A Functional Perspective on Emotion Elicitation: Some Considerations for the Development of Emotional Architectures

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Abstract

Appraisal theory, a functional approach to understanding emotion elicitation is described. Three distinct classes of appraisal models are reviewed: *structural* – which describe the cognitive contents of appraisal and how those contents map onto the elicitation of various distinct emotions; *procedural* – which describe the cognitive processes underlying appraisal; and *relational* – which describe how both person and situation information is combined in producing specific appraisal outcomes. A theoretical example of each class of model is described, and the state of the empirical literature addressing such models is reviewed. The relevance of the general theoretical approach, and of the three types of appraisal models, to developing architectures for modeling emotion are discussed.

Introduction

In developing architectures for modeling emotion, it is important to work from a solid understanding of the functions served by emotion. Such an understanding would include a consideration of both the overarching, general functions served by emotions in human life, as well as the more specific functions served by particular emotions, such as happiness, sadness, fear, and anger. Thus, the types of issues addressed by such an understanding might range from: "Why is emotion so pervasive in human life?" to "When do we get angry, and why does anger take the specific form that it does?"

This type of understanding should be useful in the development of emotion architectures across a wide variety of applications for the resulting models of emotion. For instance, such an understanding should be useful if one's goals are to use the emotion models to give agents in game or virtual reality environments more life-like "human" emotional reactions, just as it should be useful if the models are to be used to endow an autonomous device with an analog to the human emotion system to be used for purposes of self-regulation, etc.

In an effort to contribute to the development of a richer theoretical understanding of the functions served by emotion, the present contribution highlights a theoretical approach to the psychological study of emotion, appraisal theory, that has developed out of a functional analysis of emotion (e.g., Lazarus, 1991; Scherer, 1984).

The primary focus of this theoretical approach, to date, has been on explaining and modeling the elicitation of emotion. As is described in more detail below, a fundamental assumption of this approach is that emotions are elicited as the result of a meaning analysis in which the significance of an individual's circumstances for personal well-being are assessed. Efforts to develop this theoretical perspective have resulted in two distinct classes of appraisal models.

First, over the past 20 years, a number of *structural* models have been developed to describe the conditions under which various emotions, such as anger versus fear versus sadness, etc., are evoked (e.g., Lazarus, 1991; Roseman, 1984; Scherer, 1984; Smith and Lazarus, 1990) More specifically, these structural models have been developed to describe the *contents* of appraisal. They have been designed to describe both the major issues, or questions, that are evaluated in appraisal, and the specific outcomes, or answers, to these evaluations that are responsible for evoking various particular emotions. Because these models have been under development for some time, a considerable body of research has been directed toward testing these models, and substantial evidence in support of them has accrued (e.g., Frijda, Kuipers, and ter Schere, 1989; Roseman, 1991; Scherer, 1997; Smith and Ellsworth, 1985, 1987, Smith and Lazarus, 1993).

The second class of models are *procedural* ones designed to describe the cognitive processes underlying the emotion-eliciting appraisals. That is, these models describe the cognitive operations by which the appraisals are made. An initial process model was outlined some time ago (Leventhal and Scherer, 1987), but it is only fairly recently that concerted efforts to develop and test such models have been undertaken (e.g., Scherer, 2001; Smith and Kirby, 2000, 2001). Thus, although there is good support for the general plausibility of these models (e.g., Sloman, 1996; Smith and DeCoster, 2000), few data have yet emerged that directly test them.

In the present contribution, I first consider the major functions that have been posited for human emotions, and discuss how, in general, consideration of these functions have contributed to the development of appraisal theory. Then, in turn, I will consider both the structural and procedural appraisal models in more depth. For both classes of models, I will focus on a specific appraisal model (Smith and Lazarus, 1990 for the structural models; Smith and Kirby, 2000 for the procedural ones) to illustrate how the development of both types of models have been shaped by a careful consideration of the functions served by emotions – both the functions served by emotion in general, and the more specific functions served by individual emotions. To conclude the paper, I will discuss the need to develop a third class of appraisal models in order for appraisal theory to be able to more effectively inform the development of emotion architectures, and will briefly consider how the various types of appraisal models might inform the development of such architectures.

