]. No significant interaction was observed [$F1(1,55) < 1$; $F2(1,78) < 1$]. Planned comparison t tests confirmed that there was significant priming for both concrete items [$t1(55) = 1.93$, $SE = .02$; $t2(39) = 1.99$, $SE = .02$] and abstract items [$t1(55) = 3.36$, $SE = .02$; $t2(39) = 3.56$, $SE = .02$]. The most critical finding in this experiment concerned the implicit general knowledge test; we did not find a significant difference between the priming scores for abstract items and the priming scores of concrete items on our implicit general knowledge test [$t1(55) < 1$; $t2(78) < 1$]. Thus, we failed to find a concreteness effect in our conceptual implicit memory test.

To help ensure that this failure to find a significant concreteness effect on our implicit conceptual test was not due to the small levels of priming observed in this task, we reanalyzed the data by dividing the data for high and low responders. Specifically, we examined whether we would see a concreteness effect emerge if we only analyzed the performance of those participants who showed relatively high levels of priming. The data were divided in half according to the proportion of overall priming observed for each participant. A within subject t test was then performed on the data for the high-scoring participants in the implicit general knowledge test. However, no significant difference was found for the priming scores of concrete ($M = .13$) and abstract nouns ($M = .16$), $t(27) < 1$, of these high responders.

Discussion

As predicted by the transfer appropriate processing framework, there was a significant levels of processing effect on all the conceptual tests (both explicit and implicit) and as we expected on our explicit perceptual task.³ Also as

³ We note here that even though we did obtain a levels of processing effect on the explicit word fragment completion task we failed to find a concreteness effect on this task. We do not have a ready explanation for this discrepancy for the explicit word fragment completion task. Although, as previously mentioned, we believe this finding may suggest that concreteness is not as strong a manipulation of conceptual processing as is levels of processing.

predicted there was no levels of processing effect on the implicit perceptual test. These findings suggest that, according to the assumptions of the transfer appropriate processing framework, we identified the processing requirements of our tests correctly. Also, as predicted by transfer appropriate processing framework, we did not find an effect of the conceptual manipulation of concrete and abstract nouns on our perceptual tests. Furthermore, our conceptual tests of free recall and the explicit question cued recall did produce the concreteness effect.

The finding of major interest in this experiment is that we failed to obtain a concreteness effect on the implicit general knowledge test. According to the transfer appropriate processing framework, a conceptual manipulation should affect performance on a conceptual task. We did find a levels of processing effect on the implicit general knowledge test, thereby illustrating that the test is sensitive to a conceptual manipulation. However, we failed to find a concreteness effect on this task. In addition, a concreteness effect was found when the same test cues were given with explicit instructions (question cued recall), illustrating that our failure to find a concreteness effect on our implicit general knowledge test was not attributable to the nature of the test cues themselves. Before we set out to describe the theoretical ramifications of our findings, we sought to rule out two empirical possibilities that may have counteracted a potential concreteness effect in our conceptual implicit memory test. The first of these two possibilities was tested in Experiment 3.

One potential reason why we did not find a concreteness effect on our implicit conceptual test might be that we also included a levels of processing manipulation at study. That is, including a levels of processing manipulation at study may have changed the way in which our items were encoded and, therefore, eliminated the concreteness effect. The possible mechanism by which such elimination may occur is as follows. The concreteness effect is presumed to be due to a concrete items entailing more conceptual encoding compared to abstract items (Paivio, 1971). However, specifically requiring participants to encode both concrete and ab-

TABLE 2

Mean Proportion of Studied and Nonstudied Items Retrieved and Standard Deviations for Each Item Type in Experiments 3 and 4

	Concrete			Abstract		
	Studied	Nonstudied	St.-Nst.	Studied	Nonstudied	St.-Nst.
Experiment 3	.34 (.16)	.29 (.12)	.05 (.15)	.35 (.15)	.29 (.12)	.06 (.14)
Experiment 4	.28 (.18)	.23 (.12)	.05 (.14)	.30 (.14)	.26 (.12)	.04 (.16)

stract nouns for meaning in our experiment may have reduced the default differences in the conceptual encoding of these items. The explicit conceptual tests may have been less prone to this problem because these tests utilize intentional retrieval. The use of a deliberate retrieval strategy may permit the subtle differences in the conceptual and distinctive attributes of items at encoding to emerge (see Roediger et al., 1992), thereby giving the concrete words an advantage over the abstract words despite the use of the levels of processing encoding.

