The Effect of Semantic Representations on Episodic Memory for Unrelated Sensory Information

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Abstract

The present research investigated the integration of meaning and sensory information within episodic memory. Early research (e.g. Morris, Bransford & Franks, 1977; Stein, 1978, as well as Tulving & Thomson, 1973; Fisher & Craik, 1977) investigated episodic memory based on 'transfer appropriate processing' or 'encoding specificity' explanations of memory treated memory for meaning and sensory information as separable processes. In contrast, recent research (e.g. Hayman, Servais & Macdonald, 1995; Cofell, 1994) has found evidence of an interactive representation of meaning and sensory information within episodic memory using words as the target stimuli. The present experiments extend these findings to pictorial material using congruent and incongruent manipulations of both the meaning and the colour of pictures at study. Experiment 1 replicated the findings of Hayman et al. (1995) in which episodic memory is better when both meaning and sensory information are processed simultaneously at study. Experiment 2 replicated the results of Experiment 1, as well as investigated the relationship between 'remember' and 'know' recognitions (Gardiner, 1988;

Tulving, 1985) and episodic memory for sensory features. The results supported an interdependent representation of meaning and sensory information within episodic memory when responses were conditional upon a 'remember' recognition response, although the independence of 'remember' and 'know' responses was not clear.

The Effect of Semantic Representations on Episodic Memory for Unrelated Sensory Information

An unresolved problem in memory research is how meaning and sensory information are represented within episodic memory. Some studies (e.g., Morris, Bransford & Franks, 1977; Stein, 1978; Marks, 1991) treat the representation of meaning and sensory information in episodic memory as if they are independent processes. Other research (e.g., Hayman and Rickards, 1995; Hayman, Servais & Macdonald, 1995; Cofell, 1994), treats the representation of meaning and sensory information as related processes. These studies, however, used only words as the to-be-remembered stimuli. The following research attempted to generalize the finding that meaning and sensory information are processed interactively within episodic memory from words to pictures.

Historical Overview of Memory Research

Episodic and semantic memory are two systems of propositional memory which function to acquire, retain, and retrieve information that is external to an individual (Tulving, 1984; 1993). Tulving (1972) refers to episodic memory as a process whereby a previously experienced autobiographical event is consciously reconstructed with a deliberate effort to maintain temporal and spatial relations. The unit of information in episodic memory is said to be an event or an episode. When discussing episodic memory, it is said that we are examining our representations of an event that have occurred at a certain time and in a certain place, and thus, episodic memory must contain specific spatial-temporal characteristics in order to be identified as a unique episode.

Semantic memory refers to memory such as that necessary for the use of language (Tulving, 1984). There is no single unit of experience within semantic memory, rather basic facts, ideas, rules and concepts, that can be used as a basis of an individual's knowledge of the world, form the basic unit. These units do not code for spatial location or temporal organization.

There is debate surrounding the relationship between episodic and semantic memory. For example, Tulving (1983) suggested that episodic memory is a subsystem of semantic memory, that is, it arises from, and is embedded in, semantic memory. Other researchers have claimed that semantic memory derives from episodic memory (Seamon, 1984; Wolters, 1984), or that semantic and episodic memory represent opposite ends of a continuum (Craik, 1979; Lachman & Naus, 1984), while others assert that semantic and episodic memory represent differing aspects of the same memory system (Baddeley, 1984; Kihlstrom, 1984). In addition, Wood, Taylor, Penny & Stump (1980) measured cerebral blood flow during episodic and semantic tasks and found support for the separate coexistence of each memory system, while other studies (e.g., Williams & Smith, 1954), have provided clinical descriptions of amnesic syndromes based primarily in semantic, or episodic memory.

The following discussion assumes that episodic and semantic memory represent different specializations of memory, which are, in part, neurologically separable, but, in terms of everyday functioning, interdependent (Hayman, Macdonald & Tulving, 1993). From this perspective, explicit retrieval of information about an event in episodic memory requires an initial interactively encoded representation of the incident based upon categories supplied by semantic memory. This leads to two important inferences about episodic memory. For individuals to access information from episodic memory, they must first represent the event in similar terms at both study and test (Tulving & Thompson, 1973). Second, to remember a specific detail of an event in episodic memory, an individual must recollect the episode in terms of its interrelated parts. That is, an individual must remember the episode as a patterned whole, in order to extract specific details which occurred during the episode. The latter inference has the implication that any form of information, meaning or sensory, in an event, can potentially increase the memorability of other episodically linked information (e.g., meaning or sensory) (Hayman & Rickards, 1995).

Craik and Lockhart (1972), proposed the 'levels of processing' theory, to account for variability in memory. According to this theory, stimuli that are only elaborated in terms of sensory or physical levels of description display weak memory traces. In contrast, memory traces resulting from focused attention to meaning characteristics yield a stronger memory trace. By definition, meaning relations are deeply processed and therefore are expected to have a strong, durable memory trace, whereas, sensory information, such as the physical characteristics of words or pictures, are shallowly processed and are expected to have a weak memory trace.

The 'levels of processing' theory stimulated extensive research into the nature of retention. Craik and Tulving (1975) performed several experiments to determine the nature of the 'levels of processing' theory. They manipulated intention to learn, the difficulty of the task, the amount of time making judgements, as well as the amount of rehearsal the items received and found that these manipulations were unable to explain the recall or recognition of information. They concluded that it was strictly the qualitative nature of the task (the kind of operations performed on the items) that determines retention. An experiment by Hyde and Jenkins (1969) was used to demonstrate how different tasks or different levels of processing influenced a subjects' retention of the target stimuli (in this case, words). During study, the subjects were either asked to note whether there were any _e_'s in the words (low level of processing), or to rate the pleasantness of the words (deeper level of processing). The subjects were not told beforehand that there would be a test of memory. Those asked to rate the pleasantness of words recalled almost twice as many words as those asked simply to note the presence of a specific letter.

The manipulation of meaning has been found to have a large, and reliable effect on yes/no recognition tests (e.g., Craik & Lockhart, 1972; Lockhart & Craik, 1979). In a study by Craik and Tulving (1975), it was found that words were recognized at a much higher rate when the words were encoded meaningfully. For example, the experimenters presented a word, followed by a sentence containing a blank, and a statement asking subjects to respond 'yes' or 'no' to the question "would the word fit into the blank in this sentence". It was discovered that words that were encoded by meaning were recognized significantly better than words that were presented with no statement of meaning. According to the 'levels of processing' theory, the type of operations performed on each item (e.g., visualising a word within a sentence), determines the probability of recollection during a subsequent test of memory.

An alternative account of memory, to the 'levels of processing' theory, was the 'transfer appropriate processing' theory (Morris, Bransford & Franks, 1977) which was an extension of the 'encoding specificity' principle (Tulving & Thomson, 1973). According to this theory, information that is encoded in a certain fashion will be better recognized or recalled if tested in a similar fashion. In studies designed to support 'transfer appropriate processing' accounts of memory, the researchers required subjects to encode information either structurally (such as examining physical characteristics of words) or by encoding the meaning of the words. In a subsequent test of memory, subjects were required to identify the physical (structural) characteristics of the words or identify the meaning of the words. Studies (e.g., Morris, Bransford & Franks, 1977; Stein, 1978), crossed the type of study processing with different types of test conditions and found that information studied in a certain fashion, was best recalled if tested in the same fashion. In these studies, sensory tasks were found to be superior to meaning tasks when the test condition was also sensory. That is, different tasks were found to predict memory for meaning and for sensory information, thus, by inference memory for meaning and sensory information were seen as separate processes.

A limitation of the 'transfer appropriate processing' experiments is the confounding of necessary information with sufficient information. In experiments designed to demonstrate 'transfer appropriate processing', meaning and sensory information were processed separately, in order to isolate information which was critical (necessary) for a task. However, while information may be necessary for a task it may not be sufficient. For example, processing the sensory characteristics of an item may be necessary for subsequent recall/recognition of these physical characteristics, but processing of meaning may be important to the storage and retrieval of an episodic memory of the event.

Recent Research

Following a 'transfer appropriate processing' paradigm in which different types of processing are crossed independently at study and test, recent studies (e.g., Marks, 1991) continue to study the contribution of meaning and sensory characteristics on episodic memory as separate factors. Using the crossed study-test paradigm, Marks (1991) concluded that different visual encoding tasks at study had different effects at test on the subject's memory for picture names and picture details. In these experiments, subjects either encoded pictures in terms of questions about category or in terms of questions about the distinct physical characteristics of the pictures. Recognition of the names of the pictures was better when encoded at study with categorical questions, but their recognition of the details of the pictures was better when encoded at study with sensory questions. Marks (1991) concluded that memory appeared to depend on the type of encoding at study, thus supporting a transfer appropriate processing theory of memory.

