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Evaluative Conditioning as Memory-Based Judgment

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Abstract

The article proposes a view of evaluative conditioning (EC) as resulting from judgments based on learning instances stored in memory. It is based on the formal episodic memory model MINERVA 2. Additional assumptions specify how the information retrieved from memory is used to inform specific evaluative dependent measures. The present approach goes beyond previous accounts in that it uses a well-specified formal model of episodic memory; it is however more limited in scope as it aims to explain EC phenomena that do not involve reasoning processes. The article illustrates how the memory-based-judgment view accounts for several empirical findings in the EC literature that are often discussed as evidence for dual-process models of attitude learning. It sketches novel predictions, discusses limitations of the present approach, and identifies challenges and opportunities for its future development.

Keywords

evaluative conditioning, MINERVA 2, memory-based judgment

Evaluative conditioning (EC) effects can be understood as resulting from judgments based on the contents of episodic memory. The basic assumption of this view is that EC—especially when incidentally learned—can be explained by current single-process models

of episodic memory, together with assumptions about how the information available in memory is used to inform the specific dependent measures with which EC is assessed. This *memory-based-judgment* view is not a new theory of EC; to the contrary, it relies on a collection of established ideas and accounts of the EC phenomenon in terms of the processes of episodic memory, and of judgments and decisions based on its contents. It combines a set of simple and fairly uncontroversial assumptions based on established findings from cognitive psychology, which (as will be shown) can accommodate for a wide range of results reported in the EC literature that are often interpreted as evidence for dual-process models of learning.

Learning about the evaluation of novel objects may proceed via domain-general propositional reasoning processes (Gawronski & Bodenhausen, 2006; Mitchell, De Houwer, & Lovibond, 2009). The theoretical dispute in learning and attitude research centers on whether several dissociations reported in the EC literature are in fact evidence that cannot be explained by single-process learning models (e.g., Shanks, 2010). Such an interpretation of the literature would suggest that EC may proceed via a distinct, automatic, associative process. In line with the present perspective, a recent review has found little support for automatic associative attitude learning and suggests that a single-process account may be sufficient (Corneille & Stahl, 2018). To illustrate our interpretation of the literature, we propose a formal single-process account that can explain the empirical findings in the EC literature that are discussed as evidence for dual-process models of attitude learning.

The present perspective has previously been proposed by other researchers who have suggested that dissociations in the EC literature may be explained not by dual learning but dual retrieval processes (e.g., De Houwer, 1998). It can be seen as reflecting an integral part of the single-process propositional approach to learning (PAL; Mitchell et al., 2009), which understands learning as propositional reasoning based on the contents of episodic memory. The present approach has a more limited scope than the PAL in that it aims at explaining EC phenomena that *do not involve propositional reasoning* and thereby focuses on episodic memory processes. Nonetheless it is meant to account for a wide range of EC procedures—making additional assumptions about perception and retrieval where necessary. The present view goes beyond the PAL in that it builds on well-specified formal models of episodic memory to illustrate how learning can occur as a product of storing instances in memory while making minimal assumptions about how the retrieved contents of memory informs behavior.[1]

Basic Hypotheses

The present account is located at a cognitive or algorithmic level of analysis (De Houwer & Moors, 2014; Marr, 1982). In discussing the present view and its basic hypotheses, it is necessary to distinguish between the cognitive processing stages of encoding or learning, main-

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[1] Its limited scope (or universality) is therefore balanced by increased specificity (or precision; for a discussion, see Glöckner and Betsch (2011).

tenance or retention, and retrieval or performance (Boddez, Haesen, Baeyens, & Beckers, 2014). Contrasting dual-process accounts that focus on the learning stage, the present view holds that many of the dissociations reported in the literature involve later processing stages.

The basic hypothesis is that EC is the result of a single learning (i.e., encoding) process that encodes and stores learning instances in declarative episodic memory, the contents of which can be retrieved to inform evaluative judgments (as well as other judgments and behaviors). A learning instance or episode binds together the information that is extracted from the current stimulus situation (i.e., the stimuli presented by the experimenter, the situational context, as well as internally generated information such as spontaneous ideosyncratic thoughts and impressions, or retrieval of prior knowledge or experience).[2] The learning episodes stored in memory affect subsequent evaluative responses to the degree that the critical information—CS features and US valence—is retained and can be retrieved. When an evaluative judgment about the CS is to be made, memory is searched to retrieve relevant evaluative information about this CS. The evaluative information retrieved from memory is then used to inform evaluative dependent measures.[3]

This hypothesis implies that all factors known to affect episodic memory across the encoding, maintenance, and retrieval stages are also potential influences on EC[4] (a related view is proposed in the current issue by Anne Gast; we discuss some of her work below). Critically, the present view predicts that the effects of any such factor on EC will parallel its effects on other forms of memory measures (e.g., recognition or recall). As will be illustrated below in more detail, different factors are relevant at different processing stages: Encoding into episodic memory is affected by bottom-up factors such as stimulus strength (e.g., sub- vs. supraliminal presentation) as well as top-down factors such as attentional resources (e.g., selective attention, cognitive load) and processing goals (e.g., memorize pairings vs. form impression). During retention, the contents of memory can be affected by rehearsal and forgetting. Retrieval from memory may involve different processes such as recognition and recall. Moreover, the contents of memory may be cued, retrieved, integrated, and summarized in different ways depending, for example, on instructions, context, and dependent variables. These considerations further imply that properties of the learning task interact with properties of the dependent measures. Such

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[2]   The notion of episodic binding is a fundamental theoretical tenet of current theories across domains (Baddeley, 2000; Gershman & Daw, 2017; Hommel, 2004; Ranganath, 2010; Schmidt, De Houwer, & Rothermund, 2016; Whittlesea & Dorken, 1993). The notion of internally generated contents of memory features most prominently in the source monitoring framework (M. K. Johnson, Hashtroudi, & Lindsay, 1993), which holds that recollective memories can be identified as reflecting true events by recognizing the spontaneous self-generated thoughts that accompanied the event. In addition, its reality-monitoring aspect focuses on (the difficulty of) distinguishing memories for true events from those for self-generated thoughts.

[3]   This allows for retrieval of stable summary evaluations (Fazio, 2007) as well as for contextualized evaluations created at the time of judgment (Schwarz, 2007).

[4]   An exhaustive list of such factors is not provided as they do not necessarily follow from the basic hypothesis and are not an integral part of the present account of EC. The strength of support for the relevance of a given factor depends on independent evidence provided by the memory literature.

task-measure interactions determine how information is integrated to inform performance on the respective dependent measures (i.e., transfer-appropriate processing; Morris, Bransford, & Franks, 1977).

The above considerations are not novel and they apply to episodic memory quite generally. Yet, in their joint application to the EC literature, they may prove sufficient to explain (most of) the EC phenomena that have puzzled researchers in the past and have prompted the (in our view unwarranted) postulation of dual learning processes. The specific perspective that we will outline below has been further informed by formal models of episodic memory, such as MINERVA 2 (Hintzman, 1984). The applicability of these models to EC has been previously suggested by other researchers (De Houwer, 1998; Klauer, 2009; Mitchell et al., 2009). Next, we briefly introduce the MINERVA 2 model to illustrate how episodic memory mechanisms can explain EC.

