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## A Declarative Memory Model of Evaluative Conditioning

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### Abstract

I propose a Declarative Memory Model (DMM) of evaluative conditioning (EC). EC effects are changes in the valence of a conditioned stimulus (CS) due to previous pairings with a positive or negative unconditioned stimulus (US; e.g., De Houwer, 2007, <https://doi.org/10.1017/S1138741600006491>). According to the DMM, EC effects are found if (1) a memory trace is formed in the learning phase that links the CS to evaluative information from the US, if (2) this trace survives the retention interval, if (3) the trace or part of it is consciously retrieved when the CS is being evaluated, and if (4) the retrieved trace is used in the CS evaluation. For each of these stages, I make separate predictions about EC effects, many of which are based on empirical research on declarative memory. Where available, I report and discuss empirical evidence on EC that speaks to these hypotheses. The available empirical evidence is largely in line with the predictions of the DMM. Several predictions, however, have yet to be tested and some findings are ambiguous. While the DMM specifies conditions under which CS-US pairings should lead to a valence change, it does not deny the possibility that other processes might lead to a change in attitude as well. Advantages of the DMM are its foundation on declarative memory research, its applicability for attitude change effects in general, and its suitability for predictions of EC effects in the real world.



**Keywords**

evaluative conditioning, declarative memory, contingency awareness, encoding, retention interval, retrieval

Many of our attitudes, if not most, are learned rather than genetically determined. A simple environmental constellation that leads to a change in preference is the pairing of a stimulus (referred to as conditioned stimulus or CS) with another, typically positive or negative stimulus (referred to as unconditioned stimulus or US). This change in preference is called evaluative conditioning (EC; e.g., De Houwer, 2007; for overviews see De Houwer, Thomas, & Baeyens, 2001; Gast, Gawronski, & De Houwer, 2012; Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010). EC has been predominantly studied by researchers with a background in social cognition or social psychology. Hence, EC is most often discussed against a background of associative, propositional, or dual-process-models, which have a successful tradition of application in social psychological attitude research. However, while most researchers would agree that EC effects must at least be partly based on memory processes, little attention has been paid to what a memory perspective tells us about EC effects and which empirical hypotheses we can derive from memory research. In the current paper, I will propose the Declarative Memory Model of EC effects (DMM).

**The Basic Hypotheses of a Declarative Memory Model of EC**

The core idea of the DMM is that declarative, or conscious, memory traces that contain evaluative information can lead to a change in liking of whatever is currently being evaluated. If a participant sees a CS after an EC procedure, the probability is increased that the participant retrieves and consciously represents evaluative information from the pairing phase and that this information influences the evaluation of the CS.

According to this model, the typical EC effect is based on four events:

- (1) A memory trace is formed during the perception of the CS-US pairings; this memory trace can contain various information, but it needs to at least link the CS to evaluative information from the US.
- (2) This trace, or at least the part of the trace that links the CS to evaluative information from the US, survives the retention interval, that is, the phase between the presentation of the CS-US pairs and the measurement of CS valence.
- (3) The trace, or at least its evaluative information, is retrieved and consciously represented<sup>1</sup> when the CS is being evaluated.

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<sup>1</sup> In the following, I speak of “conscious retrieval”, although it is not the retrieval process that needs to be conscious but the ensuing mental representation.

- (4) The evaluative information from the retrieved trace is used in the CS evaluation.

If these four conditions are met, an EC effect should occur.

The model can thus explain those EC effects that follow from a procedure that gives rise to conscious retrieval of information from the conditioning phase. If conditions that promote conscious retrieval are met, EC effects should – *ceteris paribus* – be stronger. The proposal of this process, of course, does not preclude the possibility that other processes can mediate an EC effect as well. I do assume, however, that a large part of EC effects that are found with prototypical EC paradigms are in fact based on this process.

By distinguishing the first three events, trace formation, trace storage, and trace retrieval, the DMM follows a distinction that has shaped memory psychology for a long time. This is the distinction of factors and processes at the three phases of a memory effect, that is, (1) the learning phase, (2) the retention interval, and (3) the measurement or expression phase (Melton, 1963; Roediger & Gallo, 2002). According to the DMM, relevant factors in EC can also be distinguished based on whether they have an influence during (1) the learning phase, (2) the retention interval, or (3) the measurement phase. In the measurement phase, the DMM makes a further distinction that is unique to evaluative learning effects: A distinction between the retrieval and use of evaluative information.

In the following sections, I thus discuss – separately for these phases – factors that are theoretically relevant from the perspective of the DMM. Most of the factors can increase or decrease the probability that previously presented information can be correctly retrieved during the evaluation phase. Some factors can influence the temporal function of retrieval, e.g., a factor might not only influence how likely it is that a piece of information is retrieved at time  $t$  but also how much retrieval differs between  $t$  and  $t+1$ , which could also be described as the stability of memory. Finally, some factors do not feed into the probability of retrieval, but influence whether the retrieved information is used for CS evaluation.

