What creates a valuable cue?

The underestimated importance of a cues diagnostic value over the encoding retrieval match for successful memory retrieval

Tove Madsen & Paula Widén

Kandidatuppsats (15 hp)

VT 2014

Abstract

Målet med denna studie är att undersöka betydelsen av det diagnostiska värdet hos en ledtråd, en så kallad "cue" framför värdet av ett kontextuellt överlapp mellan inkodning och framplockning av minnen. Ett minnestest grundat på ledtrådsbaserat igenkännande, så kallat "cued recognition", genomfördes. Samtliga deltagare presenterades för ordpar tillsammans med kontextuella bilder i tre betingelser, (1) baseline, där kontexten mellan inlärningsfas och testfas inte överlappade, (2) icke-diagnostisk, där samma kontextuella information associerades till flera ordpar, samt (3) diagnostisk betingelse, där unik kontextuell information presenterades, så att ledtråden blev associerat med enbart ett ordpar. Deltagarna ombads fokusera på ordparen så att den kontextuella ledtråden inte sågs som direkt relevant för minnesuppgiften. Hypotesen predicerar högre sannolikhet för korrekt igenkännande i den diagnostiska betingelsen i förhållande till andra betingelser. Resultatet visade en signifikant högre prestation i linje med presenterad hypotes och tidigare forskning. Resultatet ger ytterligare stöd för vikten av en ledtråds diagnostiska värde vid lyckad minnesframplockning, samt sträcker fyndet till kontextuella miljöer då tidigare studier varit semantiskt grundade.

Keywords: Encoding retrieval match, diagnostic value, cue overload, encoding specificity, cortical reinstatement, transfer-appropriate processing

Abstract

The aim of this study is to investigate the importance of a diagnostic cue over the mere contextual overlap between encoding and retrieval in successful retention. A cued recognition test was conducted to investigate the power of a contextual cues diagnostic value in successful retrieval of memories. Participants were presented with word pairs together with a picture background in three different conditions, (1) baseline, containing no contextual overlap thus no contextual retrieval cues (2) non-diagnostic, with the context being associated with several word pairs and (3) diagnostic, with the context only being associated with one target word. The participants were asked to focus on the word pairs, making the contextual cue task irrelevant. The presented hypothesis assumes a higher accuracy for the diagnostic condition in relation to other conditions. Results showed a significantly higher level of recognition accuracy for the diagnostic condition in relation to the baseline condition and the non-diagnostic condition, supporting the hypothesis. The results provide additional support to the importance of a cues diagnostic value, while at the same time using contextual cues rather than semantic cues, which has not been done before.

Keywords: Encoding retrieval match, diagnostic value, cue overload, encoding specificity, cortical reinstatement, transfer-appropriate processing

Introduction

What creates an effective cue and which mental processes are important for predicting successful retrieval? Is it the diagnostic value of a cue that determines successfulness or is it the overall match between encoding and retrieval conditions? There have been various studies discussing the answer to this question (Goh & Lu, 2012; Nairne 2002; Poirier, Nairne, Morin, Zimmermann, Koutmeridou & Fowler, 2012). In the present study additional attempts are made to determine the mechanisms underlying successful retrieval.

In the current study a cue is referred to as the "trigger" for a specific memory. Retrieval cues used in research can take on different forms, there have been studies using semantic cues (Poirier et al., 2012), olfactory cues (Arshamian, Iannilli, Seo, Hummel, Willander, Persson & Gerber, 2013) and cues referring to the entire physical context the person found themselves in while encoding (Godden & Baddeley, 1975). Earlier theories have stated that when the amount of available cues increases (i.e. when the match between encoding and retrieval conditions increases), the probability of evoking a specific memory associated with these cues, also increases (Tulving & Thomson, 1973; Watkins & Watkins, 1975). However, subsequent studies have found that the mere overlap between encoding and retrieval is not sufficient to explain differences in the successfulness of retention.

Encoding specificity refers to the necessity of a cues presence during the original encoding event to be able to function as a retrieval cue, in the sense that without prior encoding a cue cannot provide associative and hence valuable information (Tulving & Thomson, 1973). However encoding specificity should not be misinterpreted as a synonymous with encoding retrieval match, implying that an increased match leads to a more successful retrieval. This is an unfortunate but regular misinterpretation (Poirer et al., 2012).

Within neurocognitive research, studies have shown that mental simulation can be an important part of explaining how we remember and what processes are involved in retrieval of memories. Mental simulation refers to the process in which the brain reinstates the same neural activity that was active during the experience of an event, during later retrieval of the same event (Kent & Lamberts, 2008; Schendan, Ganis, Mast, Evans, & Reeves, 2012).

