An Exploration of Implicit and Explicit Memory for Textured Shapes in the Haptic Modality

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Abstract

The notion of a dual memory system involving implicit and explicit processing has been sufficiently examined for visual and auditory tasks, although it still lacks founding in the haptic modality. Typically, implicit priming is found only for tasks that require structural encodings of a stimulus and explicit memory is found only for elaborative tasks, thus demonstrating a dissociation between the two systems. The present study explored the effects of these tasks for the processing of differently textured shapes on haptic memory. Explicit memory was clearly demonstrated; however results show no evidence of an implicit memory system for touch. Several explanations for these findings are discussed, including the possible existence of a separate memory system for the haptic modality or the necessity of a pre-existing representational system.

Recent research has indicated the presence of two separate systems within human memory. *Explicit* memory appears to contain semantic or episodic representations of stimuli that can be consciously recalled through direct tests of recall or recognition. *Implicit* memory is tested by indirect measures eliciting unintentional retrieval such as object identification tests. Elaborative information helps to encode explicit memories, but implicit memory seems to be more reliant on structural mental representations of objects such as shape and form used in identification processes for efficient encoding (Srinivas, Greene, & Easton, 1997). Implicit priming is demonstrated when previous exposure to stimuli helps one to identify the same stimuli in later test conditions (Srinivas, 1993).

A large body of research exists documenting the various dissociations of implicit and explicit memory. Initial evidence of the two systems came from studies of patients with neurological disorders such as amnesia. Amnesiacs often show impaired performance on explicit memory tasks while exhibiting normal performance on measures of implicit memory (e.g., Schacter, Church, & Treadwell, 1994). In several experiments, contingency analysis indicates that correct recall of a stimulus, an explicit memory measure, is not predictive of priming of the same item on an implicit test (e.g. Schacter, Cooper, & Delaney, 1990). This stochastic independence is evidence for separate systems. Differences between the two memory systems have been documented in verbal and non-verbal memory (Hamann, 1996; Srinivas, 1993), with common and uncommon objects (Schacter, et al. 1990; Wippich 1991), and in visually, auditorily, and haptically presented material (Musen & Treisman, 1990; Schacter et al., 1994; Wippich, Mecklenbrauker, & Norbert-Wurm, 1994). With each dissociation, evidence for the probability of the dual memory systems grows.

The majority of our knowledge of implicit and explicit memory has come from the dissociative effects of different study tasks preceding implicit and explicit tests. It has often been shown that perceptual study tasks such as word reading (e.g., Blaxton, 1989; Easton, Srinivas, & Greene, 1997), object rating (e.g., Srinivas, 1993), or physical description creation (e.g., Hamann, 1996; Srinivas et al., 1997; Wippich, 1991, Wippich et al., 1994) that allow for a structural encoding of the stimulus best facilitate implicit memory. Study tasks that involve elaborative encoding such as associative elaboration (e.g., Schacter et al., 1990, Srinivas et al., 1997) or object labeling (e.g., Wippich, 1991) tend to improve participants' performance on such explicit tests as recognition or recall.

There is still considerable disagreement as to the theoretical reasons for this dissociation. Some researchers insist that dissociated facilitation is due more to a similarity in study and test conditions than to two separate memory systems (Blaxton, 1993; Reisberg, 1997). This notion that memory performance is most successful when study and test reinstate the same processing mechanisms is commonly called *transfer-appropriate processing* (Morris, Bransford, & Franks, 1977; Schachter et al., 1990). A further example of a theory designed to explain implicit priming is offered by Reisberg (1997) who hypothesizes that priming effects are caused by an improvement in processing fluency that eases repeated perceptions of the same stimulus, rather than being caused by a specific memory type storing structural knowledge for later use.

Schachter, Cooper, and Delaney (1990), however, describe the change in performance on implicit tests as being aided by a *perceptual representation system* that encodes a mental representation of global components of the stimulus. It has been demonstrated that this structural representational system, responsible for implicit memory, depends primarily on physical cues and relations (Schacter et al., 1990). The representations have been described as pre-semantic abstract structural descriptions (Srinivas, 1991). In this view, the global structural impression of a stimulus is encoded independently of its local and meaningful features. One example of this is provided by Roediger and Blaxton (1987) who noted that variance in surface form of words (such as the font) affects performance on implicit tests but not on explicit tests. The dissociation of structural and meaningful features has also been demonstrated in an amnesiac patient who showed normal retention of structural knowledge for objects, but who could not access functional or associative properties of them (Riddoch & Humphreys, 1987). As predicted by transfer-appropriate processing, implicit priming is often best facilitated when study allows a global structural encoding of the stimulus, whereas explicit memory functions best when an elaborative, functional code is formed (Schachter et al., 1990). Such evidence has led researchers and theorists to believe that repetition priming shown on implicit memory tests is a potent indicator of mental structural representations that may be essential to identification of words and objects (Easton et al., 1997).