## The Learning Phase

According to the DMM, a memory trace needs to be formed in the learning phase that at least links the CS to some evaluative aspects of the US. There are many variables during the learning phase that are known to influence the formation of a consciously retrievable memory trace. According to the DMM, these should also influence the EC effect. I focus here on factors that are well-known to influence declarative memory at the learning stage and are thus hypothesized to also influence EC.

### Attention and Awareness of Stimuli During Encoding

Declarative memory performance is clearly better after learning with undivided attention ( Craik, Govoni, Naveh-Benjamin, & Anderson, 1996; Fisk & Schneider, 1984). Accord-

ing to the DMM, the same is to be expected for EC effects. In line with this prediction, the majority of studies show that EC effects are larger with undivided attention (Dedonder, Corneille, Yzerbyt, & Kuppens, 2010; Field & Moore, 2005; Pleyers, Corneille, Yzerbyt, & Luminet, 2009; but see Walther, 2002, for an opposing finding).

Can EC effects occur at all under sub-optimal learning conditions (subliminal stimulus presentation, divided attention, or implicit learning paradigms)? Some results, for example with the “surveillance paradigm” (Olson & Fazio, 2001), suggest that EC can occur in a procedure that, similar to an implicit learning paradigm, does not direct attention to the relevant stimulus relation. From the perspective of the DMM, it is crucial that such paradigms, however, do not preclude awareness. There is evidence that participants can become suddenly aware of stimulus relations during an implicit learning phase (Haider, Eichler, & Lange, 2011; Rose, Haider, & Büchel, 2010). In these paradigms insight into the relation seems to occur when participants search for the cause of an unexpected event during the learning phase (Rünger & Frensch, 2008). From the perspective of the DMM, this suggests that EC effects can occur in an implicit learning procedure, but only if it allows the CS-valence relation to be consciously detected (thus not with subliminal stimulus presentation) and only if the participant actually makes this detection.

Few tests have focused on whether EC effects can be found after subliminal presentations. Here the DMM would predict no EC effects. In what is likely the most thorough and highly powered investigation, Stahl and colleagues (Stahl, Haaf, & Corneille, 2016), in line with expectations from the DMM, did not find evidence for even small EC effects after subliminal or close-to-subliminal presentations. Recent work on close-to-subliminal presentation times suggests that EC effects might only be found for those stimuli that were identified above chance-level (Heycke & Stahl, 2018).

### **Amount of Exposure**

Declarative memory performance improves with the amount of exposure to the pairings and in particular with the number of repetitions of the to-be-learned stimuli (e.g., Mechanic, 1964). Mere repetition of the trials has less of an effect on memory than is often assumed (Greene, 1987) and many studies demonstrate reliable memory effects after a single presentation of each item. In line with the DMM, EC effects also increase with the number of pairing repetitions, but are not moderated by the number of pairings if memory for the pairings is perfect (Bar-Anan, De Houwer, & Nosek, 2010). Like declarative memory, EC can occur after a single learning trial (Gast & Kattner, 2016).

A special case is the repetition of study items after an interval, which can either be seen as an event in the learning phase or an event during the retention interval. This topic will be discussed in the section “Consolidation and Semanticisation”.

### **Distracting Stimuli**

In memory research, the influence of interfering stimuli is typically divided into stimuli presented before and stimuli presented after the to-be-learned pairs. Effects that dem-

onstrate the interfering effect of stimuli presented before the to-be-learned pairs are the primacy effect (e.g., Murdock, 1962) and the proactive inhibition effect (Keppel & Underwood, 1962). The DMM would predict similar interference effects due to previously presented stimuli on EC effects. However, to the best of my knowledge, this has yet to be tested. The influence of later presented stimuli, in particular the retroactive interference effect (Barnes & Underwood, 1959), will be discussed in the section about events during the retention interval.

### **Distributed Learning**

Declarative memory is better when repetitions of the relevant information are distributed over time (see Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006, for a review and meta-analysis). In line with the DMM, we recently found first evidence that EC effects also increase when stimulus presentations are distributed over time (Richter & Gast, 2017).

### **Depth of Processing and Meaningful Stimulus Combinations**

Declarative memory performance is moderated by processing instructions. The well-known levels-of-processing account ( Craik & Lockhart, 1972) predicts better performance after “deeper” encoding. Tasks that encourage semantic processing of stimuli lead to better memory performance than tasks that encourage processing of peripheral (e.g., orthographic) features (Craik & Tulving, 1975). Although semantic and non-semantic processing have not been compared for EC, there is evidence that EC effects are more pronounced if the task encourages participants to process the CS-US relation (Kattner, 2012). In other studies, participants were encouraged or instructed to process the valence of the stimuli rather than non-evaluative features (Gast & Rothermund, 2011) or to see the CS and US in a positive or similarity relation rather than in a negative or dissimilarity relation (Fiedler & Unkelbach, 2011; Förderer & Unkelbach, 2013; Peters & Gawronski, 2011; Zanon, De Houwer, & Gast, 2012; Zanon, De Houwer, Gast, & Smith, 2014). In these studies, however, the level of processing is similar in both conditions. The effects in these studies can thus not be explained with deeper encoding of the stimulus pairs, but rather with different usage of the encoded information. An interesting finding with regard to these relational effects, however, is that they are stronger when the relational information is given during or before rather than after the learning phase (Peters & Gawronski, 2011; Zanon et al., 2014). From the perspective of the DMM, this can be explained with the plausible assumption that relational information has the most impact when it is given during the stimulus presentation and can thus be encoded repeatedly together with the CS-US pair.

