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What You Feel Is What You See: A Binding Perspective on Evaluative Conditioning

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Abstract

In this paper, we outline the predominant theoretical perspectives on evaluative conditioning (EC)—the changes in liking that are due to the pairing of stimuli—identify their weaknesses, and propose a new framework, the binding perspective on EC, which might help to overcome at least some of these issues. Based on feature integration theory (Treisman & Gelade, 1980, https://doi.org/10.1016/0010-0285(80)90005-5) and the theory of event coding (TEC; Hommel, Müsseler, Aschersleben, & Prinz, 2001, https://doi.org/10.1017/S0140525X01000103), we assume that EC depends on a selective integration mechanism that binds relevant CS, US, and action features into an event-file, while simultaneously inhibiting features irrelevant for current goals. This perspective examines hitherto unspecified processes relevant to the encoding of CS-US pairs and their consequences for behavior, which we hope will stimulate further theoretical development. We also present some preliminary evidence for binding in EC and discuss the scope and limitations of this perspective.

Keywords

attitudes, associative learning, attention, binding problem, action control

A new colleague shows you a picture of a cute puppy. What do you see? You see wide eyes, fluffy fur, and big paws. If you also manage to still see the colleague that is holding the picture, a new attitude might be born. Specifically, you might start to like your new colleague because the warm feeling elicited by the puppy transfers to her. As a consequence, the probability might increase that you seek your colleague's advice, recommend her for an interesting task, or collaborate with her even under difficult circumstances, thus illustrating the importance of attitudes for predicting and controlling social behavior (see Cesario, Plaks, Hagiwara, Navarrete, & Higgins, 2010; Friese, Smith, Plischke, Bluemke, & Nosek, 2012; Vermeir & Verbeke, 2006). Importantly, the example also illustrates how attitudes are acquired in a complex environment. Specifically, attitudes can be formed through the pairing of stimuli, which is an effect referred to as evaluative conditioning (EC; De Houwer, 2007). EC is demonstrated when so-called conditioned stimuli (CSs), such as neutral objects, faces, or brand names, are evaluated more favorably after their pairing with positive stimuli and less favorably after their pairing with negative stimuli, the so-called unconditioned stimuli (USs), such as affect-laden pictures, words, or scents (Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010).

However, despite the simplicity and utility of EC for investigating attitude formation experimentally (for reviews, see De Houwer, Thomas, & Baeyens, 2001; Jones, Olson, & Fazio, 2010; Walther, Weil, & Düsing, 2011), it remains an open question as to how EC can be explained theoretically. Specifically, what are the encoding mechanisms responsible for linking features of a CS to features of a US, and, ultimately, contribute to (social) behavior?

In the present paper, we therefore propose a new framework, the binding perspective on EC, that is based on theorizing about the interface of perception and action planning, namely feature integration theory (Treisman & Gelade, 1980) and the theory of event coding (TEC; Hommel, Müsseler, Aschersleben, & Prinz, 2001). Specifically, we assume that EC depends on a selective, attention-driven integration mechanism that binds CS features, US features, and action features relevant to a current goal into an event file, a common but transient representational medium, while simultaneously inhibiting irrelevant features. By examining these processes at the intersection of perception and action planning, we hope to advance and stimulate theorizing in EC research.

The structure of the paper is threefold: First, we briefly outline the predominant theoretical perspectives on EC, identify their shortcomings, and conclude that a new perspective based on binding might be helpful to fill at least some of the explanatory gaps. Second, we delineate our framework and derive specific predictions for the integration of CS, US, and action features. Finally, we demonstrate our framework's theoretical and heuristic utility by presenting evidence for the predictions derived from a binding perspective as well as concrete examples of how a binding perspective can be applied to existing and novel research questions.

Shortcomings of Previous Theorizing

For many years, EC research has been predominantly concerned with associative and propositional explanations of EC. The former rose to prominence when Martin and Levey

(1978), who coined the term EC, translated the simplicity of the effect into an apparent simplicity of underlying processes, arguing that attitudes could be acquired in a simple, automatic way. Later, similar accounts (Baeyens, Eelen, Crombez, & Van den Bergh, 1992) specified that the contiguous encoding of CS and US suffices the formation of an association between their representations, leading to an activation of the US's representation (Baeyens et al., 1992) or its evaluation (Martin & Levey, 1978) whenever the CS is processed.

