Consciousness and Cognition 89 (2021) 103086

Contents lists available at ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

Review article

Why expectations do or do not change after expectation violation: A comparison of seven models

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ARTICLE INFO

Keywords:
Expectation disconfirmation
Expectation violation
Prediction error
Coping
Model

ABSTRACT

Individuals are often confronted with events that violate their expectations, but disconfirming evidence does not always lead to expectation change. We review seven theoretical models on how individuals cope with disconfirming expectations: associative learning theories, the ViolEx Model, the model of coping with expectation disconfirmation (Roese & Sherman, 2007), the Meaning Maintenance Model, the Predictive Processing Framework, Expectancy Violations Theory, and the Expectation-Disconfirmation Model of consumer satisfaction. We focus on the proposed processes that relate to persistence or change of expectations. We discuss similarities and differences between the models. Three core coping processes are identified across most of these models – minimization of the importance of expectation-disconfirming evidence, search for/production of future expectation-confirming evidence, and expectation change. Suggestions for refinements and extensions of the models as well as for future empirical work on model testing are drawn.

1. Introduction

In general, expectations[1] can be defined as beliefs about future events or experience (Hoorens, 2012). They may refer to future external events or to the occurrence of own behaviors or internal responses to a certain external stimulus (Laferton, Kube, Salzmann, Auer, & Shedden-Mora, 2017). Expectations are important for almost any kind of psychological domain, such as perception, motor control, decision-making, learning, motivation, and social interaction. Accurate expectations help the individual to prepare for future situations, to respond adaptively to them, and to affect future outcomes in a presumably desired direction (Roese & Sherman, 2007).

Because expectations refer to future events and experiences, they can be more easily disconfirmed than other kinds of beliefs that also include many past experiences (Hoorens, 2012; Rief et al., 2015; Roese & Sherman, 2007). For example, Hacker, Bol, Hogan, and Rakow (2000) found that less than half of students were accurate in their expectations about their future test performance, with many students having overly optimistic expectations. Weeks et al. (2012) showed that 74% of patients with advanced cancer had inaccurate expectations about the curative potential of their palliative chemotherapy. Some people tend to have overly negative expectations, as for example in the case of depression and anxiety disorders (Rief et al., 2015) or in the case of stereotype threat and discriminatory behavior (e.g., Hamilton & Garcia-Marques, 2003). The persistence of expectations despite contradicting experiences has been identified as a core factor of maintenance of some mental disorders, such as anxiety disorders or depression (Craske, Treanor, Conway,

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[1] The terms expectation and expectancy will be used as synonyms.

https://doi.org/10.1016/j.concog.2021.103086
Received 20 May 2020; Received in revised form 30 October 2020; Accepted 16 January 2021
Available online 5 February 2021

Zbozinek, & Vervliet, 2014; Rief et al., 2015). Thus, a deeper understanding of processing expectation-disconfirming information and of conditions that lead to expectation change is needed. This knowledge can help with developing interventions aimed at changing dysfunctional expectations.

Several theoretical models have been proposed about how individuals cope with information that is discrepant to their previous expectations. These models are relevant for predicting stability versus change of expectations after expectation violation, guiding the assessment of coping processes, and focusing on factors that predict different ways of coping, and stability versus change of expectations. Therefore, knowledge is needed on similarities and differences between available models (e.g., regarding scope and core assumptions), and on whether a particular model is best suited in general or for particular research questions. In addition, researchers need knowledge on whether there is a need for advancement of available models and/or for the development of new model that integrates core aspects of the available models and overcomes limitations of the available models.

The present paper pursues three goals. First, we review available models with regard to suggested processes contributing to persistence and/or change of expectations in response to discrepant information. We address the scope of the models, the definition of the coping processes, assumptions about the activation and the interplay between the processes, and available empirical evidence. The second goal is to identify common and unique coping processes across models. Finally, we conclude with recommendations for model refinements and suggestions for future research.

In order to be included in our review, either the original models should have stated explicit assumptions about processes that predict persistence or change of expectations after expectation violation, or researchers who worked with these models should have added assumptions about these processes to the models. The reviewed models could refer to expectations about a particular domain (e.g., social behavior) or to expectations in general. We do not review general theories or models about persistence and change of attitudes, beliefs, goals, or related constructs if expectations are not at their main focus. However, as some models of persistence and change of expectations have been influenced by more general theories or models, we will mention such references briefly.