Recent research (e.g. Hayman & Rickards, 1995;

Hayman et al., 1995) has challenged the inference in 'transfer appropriate processing' and 'encoding specificity' theories that there is independent memory processing in these tasks. Hayman and Rickards (1995) point out that if memory for meaning and sensory information is processed by independent systems, then, based on simple probability theory, the probability of overall recognition [P(R)] would be equal to the sum of recognition of its parts, or the sum of the probability of meaning [P(M)] and the probability of sensory [P(S)] proportions, minus the intersect (or joint contribution) of meaning and sensory proportions [P(MS)] (Equation 1). Note that if meaning and sensory proportions are independent, then the joint contribution of meaning and sensory proportions is equal to the probability of meaning proportions [P(M)] multiplied by the probability of sensory proportions [P(S)].

$$P(R) = P(M) + P(S) - [P(M) \times P(S)] \qquad (1)$$

$$P(R) = P(M) + P(S)[1 - P(M)] \qquad (2)$$

Using simple transformations (Equation 2), the equation can be rewritten to demonstrate that if meaning and sensory information are independent, then the probability of accurate sensory recognition, conditional on accurate recognition [P(S)/P(R)], would be an inverse function of meaning. Restated, for a given probability of sensory proportions [P(S)], the conditional probability of overall recognition [P(R)] would decrease as the probability of meaning proportions [P(M)] increased. This relationship was not observed in their experiment, and in fact the opposite relationship was discovered. As the likelihood of overall recognition increased following a manipulation of meaning, so did the overall probability of sensory recognition, conditional on overall recognition. Hence, the results argued against the operation of independent memory processing of meaning and sensory information.

Hayman et al. (1995) compared a modified, as well as an unmodified, version of Stein's (1978) experiment, which had been used to demonstrate the utility of the 'transfer appropriate processing' explanation of memory. In Stein's experiment, meaning and sensory encoding were manipulated separately to examine whether there would be a superiority of memory when items were tested in the same manner as they were studied. Hayman et al. (1995) point out that to observe an interdependence of memory between meaning and surface features, meaning and surface features must be manipulated simultaneously. There were two groups in Hayman et al.'s (1995) experiment, subjects in the first group were presented with a single orienting question (either case structure or meaning relations), and subjects in the second group were presented with a dual orienting question (meaning and case structure concurrently). If 'transfer appropriate processing' (Marks, 1991; Morris et al., 1977; Stein, 1978) provided a complete description of episodic memory performance, then there should be no difference between subjects' recognition of case structure, as a function of whether they studied just the case structure of the word, or the case structure accompanied by an elaboration of meaning. However, Hayman et al. (1995) found that subjects who were required to process case questions and meaning questions had significantly better recognition of case structure than did subjects who were required to process only case questions. Thus, the results suggest an interdependence in the processing of meaning and sensory information in episodic memory for sensory information.

Remember vs. Know Judgements

A recent extension of research on episodic memory has been the introduction of 'remember' and 'know' judgements of memory (Tulving, 1985). According to

Tulving (1985), subjects may 'know' something learned in a simple event, without possessing spatial/temporal knowledge about the event, or restated, 'remember' what was learned, and where and when the learning occurred. Tulving referred to 'remember' responses as those which depended upon a subject's conscious recollection of an event, while 'know' responses depended upon only a simple recognition of the event without any recollective knowledge.

In a related manner, Hayman et al. (1993) have demonstrated a dissociation between memory based on recollective ability ('remember') and semantic knowledge ('know') components of learning in amnesic patients. They demonstrated learning in an amnesic patient who, by definition, could not 'remember'. That is, they demonstrated a capacity to learn and retrieve new pieces of semantic information in the absence of an ability to 'remember' the circumstances in which they learned this information. They suggest that the same processes whereby an amnesic can acquire new semantic information in the absence of conscious recollection, may also occur in individuals with normal, and intact, episodic memory. That is, individuals may learn new semantic facts without necessarily being able to remember how and when they learned these new facts.

Research pertaining to 'remember' and 'know' responses has also emphasized the relation between recognition memory (know/remember) and 'semantic and episodic memory' (see Tulving, 1985; 1993). As described earlier, episodic memory is a process whereby a previously experienced event is consciously reconstructed with a deliberate effort to maintain spatial and temporal relations. For a subject to 'remember' an event, they must relate the event in terms of the time and place of it's occurrence, in other words, utilize episodic memory. In contrast, semantic memory is primarily necessary for the use of general knowledge, like language, and consists of facts, rules, concepts, etc., that have no specific spatial or temporal relations. In order to 'know' something, you do not require any information pertaining to where or when you encountered the material, and therefore, 'know' responses may be equated with the processes of semantic memory.

Gardiner and his colleagues (1988; Gardiner & Java, 1990; Gardiner & Parkin, 1990) have used several designs to test the assumption that 'remember' and 'know' responses represent distinct components of memory. Gardiner (1988) researched the effect of manipulating, at study, 'levels of processing' (Experiment 1) and generation effects (Experiment 2) on subsequent 'remember' and 'know' responses. He found a significant 'levels of processing' effect for words whose recognition was based upon conscious recollection ('remember' responses), whereas encoding manipulations had no significant effect on the number of 'know' responses. Gardiner (1988) found that a generation effect, that is, superior recognition for items that are generated as opposed to items that are simply observed, for 'remember' responses, but not for 'know' responses. These experiments provide evidence for the distinction between 'remember' and 'know' recognition judgements. Although, as Rajaram (1993) points out, from a 'weak memory trace' hypothesis it may be possible that the reason 'know' recognitions are not predictive of 'levels of processing' or generation effects is because of low levels of performance. According to this explanation, the effects for 'remember' and 'know' recognitions are in the same direction, but the effect for 'know' recognitions is not statistically significant. If a higher proportion of 'know' responses were obtained, the same pattern of results may be obtained for 'know' responses, as those for 'remember' responses.

Experiments by Gardiner and Parkin (1990) tested whether 'remember' and 'know' recognitions are part of a continuum, ranging from a strong memory trace (remember responses) to a weak memory trace (know responses), or whether they represent distinct components of recognition memory. Recent evidence has supported the contention that 'remember' and 'know' responses represent distinct systems of memory. For example, Gardiner and Parkin (1990) found that divided attention at study resulted in significantly fewer 'remember' responses at test, but did not affect the number of 'know' responses assigned to the items. Gardiner and Java (1991) added support for this by manipulating time intervals for 'remember' and 'know' responses. The authors obtained a significantly greater number of 'remember' responses (as opposed to 'know' responses) directly following study of items, yet the difference decreased dramatically over twenty-four hours. Gardiner and Java found that 'remember' and 'know' responses continued to diminish at a moderate rate over the next six months, and that the forgetting rates were different for 'remember' and 'know' responses. Their results support the distinction between the memory systems in two different ways. First, it is known from previous research (see Slamecka, 1985) that the forgetting rates of weak and strong memory traces do not differ. Therefore, because the rate of forgetting for 'remember' and 'know' judgements differ, then it can be inferred that they must represent distinct components. Second, when

Gardiner and Java (1991) tested memory using several time delays they discovered that few delayed 'know' responses included early 'remember' responses. From this, they concluded that there was not a gradual cross-over of 'remember' responses to 'know' responses over time, as would be predicted from a continuum perspective, rather 'remember' and 'know' responses appeared to remain as separate and distinct responses.

Gardiner and Java (1990) reported additional evidence supporting a theory of distinct memory systems. They found an independent variable (non-words) that increased the level of 'know' responses while having little or no effect on the number of 'remember' responses. The recognition of 'non-words', in contrast to words, was much higher for 'know' responses than for 'remember' responses. Previously learned words contain existing relationships which assist the subject in categorizing the word according to spatial and temporal cues and therefore, increase the likelihood of a 'remember' response. Non-words are more difficult for the subjects to process in terms of spatial or temporal cues because they have no prior relationships for these items, and therefore, increase the likelihood of a 'know' response.

Rajaram (1993) conducted a series of experiments which provided additional support for the dissociation between 'remember' and 'know' responses. Rajaram found a positive 'levels of processing' effect for 'remember' responses, but a negative 'levels of processing' effect for 'know' responses. Also, Rajaram found that correct recognition of items that were studied in picture form was superior to that of items that were studied in word form for 'remember' responses, whereas the correct recognition of items that were studied in word form, was superior to that for words studied in picture form for 'know' responses. This finding provided an additional variable that dissociated 'remember' and 'know' responses. Rajaram's findings were consistent with Gardiner (1988, Experiment 1), as well as providing evidence against a weak memory trace hypothesis for 'know' responses since the effects for 'know' responses were in the opposite direction to that found for 'remember' responses.