Relevant – and potentially problematic – for the hypothesis that EC effects should be larger after deeper encoding is the meta-analytical finding that EC effects are larger for verbal nonsensical than for verbal sensible CSs (Hofmann et al., 2010). Combinations of meaningful stimuli should be easier to encode semantically; therefore, their processing should be deeper. This should lead to better retrieval and, *ceteris paribus*, to larger EC effects. The use of meaningful CSs, however, can plausibly have at least one other effect:

Once retrieval of evaluative information has occurred, a meaningful CS might be less influenced by it because participants are more likely to already have an attitude about it.

This point exemplifies a more general point: Some factors might have an influence at different stages of the process that leads to an EC effect (i.e., during the learning phase, the retention interval, and/or the measurement phase). Important examples for factors that can influence different phases are stimulus and participant factors. Such parallel processes can have additive or counteracting influences on the EC effect. Therefore, testing the influence of the factor by only assessing the size of the EC effect does not yield conclusive information (see also the section on phase independent factors). Designs that succeed at manipulating the influence separately for the different stages or that allow the influence to be measured in the different stages can help to disentangle these processes.

Not only the meaningfulness of individual stimuli, but also their meaningfulness as a combination can influence encoding. If a CS and a US are related, it can be assumed that their pairing appears more meaningful. The encoding of a pairing of a CS and a US that are related should thus be easier. According to the DMM, EC effects should thus be larger if the CS and US are related.

### **Stimulus Features: Distinctiveness and Concreteness**

According to the DMM, EC effects can be found for all types of stimuli. Based on what we know from the memory literature, however, highly concrete (Paivio, 1986) and distinctive stimuli (Hunt & McDaniel, 1993) lead to better memory. According to the DMM, these types of stimuli should thus, *ceteris paribus*, lead to larger EC effects. Similar to meaningful stimuli, however, concrete and distinctive stimuli might not only differ in encoding but also in retrieval processes and in how likely it is that memory traces are used for their evaluation.

## **The Retention Interval**

The retention interval is the time span that lies between the learning phase and the measurement phase. Even without strong assumptions on how memory is represented during this interval, it can be useful to assume that even when nothing is currently retrieved, some information is stored and can, in principle, be accessed. This allows, for example, memory failures due to lost information to be distinguished from those due to currently inaccessible information. I refer to the stored information simply as the “memory trace”.

A broad distinction among factors that play a role during the retention interval is between the mere passage of time, on the one hand, and events on the other (Lockhart, 2000).

### **The Passage of Time**

The DMM only predicts EC effects if a memory trace that contains evaluative information is retrieved at the time that CS valence is measured. When such a trace is lost, the declarative memory account predicts no EC effect. Whether a memory trace is entirely lost after successful encoding, however, is a difficult question because memory failure after encoding

can also be due to retrieval problems (see the section on the measurement phase). Thus, research on forgetting focuses on forgetting rates or forgetting functions that can be determined by comparing performance on one memory measure at different points in time. It shows that the passage of time leads to predictable rates of forgetting of declarative information (e.g., Loftus, 1985; Rubin & Wenzel, 1996; Slamecka & McElree, 1983). Therefore, according to the DMM, EC effects, too, should get smaller as time passes.

Only a few studies have investigated the influence of the passage of time on EC effect – with somewhat mixed results. A study by Fulcher and Cocks (1997) tested EC effects immediately and after a two-month-delay. Because of drop-out that reduced the sample from 18 to 13 participants, the EC effect was not compared across time. Contrary to the predictions of the DMM, the results do suggest, however, that the EC effect did not decrease to the same degree as memory for the pairings: While memory for the pairings was reduced from 30 to six percent, there was still an EC effect for the pairs that were not remembered in the second session. In addition to the small sample, however, there are a few aspects of the study that might limit its interpretability for the DMM's hypothesis. First, the authors tested identity rather than valence memory, which might have underestimated the availability of a memory trace containing evaluative information. Second, in order to employ a liberal criterion, the authors categorized all pairs for which the participant responded correctly or gave no answer as correctly remembered. On the one hand, this might lead to an overestimation of available memory. On the other hand, it is not clear whether the memory reduction is due to forgetting or to a change in the tendency to guess when no clear memory is available. Third, the pairing procedure was atypical: Each stimulus pair (consisting of a picture of a plant as CS and a word as US) was shown only once for 25 seconds (5 seconds CS only + 20 seconds both stimuli) with the instruction to form a mental image of the two stimuli interacting with each other. This instruction could have led to the formation of additional memory traces that might have been the basis for the EC effect, but were not picked up by the memory measure.