For identifying relevant psychological models, we searched the PsycInfo database for the following terms: (expect* violation OR expect* disconfirmation OR prediction error) AND (model OR theory). The search was completed on 2020–09-03. The identified 2204 hits were checked for models or theories that address effects of violated/disconfirmed expectations on the persistence and change of expectations. If the identified papers cited references for additional models, we also checked these references. The electronic search identified six models or theories, respectively: Expectancy Violation Theory (e.g., Burgoon, 1993; 102 papers), associative learning theories (e.g., Spicer, Mitchell, Wills, & Jones, 2020; 88 papers), the Predictive Processing framework (29 papers), Expectation Disconfirmation Theory of consumer satisfaction (e.g., Oliver, 1980; 20 papers), the Meaning Maintenance Model (e.g., Proulx, Inzlicht, & Harmon-Jones, 2012; 8 papers), and the ViolEx model (Rief et al., 2015; 4 papers). Based on the check of the references sections of the papers, we identified an additional model (Roese & Sherman, 2007).

2. Core assumptions of the models on consequences of expectation violation

2.1. Associative learning theories

A mismatch between expectation and outcome (the so-called prediction error) is considered as critical for learning in classical and instrumental conditioning procedures (Rescorla & Wagner, 1972). The term prediction error is a synonym for expectation violation, indicating a discrepancy between a conditional prediction (if A then B) and the actual contingency between predictor and outcome (B did not follow A). Prediction errors are interpreted as teaching signals, guiding humans and animals to adapt their expectations and behavior, although some prediction errors may be ignored as expected noise (Hohwy, 2017). According to the delta-rule (Rescorla & Wagner, 1972), individuals will be more likely to change their expectation if there is a larger discrepancy between the expectation and the disconfirming event. In addition, expectation will more likely change if the disconfirmation is made salient (if individuals are aware that B did not follow A; Craske et al., 2014).

The main focus of associative learning has traditionally been on expectation change rather than persistence. Nonetheless, conditioning studies may explain persistence of simple "if-A-then-B" expectations via learning of more complex association patterns. For example, in context-dependent conditioning (Bouton, 2004), A may reliably predict B within context X. While individuals may learn that A does not predict B anymore within context Y, conditioned responses can still be observed back in context X. In a similar fashion, the conditioned inhibition phenomenon describes that a newly introduced cue C may lead to reduced conditioned responses when presented simultaneously with the cue A and not followed by the consequence B, while the expectation that A is followed by B is maintained if C is not present (Sosa & Ramírez, 2019). Recently, Spicer et al. (2020) suggested that individuals will protect expectations that they are highly certain of by attributing unexpected outcomes to other present cues that have been less certainly associated with the outcome. If individuals are certain that A precedes B (e.g., expecting a causal relationship) and are less certain about whether C would precede B, then nonoccurrence of B after confrontation of A plus C leads mainly to learning about the association between C and B. In contrast, the subjectively certain expectation that A precedes B as long as there are no inhibiting cues (and that A causes B) will not be changed (because C is now expected to have caused the non-occurrence of B). Spicer et al. (2020) labeled this phenomenon "*theory protection in associative learning*". Given that predictors rarely occur in isolation, it is plausible that such mechanisms may explain real-life phenomena of expectation persistence.

2.2. The violated expectation model (ViolEx Model)

The ViolEx (**Viol**ated **Ex**pectation) Model has been developed for explaining persistence and change of expectations after being

confronted with expectation-disconfirming information (Gollwitzer et al., 2018; Rief & Glombiewski, 2016; Rief et al., 2015). It was strongly influenced by Brandtstädter and colleagues' model of coping with information that is inconsistent to the self-concept (e.g., Brandtstädter & Greve, 1994; Brandtstädter, 2007). Whether expectation violations do or do not result in a change of one's expectation depends on four coping processes: "*accommodation*", "*assimilation*", "*data-oriented immunization,*" and "*concept-oriented immunization*" (Gollwitzer et al., 2018).

"Accommodation" refers to mechanisms by which individuals adjust their expectation so that it matches the (previously unexpected) outcome and will match such outcomes in future situations. *"Assimilation"* refers to proactive behavior that prevents the occurrence of future expectation-disconfirming information. Examples would be the avoidance of situation that may provide expectation-inconsistent information (see, for example, the fear-avoidance model of pain; Vlaeyen & Linton, 2000) and increasing the probability of expected (expectation-confirming) events (e.g., "self-fulfilling prophecies").

Whereas accommodation and assimilation reduce the size of discrepancy between expectations and incoming information, *"immunization"* refers to the minimizing of the potential impact of the discrepant information. In the case of "*data-oriented immunization"*, individuals devalue discrepant information (e.g., ignoring it or doubting its validity). When using "*concept-oriented immunization"*, individuals reframe the conceptual meaning of their expectation so that former discrepant information is no longer diagnostically relevant for confirming or disconfirming the expectation[2]. For example, changing the expectation that "person X will be malicious and act upon it" to "X will be malicious deep inside" will make the positive behavior of X irrelevant for disconfirming the expectation that person X will be malicious.