Rajaram (1993, Experiments 3 & 4) also tested the distinction between 'remember' and 'know' judgements using a technique called 'masked repetition priming' to test whether 'remember' responses depend on conceptual processing, whereas 'know' responses depend on perceptual processing. In masked repetition priming, the first presentation of a word is masked so the subject is unable to identify it, but the second presentation of the word is easily identifiable. A masked repetition priming effect was found for 'know' responses, but not for 'remember' responses. Rajaram pointed out that a possible explanation for this effect is that 'know' responses are significantly affected by perceptual changes, whereas 'remember' responses, depending on conceptual processing, are less sensitive to perceptual changes.

Cofell (1994) investigated whether the type of recognition assigned to a word ('remember' vs. 'know') would predict the proportion of correct recognitions in a four-alternative, forced-choice (4AFC) test of sensory recognition. In the study, subjects were initially presented with a study condition in which words, with one letter capitalized (e.g., trAin), were preceded by incongruent or congruent statements about the meaning and the identity of the upper-case letter. Congruent statements were statements about context that are consistent with the picture as it appears to the subject. Incongruent statements were statements about context that are inconsistent with the picture as it appears to the subject. An example (for the word 'trAin') of an incongruent meaning and incongruent capital letter selection would be: 'a type of animal, has a capital R'. An example of a congruent meaning, congruent case would be 'a mode of transportation, has a capital A'. Cofell also manipulated incongruent meaning/congruent case, as well as congruent meaning/incongruent case. There were two test blocks. First, the subjects were tested with words written in lower case (containing some previously studied words, and some nonstudied words) and were asked whether they 'remember' the word from the study list, whether they 'know' the word from the study list but can't remember the situation in which the word was presented, or whether they had not encountered the word in the previous lists. Second, the subjects were given a 4AFC test, in which a given word (some previously studied and some nonstudied words) was presented with four different letters capitalized in each word string, and the subjects were asked to select the word with the same letter capitalized as in the study condition. For example, if the word 'trAin' was presented during study, then during test the subjects would see the correct form of the word along with three distracter forms of the word (e.g., Train, trAin, traiN, traIn). For words which had been previously studied, the subjects were to select the letter that had been capitalized during study, and for nonstudied words, the subjects were to guess at one of the four forms of the word. It was hypothesized that if 'remember' responses reflect an episodic representation of the event, and thus contain spatial and temporal relations, then words which were given 'remember' responses in the first test should predict correct responses during the test of sensory recognition. In contrast, if 'know' responses reflect a semantic representation of the event (and thus do not contain spatial and temporal relations), then words which were given 'know' responses in the first test should predict chance performance.

Cofell (1994) found greater correct forced-choice case recognition for words which had previously been rated as 'remembered' than words which had been rated as 'known'. In addition, during the 4AFC test 'remember' judgements were found to be dependent on the mode of study, whereas 'know' judgements were not found to be dependent on the mode of study, replicating a similar finding by Gardiner (1988).

The following describes two experiments designed to generalize the effects of meaning processing, in conjunction with processing of sensory information, on episodic memory for sensory information of verbal stimuli to episodic memory for sensory information of pictorial stimuli. Experiment 1 manipulated congruent and incongruent descriptions of both the colour and the meaning of pictures at study. It was hypothesized that the interactive representation of meaning and sensory information would facilitate episodic memory for the colour of the pictures in a test of sensory recognition. Experiment 2 was designed to provide a more stringent control over guessing, by asking subjects to categorize their recognition of the pictures into 'remember' or 'know' responses before being tested on memory of the picture colour. It was hypothesized that 'remember' judgements (but not 'know' judgements) would predict an interdependence between the study processing of meaning and sensory features, and lead to better performance than 'know' judgements on a forced-choice test of colour recognition.

Experiment 1

Experiment 1 was designed to generalize from words to pictures the interdependence between the study encoding of meaning and surface features for explicit memory of surface features reported by Hayman and Rickards (1995) and Hayman et al. (1995). The design employed a factorial manipulation of study processing of meaning and sensory features followed by two tests. A test of sensory memory and of episodic recognition of the pictures. It was predicted that there would be an interaction between the study processing of meaning and sensory features on the availability of information in the test of sensory memory as hypothesized by Hayman and Rickards (1995), and there would not be a main effect of the study manipulation of sensory encoding as suggested by 'transfer appropriate processing' experiments (e.g., Morris et al., 1997; Stein, 1978) or by 'encoding specificity experiments' (Tulving & Thomson, 1973; Fisher & Craik, 1977).

The nature of the predicted interaction was that the manipulation of attention to sensory features at study, which was appropriate for tests of sensory memory (see Morris et al., 1977; Stein, 1978; and Fisher & Craik, 1977), would be ineffective in the absence of the appropriate encoding of meaning at study. There were two specific predictions. First, that attention at study to meaning and sensory features would result in better performance in a later test of sensory memory than attention to sensory features in the absence of the processing of meaning. Second, that attention to sensory features at study in the absence of the processing of meaning would result in no better performance than attention to meaning at study in the absence of the processing of sensory features.

Because the differences between study conditions in sensory memory performance could be contaminated by guessing (when performance was affected by variability in the accessibility of memory for the episode as a whole) sensory memory for studied pictures was also assessed conditional upon correct recognition of the pictures (Hayman & Rickards, 1995; Hayman et al., 1995). That is, it was assumed that differences in accessibility of memory (cf. Tulving & Pearlstone, 1966) between study conditions would be largely removed when subjects indicated that they recognized the picture as a study picture. It was predicted that sensory memory would still show an interdependence between the study processing of meaning and sensory features even when the accessibility of the study episode was equated by examining sensory memory conditional upon accurate recognition of the picture. That is, it was predicted that factors that influenced the availability of episodic memory also influences the availability of sensory information even when memory performance has been controlled for differences in accessibility.

Method

Subjects

The subjects consisted of 24 undergraduate volunteers at Lakehead University.

Materials

One-hundred and eighty seven pictures were selected from those described by Snodgrass and Vanderwart (1980). One-hundred and twenty were used as critical target pictures, 24 as study buffers, 40 as recognition test lures and 3 as practice items. These pictures are standardized according to four variables related to processing: 1) name agreement, 2) image agreement, 3) familiarity, and 4) complexity. The use of standardized pictures will aid in eliminating differences between subjects in terms of their familiarity with the pictures. The pictures come in 16 categories, of which 10 (animals, birds, clothing, fish, furniture, grooming, insects, kitchen supplies, miscellaneous, and musical instruments) were used to construct the lists of target pictures, and 6 (tools, toys, vehicles, body parts, fruits, and vegetables) were used as study buffers, test lures and practice items. Six lists of 20 target pictures were constructed, using items from each of the 10 categories in each of the 6 sublists, for the purpose of counterbalancing the presentation of the pictures at study and test. Four sublists were study test pictures and 2 sublists were nonstudied test pictures. The sublists were rotated among the twenty-four subjects, such that each of the six sub-lists appeared in each study and test condition an equal number of times.

To implement the manipulation of sensory features, each picture was given congruent and incongruent colour descriptions. There were 5 colours (1 congruent target colour, 1 incongruent study colour, and 3 test lure colours) assigned to each picture from the experimental pool of 8 colours (red, blue, green, yellow, orange, brown, pink and purple). No picture was assigned a colour in which a prior association existed (for example, a picture of a frog would not be assigned the colour green). For example, the study colour for the picture of a horse was 'yellow', thus the congruent colour was 'yellow' and for this picture, the incongruent colour was 'green'. Chance performance in a 4AFC test for nonstudied pictures should be at or close to 25% if the target colour and the test lure colours had no prior association with the pictures. In order to implement the manipulation of colour, the pictures, which originally came as black lines on a white background (Snodgrass & Vanderwart, 1980), were colour lines on a black background.

To implement the manipulation of meaning, each picture was given a congruent and incongruent description of it's meaning. Each picture was assigned a congruent and incongruent meaning such that, to the best of our ability, no relationship existed between the assigned congruent and incongruent meaning descriptions, and other pictures presented during the study or test conditions. For example, the congruent meaning statement about the picture of a horse was 'a cowboy's transportation', whereas the incongruent meaning statement was 'a dangerous substance'.

Four study conditions were created by factorially manipulating the congruity of meaning and colour (congruent colour, congruent meaning; congruent colour, incongruent meaning; incongruent colour, congruent meaning; incongruent colour, incongruent meaning).

