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TITLE

The emotion process: Event appraisal and component differentiation

AUTHORS

Klaus Scherer

University of Geneva, Switzerland

University of Munich, Germany

klaus.scherer@unige.ch

Agnes Moors

KU Leuven, University of Leuven, Belgium

Ghent University, Belgium

agnes.moors@kuleuven.be

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CORRESPONDING AUTHOR

Klaus Scherer, Chemin Esserts 14, CH-1224 Chêne-Bougeries, Geneva, Switzerland

Tel. +41 22 349 9487

klaus.scherer@unige.ch

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KEYWORDS: emotion process, appraisal, action tendency, physiological responses, facial and vocal expression

ABSTRACT

Much emotion research has focused on the end result of the emotion process: categorical emotions, as reported by the protagonist and/or diagnosed by the researcher, with the aim of differentiating these discrete states. In contrast, this review concentrates on the emotion process itself, by examining how (a) elicitation, the appraisal of events, leads to (b) differentiation, action tendencies accompanied by physiological responses and manifested in facial, vocal, and gestural expressions, before (c) conscious representation or experience of these changes (feeling), and (d) categorizing and labelling them according to the semantic profiles of emotion words. The review focuses on empirical, preferentially experimental studies from emotion research and neighboring domains that contribute to a better understanding of the unfolding emotion process and the underlying mechanisms, including the interactions among emotion components.

INTRODUCTION/SCOPE

Past reviews of the emotion literature have generally adhered to the classic view of emotion differentiation, assuming a limited set of discrete emotions (identified by verbal category labels); these reviews generally report research that seeks evidence for differential physiological and behavioral response profiles for these categories. In contrast, the current review adopts a dynamic view of the emotion process, focusing on the factors that trigger an emotion episode and drive response differentiation in a continuous fashion, treating categorization and labeling as a secondary, optional step.

Rather than highlighting differences between emotion theories (see Moors 2009; Scherer 2009b), this review focuses on their commonalities, and summarizes empirical literature relevant to the emotion process in a fairly theory-independent way. In doing so, the review adopts a resolutely nomothetic stance, selecting the to-be-included material based on concrete predictions and reviewing the empirical evidence to date. Privileged are hypothesis-driven studies that have used some kind of experimental manipulation in the laboratory or controlled variation in the field; the review also gives special weight to studies using advanced methodology (in particular, measures that go beyond verbal report of emotion labels). Given this emphasis, ideographic approaches are not considered. Due to space limitations, neuroscience work also is largely excluded.

COMMON GROUND AMONG EMOTION THEORIES

Theorists generally agree on viewing emotion as an interface between an organism and its environment, mediating constantly between changing events and social contexts, on the one hand, and the individual's responses and experience, on the other (Mulligan & Scherer 2012).

There is also substantial agreement that emotion episodes comprise different components such as appraisal of the situation, action preparation, physiological responses, expressive behavior, and subjective feelings. To provide a framework for the current survey, we propose to focus on two central concepts: elicitation, in particular via appraisal processes, and differentiation. Frijda & Scherer (2009) have proposed to distinguish four major functions of emotion that each dominate a different stage of the process: (a) the *appraisal* of events that happen to us in terms of their relevance and consequences for our needs, plans, and values (elicitation of an emotion episode), (b) the *preparation of action* appropriate for dealing with or adapting to these events, both mentally, in the form of states of action readiness or action tendencies, and physically, in the form of physiological responses, (c) the *integration* of information acquired from these two steps in a central *representation* that allows monitoring and regulating the potential responses, and (d) often but not always, the *categorization* and *communication* of the emotion episode to other people.

Imagine the following situation: During a party you happen to overhear two of your friends say unpleasant things about you. Would this elicit an emotional reaction in you and if so, which one? In response to this question, the following answers were obtained in a sample of more than 3000 working adults in different countries (in %): Anger 42.8, Contempt 23.8, Fear 0.7, Good humor 14.2, Guilt 2.3, Sadness, 38.3, Shame, 4.0, Worry 5.0. Responses were obtained with a forced choice list of emotions. In many cases, respondents indicated more than one emotion, suggesting the experience of mixed or blended emotions (Scherer 2018). Most likely, with open response options, an even larger range of different emotions would be obtained, including no emotional reaction at all. Ideally, psychological science should provide a theoretical framework that predicts for whom an emotion episode will be triggered in this situation (elicitation), what the nature of the reaction will be (differentiation), what type of nonverbal

feeling will be experienced (representation), and how it will be verbally described (categorization, labeling).

Figure 1 illustrates the complete emotion process in line with the definition of functions and components proposed above. Emotions are not random events –they occur when something happens to us. In the elicitation stage, triggers of emotions can be objects (visual, verbal, olfactory), acts of nature, the behavior of others, and our own actions. Possible elicitors can also be internal processes, such as imagination or memories of events, hormonal changes or drug effects, and voluntary decisions to experience certain emotions. The elicitors impacting on our organism are filtered by our sensory organs and subject to intensive information processing, most often multi-level appraisals (e.g., Do they really mean this? Did I do something wrong? What will this mean for our relationship? What can I do?).

--- Figure 1 about here ---

The appraisal results produce differentiation—various action tendencies and corresponding physiological responses, motor expressions, and feelings (e.g., a tendency to aggress or avoid, an increase or decrease of muscle tonus, brow lowering or raising, and feeling hot or cold). The continuous changes in these mental and bodily components are integrated and centrally represented as feelings (in nonverbal form, see Moors 2017; Scherer 2009a); these responses can be categorized and labeled with emotion terms (e.g., anger, fear, sadness) or descriptions referring to dimensions (e.g., feeling good or bad, feeling aroused or calm; see Scherer 2001, 2009a). Most of the relevant research to date has measured feelings with self-report via rating scales with emotion or dimension labels. Given the difficulty of the task, there

have been virtually no attempts so far to measure the non-verbal content of the central representation.

Most emotion theorists do not fundamentally disagree about the emotion process as conceptualized in Figure 1, but differ in the components they focus on. In addition, theories that focus on similar components differ with regard to the details of the mechanisms involved. For instance, theories postulating that some kind of appraisal initiates the emotion process tend to assign different weights to the various appraisal criteria, so they have put forward different hypotheses regarding the influence of these criteria on the other components of the emotion episode. Proposals range from template-based stimulus mapping as in simple S-R models, over attribution models (focusing on the attribution of stimuli to different types of causes), social judgment models (focusing on social relationships), decision theories (focusing on values and expectancies of action alternatives), and appraisal theories (proposing a set of appraisal criteria or dimensions such as goal relevance, valence, control, agency, and fairness; for a review of various theories see Moors 2009, 2017; Scherer 2009b; Scherer & Peper 2001). The different emphasis placed by different theories does not necessarily make them incompatible. The remainder of the review will not focus on potential differences. Rather, it will present a summary of empirical research that speaks to a variety of theoretical predictions in the literature.

AN APPROACH TO ORGANIZE EMPIRICAL WORK REGARDING THE EMOTION PROCESS

The relevant empirical work is systematically organized by relations among components of the emotion episode, depicted by the arrows in Figure 1. Despite the fact that many contemporary emotion theorists endorse a componential view, many others continue to study emotions by focusing on emotion categories, thereby neglecting to address the entire emotion process and the relations among components. Nevertheless, scanning the literature reveals a substantial body of

research on these relations. Most of this research, however, has studied the relation among only two components at a time, with the exception of a few studies that have studied several components simultaneously (Bossuyt et al. 2014; Gentsch et al. 2014).

