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The diagnostic value of cues in memory recall within retrieval-induced forgetting

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Abstract

The present study investigated if the diagnostic value of cues could reduce the need for inhibition operating within the retrieval-practice paradigm, which is part of the retrieval-induced forgetting (RIF). The results of 32 participants (female: 20, age: *M* = 24.97 years, range: 20 – 32 years) were reported. The method used was a standard RIF procedure with an added manipulation. The category-item pairs were presented with an image in the background that was either specific to the item of the category and in this way the diagnostic value of cues were manipulated. Half of the category-item pairs had unique images associated to them while the other half did not. With the use of unique images as potential cues, a unique memory trace can be established which increases the diagnostic value of the cue. It was hypothesized that with unique images there would not be a RIF effect while there would be with non-unique images. Contrary to the hypotheses, there was a statistically significant RIF-effect with large effect size with the unique cues but not a statistically significant RIF-effect with non-unique cues. The results are discussed in relation to the integration of items that improves recall.

Keywords: RIF-effect, diagnostic value of cues, unique cues

The diagnostic value of cues in memory recall within retrieval-induced forgetting

Memory is a remarkable capacity that humans possess. It enables people to function in everyday life. Just looking around, you encounter a tremendous amount of stimuli or objects that you are familiar with since before. However, everything is not remembered, some things are forgotten while others are recalled. At first sight forgetting might seem negative but sometimes it can be welcomed. Recalling traumatic memories is not something we wish to do. Forgetting is an adaptive mechanism that enables us to function daily without constant irrelevant reminiscence.

Remembering is an important and necessary part of our functioning, but so is forgetting as well. If something is remembered or forgotten depends on how it was encoded and which process of retrieval one employs. In order to retrieve a memory one needs to activate a memory trace (Vaidya, Zhao, Desmond & Gabrieli, 2002). A memory is activated by either using external or internal memory cues (Tulving & Thomson, 1973). Cues can be many things that are associated with the target. This association can be an established relationship based on semantic or episodic association (Anderson, Green & McCulloch, 2000) or perhaps an association that was established at encoding (Salzberg, 1976). When a cue is strongly associated with the target, the target may be effectively retrieved, but there need not be an association between the target and the cue (Humphreys & Galbraith, 1975). Participants do not necessarily associate the target and the cue when not instructed to do so, however they can make covert associations when necessary (Ley, 1977).

When you store an item in memory, you store the information about the encoding. If this information consists of a relation that item has with another word, then that other word may act as a cue at retrieval, however, even though an item is semantically related to another item, if this information about its relation is not stored, then that item cannot act as a cue to retrieve the target item. Their association has to be encoded together with their items (Tulving & Thomson, 1973). Encoding-specificity principle states clearly that for the cue to be effective it has to be encoded with the item it is meant to retrieve, irrespective of how related they are to one another (Tulving & Thomson, 1973). Using cues that were encoded together with the target item will facilitate retrieval far beyond a cue that was not encoded together with the target item or during free recall (Higham, 2002). When given the associations one made during encoding as a retrieval cue, the recall increases significantly

more than when given cues that are highly associated with the target but were not present at encoding (Ley & Huba, 1978). This means that the associative encoding is important.

A cue can be helpful in retrieving the target item but some cues are better than others. Cues that are encoded together with the target can better facilitate target retrieval than cues that are highly related to the target but only presented at recall (Goh & Lu. 2012; Ley & Huba, 1978). Cues that are not encoded together with the target are referred to as extralist cues and they only aid retrieval when participants are expecting free recall and not cued recall (Tulving & Thomson, 1973). In some cases where there is a strong association before the experiment, extralist cues can facilitate recall. If there is not a strong association before the experiment, then the encoding needs to focus on associations, only then can extralist cues aid recall (Ley, 1977). When subjects are not told that the cues they are presented with are strongly associated with the target words although they were not presented at the encoding phase, the recall was lower than with weak associates encoded with the target words (Santa & Lamwers, 1974). With instructions explaining the strong cues, recall was tremendously better than when no cue was available. Participants need to be aware of the connection between target and the cue for the strong cues to facilitate in retrieval (Santa & Lamwers, 1974).

Cued recall enables far better retrieval than free recall (Reddy & Bellezza, 1983). Even weak cues are better than free recall (Ehrlich & Philippe, 1976). On the other hand, if one organizes the items at encoding then free recall is enhanced (Epstein & Dupree, 1977). In a way, by integrating the items into a comprehensive unity, it becomes easier to retrieve those items later on. There is also a difference in recall depending on if it is free recall or forced, with better retrieval when there are strong cues when the retrieval was forced (Higham, 2002). Forced recall forces the participant to process the items more than with guessing or free recall (Pellegrino & Salzberg, 1975a).

Encoding-retrieval match

Apart from using cues to facilitate retrieval, the context can in its own way affect retrieval. According to the encoding-retrieval match, if the study phase and test phase are similar or the same, there should be an increase in accuracy of recollection (Poirier et al., 2012). When it comes to cues, certain items are more associated than others which suggest that activating one item should also activate associated items from memory. Some cues should be better at recalling its associates than other cues that are also associated, just not to the same extent. In relation to the encoding-retrieval match, regardless of the degree of

association, the association that is encoded during study phase elicits a better recollection if the test phase is similar, than an item which is more strongly associated with the target item but was not studied together (Zeelenberg, 2005).

In a way, the condition acts as a cue for retrieval. Supporting the encoding-retrieval match there is an increase in recall when the subjective context is the same at recall as it was at encoding (Reddy & Bellezza, 1983). Changing the cues from encoding to retrieval is also a type of context change. There is impairment when the context changes from encoding to retrieval, however the impairment is greater when the cue goes from being strong at encoding to weak at retrieval than a weak cue at encoding and a strong one at retrieval (Pellegrino & Salzberg, 1975b). Using fMRI, Vaidya et al., (2002) illustrated that the encoding-retrieval match is supported with memory recollection being faster if the test phase was similar to the study phase. Despite recollection of the target being faster when encoded and retrieved in the same condition, the retrieval cues were effective irrespective of the type of cue and accurately retrieved the target memory. If the cue is highly associated with the target then recall improves if conditions at encoding and test are the same. Having a weak cue at recall when there was a strong cue at encoding, then it is more difficult to recall the target memory. A cue at encoding and no cue at recall results in reduced recollection, irrespective of the type of cue it was at encoding (Ehrlich & Philippe, 1976).