However, in arguing against the zeitgeist of the cognitive revolution, associative explanations were met with controversy (Davey, 1994; Field & Davey, 1997), and motivated the formulation of an alternative perspective, the propositional explanation of EC. Propositional explanations (Baeyens, Field, & De Houwer, 2005; Davey, 1994; De Houwer, 2009; Mitchell, De Houwer, & Lovibond, 2009) emphasize the importance of reasoning processes, and explain the occurrence of EC by the formation of a propositionally represented belief about some form of CS-US relation.

Yet, despite generating a wealth of investigations (see Hofmann et al., 2010), the predominant focus on processes of associative and propositional learning, and their relative contribution to the emergence of EC, relates to several shortcomings that we identify as key obstacles to advancing theorizing about the encoding mechanisms underlying EC.

A Lack of Testable Predictions

First, one primary reason for the limited understanding of EC is that associative and propositional accounts specify only a few testable predictions for the processes linking CS, US, and action features. For example, according to the associative explanation of EC, the encoding of CS and US is assumed to be both the necessary and sufficient condition for EC to occur. Thus, associative accounts fail to specify boundary conditions of EC that go beyond the definitional requirement of pairing CS and US (e.g., De Houwer, Thomas, & Baeyens, 2001), which renders those explanations descriptive at best and untestable at worst.

In a similar but less obvious vein, propositional explanations also provide few testable predictions for feature integration. Although the idea of propositional learning specifies some boundary conditions for the emergence of EC by assuming that the formation of a propositional belief requires awareness of and an intention to process a CS-US relation, as well as sufficient processing resources (e.g., Mitchell et al., 2009), the approach does not define how a CS-US relation is established (Hofmann et al., 2010). Neither is it described in any detail how the formation of a belief about such a relation would translate into behavior. Thus, propositional accounts are usually restricted to the case that a proposition is formed, but how or why this happens is not explained. Moreover, it is not clear whether all criteria of controlled processes (effort, intention, awareness, control) are necessary or whether some of them, or a configuration of them, would already produce EC. Therefore, auxiliary assumptions need to first be specified in order to derive testable predictions about the initial encoding processes from the propositional account as well.

Process-Unspecific Investigations of Boundary Conditions

Second, and relatedly, empirical investigations conducted within the associative vs. propositional perspective have investigated processes related to the encoding of CS-US pairs in a relatively unsystematic way. In fact, due to the lacking specifications of encoding processes within the associative and propositional perspective, empirical research on EC largely made process-related inferences a posteriori. For example, an overwhelming majority of EC studies investigated the relation between EC and participants' memories for CS-US pairs (see Gawronski & Walther, 2012; Hofmann et al., 2010) with the intention of examining the role of contingency awareness during learning. Contingency awareness is considered particularly relevant because it supposedly speaks to the involvement of propositional processes in the emergence of EC and whether EC should be considered similar to other learning effects, such as signal learning (see De Houwer et al., 2001; Walther, Nagengast, & Trasselli, 2005). Moreover, these studies refer to the potentially disturbing question of whether people's attitudes could be manipulated outside of their awareness (e.g., Dijksterhuis, Smith, van Baaren, & Wigboldus, 2005; Karremans, Stroebe, & Claus, 2006). However, despite numerous efforts to optimize memory tests (e.g., Halbeisen, Blask, Weil, & Walther, 2014; Hütter, Sweldens, Stahl, Unkelbach, & Klauer, 2012; Stahl, Unkelbach, & Corneille, 2009; Walther & Nagengast, 2006), the informational value of inferring processes of encoding from memory retrieval remains questionable (for an extensive discussion, see Gawronski & Walther, 2012).

In a similar vein, several studies used different dual-task paradigms in order to determine whether EC relies on a more effortful, strategic encoding mechanism (e.g., Brunstrom & Higgs, 2002; Field & Moore, 2005; Halbeisen & Walther, 2015; Kattner, 2012; Pleyers, Corneille, Yzerbyt, & Luminet, 2009). However, given that secondary tasks in dual-task paradigms may affect a multitude of processes (Field & Moore, 2005; Halbeisen & Walther, 2015), these studies remain largely uninformative about which specific encoding mechanism the emergence of EC might require.

