Studying the Emotion-Antecedent Appraisal Process: An Expert System Approach

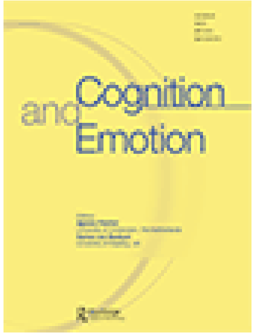
Scherer, Klaus R.

How to cite

SCHERER, Klaus R. Studying the Emotion-Antecedent Appraisal Process: An Expert System Approach. In: Cognition and Emotion, 1993, vol. 7, n° 3/4, p. 325–355. doi: 10.1080/02699939308409192

This publication URL: https://archive-ouverte.unige.ch//unige:102025

Publication DOI: 10.1080/02699939308409192



Cognition and Emotion

ISSN: 0269-9931 (Print) 1464-0600 (Online) Journal homepage: http://www.tandfonline.com/loi/pcem20

Studying the emotion-antecedent appraisal process: An expert system approach

Klaus R. Scherer

To cite this article: Klaus R. Scherer (1993) Studying the emotion-antecedent appraisal process: An expert system approach, Cognition and Emotion, 7:3-4, 325-355, DOI: 10.1080/02699939308409192

To link to this article: https://doi.org/10.1080/02699939308409192

Published online: 07 Jan 2008.

COGNITION AND EMOTION, 1993, 7 (3/4), 325–355

Studying the Emotion-Antecedent Appraisal Process: An Expert System Approach

Klaus R. Scherer
University of Geneva, Switzerland

The surprising convergence between independently developed appraisal theories of emotion elicitation and differentiation is briefly reviewed. It is argued that three problems are responsible for the lack of more widespread acceptance of such theories: (1) the criticism of excessive cognitivism raised by psychologists working on affective phenomena; (2) the lack of process orientation in linking appraisal to the complex unfolding of emotion episodes over time; and (3) the lack of consensus on the number and types of appraisal criteria between theorists in this domain. Although readers are referred to recent theoretical discussions and evidence from the neurosciences with respect to the first two issues, an empirical study using computerised experimentation is reported with respect to the third issue. Data obtained with an expert system based on Scherer's (1984a) "stimulus evaluation check" predictions show the feasibility of this approach in determining the number and types of appraisal criteria needed to explain emotion differentiation. It is suggested to use computer modelling and experimentation as a powerful tool to further theoretical development and collect pertinent data on the emotion-antecedent appraisal process.

INTRODUCTION

The notion that emotions are elicited and differentiated via appraisal of situations or events as centrally important to a person has a venerable history. The idea can be traced from the writings of early philosophers such as Aristotle, Descartes, and Spinoza to theoretical suggestions by pioneering emotion psychologists such as Stumpf (see Reisenzein & Schönpflug, 1992). In the 1960s, Arnold (1960) and Lazarus (1968) had

---

Requests for reprints should be sent to Klaus R. Scherer, Department of Psychology, University of Geneva, 9, Rte de Drize, Carouge, CH-1227 Geneva, Switzerland.

This paper was specifically prepared for the special issue of *Cognition and Emotion* on Appraisal and Beyond. The author gratefully acknowledges important contributions and suggestions by George Chwelos, Nico Frijda, Keith Oatley, Ursula Scherer, and two anonymous reviewers.