Brief Introduction to MINERVA 2

In the MINERVA 2 model, memory is a matrix, to which a row vector is added to represent a newly encoded episode (or instance). In this episode vector, each position or value represents a stimulus or context feature (e.g., color, valence, etc.) that can be either present (i.e., represented by +1), absent (-1), or unknown (0). During exposure, each individual feature is encoded with probability *l*, the learning rate. Learning rates may differ across conditions, or for different sets of features as a function of global or selective attention. The encoded information is maintained in memory (forgetting may be modeled by randomly setting features to zero during each time interval; rehearsal may be accounted for by different forgetting rates or via retrieval and re-encoding). Retrieval from memory operates by matching, in parallel, a cue (e.g., representing the CS and possibly context features) with each memory trace vector, and computing the similarity between cue and trace. The sum of similarities across traces is called *echo strength* and represents the familiarity of the cue and can be used to inform, for example, recognition judgments. In addition, a vector is computed as a weighted sum of features across traces in which the weight of each trace is its similarity with the cue. This *echo content* represents the information recalled from memory.

The model can account for evaluative judgments as follows: Assume a CS-US co-occurrence episode is stored as a memory trace in the matrix (along with a number of episodes that contain neither the CS nor US). When cued with the CS, the newly stored trace will be highly activated, supporting recognition of the CS. As a result, the stored trace will enter the computation of the echo content with great weight, so that the other features of the episode (including, importantly, the US's valence) will be recalled. The recalled valence can then inform evaluative judgments about the CS. In this sense, evaluative ratings can be considered a variant of cued recall.

As a general memory model, MINERVA 2 does not qualify the type of information that can be encoded. Specifically, it allows anything to be encoded that can be modeled by a vector of (binary) values; it is silent as to whether this information is an association or a proposition. This is not to say that it endorses the existence of distinct types of representa-

tions, but that a (single-process) episodic-memory model may serve as a container for simple as well as more complex contents.

The present view is therefore compatible with Mitchell et al.'s (2009) suggestion that a memory model, such as MINERVA 2, may be an adequate algorithmic implementation of a memory system subserving a (functional-level) propositional account: Propositions about CS-US co-occurrences may be encoded and stored in episodic memory, to be later retrieved for evaluative purposes. On the other hand, it could be argued that the memory-based view is also compatible with associative accounts in which only unqualified co-occurrences are encoded: If only the CS and US are encoded as part of an episode, information about their co-occurrence is not represented directly (e.g., as in a proposition), but it is indirectly represented (i.e., by the fact that the CS and US were stored as part of a single episode). The latter indirect storage is similar to an association between the CS and US that is not encoded as a proposition. In this sense, the present view may be interpreted as allowing for two (or more) different types of representations (i.e., propositions and mere stimulus-stimulus links). Proponents of a propositional view may, however, point out that the latter information can also be regarded as a proposition (e.g., "CS and US have occurred as part of the same episode"), so that there would be no need for special treatment of this simplest case. The fact that some episodes contain more complex contents than others does not imply that they are encoded (nor maintained or retrieved) by qualitatively different mechanisms or processes.

We have applied the MINERVA 2 model to counterconditioning and extinction in EC (Aust, Haaf, & Stahl, in press). It can account for the expectancy-evaluation dissociation in EC-extinction paradigms by assuming that the information in memory is integrated differently for US expectancy ratings than for CS evaluative ratings. We assumed that US expectancy ratings, by default, reflect the most recent available information that provides the best prediction about the US that is about to appear in that specific moment, whereas evaluative ratings, by default, reflect an integrative summary of all available information about the to-be-evaluated CS. We tested these assumptions by modifying the default strategies (i.e., by eliciting momentary evaluative ratings and integrative US expectancy ratings) and were successful in eliminating and even *reversing* the expectancy-evaluation dissociation, while encoding was held constant.

So far, this is the only EC phenomenon that we have formally modeled with MINERVA 2. We are in the process of extending this formal approach to other EC phenomena. We believe that many (if not all) of the EC phenomena discovered so far can be explained by this model when combined with a few additional assumptions substantiated by independent research. Because MINERVA 2 is a *memory* model, additional assumptions are necessary to model, among other things, the effects of experimental manipulation of perception and attention or manipulations of higher order cognitive processes such as goals. Finally, adequate assumptions about how the retrieved information informs different dependent measures are necessary. We will discuss some of these assumptions below.

Accounting For EC From a Memory-Based-Judgment View: Processing Stages and Moderating Factors

In the following sections, we illustrate how moderating factors identified in memory research that impact processing at the encoding, maintenance, and retrieval stages account for relevant findings in the EC literature as viewed from a memory-based-judgment perspective. To foreshadow, we address the *contents of episodes*, and how the contents depend on the level of *awareness*. They also depend on the amount of available *attention* and how it is distributed among the stimuli (CS, US, and context) and their features, as well as on the *type of processing*. Once encoded, the episode is maintained in memory, where it can be subject to *rehearsal*, *retrospective integration*, and *forgetting*. Retrieval depends on the *(direct versus indirect) evaluative measure* in several ways, and it can be modulated by learning opportunities during the retrieval phase as in *extinction* protocols and contextual information. Effects of *information integration* as well as of *relational qualifiers* are relevant at multiple stages, as is the issue of *controllability*.

Encoding Stage

This section discusses what is stored in memory, the nature of the representation, the role of awareness at encoding, and the type of processes that may affect encoding of CS-US co-occurrence episodes. We also consider evidence regarding the parallel effects of encoding manipulations on EC and memory.

Contents of Episodes

According to instance-based memory theories, memory consists of a collection of episodes. The content of an episode is thought of as the set of external and internal information that is processed during the small time period that constitutes the episode (Zacks & Swallow, 2007). This may include the stimuli presented by the experimenter, but also the experimental context, as well as the thoughts, emotions, and bodily sensations of the participant. They are stored in memory together and can later be retrieved together. The precision with which each piece of information is stored depends on its salience as well as the amount of attention it receives (Dehaene, Changeux, Naccache, Sackur, & Sergent, 2006): A presented but unattended stimulus may not be encoded at all, whereas an internally generated and attended thought may very well be encoded as part of the episode (despite not being presented by the experimenter).

Awareness

The contents of consciousness during an episode determine what is encoded into memory. These contents are themselves a function of bottom-up stimulus strength and top-down processing, as affected by attention and goals (Dehaene et al., 2006). Research on awareness has distinguished between three qualitatively different stages or levels of conscious-

ness (e.g., Dienes, 2007) that are readily applicable to the issue of awareness of the CS-US co-occurrence (e.g., Heycke, Aust, & Stahl, 2017; Stahl, Haaf, & Corneille, 2016):

First, participants may fail to consciously perceive the CS-US co-occurrence episode, perhaps because only one of the stimuli was consciously perceived, whereas the second one was not perceived at all or only fragmentarily. Those (parts of the) stimuli that were perceived would be encoded jointly into a single memory episode. This case reflects *subliminal* presentation situations in which the CS and/or the US have low stimulus strength (e.g., are briefly presented and masked). Because of the weak or absent encoding of the CS-US co-occurrence information, EC is unlikely to occur.