For the present review, three paths have been selected: from appraisal to action tendencies, from appraisal to physiological responses, and from appraisal to motor expression (facial, vocal, and gestural). The choice to include appraisal in each of the relations is based on the widely shared postulate that it is the nature of the appraisal process that determines the nature of the remaining stages in the emotion process. For each relation, research is considered for each of five major appraisal criteria (see Ellsworth & Scherer 2003): novelty or expectedness, valence (intrinsic and extrinsic), agency, control or power, and fairness. Many studies have focused on the isolated influence of one of these criteria; some have addressed the influence of patterns of two or more. In this review we focus on initial appraisal after the occurrence of an event and do not address the copious literature on reappraisal as part of emotion regulation.

In experimental research about relations among components, one component must be manipulated and the other component must be measured. It is useful to organize the methods for manipulation and measurement upfront and highlight some of their advantages and disadvantages.

METHODS FOR THE MANIPULATION AND MEASUREMENT OF COMPONENTS

Manipulation

Manipulation of overt bodily components can be done *directly* or *indirectly* (see Moors & Scherer, 2013). For instance, physiological responses can be produced directly by injection of chemical substances or indirectly via behavior (e.g., running up the stairs leads to a rise in heart rate). Likewise, facial muscles can be activated directly via electrical current, or indirectly via instructions to tense the muscles in particular ways.

Mental components can in principle only be manipulated indirectly, but here too some methods are more indirect and others more direct. Appraisals of events can be manipulated indirectly by presenting real events (e.g., insulting a participant) or virtual events (pictures, films, words, stories) that the researcher expects to be evaluated in a particular way. It can also be manipulated by asking participants to imagine or recall these events (e.g., recall an episode in which you were insulted). These methods are indirect in that the researcher makes no mention of the appraisal criteria under study. More direct methods ask participants to imagine or recall events described in evaluative terms (e.g., imagine or recall a negative event in which you had low control; Fast & Chen 2009; Galinsky et al. 2003; Kuppens et al. 2003; Lammers et al. 2008) or to present the evaluative terms themselves to prime particular appraisals (Smith & Bargh 2008). Manipulating appraisals with indirect methods has the advantage that the researcher can control the non-evaluative features of the event. The more direct methods, on the other hand, have the advantage that the researcher can control the evaluative features of the event. All methods, except imagination and recall, have the further advantage that they allow manipulating the appraisal in a fairly unobtrusive way, thereby diminishing the risk for demand, as well as the activation of participants' convictions about relations between appraisals and other components (Parkinson, 1997).

Action tendencies, which are also considered to be mental entities, are manipulated indirectly via instructions to act in certain ways (e.g., to approach/avoid; Kozlik et al. 2015). The feeling component has been manipulated indirectly by instructing people to imagine or remember an instance of a specific emotion or affect, and to relive it.

Measurement

Methods for the measurement of components can be organized according to two dichotomies: an objective-subjective dichotomy and a direct-indirect dichotomy. *Objective* methods are ones in

which the measurement output is verifiable by others, which is the case with overt behavioral (e.g., facial movement coding, acoustic voice analysis) and (neuro)physiological measures (e.g., heart rate, skin conductance, EEG). *Subjective* methods are not verifiable by others and they typically rely on verbal self-reports.

Methods are called *direct* if the values of the to-be-measured variable are directly read out from the measurement outcome; they are called *indirect* when the values of the to-be-measured variable are derived from another variable that is assumed to influence the to-be-measured variable (De Houwer & Moors 2010). For instance, behavioral choice can be taken as a direct measure of behavior and as an indirect measure of action tendencies (Martinez et al. 2011), based on the assumption that action tendencies influence behavior. The combination of both dichotomies results in four types of methods: direct and indirect objective ones and direct and indirect subjective ones.

Overt bodily components can in principle be measured with all types of methods, but are preferably measured by direct objective ones. For instance, physiological responses are sometimes reported by the person having them (i.e., direct subjective), but more often they are registered with technical devices for registering heart rate, skin conductance, and blood pressure (i.e., direct objective). Facial expressions are measured with direct objective methods such as the Facial Action Coding System (FACS; Ekman & Friesen 1978), in which observers code visible facial action units (i.e., actions of parts of the face), or with electromyography (EMG), a device that registers visible and invisible facial muscle movement in an area of the face. Vocal expressions can be measured by acoustic analysis of voice and speech (Juslin & Scherer 2005)

Mental components can be measured with all types of methods except direct objective ones. Appraisals of events and central representations or feelings have been measured with self-report (i.e., direct subjective), but also with stimulus-response compatibility tasks relying on

reaction times (i.e., indirect objective). Action tendencies likewise have been measured with self-report (Frijda et al. 1987) and stimulus-response compatibility tasks (i.e., indirect objective; Kozlik et al. 2015).

With these methods in mind, the following three sections review empirical research pertaining to paths A, B, and C of the model shown in Figure 1. Paths D and E are not discussed due to space limitations and lack of a coherent body of empirical literature guided by theoretical predictions.

PATH A: FROM APPRAISAL TO ACTION TENDENCIES/BEHAVIOR

This section discusses research on the link between appraisal criteria and action tendencies or overt behavior. This link has been studied both by researchers inside, but more often by researchers outside the emotion domain.

Appraisal criteria: novelty or expectedness and goal relevance

Early observations in animal research have led to the idea that both novel or unexpected and goal-relevant events produce tendencies for orientation and exploration, both of which can be considered as forms of approach tendencies. More recent attentional bias research confirms these earlier observations. Novel/unexpected as well as goal-relevant stimuli lead to a shift in attention, which can be considered as a “mental” action tendency (e.g., Brosch et al. 2013).

Appraisal criterion: valence

Valence is used as an overarching concept covering both (a) intrinsic valence (or pleasantness), which is the appraisal of a stimulus as merely positive or negative, and (b) valence that derives from goal congruence, which is the appraisal of a stimulus as goal congruent or goal incongruent (i.e., one form of extrinsic valence). Evidence for the influence of intrinsic valence and goal congruence is discussed together because only few studies (e.g., Aue & Scherer 2011) attempt to empirically disentangle both types of valence.

A large body of evidence supports the view that positive and negative stimuli respectively lead to the tendencies to approach and avoid. In response-compatibility tasks, participants are instructed to approach positive stimuli and avoid negative ones on compatible trials, and to approach negative stimuli and approach positive ones on incompatible trials. Responses are typically faster and less error prone on compatible than on incompatible trials. This effect has been obtained across a variety of response modalities, e.g., pulling/pushing a lever, approaching/avoiding a manikin on a computer screen, nodding/shaking the head, and stepping forward/backward (see review by Kozlik et al. 2015). It has been interpreted as evidence that valenced stimuli activate action tendencies, which facilitate similar instructed action tendencies (Krieglmeyer et al. 2013).

Alternative accounts for the link between intrinsic valence and approach/avoidance have been proposed. Thus, it has been argued that compatibility effects are not evidence that valenced stimuli spontaneously activate action tendencies (Eder & Rothermund 2008). Instead, these effects could be produced by semantic overlap between the valence of the stimuli and the valence of the instructed responses. Other studies show that negative stimuli do not always lead to an avoidance tendency but rather to an aggressive tendency, and that the latter can be seen as one specific type of approach tendency (Berkowitz & Harmon-Jones 2004; Krieglmeyer & Deutsch 2013). However, if approach and avoidance tendencies are conceptualized on a higher level of abstraction, as tendencies to increase and decrease physical or social contact, the tendency to aggress can be viewed as a strategy for ultimately decreasing contact (Frijda 1986).

Negative stimuli not only lead to an avoidance tendency, but also to a tendency to repair. This is supported by research on cognitive control and conflict monitoring (Botvinick 2007; Dignath et al. 2015). Studies in this area show that conflict stimuli (i.e., stimuli that call for two competing actions such as Stroop stimuli), which are incongruent with the goal to perform well

on the task, instigate the tendency to adjust one's behavior (i.e., put in more effort in order to overcome the conflict), and activate the tendency to avoid subsequent conflict.