The ViolEx model states that direct experiences (such as the frequency of prior confirmation of the expectation and the typicality of the present situation), social and cultural influences (such as the dispersion of an expectation among significant other persons), and individual differences (e.g., in cognitive flexibility) influence the selection of accommodation, assimilation, and immunization (Rief et al., 2015).

2.3. The model of coping with expectation disconfirmation (CED)

Roese and Sherman (2007) suggested a model of coping with expectation disconfirmation (henceforth abbreviated as CED). It consists of three primary consequences of disconfirmed expectations – heightened vigilance (i.e., increased attention towards unexpected as compared to expected events), problem-solving efforts (making sense of the discrepancy and finding an explanation for the unexpected event), and cognitive repair of the inaccurate expectation. The authors suggest three classes of sense making strategies – *causal attribution* (finding causes of the unexpected event), *counterfactual thinking* (about how the event might have been under different conditions), and *hindsight bias* (a distortion of the remembered past expectation and the belief that one had expected the factual unexpected event). The sense-making activities would result in one of four inferential consequences—"*ignoring*", "*tagging*", "*bridging*", and "*revising*". *Ignoring* means that the discrepancy between the expectation and the event is ignored, which is the case in hindsight bias and, in part, counterfactual thinking. *Tagging* means that the discrepancy between the expectation and the event is recognized but without immediate consequences for expectation or discrepancy appraisal: Individuals tag the encoded discrepant information on the expectation for future evaluation. Consequently, when the expectation will be activated in the future, the memory of the discrepant information will be activated as well. In the case of *bridging*, individuals build a conceptual bridge between the expectation and the disconfirming event in order to explain away the discrepancy. They may interpret the event as a new subtype that would be an exception from the general rule. For example, they may now expect that person X usually behaves maliciously but behaves nicely in only a few concrete situations. Defining exceptions or subtypes means to maintain the core of the general expectation while reducing the generality of application. Finally, individuals may revise their expectation at a fundamental level to bring it in consistency with the disconfirming event (*revising*).

Roese and Sherman (2007) suggested that two factors determine the selection of coping processes – the magnitude of the discrepancy between the expectation and disconfirming event, and the degree of complexity or sophistication of the underlying schematic basis of the expectation. Large discrepancies were suggested to typically result in bridging/subtyping and, accordingly, persistence of the general expectation. Moderate discrepancies, on the other hand, tend to result in revision of the expectation. The degree of complexity or sophistication of the underlying schematic basis of the expectation is reflected in the expertise (e.g., amount of domain-relevant knowledge), certainty and accuracy. Discrepancies would more likely be ignored in the case of weakly elaborated schemata when the individual does not have the expertise to recognize the discrepancy. In the case of moderate expectation certainty, disconfirming information will likely lead to a revision of the core of the expectation, while in the case of high certainty, individuals tend to show bridging/subtyping. Roese and Sherman (2007) did not specify how the size of discrepancy and the complexity or the underlying schematic basis affect tagging, but tagging may be selected if these conditions do not clearly promote the selection of one of the other coping processes.

2.4. Predictive Processing (PP)

The goal of the Predictive Processing framework is to provide a unified theory of all mental phenomena or the brain's cognitive

[2] An earlier version of the ViolEx model included three more processes of dealing with disconfirming information – selective attention, post-hoc evaluation, and self-confirming mechanisms (Rief et al, 2015, p. 380). These processes have been later subsumed under the categories of assimilation and immunization, respectively (Gollwitzer et al., 2018; Doering, Glombiewski, & Rief, 2018).

functioning (Friston, Samothrakis, & Montague, 2012; Ransom et al., 2020). It assumes that the brain's overarching task is to minimize surprise (expectation violations/prediction errors). Two main processes are suggested to reduce prediction errors – revising expectations to fit the world ("*perceptual inference*"), and changing the world to fit with the expectations ("*active inference*"). Expectation disconfirmation could lead to different cognitive changes, such as change of the core expectation, change of the beliefs (or causal model) that led to the expectation, specification of the conditions under which the expectation holds true, and change in the level of detail of the expectation (Kwisthout, Bekkering, & van Rooij, 2017). The two latter processes show some conceptual overlap with subtyping (Roese & Sherman, 2007) and concept-oriented immunization (Rief et al., 2015). When getting back to our previous example, the disconfirmed expectation that person X will be malicious and act upon it could be narrowed to that this happens when the person is drunk (if he or she actually seems sober) or extended to that he or she is *sometimes* malicious.