The relationship between encoding and retrieval has not always been obvious to researchers and it has often been overlooked by earlier studies (Kent & Lamberts, 2008). When the relationship between the two factors came into light, a string of new theories was born from

the origin of this particular discovery. Transfer-appropriate processing (TAP) (Tulving & Thomson, 1973), encoding specificity and cortical reinstatement (CR) are all examples of such models (Poirier et al., 2012; Rugg, Johnson, Park & Uncapher, 2008). Encoding specificity refers to the necessity of a cues presence during the original encoding event to be able to function as a retrieval cue, in the sense that without prior encoding a cue cannot provide associative and hence valuable information (Tulving & Thomson, 1973). However encoding specificity should not be misinterpreted as a synonymous with encoding retrieval match, implying that an increased match leads to a more successful retrieval. This is an unfortunate but regular misinterpretation (Poirer et al., 2012).

TAP refers to the improved memory performance that originates from task congruent activity between encoding and retrieval. When investigating the participants performance on a semantic memory test, Morris, Bransford and Franks, (1977) discovered that the effect of levels of processing could be influenced by how a task was performed during encoding. Levels of processing is explained through the different levels in which percepted material is being processed, more explicit how deeply the encoded information has been processed before it is stored in memory, (Craik & Lockhart, 1972). In the study by Morris and colleagues (1977) the participants were studying semantic material in a test of paired associates. They found that when the task was to remember additional information and not only a recognition task, the performance was enhanced if the method used for recalling was congruent with the method used when the information was encoded. When participants were to answer whether the earlier studied words rhymed or not (phonological task), retention was facilitated when the learning involved a phonological method, even when the participants had been unaware of the later rhyming task at the time of study. Since the levels of processing were kept equal, the conclusion was that congruence between the activity engaged (semantic or phonological) during encoding and the task at retrieval, facilitated memory performance. These results were the framework for Transfer Appropriate Processing.

The underestimated power of diagnostic value
The interaction between encoding and retrieval conditions created an interest in what makes a single cue more or less valuable for successful retention. Similar to the underestimated relationship between encoding and retrieval, researchers may have underestimated the

importance of a cues diagnostic value for successful retrieval (Watkins & Watkins, 1975). Diagnostic value refers to the extent in which a cue is uniquely associated with a specific memory, thus determining the cues discrimination power (Poirier et al., 2012).

It has up until recently been widely adopted that successful memory retrieval depends merely on the encoding-retrieval match and not the diagnostic value of context cues. These ideas states that we recall better when we are in contexts similar to the ones we found ourselves in while encoding information. For the reason that a large contextual overlap leaves less gaps that needs filling in upon remembering. Despite the fact that it has been proven that other factors, such as cue overload effect the successfulness of retrieval, the general opinion is that encoding-retrieval match is a valid explanation for variations in retention (Nairne, 2002). Cue overload occurs when a cue is associated with several different memories, thereby reducing the diagnostic value of the cue for a specific memory (Watkins & Watkins, 1975).
In order for information to be as a cue, it needs to fulfil the conditions for encoding specificity.

The assumption about encoding-retrieval match has been challenged by Nairne (2002) a researcher within cognitive psychology, who in a review opposes the idea that encoding-retrieval match alone, can be used to explain the mechanisms behind successful or unsuccessful retrieval. Nairne (2002) states that although there is a positive correlation between matching conditions and successful memory retrieval, the causes of this cannot entirely be explained by the encoding retrieval match theory. Further he argues that we need to take the cue overload theory into greater account and acknowledge the significance of a cues diagnostic value, thus how uniquely associated a cue is with the specific memory, over the contextual overlap between encoding and retrieval conditions.

The theory about a cues diagnostic value over encoding-retrieval match has been tested by Poirier and colleagues (2012) in various memory tests, using both made up "non words", words with semantic meaning and geometric shapes as cues and targets. Further, it has been tested by using semantic categories with strongly versus weakly associated words (Goh & Lu, 2012).

In one of the experiments conducted by Poirier and colleagues (2012) paired associates were used to determine the importance of the diagnostic value of a cue. Through all conditions, the first word in each pair is referred to as the cue, the word that would evoke the memory of the second word, referred to as the target word. In some conditions, additional information was

provided so the contextual overlap between the encoding condition and the retrieval condition was increased.

During the test phase, the participants were given cues with varying diagnostic values. A cue with a high diagnostic value could only be associated with the target word whereas a cue with a low diagnostic value could be associated with several target words. The effect of the different conditions was measured by the participants' response time. The result showed a decrease in successful retention when there was a cue overload. Having created the ability to change both the contextual overlap and the cues diagnostic value over the conditions, Poirier and colleagues (2012) could prove that the degree of cue overload is in fact the main factor that predicts successful retrieval. The original statement by Nairne (2002) has been tested and replicated several times with same effect found in all subsequent studies (Goh & Lu, 2012; Poirier et al., 2012).