Appraisal criteria: agency and intentionality

Agency refers to the source or cause of a negative stimulus or event: the self, another person, or impersonal circumstances. Intentionality refers to whether an animate agent (self, other) produced the stimulus intentionally and is to blame for it. Two effects are discussed: the influence of other/circumstances agency/blame regarding a negative stimulus on the tendency to aggress (Effect 1) and the influence of self/non-self-agency regarding a negative stimulus on the tendency to repair (Effect 2).

Effect 1: agency/blame + valence → tendency to aggress. Early research shows evidence for higher aggressive tendencies when a person is blamed more for the occurrence of a negative (e.g., Kulik & Brown, 1979; see review by Berkowitz & Harmon-Jones, 2004). Recent studies investigate re-appraisal rather than first-time appraisal of agency (see meta-analysis by Barlett 2013). Participants are first led to believe that another person caused them harm (other-agency), after which they receive mitigating information indicating that the person did not cause the harm or was not responsible for it (circumstances-agency). These studies show a reduction in aggression after the presentation of some but not all types of mitigating information (see also Witkower et al. 2016).

Effect 2: agency + valence → tendency to repair. A first research line examines the influence of self/other-agency on the tendency to repair when the negative event happened to another person. In an early lab study by Carlsmith & Gross (1969), participants who caused harm (shocks) to another person (self-agency) were more likely to comply with an unrelated request than those who observed someone else cause the harm (other-agency). A field study by Konecni (1972) obtained the opposite pattern of results. Participants who caused harm themselves (self-agency)

repaired less but avoided more than participants who watched someone else cause it (other-agency). Later studies focused on the role of guilt feelings as a mediator between self-agency appraisal and repair behavior, with some studies showing evidence in favor (Nelissen et al. 2007) and others evidence against this interpretation (Parkinson & Illingworth 2009).

A second research line examines the influence of self/non-self-agency on the tendency to repair when the negative event happened to the participant. Here too the evidence is mixed. Zeelenberg & Beattie (1997) showed, using an ultimatum game paradigm, that self-agency combined with a negative stimulus leads to regret, and that more regret leads to a stronger tendency to repair. A different result was obtained by Bossuyt et al. (2014), who used a computer game to manipulate agency regarding a negative game event. They showed stronger feelings of regret, but not a stronger tendency to repair in the self-agency compared to the circumstances-agency trials. A subsequent recall study showed that control is more crucial for the tendency to repair, and suggested that previous studies found an effect of agency because they confounded agency with control.

Appraisal criteria: control and power (+ valence)

People have control over a stimulus when they have a goal about the stimulus (e.g., the goal to change it) and this goal is a crucial condition for the occurrence of the envisaged effect (e.g., a change in the stimulus; Moors & De Houwer 2006). It is worth distinguishing between different types of control, as they exert different influences on action tendencies. *General control* is control over a wide range of stimuli, either based on repeated experience of control in the past or based on verbal information. *Situational control* refers to control over a current stimulus. General control may influence the situational control one has over a current stimulus, but both types of control may also come apart, as when a person is used to being good at math, but is now confronted with an unsolvable math problem. Situational control can be split into (a)

retrospective control, which refers to the control one had in bringing about an already present stimulus (e.g., one made an error) and (b) *prospective control*, which refers to the expectation of being able to turn a current negative stimulus into a positive one in the future (e.g., one expects to be able to solve a problem). Retrospective control shows strong overlap with self-agency plus intentionality discussed in the previous section, and will not be revisited here.

Much research focuses on *social power*, defined as control over other people or their resources (Fleischmann et al. 2017). Social power is often operationalized as a form of general control (over stimuli in general) and not as situational control (over a current stimulus).

Next, empirical findings in favor and against four effects are discussed: the influence of general and prospective control on (a) the tendency to aggress or engage in other antisocial behavior (Effect 3), (b) the tendency to approach or avoid (Effect 4), and (c) the tendency to be active or passive (Effect 5); and the influence of control in the sense of a specific action (e.g., one can escape) on the tendency to engage in that action (e.g., to escape; Effect 6).

Effect 3: high/low control (+ valence) → more/less aggressive or other antisocial tendency. This subsection separately considers data for general and prospective control. The strongest evidence for the influence of high general control on the tendency to aggress (and other forms of antisocial behavior) comes from research on social power, in which high-power participants were more likely to act aggressively, as manifested in familial aggression, crime against minorities, sexual harassment, bullying, and corruption (Guinote 2017).

These effects are typically explained as mediated by the activation of neural circuits known as the behavioral approach system (BAS) and the behavioral avoidance system (BIS; Gray & McNaughton, 1996). High power both increases activation of the BAS, leading to a stronger tendency to approach one’s goals, and decreases activation of the BIS, leading to less inhibition of aggressive strategies to reach these goals. Both elements contribute to increased

aggression. Low power, on the other hand, increases activation of the BIS, resulting in increased avoidance.

A different set of studies suggest that people high in power engage more in prosocial than in antisocial behavior (Chen et al. 2001; Fleischmann et al. 2017). In an attempt to reconcile these contrasting findings, Guinote (2017) argued that high power increases the pursuit of salient goals. Various moderators (e.g., task demands, organization and national culture, and personality traits and needs) determine whether the salient goals are selfish or prosocial. Selfish goals lead to more corrupt and antisocial behavior whereas prosocial goals lead to more social behavior.

The hypothesis that high and low prospective control over a negative event should respectively lead to the tendencies to aggress and avoid has intuitive appeal (Ellsworth & Scherer 2003, p. 580), yet experimental evidence for it is scarce (see Berkowitz & Harmon-Jones 2004). To the extent that the studies in which general control (social power, self-efficacy) was manipulated also influenced participants' prospective control, however, they can be considered as indirect support for the link between high/low prospective control and the tendency to aggress/avoid.

Effect 4: high/low control → tendency to approach/avoid. The observation that high control sometimes leads to antisocial and sometimes to prosocial tendencies, and that these tendencies can both be captured under the denominator of approach tendencies, has led some researchers to propose that the relation between control and action tendencies is best described as a relation between high/low control and approach/avoidance (Guinote 2017), which is consistent with the BAS/BIS explanation.

Several findings speak more directly to this relationship. For instance, Smith & Bargh (2008) manipulated power by using a priming procedure. Their results revealed that high-power

participants had a stronger tendency to approach than low-power participants and non-power-primed participants. The groups showed no difference in the tendency to avoid.

Effect 5: high/low control + negative → tendency to be active/passive. Several effects described as effects on the tendency to approach/avoid could even be reinterpreted as effects on the tendency to be active/passive because in many studies, the approach behaviors were more active than the avoidance behaviors (but see Smith & Bargh 2008 for an exception). A number of research findings yield more direct support for the link between control and activity (or the intensity of action tendencies). This subsection separately considers data for general control, prospective control, and the combination of both types of control.

Early studies in the learned-helplessness literature established that subjects (animals, humans) confronted with a series of uncontrollable aversive stimuli in a training phase (unavoidable shocks or loud noise, unsolvable puzzles) showed decreased effort leading to impaired performance in a test phase compared to subjects who were trained with controllable stimuli (e.g., Hiroto 1974; Seligman 1975). This can be interpreted as evidence that high/low general control leads to the tendency to be more/less active. More recent findings from the achievement motivation literature are in line with these results. Students or workers often exhibit more persistence, resulting in better performance when they have high (compared to low) self-efficacy (see meta-analyses of Multon et al. 1991; Talsma et al. 2018) and when they have an internal (compared to an external) locus of control (see review by Galvin et al. 2018).