Further, it has been shown that recollection being better when the encoding and retrieval phase are the same is dependent on the type of experimental setup (Dewhurst & Knott 2010). Dewhurst and Knott (2010) further investigated these ambiguous results. In one experiment they used anagrams in the encoding phase while the test phase consisted of either the same anagram composition as in the encoding phase, a different kind of anagram format or intact. Their results from this experiment showed that there is an advantage of having either anagram format at the test phase over the intact version. However, things are not that simple and there seems to be a limit to the advantageous effect on recollection by keeping the study and test context the same, or at least similar. When participants were to generate items from either anagrams or fragments at study, it was not enough to increase the recollection at the test phase by simply generating the items once again (Dewhurst & Knott, 2010). Having a generation study phase and a generation test phase was not advantageous by itself, indicating that there is more to it.

It is not the context, but the cue

Nairne (2002) dismisses the importance of the encoding-retrieval match, instead argues that a cue's retrieval success is dependent on the amount of items that are associated with it. The more items that are encoded or associated with the cue, the more difficult it is to retrieve a specific target. Obviously, there has to be a match between the cue and the target, but retrieval relies on how the cue uniquely is associated with the target to be able to retrieve it from long-term memory and no other, similar items which are irrelevant at that point. Nairne (2002) does not claim that encoding-retrieval match is not valid, but simply thinks that it is more correlational than causational and that the causation could be the diagnostic value of the cue.

On the other hand, Nairne's (2002) theory could be seen as an extension of the encoding-retrieval match (Poirier et al., 2012). Cue overload, which is a part of encoding-retrieval match, states that the effectiveness of a cue is reduced the more items are associated with the cue (Nairne, 2002; Poirier et al., 2012). Encoding-retrieval match is interlinked with cue overload and together they determine the effectiveness of the retrieval cue. Alone, neither one is solely responsible for the retrieval, but together they determine the cues capacity to distinguish the target from other irrelevant items (Poirier et al., 2012). This is referred to as memory-as-discrimination, where both encoding-retrieval match and cue overload play their part together.

This theoretical prediction was supported experimentally by Poirier et al. (2012). When participants were given one cue that uniquely identifies a target, the retrieval was faster than when there were two cues, one unique cue for the target and one that is shared with other targets. Interestingly, when presented with two unique cues, the time it took to retrieve the target was the same as when it was only one unique cue. In both the condition with two unique cues and the one with a unique and a shared cue, participants had to process two cues, nonetheless the response time were different, with slower response time for the condition containing the shared cue. The results support the memory-as-discrimination approach, and cannot be explained by the encoding-retrieval match. This is because when presenting one unique and one shared cue, there is a greater overlap in the encoding-retrieval match thus should aid the retrieval. Poirier et al., (2012) found that more information is not better if it does not uniquely specify a target and, in fact it can impair the retrieval process.

The diagnostic information provided by a cue is important for the recollection of a memory. The extent to which more than one cue aids the recollection process is dependent on

the new additional information it provides (Goh & Lu, 2012). A single cue can be more effective than two cues if those two cues have a lot in common with other items. If, on the other hand, the two cues uniquely identify a certain memory item, than those two cues are better, more effective than only one of these cues alone.

Retrieval-induced forgetting

As has been show there are several different ways in which to aid retrieval, but what also needs to be considered is that remembering can also cause forgetting. Retrieval-induced forgetting, hereafter referred to as RIF, is a phenomenon that illustrates how remembering one item impairs the recollection of other related items. By retrieving certain items belonging to a cue the retrieval of other items also associated with the same cue will be impaired and this is referred to as the RIF-effect (Anderson, Bjork & Bjork, 1994; Storm & Levy, 2012).

The standard version consists of four phases and was developed by Anderson, Bjork, and Bjork (1994). The first phase is the study phase where the category and its items are presented to be learned (e.g. COUNTRY-Italy). There are eight categories, each with six items each. Out of these six items, three are typical items meaning that they are highly associated with the category but not the most associated ones. The other three items are atypical items which do belong to the category but their relation is somewhat weaker but not the least associated items that belong to the category.

Next is the retrieval-practice phase where half of the categories, randomly decided, and half of the items, the atypical items within the selected categories are to be retrieved. The participants are given cues in form of the category name and the first two letters of the item (e.g. COUNTRY-It_____? for Italy) in order to aid recall. All the atypical items from the selected categories are repeated three times. The atypical items which are retrieved in this phase are referred to as Rp+ items, while the typical items from the same categories are Rp- items. The items from the categories which are not retrieved in this phase are referred to as Nrp items and they act as the baseline. Originally, Anderson et al., (1994) did not make a distinction between the Nrp items, but later researchers have divided the Nrp items into Nrp+ which stands for the atypical Nrp items and Nrp- which are the typical items.

After this is the third phase which is a distractor phase. Different researchers have used different types of distractor tasks and for different amount of time (see Groome & Grant, 2005; Spitzer & Bäuml, 2009). The standard version, as suggested by Anderson et al.

(1994), the distractor lasts for 20 minutes. The fourth and last phase is a final test phase where the participants, with the help of category-plus-one-letter cue (e.g. COUNTRY-I____? For Italy), are to retrieve all the items from the first phase, the study phase. The outcome of this is that the retrieved items from the retrieval-practice phase are more easily retrieved while the other items from the same category which were not retrieved in the same phase are much more difficult to recall later in the final test phase, even so more than the baseline items from the categories which were only presented in the initial study phase (Anderson, Green & McCulloch, 2000).

This can be explained by how a cue activates items which are associated with it. In this case the category is the cue and the category has many associated items. A cue which shares information with many items will activate those items during the retrieval search (Nairne, 2002). One possible way in which one is able to retrieve the target item when many other items are activated during the search as well, is to inhibit the irrelevant items (Levy & Anderson, 2008). Retrieving one target item, one inhibits the other items which are also associated with that cue. What the RIF-effect shows is that by retrieving some items, other items which share the same cue are more difficult to retrieve later on. At the same time, the retrieved items are easier to recall later on as well. Simply relearning the items does not require inhibition, only retrieval does (Johansson, Aslan, Bäuml, Gäbel & Mecklinger, 2007).