To test this possibility, we conducted Experiment 3 to examine whether the concreteness effect would arise on a conceptual implicit task if we did not use the levels of processing manipulation at study. Because the concreteness effect is attributed to conceptual encoding of concrete items (Paivio, 1971) and conceptual tests should be sensitive to conceptual manipulations at encoding (Roediger et al., 1992), we predicted a concreteness effect on our conceptual implicit test once the use of the levels of processing manipulation at study was eliminated.

EXPERIMENT 3

Method

Participants. An additional group of 56 undergraduates from SUNY at Stony Brook participated in the experiment to obtain credit needed for partial fulfillment of a course requirement.

Materials and procedure. All materials and procedures were identical to that of Experiment 2 with the following changes. We used only the implicit general knowledge test because we

were interested in examining whether a concreteness effect would arise on this test once study instructions were changed. We did not use the levels of processing manipulation; instead participants were told that they were being tested for their reading reaction times and that they should read no faster or slower than they normally do. Each item was preceded by an asterisk for 1 s, and, as in Experiment 1, each item was presented for four massed repetitions of 1 s each.

Results and Discussion

Table 2 contains the proportion of correct studied and nonstudied questions for both concrete and abstract items. There was a significant main effect of study status [$F(1,55) = 13.28$, $MS_e = .01$; $F(1,78) = 14.65$, $MS_e = .01$] and no main effect of item type [$F(1,55) < 1$; $F(1,78) < 1$]. In addition, no significant interaction was observed [$F(1,55) < 1$; $F(1,78) = 1.63$]. As expected, planned comparison t tests revealed significant priming for both concrete items [$t(55) = 2.44$, $SE = .02$; $t(39) = 1.82$, $SE = .02$] and abstract items [$t(55) = 3.14$, $SE = .02$; $t(39) = 3.44$, $SE = .03$]. However, there was no significant difference between the priming scores for concrete words ($M = .05$) and the priming scores for abstract words ($M = .06$) [$t(55) < 1$; $t(78) = 1.77$]. Once again, we tried to eliminate the possibility that the failure to observe the concreteness effect on our implicit measure was due to the low levels of priming observed. Therefore, we reanalyzed the data only for that half of the participants who showed higher levels of priming. No significant difference was observed between the priming

scores for these participants on concrete ($M = .14$) and abstract items ($M = .14$) [$t(27) < 1$]. Thus, once again we failed to find a concreteness effect on a conceptual implicit test.

Given that the default differences in the encoding of concrete and abstract nouns did not produce a concreteness effect in Experiment 3, we considered the following possibility. One of the important ways in which concrete and abstract items differ is in the number of meaningful associations that can be generated for concrete and abstract nouns (see Paivio et al.'s, 1968 norms). This difference may impair the production of concrete words on open-ended tests such as the implicit general knowledge test.

As mentioned under "Method" in Experiment 2, in Paivio et al.'s (1968) norms, meaningfulness is measured by the mean number of associations participants generated for a given item. The original pool of items that we used in Experiments 2 and 3 were chosen so that the concrete items scored significantly higher than the abstract items on Paivio et al.'s imageability, concreteness, and meaningfulness scales. We used these criteria because these scales are highly correlated and because we wanted to create a large item set. However, these criteria led to the selection of concrete words that have more meaningful associations than the selected abstract words and, therefore, could potentially provide more incorrect solutions. This latter point is elaborated below.