Cue overload in context of neurocognitive research

Nairne's (2002) research, and the studies that followed have mostly been using cognitive tests based on semantic categorization of words, as cues and targets. In the current study the word pairs used as cues is semantically non-related prior to the test and is used in combination with background pictures working as contextual cues. By using context the intention is to replicate and extend the meaning of previous findings by integrating them with current neuropsychological memory theories that stresses the important differences of contextual, semantic and phonological encoding and retrieval. A recent study by Dietze and colleagues (2011) has shown the importance of not only reinstating semantic cues but the whole encoding context, to achieve successful retrieval (context reinstatement).

To further identify what creates a successful cue it is important to understand how memories are stored and created in the brain. Various neurobiological models investigate how parts of the brain overlap in its activity during encoding and retrieval (Rolls, 2000; Shiastri, 2002) and can be combined through the model of cortical reinstatement (Rugg et al., 2008). Cortical Reinstatement (CR) is a neuropsychological model for memory function that may provide additional knowledge to what creates a valuable cue. CR supports mental simulation and states that the parts of the brain that are active during the encoding of a memory, will also be active during the retrieval of the memory. The earlier mentioned model of Transfer Appropriate

Processing (TAP), argues that memories can be defined by the cognitive operations or activity engaged during the initial creation of that memory. Retrieval is facilitated when the earlier cognitive operations are reactivated (Morris et al., 1977). Neuropsychological models states that TAP is a by-product of online-processing, thus the actual event creates a trace of activity in the brain and this trace is then considered to be what we call a memory. Since various cortical areas are activated during the perception and experience of an event, same goes for the retrieval of this memory (Rugg et al., 2008). This means that when we encode an event with phonological and visual methods, (as when we experience a for instance the context of a noisy room) areas of the brain involved in processing both phonological and visual information will be reactivated during retrieval of the event (Morris et al., 1977). The core of this model is found in CR. According to CR, memories are created by a unique cortical pattern for each experience. Accordingly there is a neurocognitive overlap between the encoding of a specific memory and later retrieval of the same memory (Rugg et al., 2008). The unique pattern consists of not only the areas activated at the time of encoding but also the amount of activation within this region and its relation to other areas. This pattern is the cortical trace, or the cortical reinstatement (Rugg et al., 2008). The specific cortical pattern is stored through the hippocampus, which is also active during the later retrieval of the event. To be able to reactivate the trace and bring back the memory the hippocampus operates as kind of a storage hub and switchpad. The hippocampus has no involvement in creating the memories themselves but has a very important role in enabling both the encoding and retrieval of them (Neunuebel & Knierim, 2013). It is not necessary with a perfect overlap between the encoding and the retrieval occasions due to the hippocampus ability of pattern completion and pattern separation. Partial information of an event can be sufficient to reactivate the entire memory (Ritchey, Wing, LaBar, & Cabeza, 2012; Rugg et al., 2008). It has also been found that the amount of details we remember about an event overlaps with activated areas in the brain (Uncapher, Otten & Rugg, 2006).

In the review "The operation of pattern separation and pattern completion processes associated with different attributes or domains of memory" (Hunsaker & Kesner, 2012, p. 37) the functional role of the hippocampus for pattern completion and separation is described as following:

(1)To serve as a competitive learning network that reduces the degree of overlap among activity patterns to facilitate storage with minimal interference with other activity patterns and

(2) to serve as an auto-association network that is capable of recalling stored activity patterns from partial cues

The explanation of pattern completion and separation helps to clarify why the diagnostic value of a cue is of such importance and why a perfect encoding retrieval match is not a sufficient explanation for improved recall (Hunsaker & Kesner, 2013).

Purpose and aim

Mental simulation and the further evolved explanation of pattern completion is a possible illustration of why different levels of overlap between conditions are not sufficient to explain differing successfulness in retention and furthermore why cue overload might even complicate successful retrieval. By the support of these theories we predict that people presented with a diagnostic cue will, to a further extent, be more successful in retrieval than people presented with a non-diagnostic cue when context is held constant. This is due to a high cue overload.

To test this our intention is to create a cued recognition test (Snodgrass & Corwin, 1988) that essentially resembles Nairnes (2002) test, but differs in the sense that diagnostic/ non-diagnostic cues no longer are based upon semantic categories but on pictures. By doing so the intention is to test the encoding retrieval match with contextual stimulus thus expanding earlier findings. We want to investigate the importance of the diagnostic value by using a contextual approach since this might be a more effective type of cue, based on what we know about the nature of memory processes (Dietze, Sharman, Powell, & Thomson, 2011).

Hypothesis

Participants will perform better in a memory test during a diagnostic cue condition than under a non-diagnostic cue condition. Performance will be assessed by accuracy, which will be controlled by the rate of hits and false alarm responses to avoid accuracy level accomplished by guessing.