Concern has been expressed that the memory system paradigm is invalid in that measures of implicit memory are contaminated by previously existing representations used explicitly (McKone & Slee, 1997). In the many studies measuring implicit memory with verbal material already existing in the mental lexicon (e.g., Blaxton, 1989; Easton et al., 1997; Hamann, 1996, Schachter et al., 1994), it is likely that pre-existing representations of words are drawn upon. Even when non-words are used as stimuli, there exist familiar representations of letters and letter groupings that might be modified and used as explicit memory in implicit tests (McKone & Slee, 1997; Schacter et al. 1990). It is also probable that the use of pictures, common objects, or numbers in tests of implicit memory may invoke some sort of existing verbal representation (e.g., Lawrence, Cobb, & Beard, 1989; Srinivas, 1993; Wippich, 1991; Wippich et al., 1994). Musen and Treisman (1990) suggest that an effective way of eliminating this semantic activation is to measure novel stimuli with no pre-existing representations. The experiment at hand study will follow this model.

Although Easton et al. (1997) believe that the haptic system may be particularly proficient in perceiving structures, implicit memory and the structural representation system have not yet been examined for tactual stimuli. Most often, memory tasks for the haptic domain have been designed around visual perceptual skills rarely performed by touch, thus causing an inherent disadvantage for haptic performance (e.g., Easton, et al., 1997, Heller, 1989; Lawrence et al., 1978; Srinivas 1997; Wippich et al., 1991, 1994). Researchers have designed most of these measures simply by translating materials used for visual tests into stimuli for tactile tasks (e.g., size discrimination, spatial localization, verbal processing, picture identification, etc.) (Lederman, 1982; Lederman et al., 1990). Lederman (1982), therefore, recommends tasks using textural characteristics as the most valid for haptic examination (Lederman, 1982). These characteristics will be the primary discriminating traits of the stimuli manipulated in the following experiment.

Several studies have shown distinct visual and verbal contamination in measures of haptic memory. Lederman et al. (1990) discovered that haptic recognition of two-dimensional pictures was caused by a visual translation process and that pictures with high imaginability ratings were also those best recognized later by touch. And contrary to the theory of transfer-appropriate processing, Easton et al. (1997) found no effects of modality change in implicit or explicit memory for verbal material when test and study conditions changed from haptic to visual and vice versa. This finding strongly suggests that verbal material is encoded identically in different presentation modes. And although practical and applicable to the outside world, studies assessing memory for Braille (e.g. Hamann, 1996) are measuring verbal memory rather than haptic performance. Such research clearly indicates the danger of crossover of visualization and verbal representations into pure haptic memory measures.

The present experiment attempts to examine implicit and explicit memories by measuring them in the haptic modality with texture as the discriminative characteristic for the stimuli. A task was designed to minimize verbal or visual contamination for this purpose. As recommended by previous studies for most effective processing, a task of active touch was utilized (Lawrence et al., 1978; Wippich, 1991; Wippich et al., 1994) to facilitate natural and efficient performance. Following the Schacter et al. (1990) model of transfer-appropriate processing in implicit and explicit memory for uncommon objects, this study explored the effects of elaborative and global study tasks on an object identification task as the implicit measure and a recognition task as a measure of explicit memory.

If structures underlying the processing of haptically experienced material operate in the same manner as those for visually and auditorily presented material, then it may be assumed that information for objects is encoded similarly across modalities. However, if they do not, then, like Lederman et al. (1990), we may need to consider the sense of touch as possibly utilizing a separate system of processing and memory. If two memory systems are demonstrated, the present study may be used in conjunction with studies in other modalities for objects without pre-existing representations (e.g., Schacter et al. 1990) to further substantiate the dual memory system. If implicit memory is not demonstrated, however, we may be called to consider the McKone and Slee (1997) proposition that implicit memory is dependent on pre-existing structural representations that would not exist for a novel haptic task.