Signals perceived to be most reliably informative (precise) are suggested to exert the strongest impact on change of violated expectations. In the case of (perceived) imprecise signals, prior expectations will likely be maintained despite the experience of expectation violation.

2.5. The meaning maintenance model (MMM)

The MMM (Proulx, Inzlicht, & Harmon-Jones, 2012; Proulx & Inzlicht, 2012) generalizes assumptions from different inconsistency compensation theories, such as Cognitive Dissonance Theory (Festinger, 1957). According to the MMM, the inconsistency between expectation and experience leads to a state of aversive arousal and a common array of compensation efforts aimed at reducing the aversive arousal (affirmation, abstraction, or assembly). Two kinds of compensatory efforts are directed towards reducing the inconsistency between expectation and disconfirming evidence. For defining these two kinds, the MMM uses two terms from Piaget's theory of cognitive development (Piaget, 1936)—"*assimilation*" and "*accommodation*". Proulx et al. (2012) defined *assimilation* as reinterpreting experiences in such a way that they are consistent with the expectation while *accommodation* refers to the revision of expectations so that they become consistent with the formerly discrepant experience. If the expectation violation is below the threshold of conscious awareness or if cognitive abilities are limited, the MMM predicts that individuals will generally show assimilation and perceive or evaluate the information as consistent with their expectation. If individuals recognize the expectation violation and have adequate cognitive resources, they may accommodate (change) their expectation to bring it in line with former disconfirming information.

The remaining three responses—"*affirmation*", "*abstraction*", and "*assembly*"—serve a palliative function by reducing the aversive arousal following from expectation violation. *Affirmation* describes heightened commitment to other expectations or beliefs that one has and that have not been disconfirmed (thereby regaining a sense of meaning and security). *Abstraction* refers to finding (abstracting, learning) new expectations from perceived associations in the environment that are unrelated to the disconfirmed expectation. Meanwhile, *assembly* means that the individual creates new expectations and meaning frameworks. Abstracted (learned) or assembled meaning frameworks allow building expectations that may likely be confirmed. In some cases, assembled new meaning frameworks may also give meaning to the expectation violation ("this happened for a reason") and replace the old (violated) frameworks.

With regard to the target of affirmation, people will prefer to affirm meaning frameworks that directly address the source of expectation violation over those that do not (Tullett, Teper, & Inzlicht, 2011). Proulx and Inzlicht (2012) suggested additional factors that affect the choice of responses towards expectation violation, such as whether disconfirming information is more positive or more negative than expected or whether the expectation violation is self-relevant. One could suggest that negative expectation violations (if the situation is worse than expected) would be more likely to cause *aversive* arousal and related arousal-reducing efforts than positive expectation violations (Moser & Schroder, 2012).

2.6. Expectancy violations theory (EVT)

While the former five models addressed expectation violation in general, the EVT (Burgoon, 2016) focuses on violations of expectations about social interaction in particular – when interaction partners behave in an unexpected way. The EVT assumes that expectations (and beliefs) entail both a predictive component (how an individual person is expected to behave) and a prescriptive component (how social partners should behave in general). This permits arraying experiences on a valence continuum ranging from good to bad.

As an interaction-based theory, the goal of the EVT is to predict and explain actual social behavior rather than to predict expectation change. Nonetheless, some ideas about the processing of expectation-disconfirming information have been formulated. Similarly to the MMM and the CED model, the EVT states that violated expectations are physiologically and psychologically arousing, often cause uncertainty, and draw the attention toward the violation. According to Afifi and Burgoon (2000), an initial expectation violation can be ignored (e.g., in the case of minor violations), discounted, or rationalized. "*Ignoring*" and "*discounting*" becomes less likely, if violations are more severe and if the unexpected behavior persists. Here, individuals try to find an explanation for the unexpected behavior ("*rationalizing*") and decide on whether they should change their behavior towards the social partner. In the latter case, they may respond with "*compensation*", and "*reciprocity*".

Compensation means that persons actively try to shape the social interaction consistent with their generalized expectation about how the communication should be. Thus, they will engage more after learning that the social partner does not show the expected and desired engagement. Here, persons probably changed their expectation about the future behavior of the partner while the prescriptive expectation about the desirable mean level of engagement seems to remain unchanged. In the case of *reciprocity*, persons reciprocate the unexpected behavior of the partner. In this case, persons probably changed their expectation about the future behavior of the

Table 1
Comparisons of the Psychological Consequences of Expectation Violation Proposed by the Models/Theories.