Procedural Diversity

Third, and although conceptually independent of the associative vs. propositional focus, the findings of many investigations are hardly comparable due to a lack of standardized research methods. Different from cognitive psychology, in which well-defined experimental paradigms exist that make results from different studies comparable, EC is used as an umbrella term for a wide array of experimental protocols, differing in nearly all relevant parameters (e.g., ISI, ITI, stimulus material and positioning etc.), with the only common denominator that stimuli are paired. While procedural diversity is informative for the robustness of EC and helpful in generating novel research questions (for example, about the specific ways that procedural parameters affect EC, Sweldens, van Osselaer, & Janiszewski, 2010), identifying the relevant encoding mechanisms demands a more theory-driven and systematic variation of encoding-relevant parameters.

A Tendency Toward Theoretical Isolation

Finally, the self-referential focus on associative vs. propositional explanations of EC coincided with an almost nonexistent consideration of related research areas, limiting alternative conceptualizations of EC. For example, findings on implicit learning suggest that regularities of the environment are registered automatically (e.g., Eberhardt, Esser, & Haider, 2017), and that learning can occur without the intention to learn and without awareness of what is learned (but see Deroost & Coomans, 2018). However, the question of whether EC might be similar or different to instances of implicit learning (at least under certain conditions) has hardly been discussed. Moreover, implicit learning can be highly selective (e.g., Eitam, Schul, & Hassin, 2009; Jiang & Chun, 2001; Turk-Browne, Jungé, & Scholl, 2005), suggesting that the often-assumed unity of aware and intentional processes is unwarranted (see Keren & Schul, 2009). It would be important to examine whether EC would be similar or different from implicit learning in this respect.

In sum, EC research has been predominantly concerned with processes of associative and propositional learning, but neglected to specify the encoding mechanisms that link CS, US, and action features. Specifically, a lack of testable predictions about these encoding mechanisms, a process-insensitive research focus, procedural diversity, and a tendency toward theoretical isolation have limited the theoretical understanding of EC. To be clear, there are also many positive examples of theoretical innovation (Jones, Fazio, & Olson, 2009) and experimental rigor as well as standardization (Stahl, Haaf, & Corneille, 2016). Nevertheless, as the identified issues can be applied to many investigations, further theoretical development calls for an additional, broadly-informed perspective, that provides testable assumptions about the specific encoding mechanisms underlying EC.

In what follows, we will delineate a theoretical perspective on EC which is based on feature integration theory (Treisman & Gelade, 1980) and the theory of event coding (TEC; Hommel et al., 2001; Hommel, 2004). Given the fact that "TEC is more a loose framework of theoretical principles rather than a strict, formal theory" (Hommel et al., 2001, p. 850), this framework does not cover all processes related to EC, such as the nature of a conditioned attitude's representation (i.e., whether the structure can be described as associative or propositional), or how conditioned attitudes are retrieved and expressed (for a detailed account, see Gawronski & Bodenhausen, 2006). However, testable hypotheses for the integration of CS, US, and action features can be derived from this framework and it thus builds a promising starting point to address a relatively early stage of these hitherto unspecified encoding processes.

A Binding Perspective on EC

When you see the cute puppy, you perceive a coherent stimulus rather than separate features. Nevertheless, its different features, such as color, size, and location are encoded in a distributed fashion, resulting in numerous so-called *binding problems*. The multiplicity of binding problems becomes apparent when considering that binding problems have been identified in several research areas, like implicit learning (Haider, Eberhardt, Esser, & Rose, 2014), image segmentation (Mozer, Zemel, & Behrmann, 1992), memory (Baddeley, 2000), and, among others, consciousness (e.g., Reder, Park, & Kieffaber, 2009; Singer, 2001). Indeed, binding problems are not restricted to the integration of features across the visual domain, but also expand to other modalities, like audition (e.g., Vatakis & Spence, 2007; Zmigrod, Spapé, & Hommel, 2009), or the binding of neural signals across cortical areas (e.g., Keizer, Colzato, & Hommel, 2008), to name a few. In order to resolve these problems, some kind of integration mechanism is needed that binds together the distributed feature-codes that belong to the relevant event, while avoiding the intrusion of irrelevant feature-codes (see Treisman, 1996).