Method

Participants

A pilot study was first conducted including 11 participants. A revised test was then used for the actual experiment. Initially, 48 participants all currently studying at a higher-level education

(College or University) was included in the study. However, three of these were removed due to misinterpretation of the instructions, (final N = 45).

The age of the participants ranged from 19 to 29, M=23, standard deviation (SD) = 2,29. The participants were asked to sign an informed consent for the study.

Material and design

The created material included three lists of words referred to as list A, B and C, each consisting of 180 words containing between 4 and 8 letters, giving a total of 540 words. The lists were all matched regarding frequency, word length and divided into categories of living/non living things. The frequency used was medium low word frequency and chosen through a word bank (Korpus) created by Gothenburg University. Minimum frequency was 0.5 and maximum frequency 8.5 per million words in the Swedish language. The chosen words were semantically unrelated prior to the study and were all nouns. Lists A, B and C were used in the test as either cue word, target words or non-targets (extra list cue words) and since the lists were already matching, the conditions was kept constant for the separate list during the whole test.

Further these lists were divided into three subgroups creating, A_1, A_2, A_3 and so forth. Each subgroup was used in the different conditions, either representing the diagnostic- non-diagnostic or baseline condition. The three lists with their three subgroups created nine possible combinations of lists and conditions. To counterbalance possible effects of order the minimum amount of participants for this test was nine. The material also included 160 photographs, all representing different contexts and none, which included living creatures since this might have risked the effect of bias.

The first word of the pair was referred to as the cue, and the second as target word, target being the requested word in the test trial. The later was to be remembered by the participant in the recall-situation. The pictures were also considered to be cues. In the diagnostic condition the word pair was presented in a context associated with only one word pair, creating a unique context. In the non-diagnostic condition the word pair was presented with the same context as four other word pairs and since the context could be associated with several word pairs it created a non-unique context.

Participants were presented with instructions informing them of their participation in a memory test consisting of five cycles where the task is to memorize word pairs and pictures.

Further that each cycle consisted of a study phase and a test phase, both containing 30 word pairs with associated pictures.

Between the study and test phase participants were presented with a distraction task before proceeding to the test phase. The distraction task consisted of a simple calculus task where the participants was presented with a random number and instructed to count backwards from the given number in blocks of 7 for 30 seconds when they were told to stop. For instance if the presented number was 785 correct counted would be 778, 771, 764 and so forth. Afterwards they were instructed with the task of correctly identifying whether the second word of the word pair was presented together with the cue word in the study phase or if it is a new word. If the words match participants were instructed to press the key "K" if the do not match press the key "F". The keys "K" and "F" were counterbalanced so that they were equally presented as the correct and incorrect answer. Participants were not instructed of this change of response keys before initiating the test. The change was made to balance out possible effects in response time due to usage of the right versus left hand.

Procedure

Each participant was tested on one occasion, each test lasting about 40 minutes. During the five cycles each word pair and associated picture was presented during 4 seconds. The predecessors within similar studies have often presented their stimulus during 2-3 seconds but due to the more complex contextual stimulus we found it necessary to extend the time making it possible for participants to study both word pair and picture.

During the distraction task participants was asked to count out loud to make sure directions were being followed correctly. In the test phase, memory retrieval was induced by sequential presentation of the stimuli, first introducing the picture, followed by [cue-word] + [?], and ultimately presenting target or non-target word. This was made to try to activate the contextual memory created during study phase. Figure 1 shows example of experimental design.

Figure 1. *Example of experimental design*
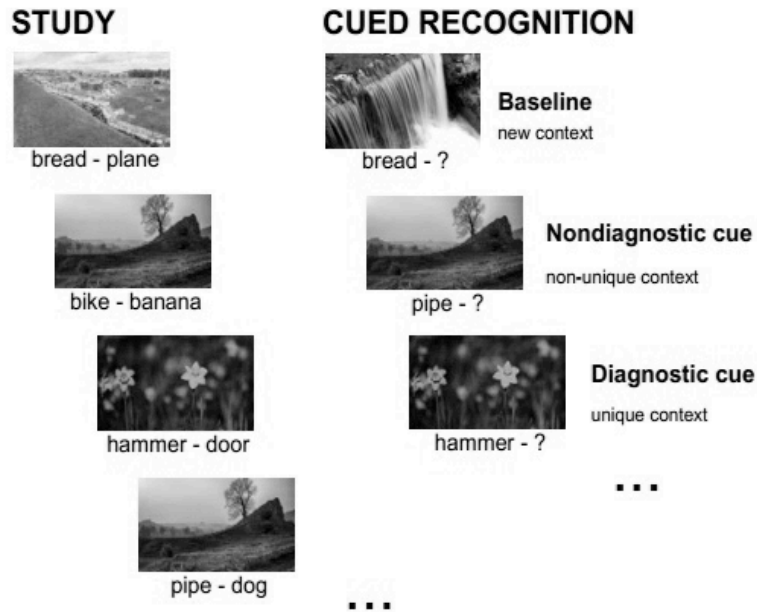
Method