A Macintosh IIci computer was used for presentation of the pictures and statements, and to collect responses.

Design

A 2 X 2 within-subjects factorial design was used for studied pictures. The first study factor was the manipulation of meaning (congruent/incongruent), and the second study factor was the manipulation of colour (congruent/incongruent). There were two dependent measures: 1) recall of the colour of the pictures on the 4AFC questions; and 2) recognition of the pictures during study (yes/no).

Procedure

Subjects were tested individually. During the study condition, two orienting questions (one about meaning and the other about colour) were presented simultaneously on the computer screen for 4 seconds. The coloured picture was presented 1 second after the questions disappeared, and remained on the screen for 3 seconds. The subjects were required to choose between 4 alternatives, pertaining to the relationship between the previously presented statements and the coloured picture: 1) Colour Yes (congruent colour), Meaning Yes (congruent meaning); 2) Colour Yes (congruent colour), Meaning No (incongruent meaning); 3) Colour No (incongruent colour), Meaning Yes (congruent meaning); and 4) Colour No (incongruent colour), Meaning No (incongruent meaning). Subjects were allowed as much time as necessary to respond. The next trial began 2 seconds after the last response. Each subject was presented with 104 question/picture pairings (80 target pictures preceded by 8 primacy and followed by 16 recency buffers).

Immediately following the study condition, each subject was asked to complete a paper and pencil 'famous names' quiz for 5 minutes. Subjects were instructed to identify the occupation or source of fame for as many names as possible from a list of 50 names taken from public sources (e.g., magazines). No subject completed the task within the time allowed.

Following the famous-names quiz, the subjects were presented with a 4AFC test containing 160 pictures (80 previously studied target items, 40 nonstudied target items and 40 test lures). Each picture was drawn in 4 colours (1 target and 3 lure colours), and presented in 4 spatial locations corresponding to the edges of a square. None of the 3 recognition lure colours matched the incongruent study colour. The subjects were asked to choose, using the keyboard, the correct colour of the picture from the study condition. If they were not sure of the target colour of the picture, they were asked to guess a colour. Following the subject's 4AFC colour response, each subject was asked to indicate whether they recognize the picture from the study session, as well as whether they recognize the study colour of the picture. The subjects were required to respond by choosing one of 4 ratings: 1) they were sure that the picture and the colour were presented at study, 2) they were sure they saw the picture during study, but they guessed at the colour of the picture, 3) they guessed the picture was studied, or 4) it was a new picture.

Results

The alpha level for the within-subjects ANOVAs was set at .05. T-tests (comparing critical differences between means) used a standard error term calculated from the Multivariate Mean-Square error term. The alpha level for the t-test comparisons was set at .01, and all comparisons were two-tailed. Response times were measured in seconds. The results for the two nonstudied target item conditions were collapsed into one condition to make interpretation of the results less complicated.

4AFC Responses

The means and standard deviations for the proportion of correct colour selections during the 4AFC test for the five conditions (congruent colour, congruent meaning (cc-cm); congruent colour, incongruent meaning (cc-im); incongruent colour, congruent meaning (ic-cm); incongruent colour, incongruent meaning (ic-im); and nonstudied) are presented in Table 1. The means are consistent with the hypothesis that 4AFC responses are above chance in all study conditions, and that the congruent colour, congruent meaning condition would result in the best performance. The within-subjects ANOVA was significant, $F(4,92)=24.03$, $MS_e=.01$, indicating that the five study conditions differed in number of correct 4AFC responses. A critical difference of .08 ($t_{crit}=2.81$, df=23) was used to compare the mean differences. The proportion of correct responses for studied items was found to be significantly higher (cc-cm=.50; cc-im=.34; ic-cm=.39; ic-im=.34), than for nonstudied items (mean=.22). The same critical difference (.08) was used to compare the differences between the four study conditions. As hypothesized, the congruent colour, congruent meaning condition produced a significantly greater number of correct 4AFC responses (mean=.50) than any of the other study conditions (cc-im=.34; ic-cm=.39; ic-im=.34). No other significant differences were found.

Yes/No Recognition

To make analysis of conditional proportions similar to previous studies (Hayman & Rickards, 1995; Hayman et al., 1995; Cofell, 1994) recognition responses were collapsed into 'yes' or 'no' responses. 'Yes' recognition responses were dependent upon the subject responding either 1) they were sure that the picture and the colour were presented at study, or 2) they were sure they saw the picture during study, but they guessed at the colour of the picture. Pictures in which the subjects responded either that 3) they guessed the picture was studied, or 4) it was a new picture, were coded as 'no' responses. The means and standard deviations for the proportion of correct recognitions for each of the five test conditions are shown in Table 2. The means are consistent with the hypothesis that recognition responses are above chance in all study conditions, and that the processing of congruent meaning at study would result in the best overall recognition. The within-subjects ANOVA was significant, $F(4,92)=292.55$, $MS_e=.01$, demonstrating that the subject's recognition differed across the five study conditions. A critical difference of .08 ($t_{crit}=2.81$, df=23) was used to examine the differences between the five conditions. Subject's recognition of studied items was significantly greater (cc-cm=.92; cc-im=.72; ic-cm=.86; ic-im=.70) than that of the nonstudied condition (mean=.03). The same critical difference (.08) was used to examine the differences between the four study conditions. The congruent colour, congruent meaning condition produced significantly more recognition responses (mean=.92) than did either of the congruent colour, incongruent meaning condition (mean=.72) or the incongruent colour, incongruent meaning condition (mean=.70). In addition, the incongruent colour, congruent meaning condition (mean=.86) led to significantly more recognition responses than either the congruent colour, incongruent meaning condition (mean=.72), or the incongruent colour, incongruent meaning condition (mean=.70).

A 2 X 2 analysis of variance was performed to compare recognition in the meaning congruent conditions (cc-cc and ic-cm) against the incongruent meaning conditions (cc-im and ic-im), and in congruent colour conditions (cc-cm and cc-im) against the incongruent colour conditions (ic-cm and ic-im). There was a significant effect of meaning, $F(1,23)=55.98$, $MS_e=.01$, where the two conditions in which the meaning question was congruent with the picture led to a significantly greater recognition (mean=.89) than did the two conditions in which the meaning was incongruent with the picture (mean=.71). There was also a significant main effect of colour, $F(1,23)=4.50$, $MS_e=.01$. The two conditions in which the colour question was congruent with the picture led to greater recognition (mean=.82) than did the two conditions in which the colour was incongruent with the picture (mean=.77). There was no significant interaction between colour and meaning ($F<1$).

4AFC Responses, Given Recognition

The 4AFC test was also analyzed conditional upon the subjects providing a 'yes' recognition response. This procedure reduces the influence of colour guessing in the 4AFC results. Nine subjects were eliminated from the analysis because they did not provide any 'yes' recognition responses to nonstudied pictures. The mean proportion of correct responses (and the standard deviations) on the 4AFC test conditional on a 'yes' recognition response are shown in Table 1. The means are consistent with the hypothesis that 4AFC responses are above chance in all study conditions, and that the congruent colour, congruent meaning condition would result in the best performance. The within-subjects ANOVA was significant, $F(4,56)=18.07$, $MS_e=.03$, demonstrating that the five conditions differed in the proportion of correct 4AFC colour recognitions. Using a critical difference of .14 ($t_{crit}=2.81$, df=14) it was found that study items produced a significantly greater number of target colour selections (cc-cm=.52; cc-im=.34; ic-cm=.43; ic-im=.36) than did nonstudied items (mean=.13). Using the same critical difference (.14) it was found that the congruent colour, congruent meaning condition produced significantly greater correct recognitions (mean=.52) than did the congruent colour, incongruent meaning condition (mean=.34), or the incongruent colour, incongruent meaning condition (mean=.36). There was no significant difference between the congruent colour, congruent meaning condition and the incongruent colour, congruent meaning condition using the common error term. A paired t-test found that the congruent colour, congruent meaning condition produced significantly more target colour responses (mean=.52) than did the incongruent colour, congruent meaning condition (mean=.43), $t(23)=3.10$, $p<.01$. It is suspected that the reason no difference was found between the two conditions using the multivariate mean square error term was because of high standard deviations in the other conditions.

Reaction Times

The mean reaction times for the five test conditions are presented in Table 3. For the 4AFC test there was a significant within-subject effect between the five conditions on reaction time differences, $F(4,92)=11.47$, $MS_e=42.39$. Using a critical difference between means of .64 ($t_{crit}=2.81$, df=23) it was found that subjects took significantly longer to make a response when the item was from one of the four study item conditions (cc-cm=3.37; cc-im=3.27; ic-cm=3.68; ic-im=3.15) than when it was from the nonstudied item condition (mean=2.22). There were no significant differences between the four study conditions.