On the Functions Served by Emotion

In line with many contemporary approaches to emotion, a fundamental assumption underlying appraisal theory (e.g., Smith and Lazarus 1990) is that emotions are highly organized and coherent responses that serve basic adaptational functions. Two of the general functions that have been commonly proposed for emotion are self-regulation and social communication.

On this view, emotions are complex, information-rich signals that are evoked in response to adaptationally relevant situations representing various types of actual or potential harms or benefits. With regard to self-regulation, emotions serve several interrelated sub-functions. First, building on Simon's (1966) seminal analysis of emotion as an "interrupt" mechanism, emotion is hypothesized to play an important role in attention regulation (e.g., Frijda and Swagerman, 1987; Smith and Kirby, 2000). Specifically, the subjective experience of an emotion serves to alert the person that he or she is in an adaptationally relevant situation that may require his or her attention. However, emotion does not serve as a simple, unidimensoinal alert merely indicating the presence of some unspecified adaptationally relevant circumstances. Instead, each distinct emotion is hypothesized to be a response to a particular, distinct type of harm or benefit, and to be characterized by its own distincitive subjective feeling state. Thus, the identity of the emotion being experienced carries considerable information regarding the adaptational nature of the circumstances in which it was elicited. In addition, each emotion is hypothesized to be associated with a distinct action tendency that motivates the person to respond to the situation in a certain way. Moreover, the emotion is hypothesized to be further characterized by a particular pattern of physiological activity that, in part, serves to physically prepare the person to respond behaviorally to the adaptational implications of the circumstances, in line with the motivational urges reflected in the action tendencies (Scherer, 1984; Frijda, 1986; Smith and Lazarus, 1990). Thus the emotion is viewed as an information-rich signal that alerts, motivates, and physically prepares the individual to respond to the adaptational implications of his or her circumstances.

The second major function served by emotion is social communication. Through their facial, postural, vocal, and otherwise observable expression, emotions communicate important information to others in the social environment regarding a person's psychological state and likely behaviors. Further, by communicating how the person is perceiving the adaptational implications of a situation, these expressions can also serve as an indication that the situation might have similar implications for the observer. For instance, observing the expression of fear in another can often serve to alert observers that they, too, are in danger.

Both of these general functions depend heavily on the fact that the emotional responses are information-rich, and indicate much about their eliciting conditions (that is, about the particular type of harm or benefit confronting the individual). As responses to particular types of harm or benefit, emotions necessarily are highly context sensitive. An important theoretical puzzle for the student of emotion concerns how emotions achieve this context sensitivity.

Appraisal theory provides one solution to this puzzle. According to the theory, emotions are responses to the results of a meaning analysis in which the implications of one's circumstances for personal well-being are evaluated. Each distinct emotion is a response to a distinct evaluation representing a particular type of harm or benefit. The various components of the emotional response are hypothesized to be organized around the adaptational implications of these evaluations, or appraisals (e.g., Lazarus 1968; Smith and Lazarus, 1990). Thus, the facial expression is hypothesized to reflect, in part, how the person is appraising the situation; the subjective feeling state motivates a response in some way appropriate to the appraised harm or benefit; and the physiological arousal physically prepares the person to enact that response.

Thus, according to appraisal theory an important key to understanding the nature of various emotions and the functions they serve is to understand the nature of the meaning analysis that elicits them. As indicated above, to date, progress in the development and testing of appraisal theory has resulted in the advancement of two general classes of models: structural and procedural. Below I consider both types of models in turn.

Structural Models

Several models have been proposed to describe the contents of appraisal (e.g., Roseman 1984; 1991; Scherer 1984; Smith and Ellsworth 1985; Smith and Lazarus 1990). Typically, these models attempt to describe both the issues, or questions, that are evaluated in appraisal (typically referred to as appraisal dimensions, or appraisal components), and how the answers to these questions

differentiate among various emotions. Although the specific structural appraisal models proposed by various theorists (e.g., Lazarus, 1991; Roseman 1984; Scherer 1984; Smith and Ellsworth 1985; Smith and Lazarus 1990) differ in a number of important respects (e.g., in some of the specific appraisal dimensions proposed to differentiate emotional experience; see Scherer 1988 for an in-depth comparison of several of these models), far more telling is the fact that, overall, they are highly similar in the appraisal dimensions they propose and in the ways that outcomes along these dimensions are hypothesized to differentiate emotional experience.