explicitly formulated theories incorporating rudimentary appraisal criteria in an effort to explain the emotional consequences of being faced with a particular event. At the beginning of the 1980s a number of psychologists independently proposed detailed and comprehensive sets of appraisal criteria to explain the elicitation and differentiation of the emotions (De Rivera, 1977; Frijda, 1986; Johnson-Laird & Oatley, 1989; Mees, 1985; Ortony, Clore, & Collins, 1988; Roseman, 1984, 1991; Scherer, 1981, 1982, 1983, 1984a,b, 1986; Smith & Ellsworth, 1985, 1987; Solomon, 1976; Weiner, 1982) and engaged in empirical research to demonstrate the validity of these hypothetical suggestions (Ellsworth & Smith, 1988; Frijda, 1987; Frijda, Kuipers, & ter Schure, 1989; Gehm & Scherer, 1988; Manstead & Tetlock, 1989; Reisenzein & Hofmann, 1990; Roseman, 1984, 1991; Roseman, Spindel, & Jose, 1990; Smith & Ellsworth, 1985, 1987; Tesser, 1990; Weiner, 1986). In a comparative review of such "appraisal theories of emotion differentiation" Scherer (1988) attempted to show the extraordinary degree of convergence of the different theoretical suggestions, especially with respect to the central criteria postulated in the different approaches (see Table 1, reproduced from Scherer, 1988). This convergence is all the more surprising since the theorists concerned come from widely different traditions in psychology and philosophy. The impression that appraisal theories of emotion differentiation have generated a highly cumulative body of research has been confirmed in more recent reviews as well as in some comparative empirical studies (Lazarus & Smith, 1988; Manstead & Tetlock, 1989; Reisenzein & Hofmann, 1990; Roseman, et al. 1990; Scherer, 1988).

It seems reasonable to take such theoretical and empirical convergence as an indication of the plausibility and validity of appraisal theories, particularly in the light of the absence of rival theories that could reasonably claim to explain emotion differentiation by alternative conceptual frameworks. Yet, appraisal theories currently face three major challenges which seem to prevent more widespread acceptance of this explanatory framework: (1) the reproach of excessive cognitivism; (2) the lack of process orientation; and (3) the lack of consensus on the number and types of appraisal criteria.

1. The Reproach of Excessive Cognitivism

Appraisal theorists are often accused of excessive cognitivism by psychologists dealing with a wide variety of different affective phenomena. Critics question the likelihood that elaborate cognitive evaluations are performed during the few milliseconds that seem sufficient to bring about an emotion episode. It is further suggested that affective arousal can be triggered without any evaluative processing at all (Zajonc, 1980). The "cognition-emotion controversy" (Lazarus, 1984a,b; LeDoux, 1987, 1989; Leventhal

TABLE 1
Convergence of Sets of Appraisal Criteria as Suggested by Different Appraisal Theorists

Scherer	*Frijda*	*Ortony/Clore*	*Roseman*	*Smith/Ellsworth*	*Solomon*	*Weiner*
Novelty	Change			Attention		
Suddenness						
Familiarity	Familiarity					
Predictability		Unexpectedness				
Intrinsic pleasantness	Valence	Appealingness		Pleasantness		
Goal significance						
Concern relevance	Focality		App/Ave Motives		Scope/Focus	
Outcome probability	Certainty	Likelihood	Probability	Certainty		
Expectation	Presence	Prospect realisation				
Conduciveness	Open/Closed	Desirability	Motive consistency	Goal/Path obstacle	Evaluation	
Urgency	Urgency	Proximity		Anticipated effort		
Coping potential						
Cause: Agent	Intent/Self-Other	Agency	Agency	Agency	Responsibility	Locus of causality
Cause: Motive				Agency		Stability
Control	Modifiability					Controllability
Power	Controllability		Power		Power	Controllability
Adjustment						
Compatibility standards		Blameworthiness				
External	Value relevance			Legitimacy		
Internal						

App, Approach; Ave, avoidance. Reproduced from Scherer (1988, p. 92).

& Scherer, 1987; Zajonc, 1980, 1984; Zajonc & Markus, 1984) is centrally concerned with this issue. The crux of the matter, however, is the definition of *cognition*, a term which has not gained in precision by becoming increasingly fashionable. Although the formulations used by some theorists may suggest that appraisal is viewed as a conscious, and consequently exclusively cortically based process, other theorists in this tradition have insisted early on that the cognitivistic connotations of the terms "appraisal" or "evaluation" do *not* preclude that a substantial part of these processes occur in an unconscious fashion, mediated via subcortical, e.g. limbic system, structures (Scherer, 1984a,b). Leventhal and Scherer (1987) have pointed out that evaluation can occur at the sensorimotor, schematic, or conceptual levels, respectively, and that, rather than discussing the cognition issue on an abstract level, one should determine the precise nature of the information-processing involved.