When reaction times were analyzed for 'yes/no' recognition, nine subjects were eliminated from the analysis because they did not provide a 'yes' recognition response to nonstudied items. There was a significant effect across the five conditions,

$F(4,56)=2.65$, $MS_e=10.19$. Using a critical difference of .40 ($t_{crit}=2.81$, df=14) it was found that subject's took longer to make a recognition response during the test of recognition for nonstudied items (mean=1.25) than for pictures in either of the four previously studied conditions (cc-cm=.99; cc-im=.98; ic-cm=1.02; ic-im=1.02). There were no significant differences between the four studied conditions on reaction times during the test of recognition.

Discussion

As predicted, Experiment 1 found an interaction between the processing of meaning and sensory features at study on the proportion of correct colour recognition responses given to pictures. When meaning and sensory information were congruent with the picture at study, there was a significantly greater proportion of correct colour recognition responses than when sensory information was congruent with the picture and meaning information was incongruent with the picture, or when meaning information was congruent with the picture and sensory information was incongruent with the picture. As hypothesized, it was also found that processing congruent sensory information with incongruent meaning information produced no more correct colour recognition responses than processing congruent meaning information with incongruent sensory information. The recognition of the colour of a picture (sensory feature) appears to be dependent on an interaction between the processing of meaning and sensory information at study, therefore supporting an interactive representation of meaning and sensory information within episodic memory. These results do not support 'transfer appropriate processing' (Morris et al., 1977; Stein, 1978) or 'encoding specificity' (Tulving & Thomson, 1973; Fisher & Craik, 1977) explanations of memory, which would predict that on a test of sensory memory, attention to sensory information at study would result in better performance than attention to meaning information. Therefore, meaning and sensory information must be processed interdependently within episodic memory.

As expected (Hayman et al., 1995), when the statements of meaning were congruent with the picture, the proportion of 'yes' recognition responses was significantly greater than when the statements of meaning were incongruent with the picture. Although, when the statements of colour were congruent with the picture, the proportion of 'yes' recognition responses was also significantly greater than when the statements of colour were incongruent with the picture. The discovery that the manipulation of both meaning (congruent vs. incongruent) and colour (congruent vs. incongruent) produced differences in 'yes/no' recognition may reflect the fact that this study used pictures, whereas other experiments used words (e.g., Hayman et al., 1995; Cofell, 1994). To summarize, only meaning information may be important when remembering words, whereas both meaning and sensory feature information may be important when remembering pictures.

Experiment 2

Although examining sensory memory conditional upon recognition of a studied item should largely remove differences between study conditions due to differences in the accessibility of episodic memory, the use of conditional responses is effective only to the extent that recognition responses reflect access of an episodic memory trace. The suggestion by Tulving (1985; and others, e.g., Jacoby, 1981; Mandler, 1980) that recognition responses may not be a unitary response, would imply that conditionalizing sensory memory responses on a correct recognition response may be overly lenient. Tulving suggested that recognition responses reflect two sources of memory, episodic memory and semantic memory which results in two types of recognition responses, 'remember' and 'know'. Only 'remember' recognition responses are thought to reflect access to a coherent and integrated representation of the spatial/temporal characteristics of an episode, while 'know' recognition responses are thought to reflect ability in accessing a stable, context-free, description of knowledge. Presumably, only 'remember' recognition responses should predict memory for sensory information which is unique to an episode, while 'know' recognition responses should predict memory for sensory information that is at chance. Cofell (1994) found exactly this result when 'remember' and 'know' judgements were used to predict sensory recognition (of case) in words.

If recognition responses from different study conditions reflect different mixtures of 'remember' and 'know' memory (and subjects have to guess about sensory memory when in a 'know' state of recognition), then examining sensory memory conditional upon recognition of a studied item could be ineffective in removing differences in sensory memory performance due to guessing. Examining sensory memory conditional upon a 'remember' recognition response, however, should further reduce differences in sensory memory performance due to different rates of guessing in different study conditions.

Experiment 2 was designed to provide a more stringent control over guessing because of a failure to access episodic memory by assessing sensory memory for pictures conditional upon a 'remember' recognition response. It was predicted that sensory memory would still show an interdependence between the study processing of meaning and sensory features even when the accessibility of the study episode was equated by examining sensory memory conditional upon 'remember' recognition responses of the study pictures. In addition, Experiment 2 served to replicate the general results of Experiment 1.

Because the design of Experiment 2 generally followed that described by Cofell (1994) for examining the sensory memory of words conditional upon 'remember' recognition responses, Experiment 2 also served as an attempt to generalize Cofell's results for words to pictures. Thus, it was predicted that 'remember' recognition responses, but not 'know' recognition responses should predict differences between study conditions, such that attention to meaning and sensory features at study should predict better performance on a test of sensory memory than when either meaning or sensory feature information is absent. In addition, based on Cofell (1994), it was hypothesized that sensory memory would be predicted better by 'remember' recognition responses than by 'know' recognition responses and, that sensory memory of pictures associated with 'know' recognition responses would be at chance.

Method

Subjects

The subjects consisted of 24 undergraduate volunteers from Lakehead University.

Materials

The same materials were used in Experiment 2 as in Experiment 1.

Design

A 2 X 2 within-subjects factorial design was used for studied material. Two independent variables were manipulated at study, colour (congruent vs. incongruent), and meaning (congruent vs. incongruent). There were two dependent measures: 1) type of memory response (remember, know or nonstudied), used to predict performance on the 4AFC test of colour recognition, and 2) responses on the 4AFC test of correct colour recognition.

Procedure

The study procedure and famous names quiz were identical to that used in Experiment 1, with the exception that the subjects were allowed 10 minutes for the quiz in Experiment 2 (as opposed to 5 minutes in Experiment 1) to reduce the likelihood of ceiling effects on the recognition test (Rajaram, 1993).

Upon completion of the 'famous names' quiz the subjects began the recognition test. The subjects were provided with a description of 'remember' vs. 'know' recognitions (see Appendix A, from Rajaram, 1993). Once the subjects read and indicated they understood the difference between 'remember' and 'know' judgements, the experimenter verbally repeated the distinction between 'remember' and 'know' judgements and answered any of their questions.

In the recognition test subjects were asked to rate 160 black and white pictures (80 study targets, 40 nonstudied targets and 40 test lures, presented individually) using the computer keyboard to respond. Subjects were asked to respond by providing one of 3 ratings: 1) 'remember' the word from the study list,

2) 'know' the word (or a similar one) from the study list, or 3) the word was not from the study list. The picture was presented until the subjects responded. Immediately following the recognition test, all subjects were tested on the 4AFC colour recognition test. The test consisted of 120 target pictures (80 study targets and 40 nonstudied targets). The format for the 4AFC test was identical to that used in Experiment 1, with the exception that there was no recognition rating following each 4AFC response.

Results

The alpha levels and computations of critical differences were identical to that in Experiment 1.

Four-Alternative, Forced-Choice Test

The mean proportion of correct colour recollections for the five conditions (congruent colour, congruent meaning (cc-cm); congruent colour, incongruent meaning (cc-im); incongruent colour, congruent meaning (ic-cm); incongruent colour, incongruent meaning (ic-im)) during the 4AFC test are presented in Table 4. The means are consistent with the hypothesis that 4AFC responses are above chance in all study conditions, and that the congruent colour, congruent meaning condition would result in the best performance. The within-subjects ANOVA was significant, $F(4,92)=30.13$, $MS_e=.01$, indicating that there was a difference between the five study conditions in the number of correct 4AFC responses. Using a critical difference between means of .08 ($t_{crit}=2.81$, $df=23$) it was found that the proportion of correct colour recognitions for studied items was significantly greater (cc-cm=.53; cc-im=.38; ic-cm=.40; ic-im=.35) than that of the nonstudied items (mean=.22). Using the same critical difference (.08) it was found that the congruent colour, congruent meaning condition (mean=.53) produced a significantly greater proportion of correct colour recognitions than either of the remaining three conditions (cc-im=.38; ic-cm=.40; ic-im=.35). No other significant differences were found. These results replicated the pattern found in Experiment 1.