Thus, in one form or another, the existing appraisal models generally include some sort of evaluation of how important or relevant the stimulus situation is to the person, whether it is desirable or undesirable, whether and to what degree the person is able to cope with the situation, and who or what caused or is responsible for the situation (and thus toward what or whom one's coping efforts should be directed). Different patterns of outcomes along such dimensions are hypothesized to result in the experience of different emotions. Moreover, the specific pattern of appraisal hypothesized to result in the experience of a given emotion is conceptually closely linked to the functions proposed to be served by that emotion. The model of Smith and Lazarus (1990), can be used to illustrate how these models are organized.

Appraisal and the Differentiation of Emotion

According to the Smith and Lazarus (1990) model, situations are evaluated along seven dimensions: motivational relevance, motivational congruence, problem-focused coping potential, emotion-focused coping potential, self-accountability, other-accountability and future expectancy. Motivational relevance involves an evaluation of how important the situation is to the person. Motivational congruence is an appraisal of the extent to which the situation is in line with current goals – circumstances viewed as consistent with ones goals will be appraised as highly congruent, or desirable, whereas those viewed as inconsistent will be appraised as incongruent, or undesirable. Problem-focused coping potential is an assessment of the individual's ability to act on the situation to increase or maintain its desirability. Emotion-focused coping potential evaluates the ability to psychologically adjust to and deal with the situation should it not turn out as desired. Self-accountability is an assessment of the degree to which an individual sees her/himself as responsible for the situation, whereas other-accountability is the extent to which the individual views someone or something else as responsible. Finally, future expectancy involves an evaluation of the degree to which, for any reason, the person expects the circumstances to become more or less desirable. According to the model, different patterns of outcomes along these dimensions (having different adaptational implications) result in the experience

Table 1. Functional Analysis of Some Illustrative Emotions

Emotion	Proposed Adaptive Function	Important Appraisal Components
Anger	Remove source of harm from environment And undo harm	1) Motivationally Relevant 2) Motivationally Incongruent 3) Other Accountability
Guilt	Make reparation for harm to others/ Motivation socially responsible behavior	1) Motivationally Relevant 2) Motivationally Incongruent 3) Self-Accountability
Fear/Anxiety	Avoid Potential Harm	1) Motivationally Relevant 2) Motivationally Incongruent 3) Low Emotion-Focused Coping Potential
Sadness	Get help and support in the face of Harm/Disengage from a lost commitment	1) Motivationally Relevant 2) Motivational Incongruent 3) Low Problem-Focused Coping Potential 4) Low Future Expectancy
Challenge/Determination	Motivate mastery and gain	1) Motivationally Relevant 2) Motivationally Incongruent 3) High Problem-Focused Coping Potential 4) High Future Expectancy

of different emotions (serving different adaptational functions; see Table 1). Thus, these appraisal dimensions are held to be responsible for the differentiation of emotional experience.

The first two dimensions, motivational relevance and motivational congruence, are relevant to every emotional encounter, and thus are sometimes referred to as dimensions of "primary appraisal" (e.g., Lazarus 1991; Smith and Lazarus, 1990). By themselves they can distinguish between situations that are irrelevant to well-being (low motivational relevance), and thus are not emotionally evocative, and those that are either beneficial (or "positive;" high motivational relevance and motivational congruence) or stressful (or "egative;" high motivational relevance and motivational incongruence). In general, as motivational relevance, or subjective importance, increases the intensity of the resulting emotional response, be it beneficial or stressful, should increase as well.

However, the two dimensions of primary appraisal, taken by themselves, are insufficient to differentiate between distinct emotional states. Instead, this differentiation is accomplished through the additional appraisal dimensions concerning accountability and coping potential (often referred to as dimensions of "secondary appraisal" in the terminology of Lazarus [1991] and colleagues). Especially in the case of stressful situations (i.e., those appraised as both motivationally relevant and motivationally incongruent), the dimensions of secondary appraisal allow for considerable differentiation of the emotional response to circumstances that can vary greatly in terms of their specific adaptational implications (Table 1, see also Smith and Lazarus 1990).