Consequences of disconfirmation	Theories of associative learning	ViolEx model	MMM	CED model	PP	EVT	EDM of consumer satisfaction
Attention and physiological arousal			aversive arousal	heightened vigilance		heightened attention	
Minimizing the importance of disconfirming information	perceiving single disconfirmations as noise	data-oriented immunization	assimilation of the experience so that it matches the expectation	ignoring, counterfactual thinking		ignoring, discounting	confirmation (expectation-consistent perception of events) minimizing importance of the expectation violation
Search for confirming evidence		assimilation (situation change aimed at generating expectation-confirming information)			active inference	compensation	adaptation (triggering confirming behavior of service providers)
Change of the surface of the expectation so that the discrepant info. is no longer relevant	theory protection (=building an expectation about an alternative cause of the unexpected event)	concept-oriented immunization		bridging, subtyping	change of scope or detail of the expectation		
Change of the core of the expectation	prediction error learning	accommodation	accommodation	revising of the expectation about the future, hindsight bias	perceptual inference	reciprocity (change of behavior and expectation in line with unexpected behavior)	prospective calibration of expectations; backward assimilation (adjusting remembered expectations)
Focusing on alternative beliefs			affirmation, abstraction, assembly				
Delay of solving the discrepancy between expectation and reality				tagging the disconfirming information on the expectation			

partner to match the partner's present behavior. This might be accompanied with changes in prescriptive expectations if the definition of the relationship changes, for example, when the social partner is no longer perceived as a friend who deserves kindness.

2.7. Expectation-disconfirmation model (EDM) of consumer satisfaction

The EDM is an extension of Cognitive Dissonance Theory (Festinger, 1957) to consumer expectations and satisfaction (Oliver, 1980, 2010). It proposes that the comparison of perceived present performance of goods and services with previous expectations contributes to customer satisfaction and to (the expected) future usage of the goods or services. Consumers are believed to accept a range of performance below and above the expectation level as essentially meeting expectations (zone of expectation confirmation) while lager discrepancies indicate expectation disconfirmation (Oliver, 2010). Expectation change refers to the prospective calibration of expectations in response to disconfirmation.

In the first version of the EDM, experiences were suggested to affect expectations while expectations were not assumed to have a direct impact on experiences (Oliver, 1980). However, later revisions of the EDM incorporated effects of expectations on perceived and actual experiences: For example, Isac and Rusu (2014) stated that after expectation violation, individuals may distort (change) the remembered past expectation and the perception of the product or service, and/or minimize the relative importance of the experienced disconfirmation, such as perceiving the situation as atypical. With regard to the former processes, Pieters, Koelemeijer, and Roest (2015) used the terms "*backward assimilation*" and "*forward assimilation*". *Backward assimilation* means that the present receipt of information about the product or service leads to a change of the remembered expectation to bring it closely to the perceived actual characteristics of the product or service. In contrast, *forward assimilation* means that consumers either distort the perception of the product or service to be consistent with their expectations ("*confirmation*") or change the reality to bring it closer to their expectations ("*adaptation*"). In the first case, consumers perceive more confirmatory evidence than actually exists. *Confirmation* may be found if the size of discrepancy between expected and actual product and service characteristics is rather small and when actual consumer experiences are ambiguous. In the case of *adaptation*, consumers actually change outcomes of events by adapting their own behavior and/or the circumstances so that they produce the expected outcomes. Adaptation processes are likely to occur in service encounters where consumer behavior towards the service provider can change the provider's behavior in line with the original consumer expectation. For example, behaving unfriendly towards a bank clerk may promote unfriendliness of the service provider and confirm the expectation that a bank clerk will not be empathic.

3. Similarities and differences between coping processes of the models

There are similarities and differences in the scope of the models and the suggested ways of dealing with expectation violations. Regarding similarities, all models address coping with expectation violations. In addition, all models highlighted that expectation violations do not always lead to expectation change. Furthermore, the models show a considerable overlap of the proposed coping processes: Expectation change was included in all models. Six models emphasized that individuals may minimize the importance of the discrepant information, and the remaining PP framework indirectly refers to this phenomenon when emphasizing that discrepant information of low precision would not lead to expectation change (e.g., Ransom et al., 2020). Four models included the search for (production of) future confirming evidence, thus indicating that there is also some agreement on the relevance of this process (Table 1).

The models differ with regard to a) their scope, b) some of the proposed processes of coping with expectation violations, and c) the labels used for the proposed coping processes.