Further support for the link between high/low general control and the tendency to be active/passive comes from research on social power. Galinsky et al. (2003) found that power holders have an increased action orientation, irrespective of whether this action was prosocial or antisocial.

The studies cited on learned helplessness, achievement motivation, and social power speak not only to the influence of *general* control on the tendency to be active/passive. Insofar as the manipulation of general control (or social power) in the training (or priming) phase transferred to the stimuli in the test phase, these studies also provide evidence—albeit indirectly—for the influence of high/low *prospective* control on the tendency to be active/passive.

Research on achievement motivation provides more direct evidence for the latter link. In this research, prospective control or the expectancy to be able to perform a particular task is typically operationalized in terms of task difficulty (with easy/difficult tasks considered as easy/difficult to control). Expectancy-value theories argue that the expectancy to succeed on a task interacts with (i.e., is moderated by) the value attached to succeeding on the task (Nagengast et al. 2011): High prospective control only leads to the tendency to be more active if the outcome of the action is also desired.

Other studies, by contrast, showed a different pattern of results: Low prospective control did not lead to passivity, but rather to reactance (resistance, opposition). This is also opposite to Effect 3. In an early study, Donnerstein & Wilson (1976) observed that participants who had to solve a math task under high-intensity noise displayed more aggression when they had low compared to high control over the noise. Wortman & Brehm (1975) reconciled these contradictory results by arguing that when participants initially experience a low amount of failure, they still expect some control over the stimulus, which generates a reactive tendency. As failures accumulate, they no longer expect control, which results in a passive tendency.

In some studies on achievement motivation, general and prospective control were manipulated or varied orthogonally. A meta-analysis by Stajkovic & Luthans (1998) reported that participants with high/low self-efficacy had high/low work performance for easy, medium,

and difficult tasks. Yet the effect was most pronounced for easy tasks, suggesting an additive effect of general and prospective control on the tendency to be active. A somewhat different pattern of results was obtained by Smith & Kirby (2009), who asked participants varying in subjective and objective math ability to solve easy vs. difficult math problems. They also found that higher ability participants had higher persistence and higher performance, but only for the difficult tasks. Importantly, the effect was mediated by appraisals of higher prospective control (which they termed "problem-focused coping potential").

Effect 6: Control in the sense of a specific action → tendency to engage in that action. McCloskey et al. (2005) showed that having more options to control an aversive outcome does not always lead to an aggressive but sometimes to an escape tendency (i.e., the reverse of Effect 3). This is in line with older studies (e.g., Cherek et al. 1990) that show that aggressive responses were maintained when they were rewarded by escape from point loss, but were extinguished when they were no longer rewarded. This is in line with expectancy-value theory according to which the action tendency activated is in large part determined by the expected utility of the action (Moors et al. 2017; Moors 2017).

Appraisal Dimensions: Fairness

Most research relevant for the influence of fairness on action tendencies/behavior is conducted with the ultimatum game (reviews and meta-analyses by Güth & Kocher 2014; van Damme et al., 2014) in which a first player proposes a division of a sum of money between herself and a second player. If the second player accepts it, the money is divided as indicated; if he/she rejects it, neither player receives anything. A recurring observation is that players reject unfair offers, causing harm to both players. Thus, this research documents the influence of unfairness on the tendency to engage in costly aggression. Rejecting any division that delivers more than zero has been labeled as irrational, at least if the (selfish) goal to maximize profit is the only goal that is

considered. If the (altruistic) goal for fairness is taken into account, however, rejecting unfair offers no longer qualifies as irrational.

The standard explanation for the observed effects is that receiving an unfair offer leads to a negative emotion, which in turn, leads to rejection (e.g., Matarazzo et al. 2016). Alternative explanations leave out (full-blown) emotions as mediating entities (Bierbrauer et al. 2017; Civai 2013; Schank et al. 2017).

Bediou & Scherer (2014) manipulated both the goal incongruence and fairness of offers in an ultimatum game. They found that participants' rejection rates of these offers was more influenced by goal incongruence than by fairness.

PATH B: FROM APPRAISAL TO PHYSIOLOGICAL RESPONSES

Starting with the pioneers (Darwin, Irons, James, Wundt) the physiological correlates of emotion have occupied a central position in emotion research generating a remarkable number of studies. The underlying assumption guiding this work was that different emotions could be clearly distinguished by different profiles of physiological responses. Kreibig (2010) reviewed 134 articles on autonomic nervous system (ANS) reactions to different emotions. Scrutiny of the evidence does not confirm the a priori expectation of a clear-cut differentiation of the major emotions. Out of the large number of parameters measured in these studies (20 cardiovascular, 3 electrodermal, and 13 respiratory variables), only heart rate and respiration rate showed stable effects pointing in the same direction (concurrent evidence from at least 3 studies). The differentiation afforded by these two parameters concerns mostly the typical level of arousal for specific emotions: sympathetic responses for high arousal emotions such as anger, fear, joy, and surprise in contrast to parasymphathetic responses for low arousal emotions such as sadness, contentment, and affection. In line with the framework proposed here, variants of specific emotions (e.g., acute vs. anticipatory sadness and sadness with or without crying) suggest that it

is not so much the nature of the emotion but the type and urgency of the action tendency involved (e.g., heart rate increases as threat becomes more acute and requires faster responding; see also Ortony & Turner, 2001).

Pecchinenda (2001) suggested that the disappointing results of this research tradition are due to the lack of theory-based predictions regarding the pattern of ANS activity associated to each emotion. She proposed that, rather than focusing solely on the final outcome (the emotion category), researchers should place greater emphasis on emotion-antecedent information processing. Early studies that measured the physiological effects of specific appraisal outcomes support to the notion that physiological activity associated with emotional reactions is organized around the personal meaning attributed to the situation through an appraisal process (Pecchinenda 2001, pp. 306-7).

The next sections discuss evidence on the effect of appraisal criteria—often mediated by action tendencies—on physiological responses in the peripheral nervous systems.

Appraisal criteria: novelty/expectedness and goal relevance

There is solid evidence that novel and unexpected stimuli in all sensory modalities not only elicit an attentional (see above) but also a physiological orienting response, characterized by massive changes in the ANS (e.g., an increase in muscular tone and skin conductance, a decrease in heart rate, pupil dilation, and a pause in respiration that is often followed by an increase in respiratory depth and a decrease in respiratory rate; Reisenzein et al. 2017). Likewise, Aue et al. (2007) showed that highly goal-relevant (threatening) pictures compared to neutral ones increased heart rate. The orienting response serves to recruit extra sensory and cognitive resources to identify and make sense of the source of the novelty/unexpectedness and/or goal relevance (Nieuwenhuis et al. 2011).

Appraisal criteria: valence (+ novelty)

There is much work on the effects of intrinsic valence and goal congruence on autonomic indicators, especially cardiac and electrodermal responses. Yet many of the relevant studies were concerned with mediating effects such as situational context and individual differences, often related to clinical symptoms. There is a large amount of research on valence involving sensory input such as touch, sound (music), and visual stimuli (pictures; e.g., Hamm et al. 2003; Lang 2014; Triscoli et al. 2017; Sumpf et al. 2015). Goal congruence (reward/punishment) has often been studied by comparing winning and losing in a gaming context or by comparing success and failure in ability tasks (Richter & Gendolla 2009, Lole et al 2012, Löw et al. 2008, Silvia et al. 2014).

Recent research has compared the physiological effects of intrinsic valence and goal congruence. Van Reekum et al. (2004) used a computer game to manipulate both appraisals in a game context and they measured a range of physiological reactions. Goal congruence had little effect on muscle activity but significant autonomic effects, including changes to interbeat interval and pulse transit time of heart rate, skin conductance, and finger temperature. The manipulation of intrinsic valence had comparatively little impact on physiological responses.