Features Are Bound by Selective Attention

The most prominent theory addressing the binding problem is the feature integration theory by Treisman and Gelade (1980), which emphasizes processes of selection, i.e., attention, in order to explain binding[1]. Treisman and Gelade (1980) assume that separate features, for example, round, brown, and small that are present in the same focally attended location are integrated into an object-file. That is, the selective processing of one particular stimulus, for instance, a visual depiction of a puppy, leads to a parallel activation and integration of all the feature-codes representing the puppy. Thus, according to feature integration theory, selective attention provides the key process leading to a coherent representation of objects.

Extending feature integration theory, Hommel et al. (2001) assume that cognitive representations serve not only representational functions (e.g., for perception, imagery, memory, and reasoning), but also action-related functions (e.g., for action planning and initiation). In fact, TEC suggests that perceived events and planned actions are functionally equivalent because they both refer to the internal representation of external events. The cognitive architecture supporting perception and action planning is then, according to TEC, a common representational domain shared by events perceived and intended in which perceptual codes and action codes may prime each other. Thus, going beyond the idea of an object-file that merely reflects the representation of perceived events, TEC postulates the encoding of stimulus and action feature-codes of a given event in a common representational medium, the so-called *event-file*.

Moreover, and as a logical consequence of the idea of a common representational domain, the concept of an event-file also implies an abstract rather than a modality-specific representation of perceptual and action-features. That is, although perception and action

[1] To avoid potential confusion, it is important to consider that attention, in the context of feature integration, refers to the necessity in action planning to process only certain aspects of environmental information relevant to a current goal while ignoring other aspects. It does not refer to limitations in working memory capacity, although both are frequently confounded theoretically and empirically.

may have common external referents and therefore need to match, the neural patterns underlying perception and action are inherently dissimilar. For example, when you reach for the aforementioned picture of the puppy, your hand's intended movement needs to match the perceived hand-picture distance, but the sensory activation of distance perception will not match the pattern of muscular innervation that is driving your hand's movement. Going beyond the structural assumptions of associations and propositions, the concept of an event-file thus implies that a binding of perceptual and action-features may only occur on an abstract, or distal level that relies on the informational content of the to-be-integrated events, irrespective of their modality- or domain-specific characteristics (see also Prinz, 1992).

Similar to Treisman and Gelade (1980), however, the integration of relevant stimulus and action feature-codes in an event-file is still assumed to depend on their selective processing in a given situational context. As the TEC considers humans as active agents that strive for goals and selectively process their environment in accordance with their goals (Hommel, 2015), the primary function of selective attention is thus to deal with control problems originating in the distributed processing of stimulus- and action features (Hommel, 2010) and to guarantee the smooth transition from offline, anticipatory action planning to online action adjustment. In this regard, selective attention mechanisms reflect the main function of cognition, namely the preparation of goal-related behavior (Hommel, 2010), and not only the administration of the scarce resources of a processing system.

EC Requires the Binding of CS and US Features

When viewed from a binding perspective, the occurrence of EC refers to the question of how CS and US features are integrated into one cognitive representation, i.e., an event-file. Based on TEC, we assume that affective learning involves an early stage of feature integration as the basis of any subsequent encoding and retrieval processes. In terms of TEC, CS and US features can refer to both perceptual features and response features, such as affective reactions towards the US or even arbitrary motor reactions performed in response to the stimuli. Although bindings may only be considered a transient representation of linked features (Giesen & Rothermund, 2014), a repetition of features can re-activate an event-file (Moeller, Frings, & Pfister, 2016) and thus promote the establishment of a longer-lasting representation.