Second, participants may consciously perceive both the CS and US. The two stimuli are therefore part of the encoded episode. Yet, participants need not be aware of this fact (i.e., if their attention is directed entirely toward sensory experience, they can be aware of the stimuli themselves but not of their being aware of the stimuli). As a consequence, they can also be unaware of the co-occurrence of (or the association between) the CS and US. This case represents *incidental* learning situations such as those occurring when participants are merely instructed to attend to all stimuli (e.g., with the goal to detect a target stimulus) as in the surveillance paradigm (Olson & Fazio, 2001). When the CS is presented as a cue, for instance in an evaluative judgment task, the associated US valence can be retrieved from memory to inform this judgment, thereby supporting EC effects.

Third, participants may have higher-order thoughts about the contents of their consciousness: Given that some amount of attention is directed toward their own mental state, they may be conscious of the fact that they currently perceive the CS and US as part of the same episode; or they may consciously expect to see a US of a specific valence given that they just have seen a specific CS. This third case is more likely under *intentional* learning conditions (i.e., when participants are instructed to learn about the pairings or contingencies). It may however also occur spontaneously, without such instructions, during incidental-learning paradigms, perhaps especially so if participants are not engaged in an effortful or distracting task. Such higher-order thoughts are required for propositional reasoning; they allow for an additional set of possible operations on the input during the learning phase (e.g., trigger active search for regularities, hypothesis testing, impression formation). For instance, verbally communicated relational qualifiers (such as "friend" vs. "foe", Fiedler & Unkelbach, 2011; or "cause" vs. "prevent", Hu, Gawronski, & Balas, 2016) may readily inform on-line impression formation processes and influence subsequent EC effects.

Attention, Resources, and Goals

In line with the PAL (Mitchell et al., 2009), the present view contends that automaticity features of memory should also apply to EC. As argued above, the type of awareness experienced during stimulus exposure should affect the content of the memory trace. In addition, the amount and direction of attentional resources as well as processing goals impact encoding and therefore EC.

At encoding, we can distinguish influences due to properties of the stimulus situation (i.e., bottom-up effects) from influences due to properties of the cognitive system (top-down effects). For instance, bottom-up stimulus strength and top-down attention interact to determine the level of conscious processing (Dehaene et al., 2006). Stahl et al. (2016) have investigated the interacting effects of both contributions to EC: EC effects have been shown to increase with stronger stimuli (e.g., longer CS presentation durations), and to depend on attention (e.g., on the CS-US pair vs. only the CS) and goals (e.g., encoding valence vs. detecting a surveillance target). The notion that attention and stimulus strength co-determine what is encoded during learning accounts for the finding that EC effects increase with longer CS presentation times and that supraliminal presentation is necessary but not sufficient for EC (Stahl et al., 2016). It is also consistent with the finding that reducing attentional resources at encoding interferes with (or even eliminates) both EC and explicit memory for CS-US pairings in parallel (Stahl & Heycke, 2016).

Beyond top-down attention, the specific type of processing task during learning has also been shown to influence EC (e.g., Corneille, Yzerbyt, Pleyers, & Mussweiler, 2009; Moran, Bar-Anan, & Nosek, 2015; Stahl et al., 2016). For instance, larger EC effects were found when the task induces a focus on processing the CS-US pair (e.g., Kattner, 2012) and on the valence dimension (Gast & Rothermund, 2011); smaller effects were found when the focus was on irrelevant (e.g., brightness) rather than relevant (e.g., valence) dimensions of the pair (Stahl et al., 2016). From a memory-based judgment perspective this is to be expected. The levels-of-processing literature (e.g., Craik & Lockhart, 1972) suggests that the specific type of processing is likely to also affect the contents of memory. Hence, in the presence of awareness and resources, EC will depend on deliberate processing goals that determine what is attended and therefore encoded; information irrelevant to that goal may be ignored (and therefore less likely to be encoded). Furthermore, in accordance with the notion of transfer-appropriate processing, the type of processing during learning will also be likely to interact with the type of dependent measure that is used to assess learning [e.g., Hastie and Park (1986); see also the section on *On-line versus memory-based integration*].

Sequential Versus Simultaneous Pairings

Beyond stimulus strength, another bottom-up manipulation that affects encoding of CS-US pairs is their simultaneous versus sequential presentation: When both stimuli appear next to each other on the screen, they are more likely to be encoded as part of a single episode; in contrast, when they are presented sequentially one after another, memory traces are more likely to contain single stimuli instead of pairs. In line with a single encoding process, this affects not only EC but also explicit memory; both are increased for simultaneous as compared to sequential pairings (Hütter & Sweldens, 2013; Stahl & Heycke, 2016). In sum, consistent with the present model, effects of manipulations at encoding on EC were paralleled by effects on memory.

Maintenance Stage

In between encoding and retrieval, the encoded information is subject to intervening processes such as rehearsal or forgetting. In addition, retrospective integration has been proposed as an information-integration process that operates during maintenance.

Rehearsal

Rehearsal processes that operate on the CS-US episodes may affect memory for these episodes and consequently later evaluation of the CS, because rehearsal episodes are also encoded into memory. Rehearsal may occur during the learning phase of a study as well as during subsequent stages. Considering that EC resembles a paired-associate learning situation, participants may attempt to retrieve the US associated with a CS during the learning phase, especially in an intentional learning situation using a sequential presentation schedule in which CSs are presented before USs with sufficient delay between stimulus presentations. Successfully recalling the US that was paired with a given CS constitutes in itself another episode in which the CS and US co-occur (if "only" in participants' minds), which can strengthen memory for the pair. Similarly, recalling one's own integrative evaluation of the CS during an intervening task can strengthen later evaluation of the CS (in other words, such rehearsal prepares an evaluative response and/or facilitates its later retrieval).

Retrospective Integration

A related mechanism, termed *retrospective integration* (Shohamy & Daw, 2015), refers to a process by which overlap in memory episodes triggers an integration of episodes during learning. This may happen, for instance, if a CS-US co-occurrence episode E triggers retrieval of an episode E' in which the CS has been presented with another CS'. In this case the newly encoded episode E contains the external stimulus information about the CS and US (presented by the experimenter) together with the internal stimulus information about the CS and CS' (i.e., the retrieved episode). When the CS' is subsequently presented as a cue, the integrated internal stimulus information enables retrieval of the US, although the CS' and US have not co-occurred. This example illustrates that the present view can readily explain sensory preconditioning and may also explain revaluation effects (e.g., Baeyens, Eelen, Van den Bergh, & Crombez, 1992). Note that this mechanism can be seen simply as a form of rehearsal of cue-target (CS-US) pairs as discussed above.