All of our general knowledge questions had many possible solutions. Due to the nature of the questions, all of the possible solutions to a given question were associated with each other. For example, our general knowledge question "What animal is a political symbol?" had the target response "elephant." However other possible solutions to that question were donkey, eagle, and dove. Note that all possible solutions are associated with each other since they all belong to the category "animals." Because our test was implicit (participants were instructed to complete the item with the first word that came to mind), and many possible solutions to the questions were associates of one another, the intrusions may have been affected by the num-

ber of meaningful associations for a particular item. Specifically, the more meaningful associations a particular item can produce, the more potential incorrect solutions exist to our question for that particular item. This problem is unique to implicit open-ended tests because these tests can be completed with any solution and, therefore, competing responses may not be suppressed as would be done in the explicit versions of the same tests.

It should be noted that the meaningful associates for concrete and abstract nouns do not differ on at least one other measure of meaningfulness. Nelson and Schreiber (1992) recently provided the meaning set size norms in which little differences were observed between the meaning set size for abstract and concrete nouns. In this approach, meaning set size is measured by having large groups of participants provide the first meaningful associate that comes to mind for a given item. The number of different items generated by a pool of participants for a given item constitutes its meaning set size. Note that this measure of meaningfulness differs from Paivio's measure. In Paivio's multiple association measure of meaningfulness, each participant provides many responses, whereas in Nelson and Schreiber's single association measure, each participant provides only one response.

Based on Nelson and Schreiber's (1992) single association measure of meaningfulness, one would not expect response competition to play a role in the production of concrete and abstract nouns on our conceptual implicit task. However, based on Paivio's multiple association measure, response competition remains a possible confound in our previous experiments. Furthermore, Nelson and Schreiber (1992) also found that concrete and abstract nouns differed on meaningfulness scales similar to those used by Paivio even though the meaning set sizes of concrete and abstract nouns did not differ. For these reasons, the goal of Experiment 4 was to determine whether the larger size of associated responses to concrete nouns had diminished the production of target concrete words in an open-ended task such as implicit general knowledge in our prior experiments. We tested this idea by

holding constant the meaningfulness scores for concrete and abstract nouns from Paivio et al.'s (1968) norms. We predicted a concreteness effect on our conceptual implicit task in Experiment 4 because this measure of meaningfulness was controlled.

EXPERIMENT 4

Method

Participants. An additional group of 86 undergraduates from SUNY at Stony Brook participated for credit needed for partial fulfillment of a course requirement. Of these 86 participants, 30 took part in a norming study and 56 took part in the experiment.

Materials and procedure. A pool of 60 items (30 concrete and 30 abstract) was selected from both Experiment 2 and from Paivio et al.'s (1968) norms such that the abstract and concrete items only varied on the imageability and concreteness scales and not the meaningfulness scales [concrete $M = 5.82$, abstract $M = 5.76$; $t(58) < 1$]. For each new item, a general knowledge question was constructed and normed so that the mean baseline rate of completion accuracy for this pool of 60 items was 28%. All procedures were the same as in Experiment 3 except that the participants saw 30 items at study (15 concrete and 15 abstract) and 60 items at test (30 old and 30 new).

Results

There was a significant main effect of study status [$F(1,55) = 9.76$, $MS_e = .01$; $F(1,58) = 9.42$, $MS_e = .01$]. There was no main effect of item type [$F(1,55) = 2.99$; $F(1,58) < 1$]. There was also no interaction found [$F(1,55) < 1$; $F(1,58) < 1$]. As can be seen in Table 2, we obtained significant priming for concrete items [$t(55) = 2.85$, $SE = .02$; $t(29) = 2.91$, $SE = .02$]. The priming was also significant for abstract items by subject [$t(55) = 1.92$, $SE = .02$], but not by item [$t(29) = 1.64$] (but note that the means were in the right direction). However, there was no significant difference between the priming scores for concrete words ($M = .05$) and the priming scores for abstract words ($M = .04$) [$t(55) < 1$;

$t(58) < 1$]. Once again, to help eliminate the possibility that the low levels of priming observed on this task were masking the concreteness effect, we reanalyzed the data for only those half of the participants who demonstrated higher levels of priming. No significant difference was found between priming scores for concrete ($M = .15$) and abstract items ($M = .13$) for these participants [$t(27) < 1$]. Thus, we did not find a concreteness effect on the conceptual implicit test even when we equated for the number of meaningful associations (Paivio et al., 1968) for concrete and abstract words.