To some extent, our binding perspective is reminiscent of Martin and Levey's (1978) original formulation of EC involving a "fusion" (rather than an association) of a CS representation with a US's evaluative response in "immediate memory" (p. 63), as well as with Jones et al.'s (2009) conception of EC as a misattribution of an affective response toward a CS. However, Martin and Levey did not specify how the fusion process is assumed to occur, and Jones et al. (2009) conceived of EC only as an error in feature integration processes. In comparison, we assume that feature integration is an adaptive process tailored toward situational demands (Hommel et al., 2001, p. 863) instead of conceptualizing EC as a failure of the cognitive apparatus that results in the formation of illusory conjunctions between CS and US features. Specifically, the integration mechanism underlying EC is presumed to rely on the selective processing of CS and US features in accordance with the perceiver's current goals. Thus, taking a binding perspective, the encoding mechanism underlying EC can be considered as a selective, goal-directed mechanism, emphasizing the important control function of attitudes in guiding social perception and action[2].

Taking a binding perspective on EC allows for the formulation of two central predictions that are in their precision unique to this approach. First, it can be predicted that any variable that influences the selective processing of CS and US with regard to a specific goal (such as perceptual salience, action relevance, congruency, contingency, etc.) also influences EC. Second, because the mechanism relies on a common, distal coding, EC only requires an informational match between CS and US features, but not a domain or modality-specific match. Note that such an assumption goes beyond a mere associative learning model that would always suggest a processing advantage for similar as compared to dissimilar CS-US pairs (e.g., CS-US pairs belonging to the same modality), but without imposing the propositional account's (potentially unwarranted) limitations on relational encoding.

Scope and Limits of the Binding Perspective on EC

During the last two decades cognitive science discovered that perception and action are intimately related and integrated in temporary representations that allow the execution of actions in specific situations. In sharp contrast to the often-noted behavior-guiding functions of attitudes (Ferguson & Bargh, 2004), attitude formation via EC was hitherto not addressed from the perspective of integrating perception and action control.

Building on a framework developed to explain action control (Hommel, 2004; Hommel et al., 2001), we argue that binding is a key process in EC and that the alignment of selective attention in accordance with current goals plays an important role. Hence, all processes that may inhibit or enhance the selective processing of CS and US with regard to current goals may also influence their integration and thereby EC. Different from previous research, we thus try to specify the relatively early encoding stage of information processing by referring to feature binding. Methodologically, the binding perspective has the advantage that the presumed process parameters can be tested by the adaptation of well-defined cognitive paradigms, and that testable hypotheses can be derived from this framework. In what follows, we outline some of these hypotheses in more detail.

CS-US Pairings Are Not Sufficient: EC Requires the Selective Processing of CS and US Features

One core assumption from our binding perspective is that the occurrence of EC depends on the integration of CS and US features in a common representation, which in turn is de-

[2] It is important to note that Jones et al. (2009), although arguing for EC as an error in feature integration, induced participants to nevertheless selectively process CS and US in order to find EC. Thus, their findings also support the view of binding as a standard process inherent to perception and action.

pendent on their selective processing with regard to current goals. Preliminary evidence for this hypothesis was derived from a set of studies from Blask and colleagues (Blask, Walther, & Frings, 2017a, 2017b), showing that EC strongly depends on the selective processing of CS and US. Transferring the logic of a typical selective attention task, namely the Eriksen Flanker task (Eriksen & Eriksen, 1974), to an EC paradigm, participants in these studies were asked to respond and hence selectively attend to the CS while ignoring the US. Consequently, the CS appeared as the to be attended target and the US as the to be ignored distractor. In order to vary the selective processing of the US in relation to the CS, and thus the probability for their integration, the authors varied the degree to which the USs had to be selectively ignored either on a perceptual or on a response level. It was found that both, selection at the level of stimulus features (Blask et al., 2017a) and the level of response features (Blask et al., 2017b), significantly modulated EC. In particular, EC was significantly reduced, despite the CS-US pairing, if the US had to be selectively ignored on either a perceptual or a response level. Thus, CS and US features seem to be integrated to the extent that they are relevant with regard to current processing goals. Note that these assumptions also provide a more parsimonious explanation for related findings such the modulation of EC via explicit instructions (Gast & Rothermund, 2011; Gawronski, Balas, & Creighton, 2014; Kattner, 2012).