Forgetting

If not rehearsed, information stored in memory is forgotten over time (due to decay and/or retroactive interference). Forgetting may differently affect different aspects of the stimulus episode in a systematic way. For instance, forgetting occurs at a higher rate for more detailed, low-level (verbatim) information about a stimulus, whereas more abstract high-level (gist) information is retained over a longer time (e.g., Brainerd & Reyna, 2002).

In addition, information shared across multiple instances is retained for longer, whereas instance-specific detail is more readily forgotten (Hintzman, 1984). Applied to EC, it follows that perceptual detail of a US stimulus associated with a given CS (i.e., low-level information that allows it to be distinguished from other USs of the same valence) is more likely to be forgotten, whereas its valence (a high-level feature) is retained for longer. When asked about their memory for the USs paired with a given CS, participants can therefore be expected to show higher levels of memory for the USs' valence category than for their identity (Stahl, Unkelbach, & Corneille, 2009). This also explains why a subset of CSs may show EC effects despite participants being unable to report specific details about the associated USs, as has been reported in the surveillance paradigm (Olson & Fazio, 2001; Stahl & Heycke, 2016; Stahl et al., 2009). The same asymmetry can also contribute to accounting for dissociations between the memory and attitude parameters of Hütter, Sweldens, Stahl, Unkelbach and Klauer's (2012) process-dissociation (PD) model. For instance, it explains the finding that a one-week retention interval affected the memory parameter but not the attitude parameter in the PD model (Hütter et al., 2012; Experiment 3), if one takes into account that retrieval of episodic detail is associated with entering the subjective state of remembering or recollection (and therefore to follow the "memory" instruction of the PD procedure).[5]

Retrieval Stage

The contents of memory constantly inform cognition and behavior, but different affordances of dependent measures may affect how information is retrieved and integrated in a specific situation and for a specific purpose (e.g., Matute, Lipp, Vadillo, & Humphreys, 2011). This section addresses dissociations between dependent measures that may arise when comparing direct versus indirect measures (and model parameters, as in the process-dissociation approach), or evaluative versus expectancy judgments.

Direct Versus Indirect Evaluative Measures

The information encoded into memory can be used in different ways by different dependent measures. Properties of dependent measures, such as their time limits and response requirements, may affect the amount and quality of information that is retrieved, and how it can be integrated and used to inform the dependent measure. Importantly, again, the present account predicts that such effects are comparable for memory and EC phenomena.

Deliberate evaluations are typically assessed using rating scales in unspeeded situations that allow for retrieval and careful integration of all available information in memory. In contrast, "automatic" evaluative responses are typically assessed using indirect measures (such as the IAT or affective priming task), which call for speeded binary classification decisions. Briefly, the information available in memory can be retrieved and integrated more reliably

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[5]   This is supported, for instance, by research on source memory showing that retaining episodic contextual details was associated with 'remember' judgments which represent recollective experiences (Meiser, Sattler, & Weisser, 2008).

and in its entire complexity in unspeeded situations; in contrast, time pressure will reduce the fidelity of the retrieved information and interfere with its integration. These differences may produce empirical dissociations if, in addition to the CS and US, additional detail (such as relational qualifiers) needs to be retrieved and integrated with US valence information before a summary evaluation can be generated that can inform the dependent measure. Under these conditions, the speeded measure should be less likely to reflect the additional information than the unspeeded measure. Such a pattern has been observed in several studies, and we argue that it arises at retrieval as a function of the properties of the different dependent measures (Bading, Stahl, & Rothermund, 2018; Moran & Bar-Anan, 2013).

A well-established retrieval dissociation is that people can readily control the expression of their attitudes and prejudices when filling out a survey, but such control requires much more effort (as well as task-specific knowledge and strategies) on indirect measures such as affective priming tasks (Klauer & Teige-Mocigemba, 2007; Teige-Mocigemba & Klauer, 2008). Analogously, it should be more readily possible to conditionally express or invert a newly acquired attitude about the CS (i.e., report only if considered valid, or report its opposite) on a rating scale measure than on an affective priming task. It should therefore come as no surprise that findings obtained with explicit and implicit measures sometimes dissociate; such dissociations do not necessarily imply the existence of two different learning processes or representations, but they can often be explained by differences in retrieval processes alone.

This interpretation implies that indirect measures are not necessarily a more valid approach to assess evaluative representation than direct measures. When directly and indirectly assessed attitudes dissociate, situational factors as well as the to-be-predicted behavior itself determine which outcome possesses greater behavioral relevance.

Somewhat relatedly, a retrieval explanation may account for the occasional finding of implicit US valence memory in the absence of explicit memory that is obtained in the PD procedure (i.e., when the implicit-memory parameter differs from zero; Hütter et al., 2012). This PD approach provides a measure of EC effects in the absence of explicit US valence memory. Specifically, it starts by assuming the separate existence of an implicit evaluative learning effect that is distinct from explicit memory for US valence, and proceeds by asking participants to disentangle their explicit memory for US valence (i.e., cases in which they 'remember' US valence) from their subjective evaluations under two different (inclusion versus exclusion) conditions, with the aim of empirically quantifying their separate contributions by estimating separate parameters for each process. Unfortunately, however, the mere finding that the estimate for the implicit process substantially differs from zero does not imply that the assumed second implicit process itself in fact exists (Ratcliff, Van Zandt, & McKoon, 1995). It is well possible that a single-process model may underlie the effects on both parameters, and that the dissociation can be explained, for instance, by the additional memory strength required for 'remember' judgments (Kurilla & Westerman, 2008; Rotello, Macmillan, Reeder, & Wong, 2005), or by different (analytic vs. non-analytic) strategies used for memory versus liking judgments (Whittlesea & Price, 2001). In line

with this interpretation, effects of experimental manipulations during encoding (e.g., simultaneous versus sequential pairing, attentional load, or US evocativeness) have generally failed to dissociate the explicit and implicit parameters in a manner consistent with dual-process assumptions (see Corneille & Stahl, 2018 for recent review).

Extinction

Another important dissociation between different measures that can be explained by the specific properties of these measures is the dissociation between evaluation and expectancy, as reflected in the resistance-to-extinction phenomenon (e.g., Baeyens, Crombez, Van den Bergh, & Eelen, 1988). Whereas US expectancy ratings track the CS-US contingency change from the acquisition to the extinction phases, EC remains unaffected (or is only slightly reduced), such that it is still evident after extinction (Gawronski, Gast, & De Houwer, 2015; Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010). This finding has long been used to characterize EC as a separate learning process that is distinct from classical conditioning. Yet, when considering the different properties of the dependent measures involved, it becomes clear that this claim is not supported. Instead, the dissociation reflects different defaults in how the information is used for US expectancy versus evaluative judgments. On the one hand, attitudes or evaluations reflect integrative summary judgments about an attitude object and therefore call for integrating all available information about that object. On the other hand, US expectancy judgments are typically understood as momentary predictions of an imminent event (e.g., "given this CS, do you expect a US to be presented?") and should therefore more strongly rely on recent trends (Collins & Shanks, 2002; Matute et al., 2011). As a consequence of these defaults, a CS that has signaled negative events in the past is still evaluated negatively overall, even if recent encounters were neutral and negative events are no longer expected to occur in its presence (Lipp & Purkis, 2006). Importantly, these defaults are properties of the dependent measures and therefore operate at the retrieval or performance stage; and they are malleable, allowing for reversing the resistance-to-extinction pattern to show momentary (i.e., context-specific) evaluative judgments on the one hand versus integrative (overall) expectancy judgments on the other hand (Aust et al., in press).