GENERAL DISCUSSION

The goal of this research project was to examine the effect of studying concrete versus abstract words on conceptual implicit memory. Prior research has demonstrated that a related variable of imaging the referent of a word (see Paivio, 1983) produces greater priming on the implicit general knowledge test compared to simply reading words (Blaxton, 1989). In contrast, a related manipulation of studying pictures does not produce greater priming than reading words on another conceptual implicit memory task of category association (Weldon & Coyote, 1996). Within this context, we explored the effects of concrete versus abstract words on different forms of memory. In Experiment 1 we replicated Blaxton's (1989) finding of a positive imagery effect on the conceptual implicit memory test of general knowledge. We then conducted three experiments to examine whether the concreteness effect occurs on conceptual implicit memory tests. To test this, we used the implicit general knowledge test (Blaxton, 1989). In Experiment 2, we compared memory for concrete and abstract nouns in five different memory tasks that a priori make different instructional and processing demands. These tasks were free recall, explicit general knowledge test, implicit general knowledge test, explicit word fragment completion test, and implicit word fragment completion test. The conceptual/perceptual processing demands of these tasks were confirmed with a levels of processing manipulation at study.

Specifically, free recall and explicit and im-

PLICIT versions of the general knowledge test produced significant levels of processing effects. The explicit version of the word fragment completion test also produced a significant levels of processing effect, as has been reported in other studies (Roediger et al., 1992). Furthermore, as expected, the implicit version of the perceptual word fragment completion task did not exhibit a levels of processing effect. These findings with the levels of processing manipulation are completely consistent with the predictions of the transfer appropriate processing framework (Roediger, 1990; Roediger et al., 1989, 1992).

With respect to our central question of interest, the concrete/abstract variable produced predicted results with one important exception. The predicted results included a concreteness effect on the explicit versions of the conceptual tasks, i.e., free recall and explicit general knowledge. Furthermore, no concreteness effect was obtained on the predominantly perceptual tasks, i.e., explicit and implicit word fragment completion. However, contrary to the general expectations, we failed to find a concreteness effect on the implicit conceptual memory task of general knowledge.

We conducted two more experiments to examine two possible causes of this null effect. In Experiment 3, we removed the levels of processing manipulation on the reasoning that the instructions to process both the concrete and abstract nouns at a deep (or a shallow level) may have inadvertently eliminated the default processing differences between concrete and abstract nouns. However, our hypothesis that the emergence of the default differences in the conceptual processing of concrete versus abstract nouns would produce a concreteness effect on the implicit general knowledge test, was not supported in Experiment 3. In Experiment 4, we equated the number of possible competing responses for concrete nouns compared to abstract nouns. However, this control also did not give rise to a concreteness effect.

In order to help ensure that we had sufficient power for observing the concreteness effect, we analyzed the data for all 168 participants who took part in the implicit general knowledge test

across Experiments 2, 3, and 4 in one within-subject *t* test. Even in this meta-analysis, we failed to detect a significant difference between concrete ($M = .05$) and abstract items ($M = .06$) [$t(167) < 1$]. In addition, of the 168 participants, only 72 (or 43%) demonstrated better performance for concrete over abstract nouns, 77 (or 46%) showed a reversal, and 19 (or 11%) participants showed equal performance for the two types of items. According to a Wilcoxon matched pairs sign test, the difference in performance for concrete and abstract nouns was not significant ($p = .66$). Furthermore, similar to the analysis we performed in Experiments 2, 3, and 4, we divided the data from all 168 participants in the implicit general knowledge test in half and analyzed the priming scores of those participants who showed high priming. We still failed to find a significant difference between concrete ($M = .14$) and abstract items ($M = .15$), $t(83) < 1$.