Thus, if a stressful situation is appraised as being brought about by someone else (other-accountability) anger will result, which motivates the person to act toward the perceived cause to get that agent to stop what he or she is doing, and, perhaps, to fix the situation. If, however, the situation is appraised as being caused by oneself (self-accountability), shame or guilt results, which motivates the person to make amends for the bad situation and to prevent the situation from happening again. If the situation is one that the person is unsure he or she can handle (low emotion-focused coping potential), then fear or anxiety results, which motivates the person to be cautious and to get rid of and avoid the potential harm, if at all possible. If the stressful situation is one in which the harm is perceived as unavoidable and irreparable (low problem-focused coping potential), then sadness results, which motivates the person to seek help and to adapt to the inevitable harm.

Finally, the emotional states associated with primary appraisals of stress are not always unpleasant or negative. In a stressful situation where an individual does not have something desired, but perceives that with effort the goal can be achieved (high coping potential), then a state of challenge will result that motivates the person to stay engaged and to persevere to achieve his or her goals. Even if problem-focused coping potential is low, hope might result if the person believes that, somehow, things might work out in the end (high future expectancy). In sum, different components of secondary appraisal combine with the same stress-related components of primary appraisal to yield a range of distinct emotional reactions that differ dramatically in their subjective and motivational properties in a way that reflects the adaptational implications of the appraised circumstances.

Empirical Evidence in Support of the Structural Models

Over the 20 years that have elapsed since structural models of appraisal began to appear prominently in the literature, a large body of research designed to test these models has developed. In particular, many studies have now asked participants to report on both their appraisals and a wide array of emotions across a variety of contexts, including diverse retrospectively remembered experiences (Frijda et al. 1989; Scherer 1997; Smith and Ellsworth 1985), and hypothetical vignettes (e.g., Roseman 1991; Smith and Lazarus 1993). In general, the results of these studies have been highly supportive of the appraisal approach. In each of these studies, not only have the experiences of different emotions been consistently found to be reliably and systematically associated with different appraisals, but also the specific relations observed between the appraisals and the emotions have largely been in line with the models being investigated.

It should be noted that this evidence has been critiqued due to the heavy reliance in these studies of studying appraisals and emotions in the context of hypothetical and remembered experiences. As noted by Parkinson (1997; Parkinson and Manstead, 1992), these methodlogical properties place important limits on the conclusions regarding appraisal theory that can be drawn based on this evidence. First, the memory based studies are necessarily cross-sectional, and thus preclude strong causal conclusions regarding how the appraisals and emotions are related. Second, both the memory-based and vignette studies are open to the possibility that respondents base their reports of appraisal and emotion on their implicit theories of emotion rather than on actual emotional experiences, and thus these studies may be documenting lay theories of emotion, rather than actual properties of emotional experience.

However, there have been efforts to address these concerns, and a number of studies have examined appraisal-emotion relations in the context of meaningful experiences (e.g., Griner and Smith 2000; Roseman and Evdokas, 2004; Smith and Ellsworth 1987; Smith and Kirby 2001), and in several of these studies, efforts have been made to manipulate the appraisals to be examined either quasi-experimentally (Griner and Smith, 2000; Smith and Kirby, 2001) or experimentally (Roseman and Evdokas, 2004). In each case, these methodologically stronger studies have also been highly supportive of the structural appraisal models being examined.

A Process Model

Need for a Process Model

Although the structural appraisal models described above have been quite successful in describing cognitive antecedents of emotion, taken by themselves they potentially create a problem for appraisal theory. By emphasizing that complex relational information is somehow drawn upon in appraisal, this work could give the impression that appraisal is ponderous and slow. And in fact, appraisal theory has often been criticized on these grounds. Observers of appraisal theory have tended to interpret the structural descriptions of appraisal as implying that the process of appraisal is deliberate, slow, verbally mediated, and importantly, to require considerable focal attention. They then correctly note that such a process would fly directly in the face of common observations that emotions can be elicited very quickly, unbidden, often with a minimum of cognitive effort, and sometimes with little or no awareness of the nature of the emotion-eliciting stimulus (e.g., Izard 1993; Zajonc 1980).