The extent to which recalling one memory can impair the recollection of other competing memories depends on their association and the relation it has to other competing memories. Interestingly, when the target and competitor are very similar, the competitor's impairment will be less than when they are simply just related but not that similar. Other competing memories will be more impaired the more similar they are when the target is retrieved, compared to the competing memories that are not so similar to one another (Anderson et al., 2000). In Nairne's (2002) words, the more similar the items are, the more information they share, meaning that a cue will activate all of them. There is no unique memory trace to aid the retrieval of the items. On the other hand, when there are unique memory traces the Rp- items are recalled easier and in those cases there is no RIF-effect (Jonker, Seli & MacLeod, 2012).

The reason why items need to be inhibited is because they interfere in the search for the target to be retrieved (Anderson et al., 1994). If a cue is specific to the target then there should not be any need for inhibition since other items are not activated in the search and competing for attention (Anderson, Green & McCulloch, 2000). However, the more

closely related the items are the stronger contenders they are in the search thus causing more interference (Verde, 2009). Interestingly, recalling memories fast or slow does not produce the RIF-effect. The RIF-effect only appears when the retrieval takes a moderate time for retrieving the memory suggesting that inhibition only occurs then (Keresztes & Racsmány, 2013). Fast recall suggests that the cue easily activates the target, without much interference while slow could be due to bad search strategy. Moderate time implies that the cue activated more than one item that are now interfering in the search for the target item. When there is no competition then there is no need for inhibition either (Jonker & MacLeod, 2012).

There have been some contradictory results regarding the inhibition account. If there is no competition at retrieval then there is nothing to inhibit. When experimentally reducing the competition by having the participants retrieve the category instead of the item in the retrieval-practice phase, no RIF-effect was observed (Anderson, Bjork & Bjork, 2000). The same type of experiment was conducted by Jonker and MacLeod (2012) and the opposite results were found, a RIF-effect emerged. Raaijmakers and Jakab (2012) thought that Anderson, Bjork, and Bjork's (2000) study might have been unchallenging and that presenting the target items could cause more attention to the target and not so much focus would be on the association between the target and cue (category). The researchers conducted a similar study in order to address their concerns. The difference was that instead of semantic categories the items were grouped according to their properties. The results they obtained showed a RIF-effect in a non-competitive context. In contrast to Anderson, Bjork, and Bjork (2000), the results of Raaijmakers and Jakab's (2012) study provide reasons to believe that in order to obtain a RIF-effect it is enough to strengthen the relation between the target and cue. There is no need for the inhibition of irrelevant items.

The RIF-effect has been observed even when there should not be one based on the inhibition account (Verde, 2013). When testing if the category and item are presented more than one time would later have an effect on recollection, the results showed that despite being presented twice in the initial study phase, the non-retrieved items and baseline are the same (Jakab & Raaijmakers, 2009). This poses some problems for the inhibition account since presenting something more than once should strengthen the items thus increasing the competition at retrieval, requiring more inhibition, which was not observed (Jakab & Raaijmakers, 2009). It could however be explained by the strengthening account. Another way to explain the RIF-effect is that by retrieving the items, the retrieved items gets strengthened making them easier to recall later on (Anderson, Bjork & Bjork, 1994). The

difference between the two accounts lay in the part in which the inhibition account claim that the items not retrieved in the retrieval phase are inhibited while the relative-strength competition argues that the retrieved items are strengthened thus making them competitors during retrieval of others with the same category as a cue (Verde, 2009).

The RIF-paradigm usually has a retrieval practice phase in between the study and test phase, but simply having a re-study phase where the items are presented again together with their categories, does not yield a RIF- effect (Jonker, Seli & MacLeod, 2013; Johansson et al., 2007). Retrieval of items leads to the detrimental effect and the beneficial effect that is part of the RIF paradigm, simply restudying some items instead of retrieval only leads to the beneficial effect but not the detrimental RIF-effect (Dobler & Bäuml, 2013). Inhibition theorists would argue that it is due to the lack of purpose to inhibit items since they are not retrieved, only presented once again. There is no RIF-effect since the processing of the items are the same in the study and re-study phase, however, this also means that the context in which it occurs are the same.

Jonker, Seli, and MacLeod (2013) argue that there is no RIF-effect on the account of the context remaining the same. To further support their claim of the importance of context, another experiment involving RIF and the extra-study phase instead of the retrieval-practice phase was conducted. The only difference was that in this particular experiment there was an imagination task which allowed for a change in context between the study and the extra-study phase. Contrary to the inhibition theory, there was a RIF-effect this time which supports the context account (Jonker, Seli & MacLeod, 2013). In accordance with the prediction of the context account, when experimentally manipulating the context as to reinstate the study context at the extra-study phase, there was no RIF-effect (Jonker, Seli & MacLeod, 2013). These experiments have all included extra-study instead of the normal retrieval-practice phase. Using the retrieval-practice phase and reinstating the study context upon the test phase yielded no RIF-effect, only when the context at test was different from the initial study context (Jonker, Seli & MacLeod, 2013). When the context was mentally changed from study to test phase, retrieving memories prior to the test phase actually aided the recollection for the target items at the final test (Bäuml & Samenieh, 2012). The opposite was true when the context was kept the same throughout the experiment.

The implications of RIF

The durability of the RIF-effect is contradictory at best. While some have found a RIF-effect after one week, although it was a smaller effect compared to the 5-minute delay (Storm, Bjork & Bjork, 2012), others have obtained contradictory results regarding a 24 hour delay. Abel and Bäuml (2014) found no RIF-effect after 24 hours but they did find a beneficial effect. Storm et al., (2012) and Abel and Bäuml (2014) did find the same results regarding fewer of the control items being recalled. One does remember more immediately after than after a 24 hours delay (MacLeod & Macrae, 2001). Recollection of the items belonging to the same category but which were not retrieved in the retrieval-practice phase was also lower, but not to the same extent as the control items (Storm et al., 2012). When including a retroactive interference no detrimental RIF-effect could be observed, but there was a retrieval-induced enhancement. The practiced and unpracticed items were not susceptible to interference, but the control items were explaining the results obtained (Abel & Bäuml, 2014). Both time and interference affect the control items and not the practiced and unpracticed items (Abel & Bäuml, 2014). The retrieval-practice effect is responsible for the durability of the RIF-effect (Anderson & Bell, 2001).