3.1. Scope

Five of the models address expectation violation in general (associative learning theories, the ViolEx model, the CED model, MMM, PP), while the EDM and EVT have a narrow focus on expectations about social partners and products or services, respectively. The five general models focus on persistence versus change of expectations (and processes that lead to these outcomes), although much empirical research on the MMM addressed palliative attempts to reducing the aversive arousal following from expectation violation, rather than attempts to reduce the discrepancy between expected and actual events or experiences (Proulx et al., 2012; Proulx & Inzlicht, 2012). Persistence and change of expectations are of secondary interest in the EVT and EDM, which mainly address change in social behavior and consumer satisfaction, respectively.

Despite their focus on expectations in general, most of the general models were predominantly applied in narrower fields of research, such as associative learning theory in general psychology and neuropsychology (e.g., Bouton, 2004; Spicer et al., 2020; Sosa & Ramírez, 2019), CED in social psychology (Roese & Sherman, 2007), the MMM in personality and social psychology (Proulx & Inzlicht, 2012; Proulx et al., 2012), and PP in the field of sensory and motor regulation (Ransom et al., 2020). This trend probably reflects the theoretical background of the developers of the models. Interestingly, the developers of the ViolEx model come from different fields of psychology (clinical, general, and social psychology; Rief et al., 2015), and this model has recently been applied in several fields, such as clinical psychology (e.g., Kube et al., 2019), developmental psychology (Pinquart & Block, 2020), and educational psychology (Strelow, Dort, Christiansen, & Schwinger, 2020). Focusing on the dominating theoretical model in one's own field of research implies the risk for ignoring additional processes from others model that could also be relevant.

In principle, the proposed ways of coping with disconfirmed expectations from the more general models should also be found when expectations about social partners and products or services are disconfirmed. In fact, research on the related more specific models (EDM, EVT) incorporated some processes from the general models, although with different labels (Table 1).

The general models should not only be applied to different content areas but also to different kinds of expectations – such as explicit and implicit expectations. Most examples provided in this text refer to explicit expectations that people are aware of, but implicit expectations often become explicit after expectation violation (Roese & Sherman, 2007). Some of the suggested coping processes, such as immunization and accommodation, often occur non-intentionally (Brandtstädter, 2007) and, therefore, can be easily applied to violations of implicit expectations. Although deciding to generate expectation-confirming events has been proposed to be a conscious response to violation of explicit expectations (Brandtstädter, 2007), automatic expectation-confirming behaviors occurs after violations of implicit expectations, for example, in feedback control of motor behavior (Shadmehr, Smith, & Krakauer, 2010). In the MMM, affirmation and abstraction have been described as a reaction towards violation of implicit and explicit expectations (Proulx & Inzlicht, 2012). Thus, the processes of coping with expectation violations are applicable to violations of explicit and implicit expectations.

3.2. Proposed processes

There is no full agreement between the models on whether individuals search for confirming evidence, change the surface of their expectations in order to protect the core, focus on non-violated beliefs, or tag the disconfirming information while maintaining their expectation. Generating future expectation-confirming events may have been missed in some models because this behavior refers to the prevention of future expectation violations rather than to the reduction of present discrepancy between expectation and reality.

Surface changes of expectations in order to protect their core (Table 1, line 4) may have been lacking in some models because of the overlap with devaluation of the discrepant information (Table 1, line 2), although both processes can, in principle, be distinguished (Gollwitzer et al., 2018). For example, in the case of devaluing an unexpected event as outlier or exception from the rule, individuals also have to modify the expectation that the rule always applies.

Only two processes of coping with expectation violation were specific to a single model. In the MMM, shifting attention to existing or newly created, non-violated expectations (affirmation, abstraction, assembly) has the main function of reducing the aversive arousal that resulted from expectation violation (Proulx et al., 2012; Proulx & Inzlicht, 2012). This attention shift functions as data-oriented immunization as it reduces attention to the violated expectation. However, according to the MMM, these processes also have an additional, unique function by gaining a sense of predictability and control in other domains or constructing new meaning frameworks that are independent from the disconfirmed expectation (Proulx & Inzlicht, 2012).

Tagging was included only in the CED (Roese & Sherman, 2007). It indicates that the discrepant information was too important to be ignored but not clear or reliable enough to lead to expectation change. Tagging may be a precursor of future expectation change once more expectation-disconfirming information comes up that is similar to the tagged information, thus producing a cumulative effect. However, tagging could also inhibit expectation change if future expectation-violating events are also discrepant to the tagged information (e.g., if a better-than-expected event later follows the tagged worse-than-expected event).