We used the program E-prime to create our test, which contains one study phase and one test trial. Furthermore the test was divided into cycles each containing 30 word pairs. The test has a repeated measure design with each cycle containing three conditions, baseline-, diagnostic- and non-diagnostic condition. During the study phase E-prime would randomly select a subgroup of words from either the A B or C list. List A contains the words used as cue words, list B contains the words used as target words and list C contains the words used as non-target words.

The lists were then rotated between participants to make sure all words were represented in all conditions. Each sequence used 30 words, creating 10 pairs of words for each condition. Each word pair was then presented to the participants on a background selected from the 160 different pictures in the material. In the baseline condition, we used different, unique pictures in the study phase compared to the test trial, leaving the cue word as the only cue with diagnostic value. In the diagnostic condition each word pair was presented on unique pictures in the study phase and in the test phase, the cue word was presented on that same picture. In difference to the baseline condition, the pictures in the diagnostic condition overlap between test trial and study phase. These pictures thus become diagnostic for the requested target word. With both pictures and cue word giving diagnostic information this creates a diagnostic condition.

During the last, non-diagnostic condition the 10 word pairs are shown on two different pictures as background, thus five word pairs for each picture. The pictures in the test phase are the same as in the study phase and are shown together with matching cue word increasing the match of the trials but decreasing the diagnostic information, since the picture is associated with more than one target word thus becoming a low-diagnostic cue.

In each condition and test trial, the second word can either be the correct word presented in the study phase or a new word, never studied before. The target word can therefore be correctly or incorrectly identified as target word for the specific cue in the test phase. Making the possible answers either key "F" for "Yes, coded with cue in learning phase" or key "K" for "No, new word thus not coded with cue in learning phase". Participants task in test trial was to correctly identify if target word matches cue from the study phase.

Results

Hit and false alarm rates, and measures of old–new discrimination (Pr = p(hit)-p(false alarm)), and response bias (Br = p(false alarm)/p(1 - Pr)), were calculated separately for the three conditions (1) baseline, (2) non-diagnostic cue, and (3) diagnostic cue (two-high threshold theory, Snodgrass & Corwin, 1988). Descriptive statistics are given in Table 1 and Figure 2. A one-way repeated measures ANOVA was conducted to compare old-new discrimination as a function of condition. A significant main effect of condition was found, $F(2,88) = 5.16$, ($p=.008$). The effect size was medium according to Cohen's guidelines (partial eta squared $=.105$). Planned pairwise comparisons showed that there was an anticipated effect between levels of accuracy in baseline and diagnostic condition, with the diagnostic condition showing significantly higher accuracy ($p=.001$). There was also an effect between the non-diagnostic condition and the diagnostic condition, with the diagnostic condition showing significantly higher accuracy ($p=.025$). Between baseline and the non-diagnostic condition, no significant effect was found ($p=.45$).

An analogous ANOVA of response bias (Br) showed no significant effect of conditions, ($F(2,88) = 1.55, p=.22$), merely a slight tendency towards conservative behaviour in all three conditions (baseline = 0.39, non-diagnostic = 0.42, diagnostic = 0.46).

A two-way repeated measures ANOVA was conducted to examine how reaction times were influenced by condition and item type: correctly identified target words (HITS) and correctly rejected a non-target words (Correct rejections). Descriptive statistics for reaction times

are given in table 2. The ANOVA revealed significant main effects for both condition, $F(2,88) = 10.95$, $p=.002$, and item type, $F(1,44) = 5.22$, $p=.027$. Planned pairwise comparisons for condition showed a significant difference between baseline and non-diagnostic ($p=.001$) and between baseline and diagnostic ($p=.000$), with the response times for the baseline condition being significantly higher then the two other conditions. No effect was found between non-diagnostic and diagnostic ($p=.80$). Planned pairwise comparison for response showed a significant difference between HITS and correct rejections ($p=.027$) with responses for HITS being faster than for correct rejection (Mean difference -216 ms).