LeDoux (1989), from a neuropsychological point of view, has likewise advocated to address the issue of the nature of emotion-antecedent information-processing and its underlying neural pathways rather than getting sidetracked by the issue of the definition of cognition: "The process involved in stimulus evaluation could, if one chose, be called cognitive processes. The meaning of the stimulus is not given in physical characteristics of the stimulus but instead is determined by computations performed by the brain. As computation is the benchmark of the cognitive, the computation of affective significance could be considered a cognitive process" (LeDoux, 1989, p. 271). LeDoux and his coworkers have in fact empirically demonstrated the existence of subcortical stimulus evaluation patterns for affect eliciting situations in rats (LeDoux, 1987, 1989; LeDoux, Farb, & Rugiero, 1990).

The empirical demonstration of such patterns in humans is hardly to be expected at present because most current research on emotion-antecedent appraisal in human subjects uses self-report of emotional experiences (necessarily involving higher centres of the brain). Subjects are generally asked to recall or infer the nature of their event or situation appraisal, often with the help of rating scales constructed on the basis of the theoretically assumed appraisal dimensions. Clearly, verbally reported appraisal patterns are mediated via conscious, almost exclusively cortically controlled information-processing, and are thus easy targets for charges of excessive cognitivism. They are also subject to the criticism that such recall or inference illustrates social representations of emotions rather than reflecting the actual emotion-eliciting process.

Given the difficulty of settling these issues empirically, Scherer (1993) has suggested to look toward potential contributions from the neurosciences to better understand the nature of the appraisal process. The author denotes a number of possibilities of empirically studying controversial questions related to the appraisal notion with the help of modern neuroscience technology, such as electroencephalographic signal analysis and imaging techniques, and adopting neuropsychologically oriented experimental designs as well as case studies of neurologically impaired patients. Such procedures might help to overcome one of the most serious limitations of current empirical research on emotion-antecedent appraisal: The reliance on respondents' verbal reports of recalled or inferred situation evaluations.

2. The Lack of Process Orientation

The second problem mentioned earlier, lack of a process orientation in many appraisal theories, is responsible for the frequently encountered opinion that appraisal theories basically provide a semantic grid for the comprehension of the use of emotion terms or labels, and are thus limited to structural analyses or explications of semantic fields of emotion terms. This impression is due partly to the explicit semantic orientation of some of the models that have been proposed (Ortony et al., 1988), and partly to the use of verbal labels in all theories to identify the emotional states that are seen to be elicited and differentiated by the appraisal process.

It is certainly one of the legitimate applications of appraisal theories to identify the nature of the emotion-antecedent appraisal process that determines which verbal label will be chosen to communicate the nature of the emotion episode. However, appraisal theories need to go beyond semantics and attempt to specify the true nature of the emotion-antecedent appraisal process. This process might result in an emotional state that the person concerned is unable or unwilling to label with one of the standard emotion terms that are currently used in emotion research. Scherer (1984a) has argued that the stimulus or event evaluation process can elicit as many different emotional states as there are distinguishable outcomes of the appraisal process. This suggestion clearly contradicts the notion that there are a very limited number of "basic" or "fundamental" discrete emotions (Ekman, 1984, 1992; Izard, 1977; Tomkins, 1984). In order to allow systematic discussion of this issue, it is necessary to agree on a consensual definition of emotion that helps to explicate the boundaries between different emotional states and their components (see Scherer, 1993).