Moreover, if emotion elicitation were to be dependent upon such a deliberate, slow, attention-demanding process, this would greatly impede the functional role emotion has been proposed to play in attention regulation (e,g., Frijda and Swagerman 1987; Simon 1966). As discussed above, the emotional reaction is hypothesized to serve, in part, as a signal (or an "alarm") that calls the person's attention to potentially adaptationally relevant circumstances. If emotion is to serve such an alerting function, then the mechanism by which it is evoked can not solely be dependent on a process that requires focal awareness. This is because, if it were, then the emotional response could serve to call attention to only things to which the person was already attending!

Instead, an elicitation mechanism is required that is more diffuse in its attentional requirements, and that can occur continuously and automatically. At the same time, however, the eliciting mechanism must be such that it allows the emotional reaction to be both highly context-sensitive and information-rich, as both the social communicative and self-regulatory functions served by emotion would seem to require.

Appraisal theorists have been aware of these difficulties, and to our knowledge, none has claimed that appraisal need be performed consciously or that the information evaluated in appraisal need be represented verbally. To the contrary, most appraisal theorists have explicitly maintained that appraisal can occur automatically and outside of focal awareness (e.g., Arnold 1960; Lazarus 1968; Leventhal and Scherer 1987; Smith and Lazarus 1990). Only relatively recently, however, have there been attempts to develop explicit process models that would explain how appraisals can occur in this manner (e.g. Lazarus 1991, ch. 4; Leventhal and Scherer 1987; Smith and Kirby 2000). These models are still in their infancy, and there are very few data to address their validity. Nonetheless, we provide a brief overview of one such model (that of Smith and Kirby 2000) here because it illustrates how appraisal might occur continuously and automatically while allowing information-rich, context sensitive emotional reactions to be elicited quickly.

Sketch of a Process Model

Drawing upon the current understanding of cognitive processing, instead of conceptualizing appraisal as a single unitary process, this model posits multiple appraisal processes that can occur in parallel, and that involve distinct cognitive mechanisms. In particular, two distinct modes of cognitive processing have been emphasized -- *associative processing*, which involves priming and activation of memories and can occur quickly and automatically, and *deliberative processing*, or *reasoning*, which involves a more controlled thinking process that is more flexible than associative processing, but is relatively slow and attention intensive. The distinction between these modes of processing reflects a distinction between different types of cognitive processes that is quite common in the cognitive psychological literature (cf., Sloman 1996; Smith and DeCoster, 2000). According to the model, appraisals produced by both of these types of cognitive processes can elicit emotions. Therefore it is instructive to consider their respective properties.

Associative processing is a fast, automatic, memory-based mode of processing that involves priming and spreading activation (Bargh 1989; Bower 1981). Based on perceptual or conceptual similarities with one's current circumstances, or due to associations with other memories that are already activated, memories of prior experiences can become activated quickly, automatically, in parallel, outside of focal awareness, and using a minimum of attentional resources. As these memories are activated, any appraisal meanings associated with them are also activated, and when these meanings are activated to a sufficient degree, they can influence the person's emotional state.

Several assumptions concerning associative processing should be emphasized. First, it is assumed that anything that can be represented in memory, ranging from concrete representations of physical sensations, sounds, smells, tastes, and images up to representations of highly abstract concepts, is subject to this form of processing. That is, cues that can activate appraisal-laden memories include not only concrete stimuli, such as sensations, images, and sounds, but also highly conceptual stimuli, such as abstract ideas or the appraisal meanings themselves. Second, it is assumed that through processes of priming and spreading activation, full-blown appraisals associated with prior experiences can be activated very quickly and automatically. Thus, highly differentiated emotional reactions can be elicited almost instantaneously. Third, it is assumed that the activation threshold at which appraisal information starts to produce emotional feelings is somewhat less than the threshold at which the appraisal

information and its associated memories become accessible to focal awareness and/or working memory. Through this assumption it becomes possible that adaptationally relevant circumstances in one's environment, of which one is focally unaware, can activate memories and produce an emotional reaction. In this way the first conscious indication to the person that he or she might be in an adaptationally relevant situation can be the perception of the subjective feeling state associated with the associatively-elicited emotional reaction. Finally, we assume that the processes of memory activation, priming, and spreading activation occur continuously and automatically. Thus, the person can be characterized as continuously appraising his or her circumstances for their implications for well-being, albeit not in a conscious, attention-intensive manner.