Table 1. *Descriptive statistics for each of the three conditions and frequencies of HITS, False Alarms, Pr and Br*

Condition	Mean (SD)	N	HITS	FA	Pr	Br
Baseline	.65 (.20)	45	.79	.11	.65	.39
Non-diagnostic	.67 (.19)	45	.82	.13	.67	.42
Diagnostic	.71 (.17)	45	.87	.12	.72	.46

Table 2. *Descriptive statistics for reaction time between conditions and response*

Condition	Mean (HITS)	Mean (Correct Rejection)
Baseline	1911,6648	2120,3263
Non-diagnostic	1706,5619	1942,4565
Diagnostic	1712,6221	1915,3000

Figure 2. *Probabilities of HITS, False Alarms, Pr and Br*
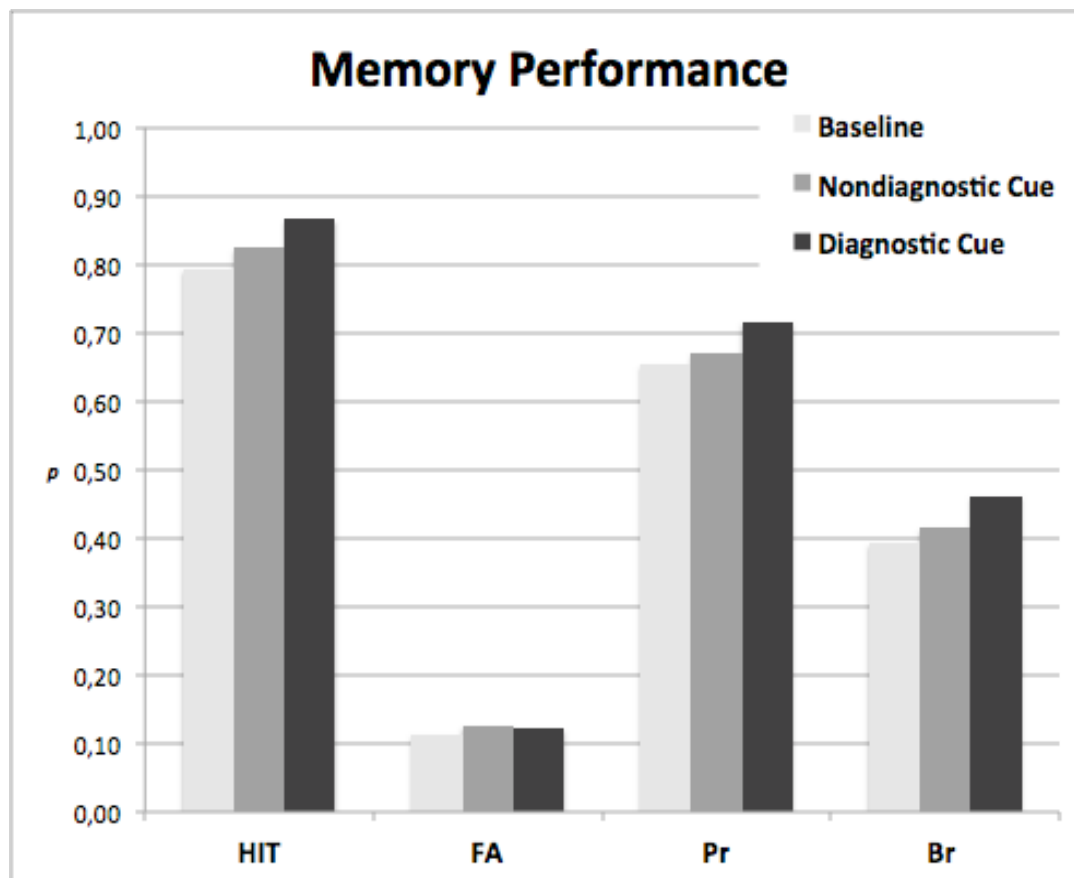
Discussion

The present study was conducted to determine the important components of successful retrieval, focusing on the importance of a retrieval cues diagnostic value and which factors determine their discriminatory value. Further the study was designed to retest, and if possible support earlier studies that questioned the importance of the encoding retrieval match. Instead of explaining differences in retention by the encoding retrieval match, the test was conducted by exploring the effect of contextual cues of varying diagnostic value. To test the effect of diagnostic value on contextual cues, three conditions were used creating a diagnostic contextual cue, non-diagnostic contextual cue or a baseline condition where no useful contextual cue was given.

The result revealed significantly higher levels of accuracy in the diagnostic condition compared to both the baseline condition as well as the non-diagnostic condition. The absence of a significant difference between the baseline condition and the non-diagnostic condition is hard

to explain from an encoding retrieval match point of view. For the encoding-retrieval match to remain valid as an explanation for differences in retention, the accuracy level for a high match condition should be higher than the accuracy level for a low match condition. However this effect was not found in the non-diagnostic condition. The matching pictures in the non-diagnostic condition will undoubtedly increase the match between the learning phase and the test phase compared to the baseline condition and still there was no significant difference in levels of accuracy between the groups. This result cannot be explained through the encoding retrieval match, it can however be explained through cue overload (Watkins & Watkins, 1975). With the increasing overload of cues confusing participants to the extent that accurate remembering was affected, thereby leaving the contextual overlap of the non-diagnostic cues meaningless. When having seen a picture many times, the number of possible targets increased so much that the picture was no longer an effective cue and of no more help than a picture never seen before.