There is a limitation to the reliability of RIF. There are differences in individual's RIF scores between test and retest. When subjects were retested with the same items later, there was a significant correlation between test and retest but such a correlation was not found when the test and retest used different items (Potts, Law, Golding & Groome, 2012). The same was found for retrieval cues using the category and the first letter or a recognition test, no RIF-effect was found. Potts et al., (2012) offer an explanation for their finding which states that the inhibition of items differs between individuals. The items used are from a standardised table but that does not account for the individual differences that might arise since everybody have their own personal associations to the items, some stronger than others. They further conclude that RIF is only reliable with the same item set (Potts et al., 2012).

The RIF-effect has an impact beyond its immediate implications. When remembering facts about a topic, related facts are forgotten like a RIF-effect. Interestingly, this RIF-effect can be a subtle one. The researchers also found that if the facts share a relation, even though the topics do not, the fact that is not retrieved is later subjected to impairment when recall is called for (Anderson & Bell, 2001). It was also found that the integration of facts reduced long-term RIF-effect (Anderson & Bell, 2001). The RIF

paradigm is truly fascinating showing that even though one has a cue which should aid retrieval, it diminishes retrieval at the same time, irrespective if it is due to strengthening the retrieved items or inhibiting the un-retrieved items. Not only that, its effect transcends beyond the laboratory setting.

The RIF-effect can be observed when recalling autobiographical memories. Retrieving some of the autobiographical memories, results in poor recall of the related but un-retrieved autobiographical memories (Storm, Barnier, Sutton & Hirst, 2013). The size of the RIF-effect was not dependent on if the autobiographical memory was their own or not. It is easier to remember negative and neutral emotions than positive, but emotion does not affect the size of RIF. Within-individual retrieval-induced forgetting and socially-shared retrieval-induced forgetting were found even for intimate couples sharing autobiographical memories. Socially-shared retrieval-induced forgetting seems to be elicited even in free-floating conversations and this is true for both strangers and couples. This also means that one person can indirectly induce forgetting to another person's own autobiographical memories (Storm et al., 2013).

One's behavior can be affected by memory. Remembering positive or negative memories will affect one's behavior accordingly. During a RIF test, when the Rp- items where positive, in other words inhibited, the participants later chose to sit further away from someone (Fernandes & Saunders, 2013). This can be interpreted as them remembering the negative traits and when encountering a person those are the traits which might be attributed to that person. When the traits which were inhibited were negative, the participants decided to sit closer to an individual, associating the person with positive traits (Fernandes & Saunders, 2013). The fact that our brain works like this affects us tremendously.

It is not all negative as it might appear to be at the moment. The RIF-effect can be seen as something positive since it inhibits the recollection of irrelevant, unwanted memories. There is a negative correlation between individuals' cognitive failure and the level of their RIF-effect (Groome & Grant, 2005). This means that people who experience few cognitive failures also gain a high RIF-effect. It could be interpreted that high RIF-effect is an indication of a good inhibition mechanism and that high RIF-effect means that one is less forgetful in real life (Groome & Grant, 2005).

Retrieving memories does not always impair the recollection of other memories. It is quite fascinating that when one works with the goal of remembering, retrieving some items will impair de recollection of other, while the opposite is true for when one does not

consciously set out to remember (Bäuml & Samenieh, 2012). This means that there are ways in which to reduce forgetting. Integrating items will reduce the RIF-effect but most remarkably people seem to be integrating items even when not specifically told to do so (Anderson & McCulloch, 1999). It might be a mechanism for processing a lot of information and making it more coherent.

Working Memory's impact on memory retrieval

Individual's working-memory capacity (WMC) can influence how information is encoded and the ease or difficulty it will be recalled with. When the encoding phase and the retrieval phase are the same, high WMC individuals outperform low WMC individuals. In contrast, when there is a mismatch between encoding and retrieval phase, the difference between high and low WMC individuals is non-existing (Unsworth, Brewer & Spiller, 2012).

Although there is no difference between individuals with high and low WMC when it comes to recalling the retrieved items from the retrieval-practice phase, high WMC individuals do show a greater RIF-effect than low WMC individuals (Aslan & Bäuml, 2011). It can be argued that the results are as such due to high WMC individuals are better able to inhibit distracting items during retrieval. In other words, high WMC individuals are better able to inhibit the items which are not to be retrieved in order to retrieve the target item thus making it more difficult to retrieve the once inhibited item later at request.

Low and high WMC individuals seem to have different search strategies. Individuals with low WMC use more items in their search for the target to be retrieved thus requiring more inhibitory capacity for the irrelevant items it activated in its search for the target (Mall & Morey, 2013). High WMC individuals are better at strategically retrieving an item from long-term memory (Mall & Morey, 2013). This is further strengthened by the fact that during free recall the difference between high and low WMC individuals were significant in the amount of recollected items. By simply giving a cue, for instance the category, reduced the difference remarkably (Unsworth, Spillers & Brewer, 2012). What needs to be noted is that adding a cue increased the recollection among low WMC individuals but did not do so much for the high WMC individuals (Unsworth, Spillers & Brewer, 2012). The researchers are arguing that the underlying reason is that high WMC individuals are better at accessing cues, which they are referring to as higher order cues.

WMC does not only involve the manipulation of information but the maintenance as well. Depending on the amount of items which are required by the individual

to store will have an effect on the retrieval process. When there are only a few items to be recalled, there was no difference between high and low WMC individuals (Unsworth, Spillers & Brewer, 2012). The capacity is restricted hence it has an impact on the outcome.

The current study

In order to retrieve a memory one can use a cue, usually an associated item, which facilitates the target memory's retrieval. Within the RIF paradigm, one is presented with cues, cues which are not only encoded together with the target items but also associated with them. This, on its own, according to the encoding specificity theory should aid the target memory's retrieval. Nevertheless, the items which are not retrieved in the retrieval-practice phase, irrespective if it is due to them being inhibited or the retrieved items strengthened, the fact remains that they are more difficult to retrieve later on in the test phase.