Method

Participants

A total of 54 Earlham College undergraduates (20 men and 34 women) ages 18-22, naive to the purpose of the study, voluntarily participated in this experiment. Some students received course credit for their participation; others received food. They were randomly assigned to experimental test conditions. In addition, five other participants were used as impartial judges and pilot study volunteers.

Materials

Seventy 13 cm x 10 cm stimulus cards were constructed of foam board. Objects of varying texture and consistency (e.g., fabrics, plastics, and metals) were cut in rectangular, irregular, or oblong shapes averaging 8 cm x 8 cm in size. These were then mounted on the foam board cards horizontally, vertically, or diagonally. No two textures were repeated. The stimuli were then classified by a panel of 3 judges as rectangular, oblong, or irregular in shape . Fifty-two items were chosen as the final experimental stimuli following the ratings of the judges and performance of the 3 pilot study participants. The cards were randomly assigned to one of 4 blocks of 13 stimuli each, with approximately the same number of each shape in each block. A 60 cm x 90 cm black opaque curtain was placed between experimenter and participant. Reaction time was measured in the implicit test phase with a Lafayette Instruments electric timer (model 54030).

Design and Procedure

The experimental design consisted of a 3 (encoding status: elaborative, physical, or non-studied) x 2 (memory measure: shape identification or object recognition) x 3 (shape: rectangular, oblong, or irregular) mixed factorial. Encoding status and shape were manipulated as within-subject variables and the memory measure was manipulated as a between-subject variable. Twenty-eight students participated in the explicit test and 26 in the implicit test. Two experimenters were needed to conduct the experiment; one measured reaction times and recorded responses, and the other presented the stimuli. The experimenter measuring performance was naive as to the nature of the study.

For each participant, one block of 13 stimuli was assigned as the elaborative encoding block, one as the physical encoding block, and two as non-studied blocks. The particular blocks serving as studied or non-studied items were rotated for each participant to ensure the equal assignment of each block in each condition over the course of the experiment.

All participants were tested individually. In the first phase (physical encoding), participants were instructed to close their eyes, slide their preferred hand under the curtain, and describe the orientation of the stimulus mounted on the card (horizontal, vertical, diagonal). They were given two practice objects preceding presentation of the target stimuli in random order. A 5 second exposure was allowed for the orientation identification of each of the 13 shapes in the first block. In the second phase (elaborative encoding), participants were instructed to formulate an idea of the composition of the object. They were again allowed 5 seconds for each of the 13 stimuli in that block. In each case, the physical encoding task preceded the elaborative encoding task to reduce the probability of elaborative encoding during the orientation judgments. Participants were given a 3 minute distracter task of tangram construction immediately following the two study conditions.

Participants in the explicit test condition were then presented with 52 stimulus cards in the same manner, half of them studied and half non-studied, randomly intermixed, and then administered a standard recognition test. They were instructed to identify the stimuli as either *new* (an item they had not felt earlier in the session) or *old* (an item that they had touched earlier in the session) and were given the same two practice cards with which to begin. Participants were allowed as much time as needed for this task, but the duration of the presentation of each stimulus was approximately 5 seconds. For each participant, the percentage of correct responses for each shape was tabulated separately for each encoding condition.

For the implicit test condition, participants were given definitions of *rectangular*, *oblong,* and *irregular* in the context of the experiment. They were presented with the stimuli in the same manner as in the explicit test and asked to identify the shape of the randomly intermixed 26 studied and 26 non-studied items as quickly as possible. Correct and incorrect responses, as well as reaction time, were tabulated separately for each shape and encoding condition.

Results

The table below shows the accuracy rates and RT for each encoding condition. A repeated measures analysis of variance found no evidence either in reaction times (RT), $F(2,24) = .23, p = .79$ or in performance accuracy, $F(2,24) = .03, p = .97$ for implicit memory. Since no facilitation (improvements in accuracy or speed) occurred from study conditions in comparison with non-study conditions, it may be assumed that no implicit priming occurred.

However, significant evidence for explicit memory was obtained. Recognition accuracy for the elaborative encoding condition was a 83% correct recognition rate, compared to a little better than chance recognition rate for physically encoded objects (58% chance correct). Recognition accuracy was calculated as the percent of correctly identified "old" stimuli for studied items. An repeated measures analysis of variance confirmed that there was a statistically significant interaction between the encoding conditions and recognition test performance, F (2, 27) = 159.89, $p < .0001$.