A further requirement for advancing in the debate on this issue is the specification of the *micro-genetic process* of appraisal and reaction. Although many emotion theories give the impression that emotions are static states that can be conveniently labelled with a single term, there can be little doubt that we need to talk about *emotion episodes* that are characterised by continuously occurring changes in the underlying appraisal and reaction processes (see Folkman & Lazarus, 1985; Frijda, 1986; Scherer, 1984a,b). In consequence, it is not sufficient to specify a pattern of appraisal results that is supposed to explain a static emotion as indexed by a label. The nature of the appraisal *process* and the immediate effects of the evaluation results on the other components of emotion (such as subjective feeling, physiological responses, motor expression, and action tendencies) need to be explored. Unfortunately, most of the appraisal theorists have so far devoted only very limited attention to the process underlying the evaluation of situations, events, or actions.

An exception to this general pattern is the component process theory suggested by Scherer (1984a,b, 1986, 1988), which postulates that the appraisal criteria (stimulus evaluation checks, abbreviated as SECs) proposed occur in an invariant *sequence* (in the order shown in Table 2). The sequence notion, which is based on phylogenetic, ontogenetic, and microgenetic (logical) considerations, cannot be discussed in detail in the present context. Generally speaking, it is assumed that the appraisal process is *constantly operative* with evaluations being continuously performed to update the organism's information on an event or situation (including the current needs or goals of the organism and the possibility to act on these). In consequence, the sequential stimulus evaluation checks are expected to occur in very rapid succession (similar to a rotating radar antenna updating the reflection patterns on the screen). This continuous operation can explain the sudden changes that can occur during emotion episodes and which are often based on re-evaluations of the event or of one's coping potential (cf. Lazarus', 1968, "secondary appraisal"; see Scherer, 1984a,b, for further details on the hypothesised sequential processing).

Many different objections have been raised against this sequence notion. Quite a few of these can be refuted on logical grounds or on the basis of recent insights into the neural bases of information-processing, particularly with respect to neural networks (see Scherer, 1993, for a detailed discussion). However, empirical research is needed to demonstrate the feasibility of the sequence hypothesis and to encourage further work in this direction. Unfortunately, our dependence on verbal report of recalled or inferred appraisal processes does not lend itself to the study of the sequence hypothesis. It is likely that the different steps of the evaluation process occur extremely rapidly and are not generally represented in awareness. Any reconstruction of these processes is likely to miss the temporal dynamics of the process. In the future, neuroscience technology might allow us to monitor such rapidly occurring evaluation sequences directly. Also, it seems feasible to develop sophisticated research designs making use of latency time measures in carefully designed stimulus presentation modes to shed some light on these time-critical processes (see

Scherer, 1993, for concrete suggestions on adopting appropriate paradigms from the cognitive neurosciences). Unfortunately, such studies might well be slow in the making.

3. The Lack or Consensus on the Number and Types of Appraisal Criteria

The third problem concerns the issue of how many and precisely which evaluation or appraisal dimensions are necessary to account for the degree of emotion differentiation that can be empirically demonstrated. Although, as mentioned earlier, there is much convergence in this field, authors do differ with respect to the number and definition of appraisal dimensions that are proposed. A few recent studies have attempted to compare different appraisal theories and to empirically determine how many dimensions are needed and which dimensions seem to account for most of the variance (Manstead & Tetlock, 1989; Mauro, Sato, & Tucker, 1992; Reisenzein & Hofmann, 1990; Roseman et al., 1990). All of these studies are limited to *post hoc* evaluation of how well the dimensions studied explain differentiation between the emotions reported by the subjects. In other words, the same group of subjects provides both the emotion and the appraisal information and statistical analysis is limited to identifying the shared variance. Needless to say, the results cannot be generalised beyond the respective set of emotions and dimensions studied. Even though such information is eminently useful for the further development of appraisal theories, it seems desirable to develop a model that emphasises the *prediction* of emotional states on the basis of a minimal set of necessary and sufficient dimensions or criteria of appraisal.

The empirical study to be reported in this paper suggests such a predictive approach. Based on Scherer's component process model of emotion (1984a,b, 1986, 1988), an expert system on emotion differentiation that contains such a minimal set of evaluation criteria is presented and submitted to a first empirical test.