Förderer and Unkelbach (2013) tested memory and EC effects immediately after the conditioning phase (T1) or after a delay of one week (T2). The authors found a reduction in memory performance. Results on EC measures were somewhat mixed with regard to the predictions of the DMM. Contrary to the predictions of the DMM, EC effects assessed with a rating measure were not reduced over time, but – in line with the DMM – EC effects on an affect misattribution procedure (AMP; Payne, Cheng, Govorun, & Stewart, 2005) were. When analyzing EC effects for only those CSs for which the paired valence was not correctly remembered after the delay, ratings showed reversed EC effects and no EC effect was found on the AMP. This finding is in line with the DMM. As the authors did not separately analyze CSs that were remembered at T1, but forgotten at T2, however, these null effects may partly be due to encoding failures rather than forgetting.

In a study that was designed to more specifically investigate the relevance of available memory in the measurement phase, Gast, De Houwer, and De Schryver (2012) also employed two sessions: CS-US pairings took place in the first phase (T1); the central valence

measures were assessed in the second session 9-10 days later (T2). Memory was assessed twice, once at T1 and once at T2. It was shown that memory for the pairings during the measurement phase (T2) was a clear predictor for EC effects (both on an explicit rating and on an affective priming measure) above and beyond memory for the pairings at T1. Results were similar when using a more liberal memory criterion where CSs were categorized as remembered when the participant selected either the correct US or a wrong US of the correct valence. Forgotten pairs (those pairs that could be reported at T1, but not at T2) showed no EC effect on any of the measures. These findings are compatible with the hypothesis that EC effects are influenced by forgetting due to the passage of time.

### **Events: Retroactive Interference, Retrieval-Induced Forgetting, Directed Forgetting, and Induced False Memories**

Events that take place during the retention interval have been shown to reduce retrieval of previously learned information. An example of this is retroactive interference (e.g., Barnes & Underwood, 1959). In a classic retroactive interference paradigm, participants first learn a list of stimulus pairs, denoted as A-B. In a next phase, participants study a partially overlapping list of stimulus pairs, denoted as A-C. This typically interferes with retrieval of the previously learned stimulus pairs A-B. Another example is retrieval induced forgetting (e.g., Anderson, Bjork, & Bjork, 1994). In retrieval-induced forgetting, people first learn partially overlapping stimulus relations A-B and A-C. If people in the next phase are cued to retrieve stimulus C upon the presentation of stimulus A, retrieval of stimulus B is later reduced. A third example are directed-forgetting paradigms, where participants study stimulus lists and are then instructed to either forget or continue remembering a specified subset of the stimuli. Several authors have shown that participants recall less of the to-be-forgotten than of the to-be-remembered items (for reviews, see Bjork, 1972; MacLeod, 1998). In a recent study, Gast and Kattner (2016) showed that EC effects from a procedure similar to a typical instructed forgetting procedure are influenced by forgetting vs. remembering instructions that are given after the initial learning phase.

No published studies have tested whether EC effects are susceptible to retroactive interference or retrieval induced forgetting manipulations. Sweldens, Van Osselaer and Janiszewski (2010), however, showed that a procedure similar to retrospective interference can decrease EC effects under conditions that promote stimulus-stimulus learning, but not under conditions that promote stimulus-response learning. Different from the interference phase in the classic retroactive-interference studies, however, the interference phase in this study did not contain any of the originally studied stimuli. Furthermore, it was not tested whether the manipulation actually interfered with memory for the CS-US pairings in one or both conditions. It is therefore not entirely clear whether EC effects actually decreased as a function of retroactive memory interference.

Events that take place between the study and the measurement phase cannot only reduce memory, but also lead to false memories. Loftus and colleagues (Loftus, 1975; Loftus, Miller, & Burns, 1978; Loftus & Palmer, 1974), for example, demonstrated an effect of false

presupposition questions. After seeing a film clip of an accident, participants were asked such questions as “Did you see the children getting on the school bus?” which increased reporting of non-existent items (i.e., the school bus). The DMM predicts that EC can also be influenced by false presuppositions. This means that participants should not only be influenced by pairings they have actually seen but also by pairings that were, during the retention interval, implied to have been presented before. While this has not been tested yet, two recent studies investigated EC effects based on inferred pairings. Participants were first presented with trials that only contained positive and negative USs and some cues to identify these. In a second step, participants received information from which they could infer the presence of CSs during these trials. The CSs changed in valence according to the USs they were supposedly paired with (Gast & De Houwer, 2012).

### Consolidation and Semanticisation

Both the mere passage of time and the repetition of study items can lead to memory *consolidation* (e.g., Dudai, 2004; Lechner, Squire, & Byrne, 1999; McClelland, McNaughton, & O’Reilly, 1995). Consolidated memory is more stable, that is, less sensitive to the influence of time and interfering events. According to the DMM, if memory for pairings becomes consolidated, EC effects that are based on these pairings should also become more stable.