In contrast, deliberative processing, or reasoning, is a relatively slow, controlled process that is effortful, requires considerable attention and focal awareness, and is largely verbally mediated. Moreover, whereas associative processing is a largely passive process, deliberative processing is a much more constructive one, whereby the contents of focal awareness are actively operated on and transformed to produce the appraisal meanings. Thus, deliberative processing corresponds closely to the active posing and evaluating of appraisal questions that has sometimes been incorrectly assumed to encompass all of appraisal.

Because deliberative processing is active and highly resource intensive, it comes at a price. In addition to being relatively slow, this mode of processing is somewhat limited in the forms of information that it can access. In contrast to associative processing, which can operate on any form of information stored in memory, only information that has been semantically encoded in some way is thought to be readily accessible to deliberative processing (Anderson 1983; Paivio 1971). That is, sensations, images, sounds, etc. are relatively inaccessible to deliberative processing unless and until they have been associated with some sort of semantic meaning. By implication, this means that while associative processing has access to all of the information to which deliberative processing has access, the reverse is not true.

Despite these limitations, deliberative processing is extremely important in that it enables the emotion system to utilize the full power of our highly developed and abstract thinking processes. Emotion-eliciting situations can be thoroughly analyzed and their meanings reappraised (Lazarus 1968, 1991). Thus, initial associatively-elicited appraisals that might not fully fit the current circumstances can be modified to provide a more appropriate evaluation and emotional response. New connections can be forged between one's present circumstances and potentially related previous experiences. It is even possible that appraisal meanings associated with previous experiences in memory can be reevaluated and changed. In addition, the "cognitive work" represented by reasoning -- the results of the interpretation and reinterpretation of the emotion-eliciting situation -- can be, and often are, stored in memory as part of the emotion-eliciting event, and thus become available for subsequent associative processing. This last fact is vital, in that it provides a mechanism by which the emotion system can "learn," and through associative processing, can quickly and automatically produce the highly differentiated, information rich signals that the motivational functions served by emotion seem to require.

Both levels of processing are hypothesized to work in concert, and to contribute systematically to the shaping and functioning of emotional experience. However, reflecting their differential properties, the respective roles served by these two levels of processing are somewhat different. Because it operates continuously, automatically, and outside of awareness, associative processing is hypothesized to play a dominant role in emotion elicitation. It is this mode of processing that allows emotion to serve its attention-regulatory function, and thus allows the person to detect, annd to begin to react to circumstances, outside of focal awareness, that have potentially important adaptational implications.

Once the emotion is elicted, however, and its associated subjective feeling state has alerted the individual to the potential adaptational implications of his or her circumstances, then reasoning may become dominant in shaping the emotional response. Through deliberate reappraisal, the person can fine-tune his or her appreciation of the emotion-eliciting circumstances, and thus his or her emotional state can be fine-tuned accordingly. As noted above, this fine-tuning can influence the appraisal meanings that are associated in memory with the person's circumstances, and thus the emotion system can be educated, such that future reactions to similar situations can become more adaptationally appropriate. In addition, reasoning-based reappraisals, because they have been made deliberately, are more likely than associatively generated appraisals to be consciously accessible. Therefore, these reasoning-based appraisals may be especially influential in influencing the behaviors the person chooses to enact in response to the felt action tendencies associated with the emotional response.

The Need for a Third Class of Appraisal Model

A combined consideration of both structural and procedural models of appraisal provides a rich and fairly detailed view of emotion elicitation that should be very useful in the development of emotion architectures. However, even a cursory consideration of the information such an architecture would likely need to be able to function in any sort of complex environment suggests at least one important gap not covered by these models. Although the models specify the appraisal outcomes that elicit various emotions, and they describe the cognitive processes underlying such appraisals, they do not specify the information that is drawn upon in making the

appraisals. In the absence of knowing about, and somehow modeling, this information, it is not readily evident how one would predict the way a given individual would appraise, and thus respond emotionally, to a given set of circumstances. Therefore, an additional class of models is needed that will provide this type of information.