To ensure that power was not an issue, we also used Cohen's (1988) power estimates. If we assume a medium size effect of concreteness, then in a one-tailed *t* test conducted with a within-subject design where the *n* is 56, according to Cohen (1988; also see Aron & Aron 1999, p. 278), we had 96% power in each of our analyses of the concreteness effect in the implicit general knowledge test. If we assume a small effect size for the concreteness effect on the implicit measure, then according to Cohen (1988; and Aron & Aron, 1999) the number of subjects needed for a one-tailed within-subject *t* test with 80% power would be 172 participants. Our collapsed data had an *n* extremely close to that ($n = 168$) but there was no sign of a concreteness effect ($M = .05$ for concrete items, $M = .06$ for abstract items) in these data. Therefore, based on our collapsed data, and on Cohen's power estimates, we conclude that our null effects are not a result of insufficient power.

Our failure to obtain a concreteness effect in a conceptual implicit memory task is similar to the reports of a failure to obtain a picture superiority effect in conceptual implicit memory tasks (McDermott & Roediger, 1996; Weldon & Coyote, 1996). However, our findings stand

in sharp contrast to the report of a positive imagery effect in an implicit general knowledge test reported by Blaxton (1989) and observed in Experiment 1 in the present series. Combined together, these findings are problematic for two influential theories of memory, the transfer appropriate processing framework (Roediger, et al., 1989) and the dual-code hypothesis (Paivio, 1971, 1991).

Before we consider the theoretical implications and possible theoretical resolutions of these findings, it is important to reiterate the significance of the specific conceptual implicit memory tasks used across these studies. In recent reports, researchers have speculated on the possibility that different conceptual implicit tasks may vary subtly in their processing requirements (Cabeza, 1994; Vaidya, Gabrieli, Keane, Monti, Gutierrez-Rivas, & Zarella, 1997; Weldon & Coyote, 1996). For example, Cabeza (1994) demonstrated a dissociation between two implicit conceptual tasks, category association and free association (similar to the word association task previously discussed), with two conceptual encoding conditions, generating category labels and generating word associations. Cabeza found that when participants encoded items by generating category labels, priming was better on the category association task compared to the word association task. The opposite pattern of priming was observed for the word association encoding condition. Cabeza's findings suggest that differences may exist both between the two types of conceptual processing at encoding and between the conceptual processing used on the two implicit conceptual tests. Note that his findings also support the transfer appropriate processing framework in that the more similar the processing overlap was between study and test, the better performance was at test.

Vaidya et al. (1997) have also demonstrated that a conceptual manipulation at study (levels of processing) can differentially affect various implicit conceptual tests. Specifically, a typical levels of processing effect was found on their implicit conceptual task of category association and word association with weak associates. However, no levels of processing effect was

observed on their implicit conceptual tasks of word association with strong associates, category verification, and abstract/concrete classification (i.e., memory measured by performance latencies for classifying words as concrete or abstract).

Therefore, both studies illustrate that implicit conceptual tasks may vary in their processing requirements. Although this is an important and necessary consideration, this reasoning is not sufficient to account for the discrepancies in the data we have discussed here. In Weldon and Coyote's (1996) and McDermott and Roediger's (1996) studies, no picture superiority effect was obtained on the implicit tasks of word association or category production. In our study, we failed to find a concreteness effect on a different conceptual implicit test, that of general knowledge. We took care to select this task because Blaxton (1989) originally reported a positive effect of a related variable, i.e., the imagery effect, on the implicit general knowledge test and we have since replicated this finding with this task.

In this context, another important point needs to be made regarding the implicit general knowledge task. Vaidya et al. (1997) have argued that the implicit general knowledge test is not a good measure of implicit memory because this task may be contaminated by explicit memory strategies. Our data do not support this claim. We conducted both an explicit and an implicit version of the general knowledge task, and together, the findings support Blaxton's (1989) original claim that the general knowledge test can tap implicit memory. We found a significant levels of processing effect on both the implicit and explicit versions of the general knowledge tests. Yet, the implicit version dissociated from the explicit version such that only the explicit version of the task produced a concreteness effect. Taken together, our findings provide strong support for the proposal that the general knowledge test is a useful measure of conceptual implicit memory.