Despite including several aspects which should aid retrieval, the RIF-paradigm includes two aspects which could be detrimental to the retrieval process. The RIF paradigm does not have the same context at study and retrieval which might be a cause for the RIF-effect. Besides the context change, within RIF one uses the same cue, the category, to retrieve more than one item. There the cue, which according to Nairne (2002), is not unique and is associated with many items making it more difficult to retrieve one specific item. According to Nairne's (2002) theory, unique, or diagnostic cues should aid retrieval while non-diagnostic cues, or cues which are associated to many items will make it more difficult to retrieve one specific target item. Considering how this phenomenon transcends into our everyday life, made it interesting to investigate if unique cues, creating a unique memory trace, could eliminate the need for inhibition by applying Nairne's (2002) theory to the RIF-paradigm.

Incorporating this, a RIF test was conducted with an added manipulation. The category-item pair were presented together with an image, which was either unique to the item or to the category. This means that for half of the categories, their items are associated with a unique image which should aid recall. The items within a category with the same image, share yet another cue apart from the category name and thus should not aid recall beyond the category name. In other words, the unique images will create a unique memory trace which should not activate other memories, not requiring inhibition and enhancing recall. The images which are the same for each item within a category will be associated with all the items and not create a unique memory trace. This way, irrespective if it is a unique image to

the target or not, the amount that needs to be processed is the same. The category-item pair has an already established association which should aid recall on its own, while the association the category-item pair have to the image will be established at encoding. According to the encoding-specificity principle, this should also aid recall in its own right since the relationship is established at encoding. However, since the final memory test within the RIF-paradigm will not contain the images, the context is changed from encoding to the test phase which according to the encoding-retrieval match should pose some problems for retrieval.

Hypothesis 1: With the unique cue encoded with each item, the RIF-effect should be lower, if any, since there is no competition between the items, hence there is no reason for inhibition.

Hypothesis 2: The non-unique cues are just adding another shared cue which should increase the RIF-effect, since no added information is provided that could make it easier to distinguish a certain item.

Method

Participants

Forty individuals participated in the study. However the results of 32 participants were included in the final analysis (female: 20, age: M = 24.97 years, range: 20 – 32 years). Forty participants completed the experiment; however, four participants did not recall a single item in one or more of the Nrp items and were excluded from further analysis. This exclusion resulted in unequal completion of conditions. To compensate for this and make sure that each category-item pair appeared equally often in a DC and a NDC condition as well as part of the retrieval-practice phase, four more participants were excluded. Their exclusion was based on a randomization within each condition.

The participants were students recruited around the campus at two universities in Sweden. They were told prior to participating that it is a memory test consisting of category-item pairs and images which they are to associate to one another and later will be tested on how much they remember. Before beginning with the experiment, all the participants gave informed consent.

Stimuli

Eight categories with 12 items each were included in the study. These were chosen from the Hellerstedt, Rasmussen, and Johansson (2012) lists of Swedish category norms. The items' taxonomic frequency was measured in a sample consisting of Swedish participants. The list excludes the three words which have the highest taxonomic frequency otherwise the participants could guess the word. There were six typical and six atypical items from each category chosen (see appendix A). None of the items within each category began with the same letter. Apart from the words, images were included as well. The images were different from one another and depicted different objects in various environments. The size of the images was kept constant and the images were depicting different objects. Every category-item pair was presented with an image. Out of the eight categories, four were provided with unique images for each item, while the other four categories have one image for each category. This means that there is a specific image for each category and every single item within that category was to be associated with that image. In total there were 52 images which were randomly assigned to either belong to one item or to the category.

Material

The experiment was programmed in E-prime. It was conducted on a 15.6 inch screen laptop.

Design

A two-way repeated measure ANOVA was carried out in order to investigate if there is a main effect of item type (Nrp and Rp), main effect of condition (DC and NDC) and a possible interaction effect. Anderson, Bjork, and Bjork (1994) have used both a significant level of .05 and .001 within the same experiment depending on the manipulation and the same can be observed in for instance Dobler and Bäuml (2013) study. Since there were only 32 participants, it seemed reasonable to keep the statistical significance level at $p < .05$.

The study is based on the standard retrieval-practice paradigm developed by Anderson et al., (1994) and thus consists of four phases. The eight categories were divided into two blocks with four categories in each. The reason for the two blocks is that together there are 96 category-item pairs which can be too much to learn all at once, so it was divided into two blocks with 48 category-item pairs each to make it more manageable. The first phase was the study phase where four of the categories and all its items were presented for the subject to

learn. The category and its item (e.g. COUNTRY-Italy) were presented together with an image. Each category-item pair was presented for 4000 ms, with a fixation cross preceding each presentation for 500 ms followed by a blank slide for 100 ms. The items were presented in a randomized order and which four of the eight categories were used in the first block was randomized for each participant. Within each block, two of the categories had unique pictures for each item and two categories had one image per category (i.e., the same background image for all items within the category). Which image was presented with which category-item pair was randomized for each participant, as well as which image became a unique image and which did not. Including two categories with unique images for each item and two categories with unique image for each category in each block was done so that the participants would not be able to guess the aim of the study. The category-item pair with a unique image is referred to as diagnostic cue (DC) since the image provides a unique cue, giving a diagnostic value to the target, while the category is a shared cue. The category-item pair with an image specific to the category and not the item is referred to non-diagnostic cue (NDC) since they simply add yet another retrieval cue that is shared, just like the category is a shared cue.

The second phase was a retrieval-practice phase where half of the categories and half of the items within these categories were retrieved from memory using provided retrieval cues. The items retrieved from the categories are the atypical items, referred to as Rp+ items. The retrieval cues consist of the category name and the first two letters of the name of the item to be retrieved from memory (e.g. COUNTRY-It_____? For the item Italy). These retrieval cues were presented together with the same image as they were presented with in the study phase. They were presented for 4000 ms and the participants were instructed to recall and say aloud to the experimenter the recalled item. Each item was presented three times. All items were presented in a randomized order. Which two category-items pairs to include in this phase was pseudo-randomized so that it was one with a unique cue to each item and one with a unique cue for the category, in other words one DC condition and one NDC condition.