When relating the proposed coping processes to each other, there seems to be a controversy about drawing attention to or away from the discrepant information. While EVT, MMM, and CED claim that expectation violation leads to heightened attention towards the unexpected event, the ViolEx Model, MMM, and the CED model state that individuals may not pay attention to discrepant events and ignore them. Whether people show heightened vigilance or ignore and discount the discrepant information depends, among others, on the size of discrepancy and on the amount of previous support for the expectation. Smaller discrepancies can be easier ignored or discounted, and a single disconfirming event could be more an exception if the expectation has been very often confirmed in the past (Proulx et al., 2012; Roese & Sherman, 2007). The examples for heightened vigilance given by Roese and Sherman (2007) refer to serious expectation violations, such as confronting infants with physically impossible events that are opposed to all of their previous experiences. In contrast, ignoring or devaluing discrepant information was the most often reported way of coping after the score of a performance test was about 20% lower than expected (Pinquart & Block, 2020).

3.3. Terminology

As the labeling of coping processes varies considerably between the models, there is the danger of misunderstanding. Table 1 shows that identical or very similar processes often received different labels in the models (e.g., data-oriented immunization, ignoring, counterfactual thinking, discounting). In other cases, the same terms are used for describing very different processes. This is particularly evident with regard to the term "assimilation" that has different meanings in the ViolEx model, the MMM, and the EDM.

Some of the suggested processes can be ordered hierarchically, as, for example, data-oriented immunization includes ignoring and discounting of discrepant information as well as counterfactual thinking, and as expectation change (accommodation) includes forward change (of present expectations about the future) as well as backward change (of remembered expectations). Given the inconsistent terminology used in the reviewed models, it would be helpful to find a 'common language' and, where possible, to use higher-order categories for the sake of parsimony.

4. An evaluation of the models of coping with expectation violation

4.1. Empirical support

Rather than testing whole models with all proposed coping processes, most available studies focused on a single coping process. Expectation change in response to expectation violations has been assessed most often, probably because it can be easily measured with repeated assessments of expectations (e.g., Rescorla & Wagner, 1972; Roese & Sherman, 2007). A number of recent studies found

that minimizing the importance of disconfirming information contributes to the persistence of expectations. For example, highly discrepant information is often perceived as outlier (Filipowicz, Valadao, Anderson, & Danckert, 2018). Other studies showed that immunization against discrepant information contributes to the persistence of dysfunctional expectations in clinical samples (e.g., Kube et al., 2019). Immunization also inhibited expectation change after worse-than-expected achievement (Pinquart & Block, 2020), but this effect disappeared after repeated expectation violations (Filipowicz et al., 2018; Pinquart, Koß, & Block, 2021). Studies have also shown that individuals protect their core expectations by defining unexpected events as subtypes (research on social stereotypes; Riek, Mania, & Gaertner, 2013), or by attributing unexpected events to special external cues (Spicer et al., 2020).

There is some empirical evidence from educational psychology that students tend to react to lower-than-expected achievement with increased achievement striving in order to fulfill their expectations at a later point in time (Pinquart et al., 2021). Empirical evidence for a shifting focus on non-violated beliefs has been summarized by Proulx et al. (2012). Research is still lacking on whether tagged expectation violations promote or inhibit later expectation change.

With the exception of tagging, there is empirical evidence that individuals use the suggested processes when coping with expectation violations, and that these processes have, at least in part, the effects that were proposed by the models. However, tests of the full models – with the full range of processes summarized in Table 1 – are still lacking. Research on immunization indicates that more efforts are needed for testing the conditions under which the proposed processes work (Filipowicz et al., 2018; Pinquart et al., 2021).

4.2. Need for model advancement

As none of the reviewed models included the complete range of coping processes proposed in the models (see, Table 1), researchers could either broaden their models or develop a new, comprehensive model. The advancement or refinement of the models should address potential influences on the use of different coping processes, the interplay of these coping processes, and put a stronger emphasis on the objectives of the coping processes.

Amount of previous expectation confirmation (Roese & Sherman, 2007), size of discrepancy between expected and disconfirming event (Afifi & Burgoon, 2000; Oliver, 2010; Pieters et al., 2015; Proulx et al., 2012; Rescorla & Wagner, 1972; Roese & Sherman, 2007), direction of expectation violation (Proulx & Inzlicht, 2012), precision (reliability) of the discrepant information (Ransom et al., 2020), and cognitive flexibility (Proulx et al., 2012; Rief et al., 2015) have been argued to play an important role when it comes to expectation persistence or change. A comprehensive model is need that describes the role of these factors for selecting the different processes of coping with expectation violations.