The issues to be addressed by such models are more complex than may first appear to be the case. Careful consideration of the issues evaluated in appraisal (as represented by the appraisal components of the structural models described above) indicates that these evaluations are not products of either the person or the stimulus situation considered by themselves. Instead, these appraisals are *relational*, in that they involve an evaluation of aspects of the stimulus situation *in relation to* properties of the person.

For instance, the appraisal of motivational relevance -- of how important a situation is to the person -- is not a pure function of either the person or the situation. Instead it is an evaluation of what is at stake in the situation *in relation to* the person's needs, goals, and values. So, too, the appraisal of motivational congruence -- of the desirability of the situation – also represents an evaluation of the situation *in relation to* the person's goals. More specifically, it is an evaluation of whether, and to what degree, the situation is consistent or inconsistent with those goals. Similarly the appraisal of coping potential – of the ability of the person to contend with the demands of the situation -- is an evaluation of the task demands presented by the situation *in relation to* one's abilities. And so on.

Therefore, in order to be able to predict how a particular individual will appraise, and thus respond emotionally, to a particular set of circumstances, the structural and procedural models considered above need to be supplemented by a third class of *relational* models that specify the aspects of both the individual and the situation that are combined by the various appraisal components in determining the adaptational significance of the situation.

The relational nature of appraisal has been recognized and discussed over the course of the development of appraisal theory (e.g., Lazarus, 1966, 1968, 1991; Lazarus and Folkman, 1984; Smith and Lazarus, 1990). In fact, Lazarus consistently emphasized the relational nature of appraisal as one of its most theoretically important properties. However, relative to the structural appraisal models, and even to the procedureal ones, little effort has been devoted to the development and testing of relational appraisal models. Nonetheless, there have been a few attempts to develop and test such models (e.g., Griner and Smith, 2000; Smith and Kirby, 2001; Smith and Pope, 1992), and these attempts have been quite supportive of the promise of this approach.

For instance, Smith and Pope (1992) used a functional analysis to generate some specific hypotheses regarding the relational antecedents of appraisals of both motivational relevance (importance), and problem-focused coping potential. For motivational relevance they hypothesized that the perceived relevance of a situation would be a joint function of a person's concerns and the degree to which a situation was relevant to those concerns. They proposed that appraised motivational relevance would only be high to the extent to which a person cared about a given concern and the situation was perceived as relevant to that concern. To generate more specific, testable hypotheses from this analysis, they noted that individuals vary in the degree to which they are committed to, or motivated by, affiliative concerns, and in the degree to which they are committed to, or motivated by, achievement concerns. They reasoned that when confronted with an achievement relevant situation, individuals high in achievement motivation would respond with higher appraisals of motivational relevance, and stronger emotion, than would individuals lower in achievement motivation. Conversely, for affiliative situations, individuals higher in affiliative motivation should respond with higher appraisals of motivational relevance and stronger emotion.

Using remembered experiences and hypothetical vignettes, Smith and Pope (1992) confirmed these hypotheses for achievement-relevant situations, but not for affiliative ones. Instead, motivational relevance was appraised as high by all participants across the particular affiliative situations examined. In a subsequent study (Griner & Smith, 2000), involving a quasi-experimental interpersonal interaction (a teaching task), while anticipating the start of the task, individuals selected to be relatively high on affiliative motivation reported that they viewed the upcoming task as having more affiliative relevance, and in line with this they reported their appraisals of motivational relevance, and their feelings of interest as being stronger than did individuals selected to be relatively low in affiliative motivation. In combination, these studies provide considerable, if somewhat preliminary, support to Smith and Pope's (1992) reasoning about the antecedents of appraisals of motivational relevance.