Only a few studies on EC have investigated the impact of a longer delay between study phase and measurement phase (Förderer & Unkelbach, 2013; Fulcher & Cocks, 1997; Gast, De Houwer, & De Schryver, 2012). None of these investigated whether EC effects are more stable and less sensitive to interfering factors after a delay. Although it has been shown that increasing the number of repetitions leads to an increase of the EC effect (Bar-Anan et al., 2010), it has yet to be tested whether this also leads to EC effects that are more stable.

Memories often change from being more to less detailed. Sometimes this process is referred to as semanticisation, that is, memories that were originally of an episodic nature (in other words, connected with “when” and “where” information) become semantic (e.g., Wiltgen & Silva, 2007; Winocur & Moscovitch, 2011). This could occur after the conditioning phase of an EC experiment, when detailed memories of the pairing phase become less detailed over time. This suggests that newly acquired EC effects are more likely to be accompanied by more detailed memories than earlier acquired EC effects. Importantly, according to the DMM, an EC effect can be based both on the retrieval of a detailed episode, but also on the retrieval of a vague memory of something positive or negative. It is thus possible that an EC effect of the same size occurs with recent, more detailed and older, less detailed memories. If the memory measure is not entirely sensitive to also detect more vague memories, however, a dissociation might be found between more and less recent EC effects and their relation to explicit memory. This might give the impression that only recent EC effects depend on memory, while in fact both recent and older EC effects depend on memory, but only recent memory is detected. Some of the findings on the development of EC effects over time discussed above in the section “The Passage of Time” might be interpreted in this light.

## The Measurement Phase

Retrieval is a crucial, if not the key, component of a memory process (Roediger, 2000). If a memory trace has been formed during the learning phase and if it has survived the retention interval, it might or might not – depending on a number of factors – be retrieved while the participant expresses their evaluation of the CS. If retrieval occurs, it also depends on a number of factors whether it influences CS evaluation. The following paragraphs discuss factors that are (1) relevant for the occurrence of retrieval and (2) relevant for whether retrieved information influences CS evaluation.

### The Probability of Retrieval From the Learning Phase

A central difference between measurement of declarative memory and measurement of the EC effect is of course that giving a valid response in a CS valence measure does not require the participant to retrieve anything at all. A participant can give an idiosyncratic evaluative response based on color, shape, or any other feature of the CS. From the perspective of the DMM, however, the likelihood that memory traces are retrieved that were formed during the learning phase is theoretically relevant.

The following factors that influence whether information from the learning phase is retrieved in the measurement phase will be discussed: (1) the presence and type of retrieval cues, (2) characteristics of the evaluative measurement task, and (3) the person's motivation to retrieve information from the learning phase.

### Retrieval Cues

After multiple CS-US pairings, the CS is an ideal retrieval cue for the US. Although other stimuli may have co-occurred with the USs, the CSs are typically the only stimuli that have a specific experimentally controlled co-occurrence history with either one specific US or with several USs of the same valence. Therefore, the probability that a participant retrieves evaluative information from CS-US pairing trials is increased during the evaluation of a CS. This factor by itself might be responsible for a large proportion of EC effects.

Various factors can influence how effectively a CS cues retrieval of information from previous phases: According to memory research, an important factor that promotes retrieval is the distinctiveness of the cue, that is, how novel it is for the participant and how unexpected in a given context (“contextually inappropriate”) (Herz, 1997; Hunt & McDaniel, 1993). The DMM predicts that a more distinctive CS is more likely to trigger retrieval of the pairing episodes and is therefore more likely to lead to EC effects. Distinctiveness of the CS, however, might also be systematically related to encoding processes and the probability that retrieval influences CS evaluation (see sections on “Depth of Processing and Meaningful Stimulus Combinations” and “Phase Independent Factors”).

Another important type of retrieval cue are context cues, which are stimuli that indicate the validity of a stimulus contingency. A context cue could, for example, indicate that

a specific CS (which by itself does not predict a positive US) in the current context predicts the occurrence of a positive US.

In the memory literature, there is strong evidence that context stimuli that are present during both the measurement phase and the study phase can facilitate retrieval (e.g., Spear, 1973). For Pavlovian conditioning as well, there is strong evidence that effects in paradigms that involve two phases with different stimulus contingencies (e.g., extinction, counterconditioning, or latent inhibition) depend on which of the phases is cued and accordingly retrieved during measurement of the effect (e.g., Bouton, 1993). The DMM predicts that EC effects should be moderated by context cues. While this has not been tested in a prototypical EC procedure, a large research line shows evidence for context effects in a related evaluative learning paradigm (Gawronski, Rydell, Vervliet, & De Houwer, 2010; see also Gawronski, Rydell, De Houwer, Brannon, Ye, Vervliet, & Hu, 2018). The authors used an attitude formation procedure where a target individual was presented together with positive or negative behavioral descriptions in a first phase and with behavioral descriptions of the opposite valence in a second phase. In the first and second phase, different background colors were used as context cues. The authors showed that the evaluation of the target assessed with an AMP (Payne et al., 2005) depended on the presence of context cues in the measurement phase and on the salience of the context cues in the learning phases. This set of findings is in line with the predictions of the DMM.