Recognition

The mean proportion of recognition responses for the five conditions can be seen in Table 5. A recognition judgement was based upon a 'remember' <u>or</u> a 'know' judgement during the recognition test. The means are consistent with the hypothesis that recognition responses are above chance in all study conditions, and that the congruent meaning conditions would result in the greatest number of recognition responses. The within-subjects ANOVA was significant, $F(4,92)=280.42$, $MS_e=.01$, indicating that there was a difference in the number of recognition responses across the five study conditions. Using a critical difference of .08 ($t_{crit}=2.81$, $df=23$) it was found that the recognition of studied items was significantly greater (cc-cm=.91; cc-im=.78; ic-cm=.89; ic-im=70) than recognition of items in the nonstudied condition (mean=.07). Using the same critical difference (.08), it was found that the congruent colour, congruent meaning condition (mean=.91) and the incongruent colour, congruent meaning condition (mean=.89) resulted in significantly higher recognition responses than did the congruent colour, incongruent meaning condition (mean=.78) or the incongruent colour, incongruent meaning condition (mean=.70). This pattern of results was identical to that found in Experiment 1.

To look at the effects of colour and meaning on recognition, a 2 X 2 ANOVA was used. Analysis of the means indicated that, as expected, there was a significant effect of meaning, $F(1,23)=30.80$, $MS_e=.02$, where the two conditions in which the meaning question was congruent with the picture led to significantly greater recognition (mean=.90) than did the two conditions in which the meaning was incongruent with the picture (mean=.74). A significant effect of colour was also found, $F(1,23)=25.67$, $MS_e=.01$, where the two conditions in which the colour question was congruent with the picture led to significantly greater recognition (mean=.85) than did the two conditions in which the colour was incongruent with the picture (mean=.80). There was no interaction between meaning and colour ($F<1$). These results provide support for findings in Experiment 1 that there is an effect of meaning, as well as an effect of colour, on recognition.

4AFC Responses, Given Recognition

The 4AFC responses were also analyzed conditional upon the subjects providing a recognition judgement ('remember' or 'know'). This procedure reduced the influence of guessing from the analysis. The mean proportion of correct colour recollections, given a 'remember' or 'know' response, can be seen in Table 4. When the results were analyzed conditional upon a recognition judgement, seven subjects had to be dropped because they provided no 'yes' recognition responses to nonstudied items. The pattern of means was similar to that found for unconditional responses. There was a significant within-subjects effect (ANOVA) comparing the five conditions on correct colour recollection, given recognition, F(4,64)=13.49, MS_e=.02. Using a critical difference of .14 (t_{crit}=2.81, df=16) it was found that there was significantly more target colour selections for studied items (cc-cm=.54; cc-im=.36; ic-cm=.41; ic-im=.38) than for items in the nonstudied condition (mean=.16). Using the same critical difference (.14), it was found that the congruent colour, congruent meaning condition (mean=.54) produced significantly greater correct colour selections (given recognition) than any of the other study conditions (cc-im=.36; ic-cm.41; ic-im=.38). This finding supported similar findings in Experiment 1.

Remember Responses

The mean proportion of 'remember' responses for each of the five conditions can be seen in Table 5. The means are consistent with the hypothesis that 'remember' responses are above chance in all study conditions, and that the congruent colour, congruent meaning condition would result in the greatest number of 'remember' responses. The within-subjects ANOVA was significant, F(4,92)=120.00, MS_e=.02. A critical difference of .11 (t_{crit}=2.81, df=23) indicated that there were more 'remember' responses to studied items (cc-cm=.79; cc-im=.53; ic-cm=.70; ic-im=.46) than to items in the nonstudied condition (mean=.01). Using the same critical difference (.11), it was found that the congruent colour, congruent meaning condition resulted in significantly greater 'remember' responses (mean=.79) than the congruent colour, incongruent meaning condition (mean=.53), or the incongruent colour, incongruent meaning condition (mean=.46). In addition, the incongruent colour, congruent meaning condition (mean=.70) produced significantly greater 'remember' responses than either the congruent colour, incongruent meaning condition (mean=.53), or the incongruent colour, incongruent meaning condition (mean=.46).

4AFC, Conditional Upon a Remember Response

The mean proportion of correct colour responses for the five conditions on the 4AFC test can be seen in Table 6. Because of the restricted number of 'remember' responses assigned to nonstudied items, only the four study conditions were compared on correct colour responses, given a 'remember' recognition response. As predicted, the means supported the hypothesis that the congruent colour, congruent meaning condition would result in a greater proportion of correct responses. A within-subjects ANOVA revealed a significant difference between the four study conditions in correct colour recollection, given a 'remember response', $F(3,66)=7.00$, $MS_e=.02$. One subject had to be eliminated from the analysis because he/she made no 'remember' responses to items in the incongruent colour, incongruent meaning condition. Using a critical difference of .12 ($t_{crit}=2.81$, df=22), it was found that the congruent colour, congruent meaning condition (mean=.54) produced significantly greater correct colour selections than any of the other study conditions (cc-im=.35; ic-cm=.40; ic-im=.40).

Know Responses

The mean proportion of 'know' responses for each of the five conditions can be seen in Table 5. There was a significant difference between the five conditions in the proportion of 'know' responses given during the test of recognition, $F(4,92)=14.77$, $MS_e=.01$. Using a critical difference of .08 ($t_{crit}=2.81$, df=23) it was found that nonstudied items were given a 'know' response significantly less (mean=.06) than either the congruent colour, incongruent meaning condition (mean=.24), the incongruent colour, congruent meaning condition (mean=.18), or the incongruent colour, incongruent meaning condition (mean=.24). The critical difference (.081) was also used to compare the proportion of 'know' responses among the four previously studied conditions. It was found that there were significantly more 'know' responses for the congruent colour, incongruent meaning condition (mean=.24) or the incongruent colour, incongruent meaning condition (mean=.24) than for the congruent colour, congruent meaning condition (mean=.13).

4AFC, Conditional Upon a Know Response

The mean number of correct colour responses during the 4AFC test, given a 'know' response, can be seen in Table 6. Because of the restricted number of 'know' responses for nonstudied items, only the four study conditions were compared on correct colour responses, given a 'know' recognition response. The within-subjects ANOVA comparing the four study conditions on correct colour responses, given a 'know' recognition response, showed no significant differences ($F<1$).

4AFC, Conditional Upon a Nonstudied Response

The proportion of correct colour recollections for items called nonstudied during the test of recognition can be seen in Table 6. There were no significant differences between the five conditions on the proportion of correct colour selections, given a nonstudied response ($F<1$).

Remember vs. Know Responses on 4AFC

To compare to proportion of correct colour selections during the 4AFC test for pictures that were given 'remember' responses versus pictures that were given 'know' responses, a two-way ANOVA was computed comparing the mean correct 4AFC responses conditional upon a 'remember' response collapsed over the four study conditions with the mean correct 4AFC responses conditional upon a 'know' response. The data was collapsed across study conditions because of the small number of observations in some conditions. It was found that there were no significant differences in the proportion of correct colour selections between pictures given a 'remember' response (mean=.40) and pictures given a 'know' response (mean=.35).

Reaction Times

The mean reaction times (in seconds) for the recognition test, the 4AFC test, as well as for 'remember', 'know' and 'new' responses during the test of recognition can be seen in Table 7. Reaction times were recorded for the length of time it took for the subjects to make a response during the test of recognition. Thirteen subjects were eliminated from this analysis because they provided no 'yes' recognition judgements to nonstudied pictures. A within-subjects ANOVA showed that there was a significant difference between the five conditions in the length of time it took to make a recognition ('remember' or 'no') response during the recognition test, $F(4,64)=2.89$, $MS_e=.73$. Using a critical difference of .85 ($t_{crit}=2.81$, df=10), it was found that it took significantly longer to make a recognition response when the item was nonstudied (mean=2.53) than when the item was in the congruent colour, congruent meaning condition (mean=1.61).

There were also no significant differences between the five conditions in the amount of time it took for the subjects to make a 'remember' response to items during the test of recognition, or were there were significant differences between the five conditions in the amount of time it took to make a 'know' response to an item during the test of recognition.

A within subjects ANOVA was used to compare the amount of time it took the subjects to make a nonstudied response to items in each of the five conditions. Thirteen subjects had to be eliminated from this analysis because they provided no 'new' responses to pictures in one or more of the study conditions. The ANOVA was significant, $F(4,48)=4.01$, $MS_e=.33$, and a critical difference of .69 ($t_{crit}=2.81$, df=10) was used to compare the reaction times of subjects when making a nonstudied response. It was found that it took significantly longer to make a nonstudied response to items in the congruent colour, congruent meaning condition (mean=2.50), or the incongruent colour, incongruent meaning condition (mean=2.26) than to make a nonstudied response to a nonstudied item (mean=1.56). No significant differences were found between the four study conditions on the length of time to make a nonstudied response during the test of recognition.