In sum, our failure to find the concreteness effect cannot be attributed to the selection of the particular task. Instead, a broader and deeper theoretical analysis is necessary to account for

our results in conjunction with the results of the other studies cited here. The discrepancy between finding a positive imagery effect on implicit conceptual tasks and not finding either the picture superiority effect or the concreteness effect raises questions about the underlying basis of these three effects. Specifically, two aspects of this issue deserve consideration. One, we need to consider whether the assumption that these three effects are based on conceptual processing is a valid one. Two, if the conceptual basis of these effects does seem to be a reasonable assumption, then we need to consider whether the underlying conceptual processing varies quantitatively or qualitatively across these three effects.

The assumption that the picture superiority effect, the imagery effect, and the concreteness effect arise from conceptual processing was based on the following logic. In the dual-code hypothesis, it is assumed that all three effects arise from the activation of verbal as well as imaginal codes. This dual activation results from cross-system or referential processing which in turn is assumed to be conceptual in nature. However, an alternate mechanism may also explain these three effects in explicit memory. These three effects may indeed arise from cross-system processing but not because of the conceptual nature of such referential processing but because cross-system processing activates the imaginal code. Because the imaginal code is assumed to be a "mnemonically superior" code in the dual-code hypothesis (Paivio & Csapo, 1973), it is the superiority of this code per se (subsequent to the cross-system processing) that gives rise to the picture superiority effect, the imagery effect, and the concreteness effect in memory. A quick clarification is needed here with respect to the nature of the "mnemonic superiority" of the imaginal code. Although Paivio considered the image code to be a mnemonically superior code, it is not clear from Paivio's description whether mnemonic superiority arises from conceptual or perceptual properties of the stimulus. The reasoning presented here assumes that mnemonic superiority refers to perceptually distinctive information. Thus, the three said effects may arise not from the

conceptual processing afforded by the referential processing but rather from the visual distinctiveness afforded by the activation of the imaginal code secondary to the referential processing.

Others have also considered some variations of this possibility. For example, Weldon and Coyote (1996) have argued that the picture superiority effect in explicit memory arises from the visual distinctiveness of pictures relative to words. This interpretation is similar to the account of the picture superiority effect in Nelson's sensory-semantic model (Nelson, 1979; Nelson, Reed, & McEvoy, 1977). According to Nelson's model, the perceptual representation of pictures involves more unique and complex visual features compared to words that are based on only 26 letters of the alphabet. This difference, according to Nelson's model, gives rise to the picture superiority effect. Weldon and Coyote (1996) have suggested that a picture superiority effect emerges on explicit memory tests because intentional efforts to distinguish between studied and nonstudied information benefit from the distinctive aspects of studied information. However, the implicit tasks make no reference to the past and are completed with the first response that comes to mind and, therefore, distinctive information does not have a particular advantage relative to other information on implicit tests of memory (see also Mulligan, 1996). Weldon and Coyote's (1996) failure to find a picture superiority effect on implicit conceptual memory tasks confirm this prediction. Thus, there is considerable support for the possibility that at least the picture superiority effect is not conceptually based.