In a parallel fashion, Smith and Pope (1992) proposed that appraisals of problem-focused coping potential were a joint function of both the demands of the task confronting the individual and the individual's perceived abilities relevant to those demands. Thus, all else being equal individuals more confident of their abilities should appraise their coping potential as higher, and respond with higher levels of challenge, and lower levels of resignation than should less confident individuals. Smith and Pope (1992) reported on a pilot study in which individuals selected to be either more or less confident of their mathematical abilities reported on their appraisal and emotions while working on a difficult math task. As predicted, higher levels of perceived math ability were associated with higher levels of appraised problem-focused coping potential, higher levels of felt challenge, and lower levels of resignation. These initial findings were replicated and extended in a subsequent, more elaborate study, as reported by Smith & Kirby, 2001).

Although promising, these initial developments only scratch the surface of what needs to be done in developing

relational models of appraisal. For the two appraisal components examined, specific hypotheses have been generated and tested for only a couple of what are undoubtedly many relevant domains. For the other appraisal components even preliminary models of their situational and personal antecedents have yet to be advanced. Nonetheless, the continued development of models of the relational antecedents of appraisal will endow appraisal theory with a predictive power that it presently lacks. As relational models come to explicate how particular aspects of the situation are combined with particular aspects of the person to produce specific appraisal outcomes, then there will be an increase in the ability of appraisal theory to predict how a given individual will react emotionally to a particular set of circumstances.

Such predictive ability will be very valuable in the development of emotion architectures. For instance, the predictive power of relational models of appraisal could be used to give an agent the ability to extract the most relevant information from its current circumstances, combine this information with a consideration of its own needs, goals, and abilities to assess the adaptational implications of the environment, and thus to spontaneously react to the environment with realistic emotions.

Final Thoughts on the Relevance of Appraisal Models to the Development of Emotion Architectures

At the outset of this contribution, I (non-exhaustively) listed two potential applications for which appraisal theory might be relevant for developing emotion architectures – with endowing human agents in artificial environments with the capacity to respond to those environments with realistic emotional reactions, and with endowing autonomous agents with a self-regulatory system analogous to the human emotion system. I would like to conclude this contribution with a brief consideration of the relevance of appraisal theory, as represented by the structural, procedural, and relational models discussed above, for both of these potential applications.

The relevance of these models to the first application should be relatively straightforward. If the goal of the modeling endeavor is to give artificial human agents realistic human emotions, then the knowledge represented by the appraisal models should be directly applicable. This need not be the case, however, when the goal is to provide an autonomous device with an emotion-like self-regulatory system, without the goal of making the device human-like.

According to appraisal theory, in line with many contemporary approaches to emotion, human emotions have evolved in the context of human ecology. Thus, human emotions represent reactions to the major types of adaptational contexts (i.e., types of actual and potential harms and benefits) that are especially important to humans. Although there are clear similarities in the emotional repertoires of other species and that of humans, there are also clear differences. For instance, the range and subtlety of human emotion appears to be quite a bit more extensive than that of other species. In part, this may attributable to the more developed and sophisticated cognitive abilities of humans, which make them able to apprehend more subtle variations than can other species in the adaptational relevance of their circumstances. However, these differences also almost certainly reflect differences in the types of contexts that are adaptationally relevant to different species due to differences in their ecologies (cf. Plutchik, 1970, 1980).

In line with this reasoning, in attempting to endow a non-human autonomous device with an emotion-like self-regulatory system it would unlikely be optimal to simply port in the equivalent of the human emotion system. Instead, it would be more advantageous to design a system that is responsive to the ecology of the specific device, including the nature of the tasks it was designed to accomplish, as well as the major ways that the device could succeed or fail at accomplishing these tasks.

Although it is rather unlikely that the specific details of the appraisal models described above would be especially useful in such an endeavor, it is very likely that a careful consideration of both the formal structures of these models, as well as of the functional analysis that went into developing these models, would be. That is, one might begin with an analysis of the major types of harm and benefit (i.e., of success and failure) that might confront the device. Then paralleling the issues covered by the structural and relational appraisal, an analysis could be done to identify the information that would need to be monitored concerning both the states of the device and of its environment in order to detect when the device was facing one of its adaptationally relevant contexts, etc. In any event, careful consideration of the three classes of appraisal models reviewed here can provide an understanding of human emotion elicitation that should prove invaluable in the development of architectures for modeling emotion.

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