Aue & Scherer (2008, 2011) simultaneously manipulated the intrinsic valence and goal congruence (reward value) of pictures and found that pictures that were both positive and goal congruent were associated with higher zygomaticus activity, lower corrugator activity, and higher heart rate than pictures that were either intrinsically negative or goal incongruent. The two appraisals had somewhat similar response patterns, but they were not identical: intrinsic valence had more robust effects on facial EMG (Aue & Scherer 2011), whereas only goal congruence significantly influenced mean skin conductance, forehead temperature, and finger temperature. Goal-incongruent events produced stronger physiological mobilization than goal-congruent ones as manifested in less habituation in mean skin conductance over the experiment (see also Van

Reekum et al. 2004). There was also evidence that the efferent effects of the two appraisals combined multiplicatively, and that predictability of goal congruence influenced the impact of goal congruence on somatovisceral responding (Aue & Scherer 2008).

Delplanque et al. (2009) used positive and negative odors and manipulated their novelty to examine the effect of these appraisal criteria on a large number of psychophysiological parameters. They found a relative heart rate deceleration in response to novel odors, and a relative acceleration for negative ones, confirming the classical distinction between orienting and defense reflexes.

Appraisal criteria: control/power (+ valence)

Lazarus & Folkman (1984) first differentiated between threat and challenge appraisals, corresponding to low and high prospective control, respectively. Tomaka et al. (1993, 1997) found that cardiac reactivity during active coping with stressors was positively related to challenge appraisals and negatively to threat appraisals, whereas vascular reactivity was positively related to threat appraisals and negatively to challenge appraisals. Recent research has confirmed the influence of threat versus challenge appraisals (based on perceived control and support) on cardiovascular reactivity (for recent examples, see Gaab et al. 2005; Gramer & Supp, 2014; Harvey et al. 2010; see also review by Denson et al. 2009 and Kemeny 2009).

Some studies combined appraisals of control and goal congruence (e.g., Chalabaev et al. 2009; Weinstein et al. 2006; Pecchinenda & Smith 1996). Johnstone et al. (2007) studied participants performing a computer task in which they could lose or gain points (goal congruence manipulation) under two levels of difficulty (control manipulation). Skin conductance indicated higher sympathetic arousal for losses than gains, particularly when difficulty was high.

PATH C: FROM APPRAISAL TO EXPRESSION

Appraisals and action tendencies produce motor expressions because they are generally functional for the preparation of elicited action tendencies. These reactions comprise (a) effects of physiological changes, (b) the preparation of specific instrumental motor actions such as information search or approach/avoidance behaviors, and (c) the production of communication signals (see Mortillaro et al. 2011; Scherer 2013). A few exceptions notwithstanding (e.g., Lee et al. 2013), these functions have rarely been studied experimentally. Most studies on expression have been devoted to people's recognition of a small number of basic emotions from facial, vocal, and gestural expressions (decoding) while only few studies have targeted the production of these expressions (encoding; see Scherer et al. 2011, for a review). As in the work on physiological responses, most work on expression encoding has taken a holistic approach by asking actors to portray specific emotions and then measuring the expressions. Yet it is possible to take a functional approach that develops predictions about links between specific appraisals and specific facial, vocal, and gestural expressions (see Scherer et al., 2017).

The next sections discuss the production of expression driven by appraisals, separately for facial, vocal, and gestural expressions.

Facial expression

Scherer et al. (2018b) reviewed actor portrayal studies in which facial expressions of discrete emotions were coded using the Facial Action Coding System (Ekman & Friesen 1978). Earlier predictions about emotion-specific facial expressions (see Ekman 1997) were only partially comfirmed. Rather, many action units were used by actors as part of their portrayals of many different emotions. Mehu & Scherer (2015) also showed that only a minority of facial action units were associated with specific emotions. This is compatible with the hypothesis that appraisals combine in many different configurations resulting in a large variety of different emotions and emotion blends. Although actor portrayal studies have been set up to find evidence

for the existence of emotion-specific facial expressions, it is possible to analyze the results in the light of this alternative hypothesis. Thus, the plausibility of the assumed functions of certain facial expressions expected to be generated by specific appraisals can be investigated by considering the links between the dominant appraisal configurations for major emotions (e.g., unexpectedness, goal obstruction, other agency for anger) and the type of facial action units consistently found for these emotions. This approach was taken by Scherer & Ellgring (2007, pp. 125-6), who interpreted their empirical data on the facial expressions in actor emotion portrayals by discussing the probability of certain appraisals being involved in generating these emotions.

More direct evidence for the hypothesis that appraisals drive specific facial actions can be obtained when appraisals are manipulated in the laboratory and their effects on the face are measured. Appraisals manipulated in the laboratory may not produce facial actions that can be detected through visual inspection, which is why electromyographic measurement (EMG) is often used to measure the innervation of specific muscles. A growing body of evidence documents specific muscle activation in response to experimental stimulus manipulations that can be interpreted in terms of appraisals, such as novelty (Stekelenberg & van Boxtel 2002) and valence (Hamm et al. 2003, Heller et al. 2014, Neta et al. 2009; Larsen et al 2003).

Recent work on facial expressions examined the appraisals of goal relevance, intrinsic valence, goal congruence, and prospective control. Aue et al. (2007) found that biological threat stimuli (high goal relevance) produced increased activity over the cheek region that resembles the “fear grin”. They also found that winning a reward (goal congruent) led to increased activity over the cheek region (zygomaticus, smiling), whereas losing (goal incongruent) led to increased activity over the brow region (corrugator, frowning). Aue & Scherer (2008, 2011) further confirmed the central role of the zygomaticus and corrugator muscles as reliable signatures for valence (particularly intrinsic valence). Wu et al. (2012) showed similar effects when they

manipulated appraisals via a priming procedure. Lanctôt & Hess (2007) used pictures and a PacMan game to manipulate appraisals of intrinsic valence and goal congruence. They replicated the basic pattern reported above, but they also found that intrinsic valence led to significantly faster facial reactions than goal congruence (as predicted by Scherer 2001). The olfaction study by Delplanque et al. (2009) showed that both novel and negative odors produced an increase in frontalis (brow) activity, and that intrinsically negative odors produced an increase in corrugator activity. They also obtained a clear sequence effect with novelty effects preceding intrinsic valence effects.

Gentsch et al. (2015a,b) found several main effects on the facial EMG measures over the corrugator, cheek, and frontalis regions for goal congruence (starting ~600 ms) and prospective control appraisals (starting ~800 ms after feedback onset). They also confirmed the sequence hypothesis, showing that the appraisal of goal congruence preceded that of prospective control. In addition, they obtained interaction effects suggesting amplified goal congruence effects when control was high in contrast to invariant goal congruence effects when control was low.

Using a different approach, Scherer et al. (2018a) asked professional actors to facially enact a sequence of events in a scenario in which appraisals of the protagonists were sequentially varied. Results showed that actors produced the predicted facial actions significantly more frequently for appraisals of high novelty, positive and negative valence, and low prospective control.

An indirect method to study the effect of appraisal on facial expressions is to use a recognition approach in which judges are asked to infer appraisals from facial expressions. Using this judgment method, Mehu & Scherer (2015) showed that facial behavior plays a significant role both in the recognition of specific emotions and in the judgment of affective dimensions such as arousal, valence, and potency. A mediation model revealed that the association between

facial behavior and recognition of the signaler's emotional intentions is mediated by perceived affective dimensions. The authors concluded that the classification of emotional expressions into discrete categories may therefore rely on the perception of affective dimensions and presumably, their underlying appraisals.