There were no significant differences between the five conditions in the length of time it took to make a response during the 4AFC test of colour recollection.

Discussion

Experiment 2 was designed to: a) investigate the relationship between 'remember' and 'know' recognition judgements and sensory memory, and b) to replicate Experiment 1. These topics will be discussed in reverse order.

Results from the 4AFC test of colour memory generalized the pattern of previous results (Experiment 1; Hayman et al., 1995; Cofell, 1994). Support was found for the observation that the best overall memorability for the sensory characteristics of a picture occurs when sensory and meaning study processes are congruent. Both the overall 4AFC test of colour memory and the 4AFC test of colour memory, conditional upon 'yes' recognition found that memory for sensory characteristics was best when pictures were studied with congruent meaning and sensory information. This result is consistent with an interactive representation of meaning and surface feature information within episodic memory (Hayman & Rickards, 1995; Hayman et al., 1995). Processing of pictures at study with one orienting question congruent and the other incongruent (e.g., congruent colour, incongruent meaning or incongruent colour, congruent meaning) led to a numerically greater proportion of correct colour responses than when both questions were incongruent, although there were no significant difference between any of these conditions. This finding replicated that found in Experiment 1, and indicated that in order to reliably create episodic memory for surface features, both congruent processing of sensory information and congruent processing of meaning information appeared to be required.

Experiment 2 (replicating Experiment 1; Hayman et al., 1995; Cofell, 1994), found an effect for meaning on the yes/no recognition test, such that words which were studied with congruent meaning were better recognized than words which were studied with incongruent meaning. This experiment also provided support for the finding in Experiment 1 that there is an effect of surface features (congruent vs. incongruent colour) when pictures are used, as opposed to words. Pictures studied with congruent statements about the colour of the picture resulted in more 'yes' recognition responses than pictures studied with incongruent statements about the colour of the picture. Hayman et al. (1995), as well as Cofell (1994), did not find an effect of surface features in their experiments using words as the target stimuli. However, as discussed earlier, this effect of the manipulation of sensory processing at study, on picture recognition, may reflect the fact that surface feature information (e.g., colour) is more important in the processing of pictures than the processing of words. When an individual is processing pictures, both meaning and sensory relations may be important to episodic memory for the picture.

Experiment 2 also explored what Tulving (1985) labelled `remember' vs. `know' judgements, as well as generalized the findings of Cofell (1994) who looked at the effect of 'remember' versus 'know' judgements on memory for the surface features of words (letter in upper case or lower case).

For the test of recognition, a significantly greater number of 'remember' responses were given when meaning information was congruent with the picture at study, than when it was incongruent, which supported findings by Cofell (1994). Cofell (1994) found that 'know' responses are generated more when meaning information is incongruent with the item at study, whereas others (e.g., Gardiner et al., 1994) did not support this effect. The proportion of 'know' recognition responses appears to be highly variable across experiments. In this experiment, more 'know' responses were provided for the three conditions in which either meaning information, sensory information, or both, were incongruent with the picture than when both meaning and sensory information were congruent with the picture, or when the item was nonstudied. It may be that the reason for the low number of 'know' responses in the congruent colour, congruent meaning condition was that the majority of pictures were assigned a 'remember' response.

Tulving (1985) and Gardiner (1988) contend that 'remember' and 'know' responses represent separate and distinct components of memory, such that 'remember' responses represent retrieval from episodic memory, whereas 'know' responses represent retrieval from semantic memory. The independence of 'remember' and 'know' responses was tested in the present experiment in two ways. First, Cofell (1994) found that the mode of study affected performance on a test of sensory memory for items that were given a 'remember' response, whereas the mode of study did not affect performance on a test of sensory memory for items given a 'know' response. When the 4AFC test was analyzed, conditional upon a 'remember' response, there was a significantly greater proportion of correct colour selections for the congruent colour, congruent meaning condition than for the other three study conditions. When the 4AFC test was analyzed, conditional upon a 'know' response during the test of recognition, no significant differences were found in the number of correct colour selections between any of the four study conditions. However, the pattern of results for 'know' responses was similar to that of 'remember' responses, and it is possible that a larger sample of 'know' responses would reveal similar effects, that is, differences in sensory memory across the study conditions would also be found for 'know' responses. Thus, this finding supports a qualitative distinction between 'remember' and 'know' responses, but does not dismiss a 'weak memory trace' hypothesis.

The distinction between 'remember' and 'know' responses was also tested based on findings by Cofell

(1994) that memory for surface features was better for items that had been given a 'remember' response, than for items that were given a 'know' response. A similar result was not found in the current experiment. That is, there were no differences in the proportion of correct 4AFC decisions for pictures that were given a 'remember' response, than for pictures that were given a 'know' response. If 'remember' responses reflect retrieval from episodic memory, whereas 'know' responses reflect retrieval from semantic memory, than 'remember' responses should predict better performance on a test of sensory feature recognition than 'know' responses. The lack of support for this finding in the present experiment may reflect the fact that 'remember' and 'know' responses were given to black and white pictures during the recognition test, and may not have provided any sensory (colour) retrieval cues. The 4AFC test presented the pictures in the same colour as at study, and may have provided a different retrieval set than did the recognition test.

General Discussion and Summary

Experiments 1 and 2 replicated and extended recent findings by researchers concerning the nature of information processing within episodic memory. Experiments 1 and 2 tested the interactive representation of information in episodic memory and generalized the results of previous experiments which tested memory for words, to memory for pictures. Thus, Experiments 1 and 2 successfully replicated the prediction by Hayman et al. (1995) and Cofell (1994) that the effects of the study processing of meaning and surface feature information is represented, and maintained, interactively within episodic memory. This result is important because previous researchers (e.g., Morris, Bransford & Franks, 1977; Stein, 1978; as well as Tulving & Thomson, 1973; Fisher & Craik, 1977) examined the effects of meaning and sensory characteristics in memory independently, based on 'transfer appropriate processing' or 'encoding specificity' explanations of memory, which do not provide for the possibility that the representation of meaning and sensory information in episodic memory are interdependent. These researchers did not test for the presence of an influence of the processing of meaning on memory for other types of information, such as sensory memory.

An important difference between the present results, and previous results (e.g., Hayman et al., 1995; Cofell, 1994), is that recognition of pictures was greater when the surface feature information was congruent with the picture, than when it was incongruent. Previous experiments did not find significant effects of manipulating sensory features on 'yes/no' recognition. The present results may reflect the fact that surface feature information is more important for the processing of pictures than it is for the processing of words within episodic memory. Another, and perhaps unlikely, explanation is that colour may be important for recognition memory, and memory for the colour of words may also be affected by the congruent processing of colour information.

Experiment 2 further investigated the interdependence of episodic memory, by looking at the relationship between 'remember' and 'know' recognition responses, and sensory memory. Analyzing results conditional upon 'yes/no' recognition may be too lenient if recognition responses are not a unitary process (Tulving, 1985). Subjects may recognize an item based on retrieval from semantic memory ('know' recognition response), which would provide no sensory memory cues. In contrast, if subjects recognize an item based on retrieval from episodic memory ('remember' recognition response) than memory for sensory information may be above chance. As predicted, based on findings by Cofell (1994) sensory memory showed an interdependence between the study processing of meaning and sensory information when the results were conditional upon a 'remember' recognition response, although 'know' recognition responses also showed an interdependence between the study processing of meaning and sensory information that approached significance. Proponents of the weak memory trace hypothesis have found that the pattern of results are similar for 'remember' and 'know' responses, and if there was a greater proportion of 'know' responses, then 'know' responses would exhibit a pattern of results similar to that found for 'remember' responses. Therefore, since Experiment 2 found that the pattern of results on a test of sensory memory for 'remember' and 'know' responses were similar, we cannot rule out a distinction between 'remember' and 'know' responses based on a weak memory trace hypothesis.

Experiment 2 also examined the distinction between 'remember' and 'know' responses based on findings by Cofell (1994) that 'remember' responses were better predictors of performance on a test of sensory memory than 'know' responses. Experiment 2 found no differences between 'remember' and 'know' recognition responses on the proportion of correct colour recognitions during the testing situation. A possible explanation for why Experiment 2 was unable to replicate Cofell's (1994) finding was that the pictures were presented in black and white during the test of recognition, which may have stimulated an abstract recognition of the picture, without containing memory pertaining to the sensory features of the picture.