### **Characteristics of the Evaluative Measurement Task**

A wealth of research from the memory literature indicates that retrieval depends on the type of retrieval task (Lockhart, 2000). From the perspective of a DMM, EC effects should thus be influenced by how likely a valence measure leads to retrieval from the pairing phase.

Crucially, the dependent measure in an EC paradigm is per definition a measure of CS valence. The participant almost never has the direct task to retrieve anything at all. This means that all EC measures are only indirect assessments of memory – even if they are direct assessments of CS valence. From this it follows that CS valence measures in general should lead to retrieval with a lower probability than direct memory measures. This assumption fits with the finding that EC does not occur without contingency memory, but contingency memory does occur without EC (Bar-Anan et al., 2010) – although the finding can also be explained by assuming that not all relevant retrievals are used in evaluation (see below).

Furthermore, different CS valence measures differ among each other in how likely they are to trigger retrieval of the CS-US pairings. A first factor in this regard is whether the CS is task-relevant in the measure. The CS is the most important retrieval cue and a CS that is task-relevant is more likely to trigger retrieval of the evaluative information than a CS that is not. In an explicit evaluative rating task, the CS is task-relevant. In many implicit measures, however, the CS is not task-relevant. In the evaluative priming task (Fazio, Sanbonmatsu, Powell, & Kardes, 1986) and in the AMP (Payne et al., 2005), for example, the participant is tasked with responding based on the valence of a target; the CS is presented shortly before as a prime and expected to influence the response to the target only uninten-

tionally. The DMM predicts larger EC effects for measures in which the CS is task-relevant than for measures where it is not.

A second relevant factor is whether the participant has to give an evaluative response. What is asked about the CS is likely to influence what is retrieved about the CS (Spruyt, De Houwer, & Hermans, 2009). It is thus more likely that a person retrieves evaluative memory episodes, such as the occurrence of the US, when they respond in an evaluative task than in a non-evaluative task. While explicit measures and some implicit measures, such as an affective priming procedure with an evaluative task, require an evaluative response, other implicit measures, such as an affective priming procedure with a lexical decision or naming task, do not require evaluative responses. The DMM predicts larger EC effects for measures with an evaluative task than for measures without an evaluative task.

A third factor is the degree of time pressure under which responses are given. Research on the retrieval of declarative memory shows that although retrieval can occur quickly, the probability of correct retrieval increases with available time until it reaches an asymptote. Recognition of recently learned word pairs has, for example, been shown to asymptote at approximately 2 seconds (Doshier, 1984). The DMM thus predicts that retrieval of evaluative information from the pairing phase, and therefore the occurrence of an EC effect, is more likely if there is sufficient time for retrieval before the response is due in the measurement task. In most implicit measures (the affect misattribution procedure and the name letter task are exceptions), participants are asked to respond quickly while this is typically not the case in explicit evaluative rating tasks.

These predictions about factors in a measurement task still need to be tested in well-controlled experiments. Currently, there is meta-analytical data available that compares EC effects for various valence measures (Hofmann et al., 2010). These need to be interpreted cautiously because of the numerous differences between measures, such as the inclusion of additional stimuli in most implicit measures, the wording of the task instructions, or the typically higher reliability of explicit compared to implicit measures.

Broadly speaking, EC effects should be larger when assessed with an explicit measure because with these measures the CS is task-relevant, participants have an evaluation task, and participants can usually take their time to evaluate the CS. This prediction is in line with the meta-analytical finding that EC effects are larger with explicit compared to implicit measures (Hofmann et al., 2010).

Within the group of implicit measures, the implicit association test (IAT; Greenwald, McGhee, & Schwartz, 1998) and the name letter task have led to larger EC effects than the affective priming procedure, which could, in the case of the name letter task, be attributed to the lack of time pressure and, in the case of the IAT, to the task relevance of the CSs. Both interpretations, however, have to be made with caution because of a complex constellation of presence and absence of relevant factors. In the IAT, the CS is task-relevant although it is not evaluated, while the attribute stimuli (positive and negative items) are evaluated (see also De Houwer, 2003). If the name letter task is used as a valence measure in an EC paradigm, the CS is the participant's name or identity and the evaluated stimuli

are letters from the person's name. These letters are thus task-relevant and evaluated, but they are not identical to the CS (the person's name) but are part of it.

### **The Person's Retrieval Motivation**

Information from the pairing phase can be retrieved intentionally or unintentionally. Intentional retrieval depends on the person's retrieval motivation, which can depend on task characteristics, reward contingencies, and cognition related personality factors, such as a person's need for cognition (Cacioppo & Petty, 1982). Studies that tested the impact of motivation on retrieval in declarative memory tasks found surprisingly weak effects (Loftus & Wickens, 1970; Wasserman, Weiner, & Houston, 1968), which might suggest that the effect of retrieval motivation is also weak in EC. In these studies on the role of motivation in declarative retrieval, however, participants in all conditions were explicitly asked to recall all paired associates with an additional reward associated with the stimuli in the high-motivation condition. Recall motivation effects in explicit memory tasks might thus suffer from a ceiling effect that is not present in EC, where participants are not usually tasked with recalling CS-US pairs. Retrieval motivation might thus play a larger role in studies on EC than in studies on declarative memory. In principle, a person might also be motivated *not* to retrieve information from a previous phase, for example, because they think that this information might distract them from the valence judgment at hand.