The third phase was a distraction task which, in this particular study was counting backwards by seven for 30 seconds. Different tasks have been used in the various studies investigating RIF and in this study the same distraction task was chosen as in Aslan and Bäuml (2011) study which also lasted for 30 sec. This was done so that the items would not be present in short-term memory. The fourth and final phase is a test phase. The final test phase is similar to the retrieval-practice phase apart from that all the categories and all the

items are supposed to be retrieved, not just certain ones. Also, the retrieval-practice phase had the retrieval cues together with the images which were associated with the category-item pair at encoding while the final test phase does not include these images. The retrieval-cues were the category name with the first letter of the item name (e.g. COUNTRY-I____? For the item Italy). The retrieval order was controlled so that all the Rp- items were tested before the Rp+ items. Although free recall is an option, it is better to have a controlled order since during free recall the Rp+ items are usually the first ones to be retrieved thus potentially causing output interference and blocking retrieval of the Rp- items at the final test phase (Anderson, 2003). In order to control for this, this study used a controlled retrieval order with Rp- items recalled before Rp+ items.

This entire procedure was repeated once again for the remaining four categories, now belonging to block II. Afterwards, the participants were once again presented with the images which they had integrated with the category-item pair at the study phase. They were presented with all the images and using free-recall they were to recall and say out loud the category-item pair that belongs to that particular image.

Procedure

First of all, participants were further informed about the experiment once they arrived. They were informed that their results will be anonymous and how their results will be handled regarding data analysis as well as confidentiality. Further, they were informed that they could withdraw at any time without stating a reason for it. Before starting the experiment the participants gave written consent. Participants were seated in front of a computer. They started with the first phase where they were introduced to the category and its items of the first block. Which categories were presented in the first block was randomized between the participants. The participants were instructed to encode the category-item pair and to do so in relation to the image. It was emphasized that it was important to encode the images in relation to the category-item pair and that there would be a memory test on them as well. Once they completed this part of the experiment, the next phases were introduced accordingly. This entire procedure was repeated using the remaining four categories.

This was followed by introducing the images on their own and the participants had to recall using free-recall the category-item pair that they encoded with in the first phase. In all, the experiment took approximately 30 minutes to complete. When all the parts of the

experiment were done, the participants were debriefed about the aim of the study and received two lottery tickets.

Results

Participants

In the beginning 40 participants completed the experiment. Due to no recall of Nrp items by four participants, they were excluded from further analysis. This led to unequal distribution of conditions, which further led to the randomized exclusion of yet four more participants in order to counterbalance the conditions. When these, now 32 participants were analysed, the descriptive analysis revealed that two participants were outliers. When comparing the mean score to the 5% trimmed mean there was a difference, one participant (M = 0.266, 5% trimmed mean = 0.260) and the other participant (M = 0.354, 5 % trimmed mean = 0.349). Although the mean score is somewhat different from the 5% trimmed mean, excluding these two outliers would have resulted in two more outliers, not to mention the exclusion of six more participants in order to counterbalance the conditions. The results of 32 participants were analysed.

The retrieval-practice phase

In the retrieval practice phase, on average of 76% of the items with a diagnostic cue were recalled, compared to 67% of the items with a non-diagnostic cue. A paired-samples t-test shows that there is a significant difference in recall between the DC condition (M = 0.759, SD = 0.144) and NDC condition (M = 0.67, SD = 0.199), t (31) = 3.095, p = .004 (two-tailed). The mean difference in recall was 0.089 with a 95 % confidence interval ranging from 0.030 to 0.148. Eta squared statistic (.236) indicates a large effect size.

RIF-effect

A two-way repeated measures ANOVA was conducted in order to investigate if there was a main effect of item type (NRP- and RP-) and condition (NDC and DC) as well as an interaction effect. There was a significant main effect of item type, F (1, 31) = 4.62, p = .040, partial eta squared = .13, indicating a general RIF-effect. However, there was no main effect of condition, F (1, 31) = 3.74, p = .062, partial eta squared = .108 and no statistically significant interaction, F (1, 31) = 2.37, p = .134, partial eta squared = .071.

Although there were no interaction, but due the mean values observed in the analysis and in order to provide sensitive tests of our predictions, paired-samples *t*-test was conducted to investigate if the general RIF-effect can be observed in both the DC and NDC condition. There is a significant decrease in recall from Nrp-DC (M = 0.354, SD = 0.150) to Rp-DC (M = 0.266, SD = 0.139), t (31) = 2.63, p = .013 (two-tailed). The mean decrease in recall was .088 with a 95 % confidence interval ranging from .019 to .157. Eta squared statistic (.182) indicates a large effect size. In other words there was a RIF-effect.

There was no statistically significant decrease in recall of items with a non-diagnostic cue, Nrp-NDC (M = 0.375, SD = 0.151) to Rp-NDC (M = 0.336, SD = 0.158), t (31) = 1.153, p = .258. The mean decrease in recall was 0.039 with a 95 % confidence interval ranging from -.033 to .108. Hence, there was no RIF-effect.

Facilitation effect

A two-way repeated measure ANOVA was conducted revealing a significant main effect of item type (Rp+ and Nrp+), F (1, 31) = 61.127, p < .0005, partial eta squared = .664. However, there was no main effect of condition (DC vs NDC), F (1, 31) = 0.363, p = .551, partial eta squared = .012. Also, no statistically significant interaction, F (1, 31) = 1.306, p = .262, partial eta squared = .040.

Follow-up paired-samples *t*-test was conducted in order to investigate if there is a difference in recall between Rp+ and Nrp+ in DC and NDC separately. There is an increase in recall, a facilitation effect, for both DC, Rp+ (M = 0.531, SD = 0.169) in relation to Nrp+ (M = 0.284, SD = 0.127), t (31) = 6.561, p = .0005 (two tailed), with mean increase of .247 with a 95 % confidence interval ranging from .170 to .324 and partial eta squared statistic (.581) indicating a rather large effect size; and NDC, Rp+ (M = 0.495, SD = 0.214) to Nrp+ (M = 0.289, SD = 0.148), t (31) = 6.773, p < .001 (two-tailed), with a mean increase of .205 with a 95 % confidence interval ranging from .143 to .267, and partial eta squared statistic (.598) indicating a rather large effect size.