A significant interaction was found between shape and encoding status only on the object recognition tests, F (2, 27) = 5.81, $p < .0005$. Participants demonstrated higher false alarm rates for rectangular shapes (41% false) than for the others (irregular = 26% false, oblong = 23% false). That is, they were more likely to identify a non-studied rectangular shapes as "old" than either of the other shapes. No significant influence of hand dominance or sex was found for either the implicit or explicit measures. These results suggest that, regardless of object shape, implicit priming does not occur on a haptic identification test, while explicit memory is clearly established by elaborative encoding.

Mean Performance on Explicit (Object Recognition) and Implicit (Object Identification) memory tests as a Function of Study Condition

Test	Study Status: Elaborative	Physical	Non-studied
Object Recognition	.828	.575	.302
Object ID:			
Accuracy	.712	.719	.722
RT (in seconds)	4.88	4.94	5.05

Note. Elaborative and physical recognition scores are the proportions of studied items called as "old" (hit rate). The non-studied recognition score is the proportion of non-studied items called "old" (false alarm rate).

Discussion

There are many points of interest in these findings. Unlike most examinations of this kind, no evidence of a second memory system was obtained. As found by many researchers, explicit memory was significantly boosted above chance levels by elaborative encoding, yet neither structural nor elaborative encoding tasks produced priming or implicit memory.

Most important of this study's implications are those concerning pre-existing structural representations. As explained by McKone and Slee (1997), a significant amount of evidence suggests that implicit memories may be reliant upon pre-existing representations. If this is true, then the demonstrations of implicit memory are not really a unique system at all, but rather the explicit utilization of previously stored material. Under this supposition, items for which no representations exist will not show effects of priming. Since there was little chance of a previously existing record of the task performed by participants in this experiment, it follows that no priming for the encoding of new structural representations occurred.

The idea of visual crossover contaminating other experiments in haptic memory is also substantiated here. These textured shapes did not have easily accessible visual representations. Therefore, visual encoding was unlikely. A case study reported by Grailet, Seron, Bruyer, and Coyette et al. (1990) provides neuropsychological evidence indicating that without visual recognition abilities, tactual recognition is impaired for structural processing. Following vascular damage to both cerebral hemispheres, their patient lost the ability to access structural knowledge from the tactile modality as well as visual modality, although he demonstrated command of objects' semantic properties. It has been suggested that the haptic and visual systems may be more closely linked than any (see Easton et al., 1990). We may need to ask if the structural representations assumed to guide implicit memory are more closely tied to visual abilities than a memory system.

These results not only provide no evidence for haptic implicit memory; they also contradict the widely accepted idea of transfer-appropriate processing. It is puzzling that a task of structural orientation identification provided no facilitation of the later identification of the same stimuli's shape. If this study had followed the patterns of implicit memory for novel shapes in the visual domain (Schacter et al., 1990), we would expect a study task that required structural processing to somehow aid the identification of those structures in the test phase. Even Reisberg's (1997) theory of processing fluency fails to apply to these results. Under his assumptions, any exposure to a stimuli under the appropriate conditions will aid the mind in a repeated perception of that stimulus. It is unclear as to why no priming of any kind occurred in the identification test.

My only hypothesis for this lack of consistency lies in the participants' reported stress levels upon completion of the tasks. Several of the participants later reported a tense uncertainty in the tasks they were performing; they were very nervous about being judged for their responses (although they performed relatively well). If stress caused the participants to perform inconsistently or more poorly, this may be a factor that skewed the data.

The results of this study should be cautiously applied to the dual memory system theory. The small amount of existing research in the haptic modality does not substantiate the assumption that haptic memory operates in the same way as the other systems. In fact, in one case of amnesia, the patient demonstrated normal short-term memory performance, while he appeared to demonstrate tactile amnesia (Scarpa & Sorgato, 1990). Such evidence indicates the possibility of a separate memory system for the haptic modality.

Much more should be done to bring these questions to light. Although Easton et al. (1997) encourage the exploration of haptic structural perception and memory, Lederman (1982) discourages the use of touch for determining structural characteristics such as form, orientation, and localization. If implicit memory is based on a system of structural perceptual representation, and touch is not suited for structural judgments, then the haptic modality is not suited for exploring implicit memory. Measures lacking in structural components, such as tasks involving two-point sensation discrimination, temperature, or moisture might be more reasonable for measuring memory in this domain. However, if the nature of implicit memory is indeed structural, such experimentation might not be fruitful. A future challenge might be to explore other areas of the tactual domain to clarify the present results and queries.

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