　　To conclude this section, while we have illustrated that different dependent measures may have different properties, it is beyond the scope of the present account to make a-priori assumptions about the properties of a representative range of measures. When those properties were relevant to our account of a phenomenon, we have sought support by building on independent evidence (e.g., Whittlesea & Dorken, 1997; Whittlesea & Price, 2001) or by deriving and testing new predictions (as we have done in our account of extinction).

Issues Involving Multiple Stages

In this section, we address dissociation findings that can arise from factors involving multiple stages (e.g., from interactions between effects operating at different stages). In particular, we discuss the distinction between on-line and memory-based information integration.

We also address the role of relational qualifiers and discuss recent findings regarding the (un-)controllability of EC.

On-Line Versus Memory-Based Integration

An important issue when making memory-based judgments or decisions concerns the processes that integrate mnemonic contents to make these judgments or decisions. The strategies used for integration will depend on properties of the task, for instance, the available resources as well as the instructions during learning, but also participants' expectations about how the learned information will be relevant for later parts of the study (i.e., the type of dependent measure they foresee). Here, we briefly sketch an important distinction relevant for information integration: online versus memory-based judgments (Hastie & Park, 1986), or prospective versus retrospective integration (Shohamy & Daw, 2015).

First, it is well-known that on-line judgment or impression-formation tasks may lead to different outcomes than deferred judgment tasks that produce their judgments only later on the basis of retrieval from memory (Hastie & Park, 1986). In memory-based tasks, participants are typically instructed to simply encode and remember the information for later retrieval in a memory test. When later asked to form a judgment about a target, participants need to first retrieve information from memory and integrate this information in order to form a summary judgment. As a consequence, summary judgments are substantially correlated with the information retrieved from memory; information that has been forgotten cannot be used to inform the judgment.

By contrast, in on-line tasks, learning instructions require participants to make use of the presented information to form a judgment about a target. In these tasks, judgments are assumed to be formed on-line and stored in memory in a summary fashion. When later asked to evaluate the target, the stored summary judgment can be retrieved without requiring further integration. In contrast to memory-based judgments, these on-line judgments are less strongly correlated with the information that can be retrieved from memory at the time of judgment, because here the summary judgment has already been formed during learning, such that later forgetting affects the retrieved information but not the summary judgment. In EC tasks, instructions take a wide variety of forms that vary along the online- versus memory-based dimension, with explicit impression formation requirements calling for on-line judgments, whereas passive viewing instructions allow participants to select their own encoding strategy, and memorization instructions call for a deferred memory-based judgment. We predict that the relation between memory and evaluative judgment will depend on the degree to which processing occurs in an online versus memory-based fashion.

A related but different distinction in memory research is that between prospective versus retrospective integration (Shohamy & Daw, 2015): Prospective integration is similar to the memory-based judgment scenario described above in that it refers to integrating the available information only at the time of decision. On the other hand, retrospective integration refers to a process by which overlap in the memories already trigger an

integration of episodes during learning (see Maintenance section above). This is conceptually close to the idea of on-line impression formation: in both cases, multiple different episodes relevant for a given target stimulus are continuously combined to form an integrated representation that contains a (weighted) summary of the information learned from these episodes. The retrospective integration mechanism allows for integration of overlapping memory traces during encoding and may replace prospective integration in these situations.

Dissociations may arise when the type of information integration interacts with properties of dependent measures. The distinction between on-line and memory-based decisions is relevant for the finding that indirect evaluative measures were sensitive to relational information only under impression-formation but not memorization goals (Moran et al., 2015): Both types of measures should tend to agree when impression-formation goals lead to encoding of a single summary evaluation of the CS; indeed, a judgment formed on-line can readily be expressed in both direct and indirect evaluation tasks (Moran et al., 2015). In contrast, under memorization goals, the measures should be less likely to agree: The effect of relational information is expected to be stronger on direct (unspeeded) than on indirect (speeded) evaluative measures because of the additional requirements of (1) correctly retrieving both the valence of the associated US and the relational qualifier and (2) of integrating these two (potentially conflicting) pieces of information (i.e., modifying the valence of the US in accordance with the relational qualifier). If asked to form an integrative judgment on the basis of information retrieved from memory, participants are therefore more likely to succeed in unspeeded direct measures and more likely to fail in speeded indirect measures.

Relational Qualifiers and Controllability

Any information about the relation between CS and US is itself a stimulus and therefore part of the episode. For relational qualifiers to affect EC requires their successful encoding, maintenance, and retrieval, and thus depends on attentional resources and processing goals during encoding, on maintenance during the retention interval, and on retrieval and integration as just discussed. Relational information may be integrated with other stimulus information during encoding (e.g., depending on memorization vs. impression-formation goals) or may remain nonintegrated (e.g., if it is presented as an indirect cue). These factors will influence the effect of qualifiers on EC.

Recent studies have claimed that EC may be uncontrollable (Gawronski, Mitchell, & Balas, 2015; Hütter & Sweldens, 2018). These studies have implemented control instructions that are conceptually similar to relational qualifiers: Participants were instructed that the presented relation is invalid, or that it should be negated. During encoding, some CS-US pairs were presented with an affirmative modifier (e.g., form an impression of the CS in line with the USs' valence), whereas others were presented with a negating modifier (e.g., form an impression opposite to that of the USs' valence). Thus, participants' encoding task was to integrate two (potentially conflicting) pieces of information under

time constraints dictated by the stimulus presentation schedule (typically a few seconds). Results showed that control sometimes failed, and this was interpreted as evidence for uncontrollable EC.

Instead we suggest a simple encoding-based explanation of control failure: The encoding task is clearly easier on affirmative than on negated trials because the latter likely require some form of additional processing, the effectiveness of which will depend on participants' strategies for implementing the control instructions (e.g., negation of US valence, imagination of a stimulus of opposite valence) and motivation. If we assume that, therefore, participants fail to perform the required relational qualification process on a subset of to-be-negated trials, this would result in an EC effect in line with—rather than in opposition to—US valence. Such a residual unqualified EC effect was found and interpreted as evidence for uncontrollable EC (Hütter & Sweldens, 2018). However, the finding that control of EC was not perfect in these specific situations does not imply that EC is (partly) uncontrollable—much as the finding that explicit memory for CS-US pairs was not perfect in these same situations does not imply that some of the pairings were unmemorizable. More adequately, therefore, the effect might be interpreted as uncontrolled EC. Research into participants' strategies for implementing the control instructions may elucidate these findings (and may identify more effective control strategies).