Comparisons of response time showed a significant difference between correct answers in the baseline condition compared to both the non-diagnostic and the diagnostic condition. This could be a result of pictures in the test phase of the baseline condition being novel to the participant, therefore the cognitive load needed to process these pictures, becomes significantly higher. It also showed a significant difference between response times for HITS and Correct Rejections, with responses for HITS being faster than responses for Correct Rejections. This could be the result of a more time consuming cognitive process for rejecting a word than to recognize it. For a rejection of a word to be made a search of the memory must be done to establish that the word was not recognized, whilst identification of a target word requires only a search until the correct words is identified.

From these results, which correspond well with the results of earlier studies (Goh & Lu, 2012; Poirier et al., 2012), we can conclude that the reason why the encoding retrieval match has seemed to be the reason behind varying successfulness in retention is that it is essential for the mere existence of retrieval cues, both diagnostic and non-diagnostic. From further investigation however, it becomes clear that an increase in the amount of overlap per se has little or no effect on successful retention. The overlap between encoding and retrieval is important simply to enable the creation and existence of cues. When this criterion has been fulfilled, the cues diagnostic value is what determines whether the memory retrieval will be successful or not.

Implications of this study

This leads us to the important issue of a psychological paradigm becoming too close to an unquestioned and accepted truth. Great findings should always be replicated when newer methods are made accessible and when a new theory emerges from solid research methods they should not be ignored even when they question earlier results and well-established theories. Research comes with the responsibility of making information accessible to the public, that otherwise would be unknown. To overlook new studies where the results might go against your own research is a violation of this responsibility, especially when the results could have a great impact on the lives of others. It is our opinion that the result from this study could have an impact on how we understand the retrieval of memories and how we should proceed to recollect these memories by using cues. By changing how we look upon the mechanisms behind retention, we could make an important contribution to the updating of present methods used in for example juridical processes. The findings in this study clearly points out how sensitive a memory cue is to interference from other information connected to it. This could increase our understanding of why the benefits of returning to the site of an incident that occurred in a familiar environment might not be as powerful as the benefits of returning to the site of an incident that occurred in an alien environment. The method used to help victims recall memories of a trauma by returning to the place where the incident happened either physically (context reinstatement) or mentally (mental context reinstatement), (Dietze et al., 2011; Geiselman, Fisher, MacKinnon & Holland, 1986), will most likely vary in effectiveness depending on the potential interference of other memories earlier retained in that context. Therefore this specific method might not be appropriate for retaining memories in cases of, for instance domestic violence.

There is also an idea that the diagnostic value of a cue can be reduced in retrospect, and this could have implications we know little about at this time. Say that a crime victim is forced to mentally return to the place and time of the incident he or she has been subjected to, several times in the juridical process. (As for the Swedish case of Thomas Quick, for further reading see Råstam, Göransson & Drake, 2013) Even if the context where the crime took place was unknown to the victim prior to the incident, the diagnostic value of this place will likely decrease every time the person returns to this place, mentally or physically. The possibility of a contextual cue's diagnostic value being reduced in retrospect remains unknown at this point.

Further research

The idea that stored memories are the trace of the cortical processes active during encoding, explained in neurocognitive theories mentioned earlier such as TAP (Morris et al.,1977) and CR (Rugg et al., 2008) could be a potential explanation to why the overload of a cue reduces its diagnostic value. The hippocampal ability of pattern separation further explains why a complete match is not necessary for successful retrieval. These are possible assumptions given the results from this study, but further investigation is needed before any conclusions can be made. It would be of great interest to conduct studies using brain-imaging techniques such as Electroencephalography (EEG) or functional Magnetic Resonance Imaging (fMRI).

The use of pictures as cues has been one step closer to imitating the real world in relation to the usage of words and symbols, due to the increase in details in the stimulus and the increased likeness to natural situations. A goal for additional research could be to try to increase the similarity to the real world even further.

In conclusion, this study has provided additional support for the questioning of the encoding retrieval match as a single explanation for successful retention. It is possible to assume that the encoding retrieval match is a necessity for the mere existence of retrieval cues, but that it's importance may stop there. The increase of match has earlier been wrongly thought of to explain retention. The absence of a significant difference between the baseline condition and the non-diagnostic condition however rejects this. The misunderstanding most likely originates from the idea that the matches enables more cues and therefore increase the likelihood of some of these cues being diagnostic.