### **The Probability That the Retrieved Information Influences CS Evaluation**

All previous sections dealt with factors that ultimately influence the retrieval of evaluative information, which the DMM assumes to be a precondition for EC effects. Predictions on whether such retrieval occurs are based on current knowledge about declarative memory. Importantly, however, an EC effect does not occur every time evaluative information is retrieved. The factors that determine whether retrieved information influences CS evaluation are heterogeneous and are not directly related to declarative memory processes. Therefore, the following discussion deals with a diverse group of factors and is somewhat speculative.

Retrieved information can influence the participant intentionally and unintentionally. In this vein, the following will be discussed: (1) intentional influence of retrieved information, (2) unintentional influence of retrieved information, (3) the applicability of the retrieved information, and (4) the presence of other sources for CS evaluation.

### **Intentional Use of Retrieved Information**

The motivation to use retrieved information for evaluations might depend on cognitive style, context, and more specific considerations about the task: First, a person might think that the retrieved information is relevant information for evaluating the stimulus; they might, for example, consider the co-occurrence of stimuli or the memory retrieval as diagnostic. These considerations might be influenced by the applicability of the retrieved information and by how the evaluative task is framed, for example whether a participant is asked to rate their "feelings when seeing the stimulus", "the visual appearance of the stimu-

lus”, or “the overall impression of the stimulus”. Second, even if the person does not think that the retrieved information is relevant for the evaluation, they might still think that letting the valence measure be influenced by it is the right or advantageous thing to do. A person might, for example, think that it is important to the experimenter that they rate the stimulus in line with the pairings or they might think that evaluating the CS according to the previous pairings is the easiest thing to do. Third, the person might think that they are being evaluated on whether their judgment is in line with the pairings and might rate a CS accordingly out of a concern for self-presentation. This might depend on tendencies to conform to perceived norms.<sup>2</sup>

Whether retrieved information is intentionally used for CS evaluation depends, besides the motivation, on the participant’s ability to integrate this information in the valence measure. The ability to integrate is higher if the participant has sufficient time and cognitive resources. In line with this prediction, Gawronski, Balas, and Creighton (2014) found that the motivation to control an EC effect only has an impact on an evaluative rating and not on a (speeded) affective priming task. Importantly, however, the authors’ interpretation of the finding is that implicitly measured EC effects are not influenced by any factors at the measurement stage. In line with this interpretation and not predicted by the DMM, EC effects in these studies occur on both ratings and on an affective priming measure, but only the EC effect on ratings is related to a recollective memory score. This finding should be interpreted cautiously as the correlation of the measures were assessed on the person- and not on the item- level and other studies have found a relation of affective priming effects and memory on the item level (e.g., Gast, De Houwer, & De Schryver, 2012). If this finding does confirm on the item level, however, it speaks to an EC effect that is difficult to explain with the DMM.

### Unintentional Use of Retrieved Information

Although it is sometimes – implicitly or explicitly – assumed that conscious stimuli are processed consciously and intentionally and unconscious stimuli are processed unconsciously and unintentionally (e.g., Rydell, McConnell, Mackie, & Strain, 2006), these different features of awareness and intentionality do not need to co-occur (Moors & De Houwer, 2006). According to the DMM, the conscious retrieval of information can be accompanied and followed by unaware and unintentional processes (see Bar-Anan et al., 2010). If a participant retrieves evaluative information, this retrieved and conscious information can thus unintentionally influence CS evaluation. Such unintentional influence can sometimes be intentionally counteracted.

<sup>2</sup> Judging whether such intentionally influenced evaluations are genuine touches on definitional issues. Importantly, not all evaluations that are intentionally influenced by retrieved information are demand effects and there are criteria that can be used to decide whether they are. I would argue that we should consider it a non-genuine evaluation if a person’s evaluation is intentionally influenced for reasons other than thinking that the information is relevant for the valence. We should consider it demand compliance if a person’s evaluation is intentionally influenced by a goal to help the experimenter or by self-presentation concerns.

## Applicability of Retrieved Information

Both the intentional and the unintentional use of retrieved information might depend on its applicability, although applicability might have a stronger influence on the intentional use of information. Applicability can, for example, be based on the similarity of CS and US or on whether the US can be seen as an attribute of the CS.

## Other Sources for CS Evaluation

The impact of retrieved information is predicted to be reduced when other sources for CS evaluation are available. For example, if the picture of a well-known politician is used as a CS, most participants probably base the evaluation of this CS mainly on their pre-existing attitude towards the person, leaving little room for the influence of retrieved information from the CS-US pairing phase. Sensical CSs are more likely to be evaluated based on other sources than non-sensical CSs. Therefore, the finding that non-sensical verbal CS lead to stronger EC effects (Hofmann et al., 2010) is in line with the assumption that information from other sources can counteract EC effects at the evaluation stage. As mentioned above, however, it does stand in opposition to the prediction of easier encoding of meaningful stimuli. It has not yet been tested how the advantage of non-sensical stimuli can be attributed.