Scherer et al. (2018b) directly tested the claim that observers first detect specific appraisals from different facial muscle actions and then use implicit inference rules to categorize and name specific emotions. They reported three experiments in which various configurations of facial action units expressed by synthesized avatars were judged for appraisals and/or emotions, and their results confirmed that participants can indeed infer appraisals and emotions in line with predictions from appraisal theories.

Vocal expression

Empirical work on emotional expression has been dominated by the face until very recently. This is quite surprising as there is an extraordinary amount of evolutionary continuity and interspecies similarity (at least for mammals) for the vocal channel of emotion expression (Briefer 2012). As is the case for facial expression, much of the work on the human voice has been fairly atheoretical, basically attempting to identify the vocal profiles that differentiate specific emotions.

Scherer (1986) proposed a theoretical framework to predict emotion-specific vocal expressions as the result of a sequence of appraisals likely to result in action tendencies and physiological (ANS and SNS) changes that could affect vocalization in a specific fashion. The following examples illustrate the approach, accompanied by available empirical evidence for several appraisal criteria.

Novelty/expectedness. The orienting response (see above) is likely to produce corresponding changes to the settings of the extrinsic and intrinsic laryngeal muscles, leading to raised

fundamental frequency (f0, heard as pitch) due to the raised vocal fold tension and respiratory changes affecting voice intensity and speech fluency.

Valence. The expected occurrence of a goal-congruent event is likely to lead to relaxation. The person can engage in resting behavior, and the resources expended during goal pursuit are replenished. This should be accompanied by ANS activity characterized by parasympathetic dominance, a balanced tone in the striated musculature, and relaxed respiration. Frijda (1986) reviewed evidence for parasympathetic dominance in rest and recovery states, including a tendency for abdominal rather than thoracic breathing, and increased saliva production. This response pattern is consistent with measurements of expressed contentment in speech, which is characterized by low f0, low to medium intensity, and relatively slow articulation. In contrast, the unexpected occurrence of a goal-congruent event might be expected to trigger an approach tendency, accompanied by general sympathetic arousal preparing for activity, such as deeper and faster respiration and an increase in skeletal motility. For example, for vocally expressed elation, increases in f0 and f0 range are typically observed as well as an increase in energy of the harmonics and in the rate of articulation (Johnstone et al. 2001).

Smiling is likely used to signal to others the presence of something goal-congruent or intrinsically positive (see section on facial expression), whether expected or unexpected. Smiling has the effect of shortening the vocal tract and widening the mouth opening, which causes a raising of formant frequencies and often also a rise in f0 (Bachorowski et al. 2001).

The perception of a stimulus of high intensity and negative valence can elicit a defense response, which leads to cardiovascular and muscular changes that facilitate moving or turning away from the stimulus (see section on physiology). Such changes could be expected to change the length and form of the vocal tract, likely to affect voice quality.

To study both intrinsic valence and goal congruence conjointly, Johnstone et al. (2005) modified a popular computer game in which they presented stimuli that were either congruent or incongruent with the goal of winning and were accompanied by intrinsically positive or negative sounds. Acoustic analysis of the standardized vocal utterances requested from the participants revealed that mean energy, f0 level, utterance duration, and the proportion of the voiced part of the utterances varied with goal congruence whereas spectral energy distribution depended on intrinsic valence. Pitch dynamics depended on the interaction between goal congruence and intrinsic valence.

Prospective control (+ valence). The appraisal criterion of prospective control becomes especially important in the case of negative events (see Gentsch et al. 2015a). This is true for many species of animals including humans. In the case of high control, especially in the presence of an aggressive tendency (e.g., in dominance fights), acoustic changes occur including a rise in vocal energy (heard as loudness) and changes in formant structure (Briefer 2012; Ko et al. 2015). Low or no prospective control, especially when leading to disengagement or resignation, should produce low sympathetic activity and lax muscle tone, which will likely produce decreases in f0 and f0 range, in vocal intensity, in the energy of the harmonics, and in the rate of articulation. This pattern has been repeatedly found in measurements of speech expressing sadness or disappointment (Goudbeek & Scherer 2010; Johnston et al. 2001). When control is moderate or uncertain, a sympathetic response is to be expected, such as in states of “stress” or high mental workload, resulting in high f0, high vocal intensity, and faster articulation (Johnstone et al. 2001; Paulmann et al. 2016).

Johnstone et al. (2007) examined the effect of goal congruence and prospective control in a computer task in which participants lost or gained points under two levels of difficulty. Results showed interactions between gain/loss and difficulty: f0 was higher for losses than for gains

when difficulty was high but not when difficulty was low. Electroglottal measures showed shorter glottal open times for losses than for gains (suggesting raised laryngeal tension). Skin conductance indicated higher sympathetic arousal for losses than for gains, particularly when difficulty was high.

Multiple appraisals. Apart from a few isolated attempts to manipulate appraisals, most of the work on vocal expressions asked professional actors to portray sets of specific emotions (portrayal studies), and some studies asked professional actors to enact scenarios designed to specific emotions (Stanislavski method). In a review of 104 studies on vocal expressions, Juslin & Laukka (2003) concluded that the patterns of vocal parameters found across studies were generally consistent with the theoretical predictions by Scherer (1986).

From these portrayal and enactment studies, one can also derive indirect evidence for the role of appraisal criteria by using the profiles of these emotions on the major affective dimensions of arousal, valence, and potency. The important role of arousal in determining vocal parameters in the expression of emotion is well established. There is less evidence for the contribution of valence and potency to vocal emotion expression. In order to investigate these dimensions further, Goudbeek & Scherer (2010) used this approach based on a large corpus of emotion enactments (the Geneva Multimodal Emotional Portrayal corpus, GEMEP; Bänziger et al. 2012) comprising twelve emotions that systematically vary with respect to valence, potency, and arousal. The accoustic profiles found for specific emotions confirmed earlier findings obtained from a similar corpus (Banse & Scherer 1996). In addition, the authors used composite scores for acoustic parameters to determine their predictive power for the underlying dimensions of arousal, valence, and potency. They confirmed that arousal dominated many vocal parameters, but they could also identify parameters that are specifically related to valence and potency, in particular spectral balance and spectral noise.

Belyk & Brown (2014) suggested that weaker effects for valence and potency may depend on differences between emotion families. In an enactment study, they divided emotional vocalizations into motivational, moral, and aesthetic families (Ortony et al. 1988). The results showed that valence interacted with emotion family for both pitch and amplitude, suggesting that there may not be a common acoustic code for valence across families of emotions.

A further reason for weak effects is that most research to date has assumed linear relationships and has analyzed the data linking acoustic parameters to the expression of different emotions with multivariate linear statistics. However, there is also a possibility of curvilinear relations, such as positive valence being expressed by either low or high intensity depending either on the respective emotion family or other factors such as task difficulty (see Johnstone et al. 2005) or emotional intensity (Bachorowski & Owren 1995).

Another indirect dimensional approach to vocal expression of emotion was reported by Laukka et al. (2005) who used five vocally enacted emotions with weak and strong emotion intensity and asked listeners to rate each enactment on arousal, valence, and potency. The portrayals were also acoustically analyzed (e.g., speech rate, voice intensity, f0, and spectral energy distribution). Results showed (a) distinct rating patterns for arousal, valence, and potency for the different emotions; (b) significant correlations of all three affective dimensions with several vocal cues, and (c) the successful prediction of all affective dimensions except valence from the vocal cues.