As shown earlier, the question of how many and which appraisal criteria are minimally needed to explain emotion differentiation is one of the central issues in research on emotion-antecedent appraisal. It is argued here that one can work towards settling the issue by constructing, and continuously refining, an expert system that attempts to diagnose the nature of an emotional experience based exclusively on information about the results of the stimulus or event evaluation processes that have elicited the emotion. The knowledge base of the expert system would contain a limited set of evaluation or appraisal criteria together with theoretically defined (and empirically updated) predictions about which pattern of evaluation results is likely to produce a particular emotion out of a limited

TABLE 2
Patterns of Stimulus Evaluation Checks (SEC) Predicted to Differentiate 14 Major Emotions

	ENJ/HAP	*ELA/JOY*	*DISP/DISG*	*CON/SCO*	*SAD/DEJ*	*DESPAIR*	*ANX/WOR*
Novelty							
Suddenness	low	hi/med	open	open	low	high	low
Familiarity	open	open	low	open	low	v low	open
Predictability	medium	low	low	open	open	low	open
Intrinsic pleasantness	high	open	v low	open	open	open	open
Goal significance							
Concern relevance	open	self/rela	body	rela/order	open	open	body/self
Outcome probability	v high	v high	v high	high	v high	v high	medium
Expectation	consonant	open	open	open	open	dissonant	open
Conduciveness	conducive	v conducive	open	open	obstruct	obstruct	obstruct
Urgency	v low	low	medium	low	low	high	medium
Coping potential							
Cause: Agent	open	open	open	other	open	oth/nat	oth/nat
Cause: Motive	intent	cha/int	open	intent	cha/neg	cha/neg	open
Control	open	open	open	high	v low	v low	open
Power	open	open	open	low	v low	v low	low
Adjustment	high	medium	open	high	medium	v low	medium
Compatibility standards							
External	open	open	open	v low	open	open	open
Internal	open	open	open	v low	open	open	open

	FEAR	*IRR/COA*	*RAGE/HOA*	*BOR/IND*	*SHAME*	*GUILT*	*PRIDE*
Novelty							
Suddenness	high	low	high	v low	low	open	open
Familiarity	open	open	low	high	open	open	open
Predictability	low	medium	low	v high	open	open	open
Intrinsic pleasantness	low	open	open	open	open	open	open
Goal significance							
Concern relevance	body	order	order	body	self	rela/order	self
Outcome probability	high	v high	v high	v high	v high	v high	v high
Expectation	dissonant	open	dissonant	consonant	open	open	open
Conduciveness	obstruct	obstruct	obstruct	open	open	high	high
Urgency	v high	medium	high	low	high	medium	low
Coping potential							
Cause: Agent	oth/nat	open	other	open	self	self	self
Cause: Motive	open	int/neg	intent	open	int/neg	intent	intent
Control	open	high	high	medium	open	open	open
Power	v low	medium	high	medium	open	open	open
Adjustment	low	high	high	high	medium	medium	high
Compatibility standards							
External	open	low	low	open	open	v low	high
Internal	open	low	low	open	v low	v low	v high

Abbreviations: *ENJ/HAP*, enjoyment/happiness; *ELA/JOY*, elation/joy; *DISP/DISG*, displeasure/disgust; *CON/SCO*, contempt/scorn; *SAD/DEJ*, sadness/dejection; *IRR/COA*, irritation/cold anger; *RAGE/HOA*, rage/hot anger; *BOR/IND*, boredom/indifference; *v*, very; *rela*, relationships; *nat*, nature; *cha*, chance; *neg*, negligence; *int* or *intent*, intention; *oth* or *other*, other person(s).

Reproduced from Scherer (1988, p. 112).

set of possibilities. At present, this system is limited to predicting the verbal labels given to the emotions experienced and to obtain the required information about appraisal processes by requesting verbal report of recalled or inferred evaluation results. As shown earlier, this is a highly imperfect approach to study the dynamic appraisal and reaction processes involved in emotional episodes, many of which do not require involvement of consciousness or language—or may not even be accessible to them. However, even an approximative approach to a predictive model seems useful at our present state of knowledge.