Whether EC-based retrievals or information from other sources “win” this competition about influencing evaluation depends on various factors. First, it might be important which piece of information is retrieved more quickly. Second, the above-mentioned applicability might play a role – especially when people have enough time and resources for an evaluation and if people make an evaluation intentionally.

## Phase Independent Factors: Stimulus and Participant Characteristics

As discussed above, in order for an EC effect to occur, different factors are relevant for different phases. However, some factors remain constant across phases and may have additive or counteracting influences on the EC effect.

Stimulus and participant characteristics are such factors that remain constant across phases. Some relevant stimulus characteristics (meaningfulness and distinctiveness) have already been discussed above.

It is known that person characteristics can influence declarative memory. Healthy young adults and older children tend to show better memory performance than older adults, young children, and people who have suffered from brain injuries or certain neurological diseases (Roediger & Gallo, 2002). When only considering the declarative memory processes, the DMM predicts corresponding differences in the size of the EC effect. This, however, ignores potential systematic differences between these groups regarding their tendency to use retrieved evaluative information, which might exacerbate or counteract the influence of the memory effect. The meta-analytical finding that EC effects are smaller

in children is in line with the prediction based on declarative memory performance (Hofmann et al., 2010). Halbeisen, Walther, and Schneider (2016), however, did not find age-dependent differences in the size of the EC effects in children aged 3 to 6. As mentioned, because it is unclear how age affects the use of retrieved information for CS evaluation, both results are currently difficult to interpret in favor or against the DMM.

## Conclusion

According to the DMM, EC effects are found when during the learning phase a link between the CS and evaluative information is encoded, survives the retention interval, is consciously retrieved while a person expresses their evaluation of the CS, and is then used in the evaluation.

The DMM is based on theoretical distinctions and empirical findings from memory research. At present, much of the existing literature on EC fits the assumption that at least a vast majority of EC effects are simply based on what we retrieve when our attitude is assessed. The assumption that many of our acquired evaluations are based on the same processes as our memory for facts and events, makes the DMM a parsimonious single-process model.

Nevertheless, it should be mentioned that several findings from the literature on EC question some of the central assumptions of the DMM. Most notably, there are several examples where EC effects have been found that did not depend on memory available at measurement (e.g., Baeyens, Eelen, & Van den Bergh (1990); Baeyens, Eelen, Van den Bergh, & Crombez, 1990; Dickinson & Brown, 2007; Hammerl & Grabitz, 2000; Hütter, Sweldens, Stahl, Unkelbach, & Klauer, 2012; Walther & Nagengast, 2006). A number, but not all, of these have been criticized on methodological grounds (see Sweldens, Corneille, & Yzerbyt, 2014 for a review). Therefore, the question remains whether these findings may result from a failure to detect subtle but consciously accessible memories or whether they indeed provide evidence for EC effects that are not based on the conscious recall of information. As mentioned, the DMM predicts the occurrence of EC effects under a set of conditions. This does not preclude the possibility that another set of conditions may give rise to other processes that also lead to EC effects. If such processes exist, another model would be needed to explain them.

The DMM was developed specifically for the explanation of EC effects, but it has the potential to be applied to other attitude learning effects, such as persuasion or mere exposure effects. The DMM also has the advantage of applicability to real-world situations. In real life, we encounter thousands of stimulus pairings each day, many of them repeatedly – for example those that we see on our way to work. It is extremely unlikely that all of these have an impact on our attitudes. Most models of EC, however, do not specify boundary conditions under which such experienced pairings will or will not change our attitudes. The DMM, on the other hand, states that only those pairings that we encode, that survive the retention interval, and that are retrieved can influence our attitudes. It thus makes more useful predictions for real-life situations.

Nevertheless, some readers might question an account that attributes attitude changes to the conscious knowledge that the attitude object was paired with something. In social psychology, it is a widely accepted notion that people tend to be unaware of the sources of their attitudes (e.g., Nisbett & Wilson, 1977). Researchers might see effects on attitude measures that are based on declarative memory not as real attitudes, but as artefacts or demand effects. After all, why would we genuinely own an attitude, if we knew that it came from another stimulus?

An important distinction in this regard is between awareness of the stimulus constellation that caused the attitude change and awareness of the causal process of the attitude change (Gast, Gawronski, & De Houwer, 2012; Moors & De Houwer, 2006; Nisbett & Wilson, 1977). People can be aware of a CS-US pairing without knowing that it changed their CS-evaluation. They might, for example, know that they saw a lemonade bottle of a specific brand together with a picture of a beach, but have no idea that this picture changed their attitude towards the lemonade.

Finally, the last decades' excitement about unaware processes might have led to an overestimation of the contribution of unaware processes to EC and attitude change in general. If, however, there is empirical evidence that in many cases we are influenced by only those stimulus pairings that we remember, then a theoretical understanding of attitude acquisition needs to take this into account.

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The author has declared that no competing interests exist.

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