Images as cues

In the experiment, four categories were in the NDC condition meaning that there were four images associated with them. The images were presented and the NDC category-item pairs were recalled 76.6 % of the time. Regarding the images associated with a DC category-item pair, about 24.2 % were recalled. A paired samples t-test shows a significant

difference between the DC (M = 0.243, SD = 0.175) and NDC (M = 0.767, SD = 0.254) t (31) = -11.622, p < .0005 (two-tailed). The mean difference was -.523, with a 95 % confidence interval from -.615 to -.431, partial eta squared = .813.

Discussion

The present study set out to investigate if it was possible to create a unique memory trace that would not be affected by the inhibition effect in the RIF-paradigm. A RIF test was conducted with a specific manipulation. The items were associated either with a unique image (DC) or an image shared by all the items within the category (NDC). The hypotheses were that for the diagnostic cues (DC), there should be a lower RIF-effect if any and for the non-diagnostic cues (NDC) there should be a RIF-effect. The analysis revealed a general RIF-effect and further analysis show there was only a RIF-effect in the DC condition, not the NDC condition.

These results are not in accordance with Nairne's (2002) theoretical assumption that the retrieval of items is dependent on the diagnostic value of cues. With two shared cues there appears not to be any inhibition of irrelevant items making them less accessible. In fact, the opposite is true since it appears as though two shared cues make it easier to recall the target item. This means that no inhibition was necessary since, even though the cues are shared, they did not activate the other associated items. At the same time, having a unique image, a specific memory trace causes inhibition of other activated items that should not even be activated. Inhibition takes place because irrelevant items are activated and need to be inhibited in order to reach the target item (Jonker & MacLeod, 2012). These results suggest that having a specific cue, a specific memory trace to a specific item also activates more than the specific item and there is a competition in retrieval requiring the inhibition of the irrelevant items. This is what the results suggest. On the other hand, the entire inhibitory control account rests on that in order to retrieve one memory one needs to inhibit other, related but currently irrelevant memories. This rests upon the assumption that the items are retrieved in the practice phase, which in this particular experiment was 76% of the DC items and 67% of the NDC items. This is, in comparison with Anderson, Bjork, and Bjork (1994), in the lower range.

If the images did not have an effect then there should also have been a RIF-effect in the NDC condition as well which there was not. Perhaps it was easier to focus on the item when it was presented in the NDC condition since the image had been processed once before

and all that was left was to incorporate items with the image. Most of the participants did not have a problem recalling which image belonged to the NDC category-items. In the NDC condition the category and the image constitute a unity meaning that if the image appears the category will also. This is a pattern that can be learned upon seeing the image and category a second time. Once this unity is established, seeing the image or the category one can automatically focus on the item and establish a connection. In a way it makes it easier to encode the association between the image and the category-item pair. Since the item belongs to the category the category-item connection is already established. It limits the possibilities of items which could appear in the study phase and at the same time could perhaps strengthen the items once they are presented in the study phase. This could mean that the items which also belong to the same category but are not used in the experiment are inhibited while the ones that are presented in the experiment are strengthened.

In the DC condition, on the other hand, the image and the category-item pair had to be processed each time and incorporated into a unity. Unlike, in the NDC condition, it might have been more difficult to establish a connection between the image and the category-item pair. Considering the short timeframe the participant had to process the image and the category-item pair might have caused some problems in establishing a relation between the two. In other RIF studies each category-item pair appeared for 4000 ms in the study phase (see Bäuml & Samenieh, 2012) while in other it appeared for 5000 ms (see Anderson, Bjork & Bjork, 1994; Jonker, Seli & MacLeod, 2013). In retrospect, they used that time to memorize only the category-item pair, adding an image means more processing involved and perhaps the participants should have been allowed more time to be able to encode the relation between the image and the category-item pair. Since the NDC condition allowed for an easier way to establish an association between the image and the category-item pair, the images did have an effect on the inhibitory processes and reduced the RIF-effect. On the other hand, in the DC condition it was not as easy to make the connection between the image and the category-item pair and in the end if the images were not encoded together with the category-item pair then it turned out to be a normal RIF experiment as the results showed.

Encoding the images together with the category-item pair could have resulted in them being integrated with one another. By integrating category-item pairs one can reduce the RIF-effect (Anderson & McCulloch, 1999). The RIF-effect can be reduced with either a semantic integration or an episodic integration (Goodmon & Anderson, 2011). This could explain why there was not a RIF-effect in the NDC condition. Including one image created a unity for the

category making it possible to integrate the items to the category and image creating an episodic integration.

Regarding encoding-retrieval match, the images were present in the study phase but not in the test phase meaning that the context has changed from study to test phase which should pose equal problems for DC and NDC. What is observed, on the other hand is that only the DC condition had problems with retrieving Rp- items compared to Nrp- items, which in turn poses some problems for the encoding-retrieval match.

According to the encoding-specificity principle, the cue which is established at encoding with the target item will aid in retrieval of that item. Within the RIF paradigm, since the cues used are the categories which the items belongs to, there is an established association but it is also further strengthened in the study phase by being presented together. One needs to be aware that even though they are category-item pairs, half of them (Rp+) are not usual items and the participants do not always know the items. Considering the Rp+ items, the cue-item relation is created at encoding. Although the image was not present in the test phase, the category and the first letter of the item were, and since the category was also present at encoding, it should aid retrieval of the item irrespective of the image. Since there is a RIF-effect in the DC condition and not in the NDC condition, makes it difficult to interpret why the same type of retrieval cue only aided in one of the conditions. However, since the results obtained were different in the two conditions, this does illustrate that the images did act as a cue on their own, which due to the lack of the images as cues affected the results.

Further, participants WMC might have affected the results. It is difficult to say anything for sure since the study did not measure each individual's WMC. One's search strategy depends on one's WMC. Individuals with low WMC use a wider net of retrieval, activating more items than perhaps necessary which in turn require more inhibition (Mall & Morey, 2013). High WMC individuals on the other hand, are better at strategically searching for items and only use inhibitory capacity when the search set activates more items (Mall & Morey, 2013). The opposite is claimed by Aslan and Bäuml (2011) who, in their study found that high WMC individuals show a greater RIF- effect than individuals with low WMC. In Mall and Morey (2013) study, high WMC individuals showed a RIF-effect only when there was competition between the items. It could be the case that since the high WMC individuals are better able to strategically search for the item, the items that could be activated as well are strong contenders in the search thus requiring more inhibition. In the case with the low WMC individuals, they activate more items but irrelevant items that could easily be dismissed and

do not require the same amount of inhibition. Also, the amount if items one can recall are dependent on one's WMC (Unsworth, Spillers & Brewer, 2012). RIF is dependent on how cues are used and how much is remembered in the different conditions. Considering that low and high WMC individuals use different search strategies might explain why sometimes a RIF effect is found and yet sometimes it is not.