The need for further refinement of the models also refers to specifying whether the different processes of coping with expectation violation typically co-occur or inhibit each other, or whether they occur in a typical order. For example, ignoring a discrepant event indicates that there would be no need to change the situation or one's expectation. However, ignoring would have to be replaced by alternative coping modes when more disconfirming events occur that can no longer be ignored (Afifi & Burgoon, 2000; Pinquart et al., 2021). Shifting attention to non-violated expectations or beliefs may occur, in particular, when the discrepancy between expectation and disconfirming event cannot be reduced (Proulx et al., 2012; Randles, Inzlicht, Proulx, Tullett, & Heine, 2015). However, Proulx et al. (2012) suggested that expectation violations that evoke assimilation and accommodation will also evoke affirmation and abstraction. If both statements are true, individuals may shift their attention to non-violated expectations or beliefs after realizing that their efforts to reduce the discrepancy between expectation and disconfirming event were not effective. Future research should therefore address the shift between different coping processes. In addition to circumstances in which individual coping strategies interfere with one another, there might be other cases where coping strategies supplement each other. For example, after realizing a larger discrepancy between an expected and achieved grade in an academic test (e.g., receiving a C instead of the expected A), it would make sense to reduce the expectation (e.g., expecting a B in the next exam) and to strive harder to fulfil this expectation.

One feature that most of the models in this review share is their focus on detailed descriptions of the processes of coping, rather than a precise specification of the objectives and constraints of these processes. In other areas of psychology, such as perception and motor control, much theoretical progress has been made in recent years by shifting the focus of theorizing and quantitative modeling from describing *how* a process happens towards *why* it happens, i.e. what its objective is. While it might be a significant effort to extend this research approach to expectation violation in general, it could be very fruitful. A successful example of this endeavor are 'ideal observer models' (Geisler, 2003) that stipulate that the goal of perception is optimal (i.e. Bayesian) statistical inference about the distal causes of sensory inputs. The achievable optimality is constrained by the available resources and the quality of sensory signals. Originally conceived as upper bounds on perceptual performance, it turned out that humans are often very close to optimality, at least when perceptual tasks are concerned that are executed frequently (see Rahnev & Denison, 2018 for a discussion of exceptions). Having specified the goal of perception in a computable form, perceptual processes (attention, illusory percepts etc.) follow as derivable consequences from the constrained optimization procedure. This approach to modeling has been extended to associative and causal learning from noisy signals (Dayan & Kakade, 2000) and sensorimotor control of noisy bodies in unpredictable environments (Todorov and Jordan, 2002). Noise and unpredictability may entail expectation violation, so many of the processes of coping with expectation violation in Table 1 are also part of these models, albeit under different names. It will be an interesting challenge for future research to determine if and under what conditions the other processes in Table 1 can be derived from optimization approaches. If such a unified approach can indeed be found, it might also provide the aforementioned 'common language'. With respect to cognitive decision making, the limitations of the human cognitive system need to be considered, such as in bounded rationality (e.g., Binz & Endres, 2019, Gigerenzer & Goldstein, 1996).

5. Implications

The reviewed models provide interesting insights in how individuals cope with expectation-disconfirming experiences. Due to a mixture of common and distinct processes across these models, deciding which model may be best suited for a specific research question can be challenging. Importantly, models that include a broader range of coping strategies seem to be better suited, as researchers will be less likely to miss some relevant processes. The application of models that include only two or three coping processes would be suited if researchers are interested in only this subset of processes or in effects of expectation violation on non-violated expectations and beliefs (MMM) and on alternative outcomes, such as social behavior (EVT) or consumer satisfaction (EDM).

The comparison of the seven models indicates that, at least, three processes should be incorporated in models of coping with expectation violation: minimization of the importance of disconfirming evidence, search for confirming evidence, and change of expectations—processes that are already incorporated in the ViolEx model, EVT, CED, and EDM. Refinements of the models should broaden the range of included coping processes, provide more testable assumptions about the range of influences on the different ways of coping with expectation violation, and put a stronger emphasis on the objectives and constraints of the individual coping processes. For better understanding of the processes behind persistence and change of expectations, we need more empirical studies that assess a broad range of coping processes and test the reviewed models. For doing this, more empirical work should be also invested in developing validated measures of the coping processes. This theoretical and empirical work would be of great value for designing effective interventions aimed at changing dysfunctional expectations (Craske et al., 2014; Rief et al., 2015). Providing more empirical knowledge on the explanatory power of the models could also make the models more visible to researchers from other fields and inspire work on the stability and change of other variables, such as beliefs or stereotypes.

Acknowledgements

The study was supported by Deutsche Forschungsgemeinschaft (DFG), Project number 290878970-GRK 2271.

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