The maintenance stage is a second possible locus at which the finding of partially uncontrolled EC may come about under memorization instructions: Let us assume that participants have perfectly encoded both the CS-US pair and the qualifying information. During the retention interval, parts of this information is likely to be forgotten or degraded (with different forgetting rates applying to specific perceptual detail versus abstract gist summaries). If the qualifier is forgotten, participants will later fail to invert their CS impression as instructed, yielding an "uncontrolled-EC" pattern for these CSs (e.g., Gawronski, Mitchell, & Balas, 2015).

Effects at retrieval may also be involved here and affect the degree to which control modifiers affect the evaluative outcomes: When participants use an analytic strategy during the evaluative task, they may take into account different subsets of the available information than under a non-analytic strategy (Whittlesea & Price, 2001). As another candidate effect operating at retrieval, under memorization instructions participants may not integrate the information until explicitly asked to do so during an evaluative task. In the Retrieval section we noted that integration may be easier on some tasks than on others, and this can lead to dissociations if the outcomes of different tasks are compared (Moran et al., 2015).

In sum, there are several possible accounts for control-failure patterns that need to be compared empirically in future research. This task may be further complicated if different accounts apply under different conditions.

Additional Issues

This section briefly addresses several additional questions relevant for this special issue.

Moderating Factors and Interindividual Differences

Generally speaking, as a judgment based on episodic memory, EC should be subject to moderation by all those factors that moderate episodic memory and simple judgments based on its contents. Similarly, any interindividual differences that affect memory should also affect EC, for instance (but not limited to), the ability to consciously perceive brief and masked stimuli; working memory capacity; and fidelity of episodic long-term memory. With regard to the MINERVA 2 implementation, the following factors should moderate EC, beyond those already discussed above: the rate at which information is learned (moderated by, e.g., stimulus complexity, presentation duration, attention, load, and goals), the relative weight of attention given to the relevant different parts of the episode (e.g., CS, US, and qualifying information), the number of repetitions of each (type of) episode, and the rate at which information is forgotten.

Critically, MINERVA 2 predicts that similarities between encoded episodes (e.g., CS, US, and context) affect EC. A fundamental assumption of the MINERVA 2 model is its similarity-based retrieval mechanism: Past episodes in memory contribute more strongly to the retrieved information if they are similar to the retrieval cue than when they are dissimilar. If CSs are highly similar, their memory traces will be difficult to distinguish, and memory traces from different CSs may be confused with each other. As a consequence, EC effects should be easier to obtain when the CSs paired with positive and negative USs are dissimilar than when they are similar (see also the Prediction section below). As previously discussed, retrieval cues may encompass the CS presented by the experimenter but also external and internal context features. Hence, the model also predicts that the similarity between contexts during encoding and retrieval moderates the EC effect (Gawronski et al., 2018; Zanon, De Houwer, & Gast, 2012). From this it also follows that novel CS stimuli should show greater EC effects: At the outset of the learning procedure, memory contains no episodes involving the CSs that affect retrieval and interfere with the experimentally induced EC effect. This pattern was reported in the recent meta-analysis (Hofmann et al., 2010).

Verbal Information and Instructed EC

On the one hand, verbal instructional information may simply be construed as a stimulus that is encoded into memory and may affect CS evaluations. Future research will show whether and when it is integrated with co-occurrence information, and whether this depends on or dissociates as a function of the dependent measure. For instance, the symbolic and discrete nature of such verbal instructions may promote their use in informing direct evaluative responses. In contrast, it may be more difficult and time-consuming to compute CS evaluations via retrieval of weak and diffuse traces of CS-US co-occurrences.

On the other hand, the effects of instructions, and of verbal information in general, are somewhat beyond the scope of the present account. As we explained in the introduction (and discuss below), beyond rather simple effects of verbal information that are a by-prod-

uct of memory processes, the present perspective is silent about effects of instructions that involve propositional reasoning processes.

Discussion

The memory-based-judgment view naturally accounts for the relation between EC and memory highlighted in current reviews, especially the finding that EC is strongly correlated with memory for pairings (Hofmann et al., 2010; Pleyers, Corneille, Luminet, & Yzerbyt, 2007), and other work showing that EC requires US valence memory (but may occur with weak or no US identity memory; Stahl et al., 2009).

More importantly, the memory-based-judgment view provides an account of a set of findings, identified in a recent review (Corneille & Stahl, 2018), that have previously been taken as evidence against a single-process view, on the grounds that what one may summarize as their 'relative automaticity' does not fit well with an effortful propositional process:

- EC is found under incidental learning conditions (e.g., in surveillance studies)
- EC may occur with weak memory for US valence (e.g., in PD studies)
- EC measures may be differentially sensitive to relational information and partly uncontrollable (e.g., forgetting of details; integration failure)

We have illustrated here how these phenomena can be understood as resulting from evaluative summaries that are affected by the information provided in the learning phase via its encoding, maintenance, and retrieval from episodic memory.

The present view implies that it will not be possible to eliminate memory without also eliminating EC. Memory and EC are not independent and cannot be doubly dissociated. It may sometimes be possible to find residual EC even at a point of low attention, suboptimal presentation, incidental learning, and with only weak memory for the pairings. But importantly, departing from this point, every manipulation that strengthens memory will also strengthen EC; it will not be possible to affect one without affecting the other.

Additional Relevant Findings

We have outlined how incidental EC phenomena can be explained by episodic memory principles and their interaction with properties of dependent measures. Highlighting the similarities between EC and memory has proven fruitful beyond this limited focus, as illustrated by the independent work of Gast and colleagues (Gast & Kattner, 2016; Richter & Gast, 2017). A memory-based account of EC naturally explains the observation that factors which improve or impair memory similarly strengthen and weaken EC. It is well known that memory benefits from distributing practice over time compared to massed practice in one session (Donovan & Radosevich, 1999; Hintzman, 1974). On the other hand, post-study instructions to forget subsets of items from the study list impair retrieval of said items (Bjork, 1972; H. M. Johnson, 1994; MacLeod, 1998; Muther, 1965). Correspondingly, Richter and Gast (2017) found greater EC effects when short CS-US pairings were distrib-

uted throughout the learning phase compared to one long presentation. Gast and Kattner (2016) found that directed forgetting reduced the EC effect.

Flexibility and Scope

The range of phenomena being discussed under a functional definition of EC is broad, covering such diverse findings as EC via verbal instruction and via experienced pairing, obtained via incidental and intentional learning, with measures such as explicit and projective judgments as well as binary classification tasks, and susceptible to moderation via a wide range of factors from top-down beliefs and goals to bottom-up viewing duration. Unless complex reasoning processes are involved, we believe the underlying machinery of episodic memory is capable of accounting for EC across this entire range. It is to be expected however, that a single set of parameter settings will not work across the entire range, but that parts of the model will need to be adapted to the specific phenomenon under study. For instance, our work on extinction illustrates that adjustments need to be made for the choice of dependent measure: If participants by default rely on momentary, context-specific information for expectancy judgments but on integrative summaries for evaluative judgments, this of course needs to be reflected in the model if it is to account for the empirical findings.