References

Arshamian, A., Iannilli, E., Seo, H., Hummel, T., Willander, J., Persson, J., & ... Gerber, J. (2013). The functional neuroanatomy of odor evoked autobiographical memories cued by odors and words. *Neuropsychologia, 51*(1), 123-131. doi:10.1016/j.neuropsychologia.2012.10.023

Craik, F. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal Of Verbal Learning And Verbal Behavior*, *11*(6), 671-684.

Dietze, P., Sharman, S., Powell, M., & Thomson, D. (2011). Context reinstatement effects in children's cued recall of strongly and weakly associated word pairs. Australian Educational And Developmental Psychologist, 28(2), 91-100. doi:10.1375/aedp.28.2.91

Geiselman, R., Fisher, R. P., MacKinnon, D. P., & Holland, H. L. (1986). Enhancement of Eyewitness Memory with the Cognitive Interview. The American Journal Of Psychology, (3), 385. doi:10.2307/1422492

Godden, D. R., & Baddeley, A. D. (1975). CONTEXT-DEPENDENT MEMORY IN TWO NATURAL ENVIRONMENTS: ON LAND AND UNDERWATER.*British Journal Of Psychology*, *66*(3), 325.

Goh, W., & Lu, S. (n.d). Testing the myth of the encoding-retrieval match. Memory & Cognition, 40(1), 28-39.

Hunsaker, M., & Kesner, R. (2013). The operation of pattern separation and pattern completion processes associated with different attributes or domains of memory. Neuroscience And Biobehavioral Reviews, 37(1), 36-58.

Kent, C., & Lamberts, K. (2008). The encoding-retrieval relationship: retrieval as mental simulation. Trends In Cognitive Sciences, 12(3), 92-98. doi:10.1016/j.tics.2007.12.004

Morris, C. D., Bransford, J. D., & Franks, J. J. (1977). Levels of processing versus transfer appropriate processing. Journal Of Verbal Learning And Verbal Behavior, 16(5), 519-533.

Nairne, J. S. (2002). The myth of the encoding–retrieval match. Memory, 10(5/6), 389-395. doi:10.1080/09658210244000216

Neunuebel, J., & Knierim, J. (2013). CA3 Retrieves Coherent Representations from Degraded Input: Direct Evidence for CA3 Pattern Completion and Dentate Gyrus Pattern Separation. Neuron, 81(2), 416-427.

Poirier, M., Nairne, J. S., Morin, C., Zimmermann, F. S., Koutmeridou, K., & Fowler, J. (2012). Memory as discrimination: A challenge to the encoding–retrieval match principle. Journal Of Experimental Psychology: Learning, Memory, And Cognition, 38(1), 16-29. doi:10.1037/a0024956

Ritchey, M., Wing, E., LaBar, K., & Cabeza, R. (n.d). Neural Similarity Between Encoding and Retrieval is Related to Memory Via Hippocampal Interactions. Cerebral Cortex, 23(12), 2818-2828.

Rugg, M., Johnson, J., Park, H., & Uncapher, M. (2008). Encoding-retrieval overlap in human episodic memory: a functional neuroimaging perspective. Essence Of Memory, 169339-352.

Rolls, E. T. (2000). Memory systems in the brain. Annual Review Of Psychology, 51(1), 599.

Råstam, H., Göransson, M., & Drake, L. (2013). Fallet Thomas Quick : att skapa en seriemördare / Hannes Råstam ; redaktörer: Mattias Göransson & Leyla Belle Drake ; förord: Leif GW Persson ; efterord: Mattias Göransson. Stockholm : Pocketförlaget, 2013 (Falun : Scandbook)

Snodgrass, J., & Corwin, J. (1988). Pragmatics of Measuring Recognition Memory: Applications to Dementia and Amnesia. Journal Of Experimental Psychology: General, 117(1), 34-50.

Schendan, H. E., Ganis, G., Mast, F., Evans, K. K., & Reeves, A. (2012). Electrophysiological potentials reveal cortical mechanisms for mental imagery, mental simulation, and grounded (embodied) cognition. Frontiers In Psychology, 31-22. doi:10.3389/fpsyg.2012.00329

Shastri, L. (2002). Episodic memory and cortico-hippocampal interactions. Trends In Cognitive Sciences, 6(4), 162-168.

Tulving, E., & Thomson, D. M. (1973). Encoding specificity and retrieval processes in episodic memory. Psychological Review, 80(5), 352-373. doi:10.1037/h0020071

Uncapher, M. R., Otten, L. J., & Rugg, M. D. (2006). Article: Episodic Encoding Is More than the Sum of Its Parts: An fMRI Investigation of Multifeatural Contextual Encoding. Neuron, 52547-556. doi:10.1016/j.neuron.2006.08.011

Watkins, O. C., & Watkins, M. J. (1975). Buildup of proactive inhibition as a cue-overload effect. Journal Of Experimental Psychology: Human Learning And Memory, 1(4), 442-452. doi:10.1037/0278-7393.1.4.442