Laukka & Elfenbein (2012) directly investigated the inference of appraisals from vocal expressions. They had actors produce vocal enactments, after which they asked participants to rate the situations that led to these enactments in terms of appraisal criteria (i.e., novelty, intrinsic valence, goal congruence, urgency, agency, prospective control, and fairness). The perceived appraisal profiles for the different emotions showed high inter-rater agreement and were

generally in accordance with predictions based on appraisal theory. The appraisal ratings also correlated with a variety of acoustic measures related to pitch, intensity, voice quality, and temporal characteristics of the enactments. A recent follow-up study reported by Nordström et al. (2017) compared an Australian and an Indian sample and found that appraisal criteria inferred from vocal expressions were consistent across cultures.

Gestural expression

Compared to facial and vocal expression, the literature on gestural and other bodily expression is extremely scarce (but see de Gelder 2006; Lhommet et al 2015). Dael et al. (2012) developed a body movement coding system, which allows describing visible activity (gestures) in parts of the body, without interpreting this in terms of emotions (similar to FACS for the face). They applied the system to the GEMEP corpus mentioned above (which contains multi-modal videos of enactments) to investigate the extent to which gestural expression patterns support different predictions in the literature. The results showed that only few emotions were characterized by a protoypical gesture pattern and that most emotions were variably expressed by multiple patterns, which may reflect configurations of appraisals and action tendencies. To follow up on this lead, Dael et al. (2013) investigated how the expression of emotions that vary on arousal, valence, and potency influence the perception of dynamic arm gestures. Participants rated the arm movements of all emotional expressions from the GEMEP corpus with muted sound and blurred faces on six spatiotemporal characteristics that were found to be related to emotion in previous research (amount of movement, movement speed, force, fluency, size, and height/vertical position). Arousal and potency were found to be strong determinants of the perception of gestural dynamics, whereas the differences between positive and negative emotions were less pronounced. These results confirm the importance of arm movement in communicating major

affective dimensions and show that gesture forms an integrated part of multimodal nonverbal emotion communication.

CONCLUSION AND FUTURE OUTLOOK

Perhaps surprising to the reader, this review has rarely mentioned the standard emotion terms that provide the backbone of classic emotion research, such as anger, sadness, contempt, fear, joy, shame, or guilt, and has avoided the discussion of whether there are discrete emotions, how many there are, and whether some of them are more basic (and universal) than others. Similarly, it has not attempted to review the relative merits of different emotion theories in terms of plausibility or empirical support. Instead, the review focused on the components of the emotion process about which there is substantial agreement (although there may be disagreement about the roles assigned to each) and on the causal links between them. The purpose of this change of emphasis is to open new perspectives to empirical emotion research interested in examining the underlying mechanisms rather than a limited number of outcomes of these processes, such as "basic" emotions.

The classic approach in emotion research has been to start with the end product of the emotion process—individual emotions as labeled by emotion words, trying to empirically determine the specificity of these emotions in terms of elicitors and response profiles across the different components. This is problematical for at least two reasons: (1) Terms like anger, fear, sadness, or joy are not homogeneous classes. The anger category may manifest itself as slight irritation or violent rage, sadness as depressed resignation or intense despair, fear as slight worry or terrorized panic, with an infinite number of intermediate states. Moreover, blends or mixtures of emotion are extremely common (Scherer et al., 2004; Scherer & Meuleman 2013). This extreme variability of the outcomes of emotion processes makes it exceedingly difficult to organize systematic research by emotion labels. (2) It is highly likely that the labeling of an

emotion episode occurs at the very end of the process, as an outcome (see Figure 1). Ideally, hypothesis-guided research specifies the causal factors and their expected interactions in determining the outcome. This is not the case in research that fixes the outcome as a class, given that it does not allow specifying theoretical predictions and is thus reduced to associative measures of class differentiation. The research reviewed here illustrates an alternative approach, which emphasizes the underlying mechanism of the process and the dynamic interactions among components. This approach should contribute to building a coherent and plausible theoretical framework that can guide future research.

This does not imply that emotion labels should be banned from emotion research, but rather that they should be placed where they belong: at the end of the emotion process. They should be treated as one class of dependent variables, allowing for a large variety of type and intensity. This is of particular importance to applied research in real life settings where the emotions encountered, and studied, are generally more subtle, often constituting blends, rather than strong prototypical exemplars. Adopting a process approach, in addition to fostering hypothesis-guided designs, may also facilitate emotion research in ecologically valid contexts.

This review discussed relations among appraisals and three other components. Testing the complete model shown in Figure 1, however, would require obtaining evidence for relations among all the components. In this review, some patterns of convergence across multiple components are already clearly discernible. For instance, novelty appraisal generates an orientation tendency which seems to be manifested by eyebrow raising in the face. Positive valence appraisal leads to the tendency to approach corresponding to smiling (AU12), negative valence to the tendency to avoid corresponding to frowning (AU4). Control/power appraisal results in the tendency to be active (in the antisocial or prosocial sense) which apparently leads to loud, powerful vocalizations (vocal energy). A combination of unexpectedness, negative valence,

and high control appraisals results in effort mobilization and activation that is likely to result in massive changes in the ANS and SNS (especially heart rate and muscle tension). A major task for future model fitting is the detailed examination of the interaction between the components and the degree of coherence of the different components. This will require large-scale collaborations between research teams with different methodological competencies.

--- SIDEBAR Model testing in semantic sedimentation --- ABOUT HERE

Component coherence is also a central issue for the question of when an emotion episode begins, in terms of being different from other, non-emotional episodes, and when it becomes conscious. One possibility is to define the start of an emotion episode by an increased synchronization and coherence among the various components beyond a certain threshold and its end by the coherence dropping below threshold. The degree of coherence might in turn be determined by the goal relevance of the event. The nature of the emotion episode could be seen as determined by the specific patterning over time of recursively generated appraisal results. Such a “kaleidoscopic” arrangement of appraisal results can generate a near infinite number of different emotion episodes without clear categorical boundaries (Scherer 2009a).

What kind of a threshold for coherence could be envisaged? One possibility is to argue that at a certain point of increased coherence a person will become aware of an "altered state". A plausible underlying mechanism is the central sensorimotor integration and representation of changes in all synchronized components in the central nervous system (CNS), which receives massive projections from both cortical and subcortical CNS structures (including proprioceptive feedback from the periphery) and serves to monitor and regulate the degree of system coherence. Thus, the degree of coherence among components might generate awareness, leading up to

“experienced feelings”. People can focus on micro-momentary changes of feeling, but they usually become aware of them as temporal chunks with phenomenal unity. These chunks might occur when a certain level of component synchronization persists.

Research into component coherence and temporal chunking has barely begun. However, there is increased interest and promising first investigations in both psychology and neuroscience. In 2014, the journal *Biological Psychology* devoted a Special Issue "Whither concordance? Autonomic psychophysiology and the behaviors and cognitions of emotional responsivity" to this topic. Apart from the complexity of dynamic measurement of changes in the appraisal and response components, sophisticated statistical and mathematical tools are required for the analysis. Recently, Rügamer et al. (2017) developed and successfully applied a new historical function-on-function regression model to measure the cross-correlation of brain processes (electroencephalographic data) and muscle innervation (electromyographic data) that were simultaneously recorded from participants while they were playing a computerized gambling task (Gentsch et al. 2014). Our understanding of the nature of the emotion process is intimately tied to further progress in this direction.

SUMMARY POINTS

1. The proposal is to move from a discrete emotion approach to an emotion process approach with an emphasis on the mechanisms and determinants underlying the unfolding of emotion episodes, treating emotion labels as dependent variables.

2. The starting point is a process model (shared across many theories) according to which emotion episodes comprise the following components: stimulus appraisal, action tendencies, physiological responses, motor expression, experienced feeling, and (in some cases) categorization and labeling.