The present view is relatively flexible because it allows for the entire range of factors that affect memory to also affect EC. Importantly, however, because the flexibility was put in place to account for a wide range of memory phenomena far beyond EC, and was not added in order to explain EC, it should not be held against the present theoretical perspective of EC. By explaining EC as following from established theory, without making any new assumptions, the present view is in fact maximally parsimonious when not only simplicity but also scope is considered (i.e., it has greater *empirical content*; for a discussion of the empirical content of decision-making models, see Glöckner & Betsch, 2011).

Limitations and Open Questions

The MINERVA 2 model is used here to serve as an illustration of how the principles of episodic memory can account for the EC phenomenon. It formalizes the underlying assumptions of our basic hypothesis, and it helps to derive predictions about EC effects in established as well as novel situations. While the MINERVA 2 model may seem a somewhat outdated choice given its introduction more than 30 years ago, it is in fact still being applied and developed in a variety of domains to account for memory-informed cognition and behavior, for example, in specific implicit learning paradigms such as artificial grammar learning (Jamieson & Mewhort, 2009a), and the serial response time task (Jamieson & Mewhort, 2009b), but also more generally to model frequency and probability judgments (Dougherty, Gettys, & Ogden, 1999), as well as hypothesis generation (Thomas, Dougherty, Sprenger, & Harbison, 2008). Its continuing success may be due to the fact that it is a relatively simple model that nonetheless shares many properties of more advanced (and more powerful and flexible) models that were developed to account

for an even wider range of phenomena. While it has certainly not been without criticism (e.g., Clark & Gronlund, 1996), on an abstract formal level it has been shown to be closely related to a wide range of current formal memory models (see Kelly, Mewhort, & West, 2017).

So far, we have formally applied the MINERVA 2 model to counterconditioning and extinction of EC. As we extend the application of this formal approach, we expect that the MINERVA 2 model can help account for many (but perhaps not all) EC phenomena that are based on relatively simple forms of memory retrieval. Additional assumptions will be required to model EC in general, and certain specific EC phenomena in particular. This is especially true for dynamic processes during encoding and maintenance, as well as assumptions about how the information retrieved from memory is weighed and integrated to inform subsequent processing. As we said earlier, the MINERVA 2 model accounts for the information available in memory at the time of retrieval or performance, and how it is retrieved. However, by itself, the model does not account for subsequent processing, such as reasoning processes that operate on the retrieved information. We have outlined how the model can be extended by introducing additional assumptions about attention allocation and information integration during encoding that have been substantiated by independent memory research. Our approach however cannot (and does not aim to) explain how reasoning processes affect evaluative judgments and behaviors; it focuses on the underlying episodic memory processes.

A related limitation concerns the underspecification of how the retrieved contents of memory informs behavior. We acknowledge that the implementation of the link between retrieved information and behavior in our own work is so far very simplistic and probably requires elaboration. For tests of theory, it is therefore important to rely on well-studied dependent measures; yet, knowledge about the dependent measures used in EC research is often lacking. Ideally, paradigms with validated formal measurement models (e.g., signal detection or drift diffusion) would be available to provide a tight link between the theory's prediction and the data.

Memory models explain how learning episodes are encoded and maintained, and sometimes address how they inform recognition judgments and recall performance. Yet, they are typically silent as to how the contents of memory inform other judgments and measures that require more complex information integration. Not all dependent measures tap the encoded information in the same way, and these differences are important for our understanding of empirical findings. In this vein, our perspective echoes the work by Hastie and Park (1986) who discussed the important distinction between judgments formed on-line (during encoding) versus later (based on retrieval from memory). Other properties of dependent measures may include the time available for memory retrieval (i.e., speeded versus unspeeded measures), the availability versus internal self-construction of retrieval cues (recognition versus recall), or whether the measure requires a global versus context-specific judgment (i.e., whether it requires retrieval of context information). As a step in that direction, a formal model of memory-based likelihood judgments has previously been

proposed by Dougherty and colleagues (Dougherty et al., 1999) and successfully applied to account for a wide range of heuristics and biases from the decision-making literature.

In the absence of validated measurement models, dissociations between dependent measures may always reflect properties of the measures themselves rather than the learning processes. Hence, it is important to keep the dependent measures constant between conditions.

Relation to Current Theories of Memory

The present account, based on MINERVA 2, is a single-process global-matching memory model that, given a cue, produces a familiarity signal and an echo that can be used to inform a variety of judgments. In the original proposition, it was conceived of as a model of declarative long-term memory and used to informing recognition decisions as well as frequency judgments (Hintzman, 1984); here we use the model in this original sense. Subsequent applications have extended it to apply to nondeclarative procedural memory domains such as motor learning (Jamieson & Mewhort, 2009b) or associative learning phenomena more generally (Jamieson, Crump, & Hannah, 2012); this suggests that the general principles of the model are capable of accounting for both types of memory systems. In principle, however, the ability of MINERVA 2 to account for a wide range of EC phenomena does not exclude the possibility that two qualitatively different memory systems—a declarative and a non-declarative one—underlie (some of these) EC effects. For instance, one may speculate that (unconscious) learning processes in performance tasks such as those reported by Greenwald and De Houwer (2017) may be based on nondeclarative memory, whereas effects on evaluative ratings in similar paradigms (Schmidt & De Houwer, 2012) may turn out to depend on declarative memory. While it appears that the response priming effect in Greenwald and De Houwer (2017) reflects nondeclarative processes, it remains unclear whether it should be interpreted as EC, which will arguably depend on the degree to which the nondeclarative learning effect turns out to be directly relevant for evaluative cognitions and behaviors.

In recognition memory, as in EC, there is a debate between single- and dual-process models (Dunn, 2008; Wixted & Mickes, 2010). The most prominent dual-process theory of memory (see Yonelinas, 2002 for a review) posits that, in addition to the graded familiarity signal based on similarity to the cue, a thresholded recollection process can contribute to recognition: If it succeeds, the target episode is reinstated (i.e., it triggers a recollective experience) and detailed episode-specific information can be reported. Applied to EC, successful recollection will retrieve the CS-US episode (and support US identity memory); but even if recollection fails, the gradual familiarity signal may suffice to support EC (i.e., in the absence of US identity memory). Evidence for EC in the absence of recollection (and US identity memory) has been repeatedly reported (e.g., Olson & Fazio, 2001; Stahl & Heycke, 2016), and it could be argued that therefore, EC can come about by familiarity alone. On the other hand, it is generally accepted that EC can come about via recollection of CS-US episodes and subsequent propositional reasoning processing based thereon. Taken together, it might be argued that these findings represent support for a dual-process account of EC.