CS-US Pairings Are Not Necessary: Features, Not Stimuli, Need to Be Integrated

Whereas these previous findings provide evidence for the key role of goal-directed selective processing in EC, implications of the TEC regarding the integration of stimulus and action features were not directly tested. In a third set of studies, Blask and colleagues (Blask, Frings, & Walther, 2016) therefore expanded the idea of the TEC to an instance of evaluative learning via operant response pairings that overlap with regard to their responses and outcomes. In two experiments, the authors showed that preferences can be formed via a transfer of valence from an unconditioned stimulus (US) to an action and then from this valence-laden action to a novel conditioned stimulus (CS), even though the US and CS were never presented together (i.e., CS and US never co-occurred, neither perceptually nor symbolically, Gast & De Houwer, 2012). Consequently, and in accordance with TEC, the formation of preferences may not only be based on the integration of affective stimulus features, but also on response features.

As simple as these results may appear, they provide first process-specific evidence for the assumed mechanism underlying EC in terms of TEC.

Specifically, they suggest that EC relies on a common coding mechanism representing attitudes in terms of action features. However, even more importantly, they also show that it is a distal coding mechanism only relying on the informational match between to be integrated events (e.g., overlap of response and outcome). In this regard, the current theoretical perspective might also provide a process specification for the just recently introduced intersecting regularities account (Hughes, De Houwer, & Perugini, 2016), wherein attitudes are presumed to result from overlaps between environmental events.

A Binding Perspective Offers Novel Insight Into Existing Research Questions

Due to the focus on the relatively early encoding stage of information processing, our binding perspective does not directly address the abstract nature of EC's underlying representations (i.e., whether the structure of representations is associative or propositional), or how conditioned attitudes are retrieved and expressed (see Gawronski & Bodenhausen, 2006). However, in its parsimony, a binding perspective offers novel insights for explaining and predicting the effects of key variables related to several open questions.

Does EC Depend on Co-Occurrences or Contingencies?

Although in most EC studies CS and US are consistently paired without presenting isolated CS or US occurrences, the absence of effects of isolated presentations of, for example, CSs during learning (referred to as manipulations of contingency) or afterwards (referred to as extinction procedures), motivated the assumption that EC would not require CS-US contingencies but only co-occurrences (Baeyens, Hermans, & Eelen, 1993; Kattner, 2014). However, from a binding perspective, it is crucial to note that the encoding of contingencies, unlike the processing of mere co-occurrences, involves the selective processing of the presence as well as the absence of stimuli, which also depends on stimulus characteristics. For example, Halbeisen and Walther (2016) recently argued that the presence of a US has a selective advantage over its absence, because affective stimuli typically attract attention (Öhman, Flykt, & Esteves, 2001). Thus, participants were expected to overestimate contingencies, masking the effect of a typical contingency manipulation that relies on CS-without-US trials (note that extinction procedures rely on these trials as well). Consistent with this hypothesis, it was found that EC is sensitive to a manipulation of contingency, but only after enhancing participants' selective processing of the absence of US. In other words, the binding perspective specifies the beneficial conditions for the encoding of CS-US contingencies, and thus for predicting their effect on later CS evaluations.

What Is Stored in Memory?

As already noted, the binding perspective is not limited to a specific representational format or structure. However, in alluding to the classical distinction between S-S and S-R representations (referring to CS and US as stimuli, S, and affect as response, R), the binding perspective is informative for the question of what elements an underlying representation consists of. Specifically, it can be assumed that an event-file in an EC context may consist of both S and R components, because the elicitation of an affective reaction (the R component), besides individual stimulus features (the S components), is the defining feature of a US. This assumption is consistent with early classical conditioning theory that assumed S-R and S-S learning always occurred simultaneously (Rescorla, 1980). However, the binding perspective is not limited to explaining S-R learning but further predicts that the weighting of the US's S and R components in the final representation depends on current situational demands that influence their selective processing. Thus, to the extent that the selective processing of a US's R components is relatively enhanced (for example, due to active responding) compared to its S components, we would expect EC to rely on an S-R rather than S-S representation (not to the exclusion of S-S-R representations, which could be predicted by considering a situation's selective requirements as well). As a consequence, the binding perspective also specifies the conditions under which S-S or S-R representations are formed and thus under what conditions later modification of a US's R component (i.e., US revaluation) should or should not change already acquired CS evaluations.