Irrespective if one has a high or low WMC the facilitation effect is the same (Aslan & Bäuml, 2011). What can be concluded is that there was a facilitation effect for both DC and NDC. One explanation for this is that when the context changes from study to test, retrieving items prior to the final test will aid recollection (Bäuml & Samenieh, 2012).

Limitations

At first glance it might appear as though the results are contradictory to Nairne's (2002) prediction regarding the impact diagnostic value of cues have on memory recall. What needs to be considered is that that claim rests on the assumption that the images were encoded and indeed became unique cues for that specific category-item pair. It is difficult to know if this was successful enough. At the same time, one needs to make sure that other factors are not influencing the results, as the integration mechanism might be.

Future studies

In the future, studies should include a measurement to make sure that the images were properly encoded, specifically in relation to the category-item pair. One way to enable deeper encoding is to have longer exposure of the images with their category-item pair.

A remarkable observation was that when the participants were presented with the images and had the task of recalling the associated category-item pair they were able to recall the items which they were not able to in the retrieval-practice phase nor the test phase. Irrespective if it was the right image or not, they were nonetheless able to recall the very items they were not able to just minutes before when presented with their category and the first letter. Future studies could focus on investigating if individuals are able to circumvent the inhibition of the items by using another cue to access them. Both the category and the image were presented in the study phase making both of them possible cues. In a way the same methodology as now however, in the final test phase use the images instead of the category-plus-first-letter cue.

To conclude the results of this study could either be interpreted as opposite to what was expected or as inconclusive. Replicating this study with a few changes should shine new light on the results.

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Appendix A

The list of category-item pairs used in the experiment.

Category	Item	Typicality	First letter
Frukt	Bigarrå	Atypical	B
Frukt	Dadel	Atypical	D
Frukt	Fikon	Atypical	F
Frukt	Guava	Atypical	G
Frukt	Litchi	Atypical	L
Frukt	Nektarin	Atypical	N
Frukt	Ananas	Typical	A
Frukt	Citron	Typical	C
Frukt	Körsbär	Typical	K
Frukt	Mango	Typical	M
Frukt	Plommon	Typical	P
Frukt	Vindruva	Typical	V
Klädesplagg	Fluga	Atypical	F
Klädesplagg	Hatt	Atypical	H
Klädesplagg	Keps	Atypical	K
Klädesplagg	Overall	Atypical	O
Klädesplagg	Pullover	Atypical	P
Klädesplagg	Rock	Atypical	R
Klädesplagg	Blus	Typical	B
Klädesplagg	Jacka	Typical	J
Klädesplagg	Trosor	Typical	T
Klädesplagg	Linne	Typical	L
Klädesplagg	Mössa	Typical	M
Klädesplagg	Shorts	Typical	S
Blomma	Dahlia	Atypical	D
Blomma	Hundkäx	Atypical	H
Blomma	Iris	Atypical	I
Blomma	Krokus	Atypical	K
Blomma	Gerbera	Atypical	G
Blomma	Magnolia	Atypical	M

Blomma	Lilja	Typical	L
Blomma	Nejlika	Typical	N
Blomma	Orkidé	Typical	O
Blomma	Pelargon	Typical	P
Blomma	Solros	Typical	S
Blomma	Viol	Typical	V
Fyrbent djur	Antilop	Atypical	A
Fyrbent djur	Buffel	Atypical	B
Fyrbent djur	Ekorre	Atypical	E
Fyrbent djur	Hyena	Atypical	H
Fyrbent djur	Igelkott	Atypical	I
Fyrbent djur	Krokodil	Atypical	K
Fyrbent djur	Giraff	Typical	G
Fyrbent djur	Lejon	Typical	L
Fyrbent djur	Marsvin	Typical	M
Fyrbent djur	Noshörning	Typical	N
Fyrbent djur	Råtta	Typical	R
Fyrbent djur	Tiger	Typical	T
Sport	Curling	Atypical	C
Sport	Diskus	Atypical	D
Sport	Fäktning	Atypical	F
Sport	Karate	Atypical	K
Sport	Squash	Atypical	S
Sport	Vattenpolo	Atypical	V
Sport	Brottning	Typical	B
Sport	Golf	Typical	G
Sport	Höjdhopp	Typical	H
Sport	Innebandy	Typical	I
Sport	Löpning	Typical	L
Sport	Rugby	Typical	R
Yrke	Arkitekt	Atypical	A
Yrke	Designer	Atypical	D
Yrke	Lantmätare	Atypical	L

Yrke	Pilot	Atypical	P
Yrke	Sotare	Atypical	S
Yrke	Veterinär	Atypical	V
Yrke	Brandman	Typical	B
Yrke	Frisör	Typical	F
Yrke	Ingenjör	Typical	I
Yrke	Journalis	Typical	J
Yrke	Kock	Typical	K
Yrke	Målare	Typical	M
Land	Bolivia	Atypical	B
Land	Holland	Atypical	H
Land	Malaysia	Atypical	M
Land	Portugal	Atypical	P
Land	Sydafrika	Atypical	S
Land	Turkiet	Atypical	T
Land	Australien	Typical	A
Land	England	Typical	E
Land	Italien	Typical	I
Land	Kina	Typical	K
Land	Norge	Typical	N
Land	Ryssland	Typical	R
Musikintrumment	Banjo	Atypical	B
Musikintrumment	Dragspel	Atypical	D
Musikintrumment	Fagott	Atypical	F
Musikintrumment	Luta	Atypical	L
Musikintrumment	Puka	Atypical	P
Musikintrumment	Ukulele	Atypical	U
Musikintrumment	Cello	Typical	C
Musikintrumment	Harpa	Typical	H
Musikintrumment	Klarinett	Typical	K
Musikintrumment	Orgel	Typical	O
Musikintrumment	Saxofon	Typical	S
Musikintrumment	Tvärflöjt	Typical	T