Such an argument would be unconvincing, however, because it overlooks the important confound of memory strength in dissociations between recollection and familiarity (Wixted & Mickes, 2010). Traditionally, recollection and familiarity have been assessed using the remember-know procedure, which relies on a subjective report of mnemonic experience (i.e., participants indicated whether their classification of an item as *old* was accompanied by a recollective experience or whether they simply knew the item was old). The measures of recollection and familiarity derived from this procedure have revealed empirical dissociations in several studies, but the critical pattern of a crossed double dissociation has not been robustly reported. Single-process proponents have argued that the evidence does not require two distinct processes, and indeed it has proven difficult to provide strong support for these models: In a quantitative review, the results from this procedure have been shown to reflect a single underlying dimension of memory strength (Dunn, 2008). Along the same lines, a recent review of the neuroanatomical basis of memory (Squire & Wixted, 2011) points to the strength confound that compromises most of the research on the dual-process model. In recent studies that have controlled this confound, both recollection and familiarity were found to be supported by the same underlying neuroanatomic structures.

These reviews confirmed the notion that the remember-know distinction was not used by participants in a way that equates memory strength across both types of responses; instead, stronger memories were more likely classified as *remember* and weaker memories more likely classified as *know*. This pattern of findings is entirely consistent with single-process accounts which hold that the likelihood of retrieving episodic detail increases with memory strength. To study whether recollection and familiarity do indeed reflect the operations of two distinct latent processes, memory strength of both types of experiences has to be controlled (Wixted & Mickes, 2010). To date, there have only been a few studies that have accomplished this control; and additional research is necessary to settle this issue. Even if this approach leads to robust dissociations, these would only imply that at least two latent parameters are necessary to account for the observed two-dimensional outcome space—however, such dissociations do not necessarily imply that these parameters must reflect distinct *processes*; alternative accounts of these dissociations have been proposed in terms of different types of information, or elements of latent computations (Kalish & Dunn, 2012). In sum, the debate between single- and dual-process theories of recognition memory is ongoing; perhaps partly because they are addressing different (functional and structural) levels of explanation, which has led some researchers to argue that it is unclear whether they are actually competing theories at all (Kalish & Dunn, 2012).

Predictions

Any predictions that can be derived from the memory literature in general, and from the MINERVA 2 model in particular, can be used to test the present view. In testing predictions, it is important to note that any dissociations may be due to differences in how the information in memory is mapped onto the specific evaluative response required by that measure. In addition, the exclusion of reasoning processes is critical for tests of the present

model. The PAL posits that learning results from reasoning processes that operate on the basis of the contents of memory; this implies that we can investigate whether a given EC phenomenon can be explained by memory processes only to the degree that the influence of reasoning processes relation is controlled. Past studies have attempted to achieve this by implementing incidental learning conditions, by presenting complex and irregular stimulus sequences, and/or by occupying participants' working memory with an irrelevant task. Bearing in mind these constraints, below we suggest a few specific predictions that can be used to test the present account.

First, from the observation that stimulus similarity is a central factor in the model, a novel prediction can be derived that may be described as an EC analogon of the false-memory effect: EC effects should be affected by CS similarity because similar CSs may activate each other's memory episodes. In episodic memory, this influence of similarity leads to false-memory phenomena in which lures that are similar or related to studied items are mistakenly recognized more often than dissimilar lures. Applied to EC, a novel (unpaired) stimulus that is similar to a CS paired with positive (negative) USs should be evaluated more positively (negatively) than a novel stimulus similar to a CS paired with negative (positive) USs.

A second prediction is that, if two highly similar CSs are paired with opposite-valence USs, then EC effects should be reduced (when compared with dissimilar CSs) because, at retrieval, the CS (at least partly) cues and retrieves episodes of the opposite valence that influence its evaluation. On the other hand, EC should be increased for similar CSs paired with same-valence USs because the CS (partly) cues a larger number of episodes that concur with the valence of the associated US.

Third, MINERVA 2 more generally predicts that EC should show similarity-based generalization patterns. Note that such patterns may however be overruled if additional verbal reasoning processes are involved (i.e., rule learning). Several studies have reported evidence for a default similarity-based pattern of evaluations (Fazio, Eiser, & Shook, 2004) that can be overridden if rule knowledge is available and applicable (Högden, Stahl, & Unkelbach, n.d.).

The above discussion of current memory theory highlights two additional predictions that can be derived from the single-process memory model:

First, nondeclarative learning effects (e.g., Greenwald & De Houwer, 2017) may be obtained simultaneously and in parallel with effects driven by declarative memory. Importantly, nondeclarative learning effects should not directly inform evaluative cognitions and behaviors.[6]

Second, it is assumed that memory strength is predicted to be the underlying factor that determines the type of mnemonic experience (recollective or not). Applied to EC, when memory strength is controlled, EC should no longer vary as a function of 'remember' versus 'know' experiences.

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[6]   Indirect effects are however possible if the effects of nondeclarative learning become available to declarative knowledge, for example, if performance on a task improves unexpectedly, which may then induce conscious hypothesis testing to detect the causes of this improvement (Haider & Frensch, 2009).

Outlook

The present memory-based-judgment perspective of evaluative learning posits that the information extracted from each learning instance is stored in episodic memory for later use. By restricting the flexibility at the encoding stage, this perspective highlights the necessity to account for processes operating at the retrieval or performance stage to specify how this information is actually used to inform cognitions and behaviors. We have shown that retrieval processes may be responsible for (some of) the observed dissociations that are often attributed to the learning stage. Links between retrieved information and behavior are often underspecified; to fill this gap, future research should focus on expanding our knowledge about dependent measures to establishing measurement theories and models that can be used to derive and test more precise predictions.

Another connection that requires specification is that between memory and reasoning (or, more generally, higher-order cognition accounts). In this respect, the present restriction to EC phenomena that do not involve reasoning can be argued to lack precision as it does not delineate what should count as reasoning. The underlying models do not provide a clear distinction: *MINERVA 2* has been used to account for relatively simple judgments, for instance, of old/new recognition, yet such judgments could also be framed as reflecting inferences about previous occurrences based on cue familiarity. The closely related *MINERVA-DM* (Dougherty et al., 1999) is capable of computing (conditional) probabilities, which can be seen as the core constituents of Bayesian theories of reasoning. Its successor, the *HyGene* model, even incorporates hypothesis generation and testing (Thomas et al., 2008). Conversely, the PAL account has been criticized on the grounds that, while it argues that propositional learning operates on the basis of the contents of memory, it fails to further specify the link between memory instances and propositions (Newell, 2009). From the perspective of the PAL account, this linking problem could be defined away by assuming that propositions are formed during learning and then stored in memory for later retrieval. If we agree, however, that non-propositional information can also be stored in memory, a mechanism is needed that specifies how it can be linked to propositional reasoning processes. The above-mentioned extensions of the MINERVA 2 model can be seen as a first step toward addressing this missing link between memory and reasoning (Dougherty et al., 1999; Thomas et al., 2008).

A tighter link between episodic memory and learning is being developed in other research areas as well. Instance-based accounts are discussed not only in associative as well as implicit learning (Jamieson & Mewhort, 2009a; Jamieson et al., 2012), but also in reinforcement learning and economic decision-making (Gershman & Daw, 2017; Shohamy & Daw, 2015), and the statistical and language learning literature (Thiessen, 2016; Thiessen & Pavlik, 2013), to name but a few. Accounting for evaluative learning within a similar framework will allow for a strong and promising integration with these literatures.

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Competing Interests

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