3. Three relationships in the process model are selected for a review of the pertinent literature: the effect of different appraisal criteria on (a) action tendencies/behavior, (b) physiological responses, and (c) motor expression (in face, voice, and gestures)

4. The review of research pertaining to relations between appraisal and other components is organized by the criteria of novelty/unexpectedness, (intrinsic and extrinsic) valence, agency, control/power, and fairness.

5. Research on the influence of appraisal on action tendencies/behavior draws a complex picture on how the various appraisal criteria influence action tendencies such as antisocial vs. prosocial tendencies, approach vs. avoidance tendencies, and tendencies to be active vs. passive.

6. Prior work on physiological responses has searched for differences between discrete emotions, but has yielded few reliable patterns; in contrast, there is consistent evidence of stable correlates of appraisal criteria on physiological correlates in the ANS and SNS, in particular for cardiovascular parameters and muscle tension.

7. Facial expression has been a mainstay of emotion research since Darwin, yet it has been difficult to show consistent differences in facial muscle activation patterns between discrete emotions even in actor portrayal studies; in contrast, experimental work on the effects of appraisal manipulations shows well-replicated effects, especially for the effect of valence on the zygomaticus (smile) and corrugator (frown) muscles.

8. Vocal expression has been relatively neglected in research, yet recent literature using advanced acoustic analyses shows many consistent response patterns, in particular linked to control/power appraisals.

FUTURE ISSUES

1. Almost all of the work in this domain has been confined to the laboratory and, in many expression studies, to actor-portrayed emotions, highlighting the need to branch out toward more ecologically valid settings, despite the effort and cost involved. One promising avenue might be the use of virtual reality environments and synthetic avatars that can be easily manipulated.

2. While much of the work reviewed here has focused on the relation between pairs of components, several studies did measure two or more components of which some reveal coherence and others reveal interaction effects, suggesting the importance of complex multifactorial designs and advanced dynamic measurement rather than before-after designs.

3. A process approach requires explicit causal modeling as well as sophisticated statistical techniques, particularly with respect to time series modeling and model fitting. While there are some promising developments, much remains to be done.

4. One of the components in the process, the experienced feeling before categorization and labeling, has been neglected so far, as it has often not been clearly separated from "emotion". This should become one of the priorities in future theorizing and research, in collaboration with neuroscientists.

5. Psychological constructionism argues that individuals "construct" their own categorization of experience and choose an emotional label accordingly. This is undoubtedly true but it is essential to theoretically link this act to what precedes in the emotion process, allowing at least some degree of prediction.

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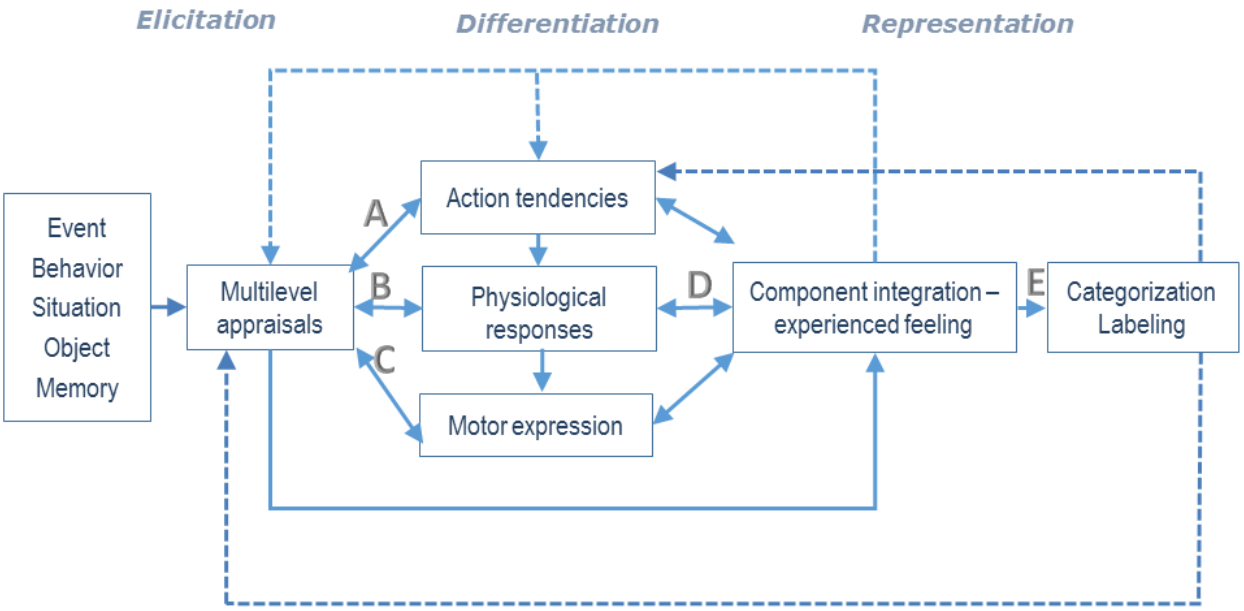
FIGURE CAPTION

Figure 1: The dynamic architecture of a multicomponent emotion process model (adapted from Scherer, 2009). The empirical research concerning Paths A, B, and C is reviewed.

Figure 1


Elicitation
Differentiation
Representation
Event
Behavior
Situation
Object
Memory
Multilevel appraisals
A
B
C
Action tendencies
Physiological responses
Motor expression
D
Component integration – experienced feeling
E
Categorization Labeling

SIDEBAR Model testing in semantic sedimentation

While waiting for the appearance of multicomponent datasets that allow sophisticated model fitting, it is profitable to explore alternative routes to examine the relationships of the components in the emotion process model. One possibility is to exploit the "sedimentation" of real world mechanisms in the semantics of emotion words. Scherer & Fontaine (2018) used a large-scale data set on the semantic profiles of emotion terms in 28 world languages that provide very stable profiles on 142 facets covering all emotion components for 24 major emotion terms. Using principle component analysis, they determined four appraisal factors (valence, novelty, prospective control, and other-agency), five response component factors (approach vs. rejection, assertive vs. submissive, high vs low autonomic arousal, control action tendency, and orientation) and four feeling factors (bad vs. good, strong vs. weak, calm vs. restless, and tired). The factor scores were used to test the process model in Figure 1 with theoretically guided hierarchical regression analyses. Here are two of the significant results: Bad/good feeling is predicted by valence and novelty appraisals, strongly mediated by approach/rejection and assertive/submissive response factors; weak/strong feeling is predicted by valence and other-agency, strongly mediated by assertive/submissive tendencies and strengthened by control action tendencies.

Glossary

Nomothetic vs. ideographic – research aimed at studying or discovering general scientific laws or regularities, valid for large groups of people, *vs*. targeting singular, individual cases or events and understanding their complex nature and causes.

Autonomic nervous system (ANS) **–** the part of the nervous system responsible for control of the bodily functions *not consciously directed*, such as breathing, the heartbeat, and digestive processes

Somatic nervous system (SNS; or voluntary nervous system) -- the part of the peripheral nervous system associated with the *conscious voluntary* control of body movements via skeletal muscles.

Sympathetic nervous system -- *the* part of the *autonomous nervous system* that serves to accelerate the heart rate, constrict blood vessels, and raise blood pressure.

Parasympathetic nervous system -- the part of the *autonomous nervous system* that serves to slow the heart rate, increase intestinal and glandular activity, and relax the sphincter muscles.

Fundamental frequency (f0 or F0) – the lowest *frequency* of a periodic waveform with several harmonics, e.g., the voice, heard as pitch.

Stimulus-response compatibility task – experiment in which stimulus features and response features are compatible (e.g., positive stimulus and positive response) or incompatible (e.g., positive stimulus and negative response).

Acronym list:

ANS -- *Autonomic nervous system*,

SNS -- *Somatic nervous system*

f0 – *undamental frequency of the voice*

AU – Facial muscle action unit