A distinctiveness hypothesis has also been considered to explain the concreteness effect (Marschark & Hunt, 1989). Specifically, according to this claim the imagery associated with concrete items causes them to be more distinct and it is this distinctiveness that drives the concreteness effect. This assumption predicts better memory for concrete items over abstract items in explicit tasks. Although no predictions were made in this context for performance on implicit conceptual memory tests, straightforward predictions can now be derived

based on Mulligan's (1996) and Weldon and Coyote's (1996) ideas that perceptually distinctive information enhances explicit memory but not implicit memory. Specifically, if the concreteness effect arises from more distinctive encoding of concrete items (as suggested by Marschark & Hunt, 1989) and implicit conceptual tests are not sensitive to distinctive encoding, then a concreteness effect should be obtained on the explicit general knowledge test but not on the implicit version of this test. Our data confirm this prediction. We found a typical concreteness effect on our explicit general knowledge test and we failed to find this effect on the implicit version of this task. This "distinctiveness" explanation is not in opposition to Paivio's dual-code hypothesis because, as noted earlier, the dual-code hypothesis assumes that the pictorial or imaginal code is a more superior mnemonic code and could, on its own, produce better memory. To the extent that cross-system processing activates the pictorial or imaginal code, both the picture superiority effect and the concreteness effect in explicit memory could be the result of distinctiveness or the superiority of the pictorial code. For this very reason, these two effects may fail to occur on the implicit versions of these tasks.

Note, however, that this explanation is not sufficient to account for the imagery effect we obtained on the implicit general knowledge task in Experiment 1 and others have reported in prior research (Blaxton, 1989; Nyberg & Nilsson, 1995; Wippich & Mecklenbrauker, 1995). Specifically, if Marschark and Hunt (1989) claim that imagery makes concrete items more distinct, then it is reasonable to assume that imaged items should also be more distinctive than read words. Furthermore, if conceptual implicit memory tests are not sensitive to this type of distinctiveness, then we should not find an imagery effect on these tasks.

Thus, the imagery effect in conceptual implicit tasks cannot be easily explained by the visual or perceptual distinctiveness interpretation without some additional considerations. Despite this complication with the interpretation of the imagery effect, it is not necessary to entirely abandon the possible interpretation that

all three effects (i.e., picture superiority, concreteness, and imagery) are the result of visual or perceptual distinctiveness. Instead, we propose that these three effects can be explained by combining the effects of visual distinctiveness of the imaginal code with the operation of conceptual processes entailed by referential processing in the processing of concrete words and imaged items.

Our proposal is derived from Paivio's dual-code hypothesis in which both referential processing as well as mnemonic superiority of the imaginal code are considered to be the bases for the three effects under consideration. However, we argue that the data from the conceptual implicit memory tasks systematically specify the conditions under which referential processes versus the superiority of the imaginal code may differentially aid memory performance and the mechanism by which each of the three effects emerge. Specifically, we agree with Weldon and Coyote's (1996) analysis that the picture superiority effect results from the activation of the more visually distinctive (or "mnemonically superior") imaginal code. This proposal also gains support from the fact that in the picture/word manipulation, participants are presented with pictures that can directly contact the imaginal code (see also Nelson, 1979) without requiring extensive referential processing. In the case of processing of imaged items and concrete items, we argue that the conceptual or referential processing plays a larger role. One possibility as to why imaging enhances conceptual priming but concrete words do not may be that referential processing is greater in magnitude during imaging than during the encoding of concrete words. This possibility is supported by Paivio's (1991) suggestion that concrete words may contact imagens to a lesser extent than either pictures or the imagery instructions. For example, in explicit memory tasks, memory for concrete words is found to be greater than that for abstract words (Paivio & Csapo, 1969, see also Paivio, 1983 for a review). In turn, explicit memory for imaged words is found to be greater than for concrete words (see Paivio, 1983 for a review). Finally, explicit memory for imaged words is equivalent to that for named pictures

(Paivio & Csapo, 1973). Thus, even though the concreteness effect is mediated by imagery in the dual-code hypothesis and, therefore, must entail referential processing (which is conceptual in nature), it is reasonable to propose that the referential processing involved in encoding concrete words is less than that involved in imagery. In sum, the extent of conceptual processing involved for different items may vary along a continuum such that abstract words, concrete words, and imagery span the continuum from lesser to greater degree of conceptual processing.