Future experiments examining the interactive representation of meaning and sensory characteristics in episodic memory should alter the type of visual sensory information tested. For example, the size or the orientation of a picture may be manipulated to find out if manipulating meaning along with manipulating size or orientation will produce results similar to those found with manipulating the case structure of letters within words (Hayman et al., 1995; Cofell, 1994), as well as manipulating the colour of pictures (Experiments 1 and 2). The 'type' of sensory information may also be manipulated. For example, future experiments should manipulate the characteristics of auditory, olfactory , and tactile stimuli. It is important to ensure that different types of sensory information (e.g., auditory, olfactory or tactile) will yield the same pattern of interaction with the processing of meaning as those found with visual stimuli (Hayman et al., 1995; Cofell, 1994; Experiments 1 and 2).

The results of Experiment 2 provide limited support for the theory that 'remember' and 'know' responses represent qualitatively distinct components of memory. Future experiments will be necessary to further understand the nature of 'remember' and 'know' responses. If the hypothesis that seeing the picture in black and white during the recognition test resulted in a 'remember' response because of an abstract (instead of a sensory) recognition of the picture is correct, then 'remember' responses should be enhanced by testing with the same colour pictures as seen at study. For example, during the recognition test the subjects could see the picture in either: a) the same colour as at study, b) a different colour than at study, or c) in black and white. If the number of 'remember' responses is facilitated when the colour of the picture is the same in the recognition test as it appeared during study, compared to when the picture is in black and white or in a different colour during the recognition test, then it is possible that in order to generate reliable 'remember' responses, the picture must be seen in the same colour as it was studied.

In conclusion, Experiments 1 and 2 successfully replicated and extended results by Hayman et al. (1995) and Cofell (1995) supporting the interactive representation of meaning and sensory information within episodic memory, and may help provide a basis for further experiments investigating the nature of information processing within episodic memory.

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Appendix A

Remember/Know Test Instructions

You will be presented with a list of pictures on the computer screen. Each picture will be presented one at a time and can be responded to at your own pace. As each picture appears, you will consider if you recognize the picture as having appeared in the study condition. If you recognize the picture you will then indicate, using the computer, whether or not you "REMEMBER" the picture from the previous list or just "KNOW" on some other basis that the picture was on the study list. Additionally, you may indicate that you do not recognize the picture as occurring in the study condition by responding "NOT a study picture". Please read the following instructions to clarify how to make "REMEMBER", "KNOW" AND "NOT a study picture" judgements.

Remember judgements: If your recognition of the picture is accompanied by a conscious recollection of its prior occurrence in the study manipulation, then indicate the number (1) for "REMEMBER" on the keyboard. "REMEMBER" is the ability to become consciously aware of some aspect or aspects of the initial experience when the picture was previously presented (for example aspects of the physical appearance of the picture, a thought that came to mind when you initially saw the picture).

Know judgements: "KNOW" responses should be made when you recognize that the picture was in the study list, but you cannot consciously recollect anything about its actual occurrence. Consequently, you should indicate the number (2) for "KNOW" when you are certain of recognizing the picture but do not have a specific conscious recollection of its occurrence in the study condition.

NOT a study picture judgement: When you do not recognize the picture as appearing in the study list, you should indicate the number (3) for "NOT a study picture".

To further explain the difference between "remember" and "know" refer to these examples. If someone asks you what your name is, you would respond in the "know" sense without being consciously aware of

Appendix A, cont'd

anything about a particular event or experience. However, when asked what the name was of the last movie you saw, you would most likely respond in the "remember" sense. That is, becoming consciously aware of some aspects of the previous experience. If you have any questions regarding these judgements feel free to ask the experimenter.

Thank you.

Table 1. Mean Proportion of correct colour recognitions during the 4AFC test, and the 4AFC, given a recognition response in Experiment 1.

Condition	Prop. Correct 4AFC	Prop. Correct 4AFC given Rn
Congruent colour, Congruent meaning	.50 (.16)	.52 (.17)
Congruent colour, Incongruent meaning	.34 (.15)	.34 (.21)
Incongruent colour, Congruent meaning	.39 (.14)	.43 (.15)
Incongruent colour, Incongruent meaning	.34 (.10)	.36 (.15)
Nonstudied Items	.22 (.07)	.13 (.21)

Note: Standard Deviations in brackets, Rn=Recognition, 4AFC=Four-alternative, forced-choice.

Table 2. Proportion of recognition responses following the 4AFC test in Experiment 1.

Condition	Mean (SD)
Congruent colour, Congruent meaning	.92 (.08)
Congruent colour, Incongruent meaning	.72 (.18)
Incongruent colour, Congruent meaning	.86 (.10)
Incongruent colour, Incongruent meaning	.70 (.18)
Nonstudied Items	.03 (.04)

Note: Standard Deviations in brackets

Table 3. Mean reaction times (in seconds) for the 4AFC test, and the 4AFC test, given a recognition response, in Experiment 1.

Condition	4AFC	4AFC given Rn
Congruent colour, Congruent meaning	3.37 (.95)	.99 (.52)
Congruent colour, Incongruent meaning	3.27 (1.05)	.98 (.49)
Incongruent colour, Congruent meaning	3.68 (1.17)	1.02 (.49)
Incongruent colour, Incongruent meaning	3.15 (1.49)	1.02 (.85)
Nonstudied Items	2.22 (.83)	1.25 (.93)

Note: Standard Deviations in brackets, Rn=Recognition, 4AFC=Four-alternative, forced-choice.

Table 4. Mean Proportion of correct colour recognitions during the 4AFC test, and the 4AFC, given a recognition response, in Experiment 2.

Condition	Prop. Correct 4AFC	Prop. Correct 4AFC given Rn
Congruent colour, Congruent meaning	.53 (.14)	.54 (.15)
Congruent colour, Incongruent meaning	.38 (.14)	.36 (.17)
Incongruent colour, Congruent meaning	.40 (.13)	.41 (.12)
Incongruent colour, Incongruent meaning	.35 (.11)	.38 (.16)
Nonstudied Items	.22 (.05)	.16 (.21)

Note: Standard Deviations in brackets, Rn=Recognition, 4AFC=Four-alternative, forced-choice.

Table 5. Mean Proportion of recognition (remember or know), remember, know and nonstudied responses during the test of recognition, in Experiment 2.

	RESPONSE			
Condition	Rec'n	Remember	Know	NS
Congruent colour, Congruent meaning	.91 (.10)	.79 (.17)	.13 (.15)	.09 (.10)
Congruent colour, Incongruent meaning	.78 (.19)	.53 (.27)	.24 (.20)	.22 (.19)
Incongruent colour, Congruent meaning	.89 (.12)	.70 (.19)	.18 (.16)	.11 (.12)
Incongruent colour, Incongruent meaning	.70 (.20)	.46 (.26)	.24 (.19)	.30 (.20)
Nonstudied Items	.07 (.07)	.01 (.02)	.06 (.06)	.93 (.07)

Note: Standard Deviations in brackets,
Rec'n=Recognition, NS=Nonstudied.

Table 6. Mean Proportion of correct colour selections given remember, know and nonstudied responses during the test of recognition, in Experiment 2.

	RESPONSE		
Condition	Remember	Know	NS
Congruent colour, Congruent meaning	.54 (.16)	.45 (.42)	.43 (.44)
Congruent colour, Incongruent meaning	.35 (.22)	.36 (.27)	.38 (.31)
Incongruent colour, Congruent meaning	.40 (.14)	.44 (.35)	.33 (.37)
Incongruent colour, Incongruent meaning	.40 (.21)	.32 (.25)	.27 (.25)
Nonstudied Items	.30 (.45)	.17 (.23)	.24 (.05)

Note: Standard Deviations in brackets,
Rec'n=Recognition, NS=Nonstudied.

Table 7. Mean reaction times (in seconds) to make a recognition (remember or know), remember, know or nonstudied response during the test of recognition, as well as to make a response during the 4AFC test.

Condition	Rec'n	Rem	Know	NS	4AFC
Congruent colour, Congruent meaning	1.61 (1.02)	1.57 (1.53)	3.01 (1.35)	2.50 (2.23)	3.44 (1.69)
Congruent colour, Incongruent meaning	1.89 (.85)	1.64 (.99)	2.78 (1.22)	2.09 (1.79)	3.53 (1.92)
Incongruent colour, Congruent meaning	1.92 (1.78)	1.57 (.99)	2.80 (1.11)	1.98 (1.03)	3.67 (1.59)
Incongruent colour, Incongruent meaning	1.84 (.82)	1.45 (.52)	2.86 (1.03)	2.26 (1.67)	3.17 (1.07)
Nonstudied Items	2.53 (2.46)	1.26 (.46)	3.67 (2.49)	1.56 (.81)	3.14 (1.64)

Note: Standard Deviations in brackets,
Rec'n=Recognition, Rem=Remember, NS=Nonstudied.