What Is the Role of Awareness in EC?

Interestingly, and similarly to the awareness debate in EC research, it is discussed whether feature binding is a conscious or unconscious process (Keizer, Hommel, & Lamme, 2015). For example, because we make unified experiences when we perceive the picture of a puppy, it could be assumed that consciousness and binding are closely related. However, by showing that behavioral effects of feature binding persist for visually masked stimuli, Keizer et al. (2015) questioned the consideration that consciousness of features is always necessary for binding to occur.

However, it is important to note that a binding perspective specifies similar boundary conditions for both aware and unaware processing of CS and US features, i.e., that they are processed selectively regarding current situational demands. This distinction between awareness and attention has only rarely been addressed before (but see Field & Moore, 2005), but might be crucial for understanding the effects of different manipulations of aware and unaware processing (Dehaene, Changeux, Naccache, Sackur, & Sergent, 2006). Specifically, we would predict that a manipulation that interferes with both the awareness and selective processing of CS and US always disrupts EC, whereas a manipulation that only interferes with awareness, but not with selective processing, should not disrupt EC. Thus far, we are not aware of any investigation that manipulated selection and awareness for both CS and US independently without changing additional parameters of the learning procedure, such as stimulus duration (Stahl et al., 2016).

Does EC Depend on (Other) Automatic or Deliberate Processes During Acquisition?

Besides awareness, EC research has also been concerned with determining the impact of other variables related to the associative vs. propositional distinction that identifies the former as unconditional (or automatic) and the latter as conditional (and in this sense, deliberate) processes. For example, several investigations found that EC partially depended on the relevance to participants' current goals (e.g., Corneille, Yzerbyt, Pleyers, & Mussweiler, 2009; Koranyi, Gast, & Rothermund, 2012; Verwijmeren, Karremans, Stroebe, & Wigboldus, 2012). However, from a binding perspective, these findings do not necessitate a distinction between automatic and deliberate processes, but merely a consideration of how goal-relevance affects the selective processing of CS and US. Specifically, it has been found that relevance, rather than mere visual orientation, guides selection and thus determines learning (e.g., Eitam, Schul, & Hassin, 2009).

Consistent with this hypothesis, we recently found that goal-relevant US are more effective at changing CS evaluations than goal-irrelevant and thus unattended US (Halbeisen, Walther, & Blask, 2018). Moreover, we found that the effect of reduced goal-relevance could be counteracted by a manipulation of selective processing (and, vice versa, that under conditions of increased relevance, manipulations of selective processing were ineffective), suggesting that the effects of goal-relevance can indeed be explained by their effects on selective processing. Moreover, by considering the importance of relevance for selective processing, it might be possible to predict inter-individual differences for the occurrence of EC. For example, in many EC studies, IAPS pictures (Lang, Bradley, & Cuthbert, 1999) are used that elicit a wide array of emotional responses in individuals. Depending on individuals' dispositions, however, such as disgust sensitivity, these pictures might differ in their relevance and thus in their effectiveness for the occurrence of EC.

Conclusion: From Complex Environments to Simple Effects

The beauty of EC and its lasting fascination presumably result from the promise of explaining how the regularities of a complex environment translate into the relatively simple liking or disliking of stimuli and corresponding behaviors. In contrast to that promise, however, our understanding of the encoding mechanisms that link CS, US, and action features still remains limited due to a lack of testable predictions about these encoding mechanisms, a process-insensitive research focus, procedural diversity, and a tendency toward theoretical isolation, all of which can be related to the field's predominant concern with associative and propositional processes.

In addressing this issue, we presented a promising framework based on feature integration theory and TEC that frames EC as a question of how CS, US and action features are integrated into a coherent representation. Specifically, we assumed that EC depends on a distal, attention-driven integration mechanism that binds relevant CS and US features into an event-file while simultaneously inhibiting features that are irrelevant to current processing goals. From this perspective, we not only derived novel predictions for the occurrence of EC, and provided first supporting evidence, but also explained how to address existing research questions. As preliminary as these considerations may appear, we hope to open a new door for future EC research.

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Competing Interests

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