On this reasoning, although conceptual priming is likely to be greater for imaged words than concrete words (as in Blaxton, 1989 and Experiment 1 in the current article), enhanced conceptual priming should occur for concrete words relative to abstract words as well. That this "weaker" conceptual processing during encoding was not picked up on a conceptual implicit task suggests that the dual-code hypothesis should be modified to explicitly include the notion of a referential processing continuum with respect to explicit as well as implicit memory tasks.

A similar idea of a processing continuum has already been adopted within the transfer appropriate processing framework. Roediger and colleagues (McDermott & Roediger, 1996; Roediger & Blaxton, 1987; Roediger & McDermott, 1993; Roediger et al., 1989; Weldon, 1991; Weldon & Roediger, 1987) have emphasized that conceptual and perceptual properties of tasks are not dichotomies but should be viewed as endpoints on a continuum. Therefore, these researchers suggest that there may be degrees or gradations of "conceptual" or "perceptual" processing. In fact two separate continua may be necessary, i.e., a perceptual and a conceptual continuum (Weldon, 1991) to account for memory performance, where each continuum may have its own endpoints of "least" and "most." This idea has been previously used to explain some of the inconsistent findings in perceptual tests and has become an accepted modification of the transfer appropriate processing framework (McDermott & Roediger, 1996; Roediger & Blaxton, 1987; Roediger & McDermott,

1993; Roediger et al., 1989; Weldon, 1991; Weldon & Roediger, 1987). However, as McDermott and Roediger (1996) have pointed out, the same notion has not been widely utilized for conceptual implicit memory tests and processes. Our findings in conjunction with those on the picture/word manipulation and imagery manipulation support the notion of such a conceptual processing continuum.

The theoretical analysis presented thus far focuses on possible quantitative differences in the conceptual processes because an explanation based on differences in the amount of conceptual processing fit the data on effects of imagery and concreteness quite nicely. However, it is important to bear in mind that conceptual processes can also differ qualitatively. Within our own study we found that both the implicit general knowledge test and the explicit fragment cued recall test were sensitive to one type of conceptual processing (the levels of processing manipulation) but not another (the concrete/abstract manipulation). Although the research presented in this article does not definitively demonstrate whether the conceptual analyses engendered by these two manipulations differ qualitatively or quantitatively, this pattern of results does point to the potential differences in the sensitivity of tasks to qualitative differences in meaning. Other recent research earlier described in our article has also demonstrated that possible qualitative differences in conceptual encoding produce differential effects on conceptual memory tasks (Cabeza, 1994; Vaidya et al., 1997). Thus, our findings and those of others suggest that conceptual processing requirements may vary qualitatively not only across tasks (as in Cabeza, 1994; Vaidya et al., 1997), but also across different encoding manipulations. Together, these patterns of data point to the varieties of meaning that guide cognitive, and in particular, mnemonic operations. A fuller exploration of these ideas may prove to be a fruitful topic for future research.

CONCLUSION

We conclude by noting that, until recently, our understanding of the relationship between

pictures, imagery, and concrete words was largely based on findings from a variety of explicit memory tasks. However, the findings from conceptual priming tasks in our study as well as in some previous studies (Blaxton, 1989; Roediger & McDermott, 1996; Weldon & Coyote, 1996) necessitate important modifications in our conceptualization of how pictures, images, and concrete words are related. Consistent with the proposals of the dual-code hypothesis (Paivio, 1991) these findings support the view that imaging requires stronger conceptual processing than processing of concrete words. With respect to the processing of pictures, we agree with the views of Weldon and Coyote (1996, also see Nelson, 1979) that the picture superiority effect arises largely from the visual distinctive properties of the pictures rather than from enhanced conceptual processing. With respect to the processing of concrete words, findings from the present series of experiments clearly indicate that conceptual processing of concrete words is weaker than that found in imaging the words. As we noted earlier, these specifications are not entirely inconsistent with the current versions of the dual-code hypothesis. However, unlike the dual-code view, we have explicitly emphasized the role of distinctiveness in picture processing and the notion of a continuum of conceptual processing to explain the effect of imagery and concrete words on memory.

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(Received August 18, 1999)

(Revision received June 27, 2000)