METHOD

Designing the Expert System

The aim was to develop a computer program that would allow a user to enter information on a situation in which a strong emotion had been experienced and have the program predict or diagnose the nature of that emotional state (as represented by a verbal label).[1] Using TurboPascal 3.0, a program called GENESE (Geneva Expert System on Emotions) was developed.[2] In contrast to expert systems based on IF-THEN rules the present system is of the type that employs algorithms determining the relative similarity between input vectors and prototypical category vectors representing the knowledge base. In the present case the "knowledge base" consists of a set of vectors (one for each emotion) which contain quantified *predictions* relative to the typical stimulus evaluation check outcomes for specific emotions. These vectors have been derived from the prediction tables published by the author in earlier work (Scherer, 1984a,b, 1986, 1988). The most recent set of predictions is shown in Table 2 (reproduced from Scherer, 1988).

Concretely, then, for each of the specific emotions contained in the expert system, a vector of numbers (which represent the predicted results of selected stimulus evaluation checks for the respective emotions) constitutes the prototypical pattern which will be used to classify user-generated input vectors. The input vector for a target emotion to be classified (which is determined by the user's choice of a recalled emotional experience he or she wants to have diagnosed) is determined by the computer asking the 15 questions listed in Table 3 and requiring the user to answer with the help of predefined answer categories. Each of these

[1] A similar approach was independently developed by Frijda and Swagerman (1987).

[2] The prototype of the system was written in 1987 by Philippe Narbel and Roland Bapst based on specifications by the author who has continuously modified the program since.

questions corresponds to a particular stimulus evaluation check or subcheck. The numbers representing the predicted prototypical answer alternatives for each question constitute the entries for the stimulus evaluation checks into the prediction vector for the respective emotion. These prediction vectors are shown in the second row of the vector matrices for the 14 emotions in Table 5.

It should be noted that although the prediction vectors have been derived from earlier prediction tables, not all of the stimulus evaluation subchecks listed in Table 2 have been included in the quantified prediction vectors of the GENESE expert system. The need for a selection of what seemed to be the most important and differentiating checks was imposed by the necessity to curtail the number of questions posed to the user. Furthermore, for some subchecks, e.g. agent of causation, several questions had to be asked to obtain the required quantitative information. Table 3 shows the correspondence between the stimulus evaluation checks or subchecks and the specific questions. It should be noted further that the prediction vectors (as contained in the system and shown in Table 5) are based on but do not necessarily correspond exactly to the earlier prediction tables (e.g. Table 2). The author considers theory development a dynamic process. Consequently, predictions change and evolve over time. For example, the prediction vectors in Table 5 show some changes over earlier hypothesising. In particular, an attempt has been made to reduce the number of "open" or "not pertinent" predictions (see Table 2)—particularly in the case of shame and guilt—as these reduce the discriminative power of the vectors in the expert system.

The present version of GENESE contains prediction vectors for the 14 emotions listed in Table 2. The choice of these 14 emotions was determined by the arguments advanced in Scherer (1986) advocating to distinguish between more quiet and more aroused varieties of some of the major emotions, e.g. irritation/cold anger vs. rage/hot anger.

The input vector, as based on the user's answers to the 15 questions, is systematically compared to the 14 predicted emotion vectors, using Euclidian distance measures. The distance indices obtained in this fashion are then adjusted on the basis of theoretical considerations concerning the need to weight particular combinations of input values. The following adjustments of the distance indices are used in the present version of the expert system:

- − 0.3 for shame and guilt if the causal agent is "self"
- + 0.8 for all positive emotions if the event is evaluated as unpleasant and hindering goal attainment
- + 0.3 for contempt except in cases in which another person is the causal agent and the act is highly immoral (− 0.6)

- 0.5 for sadness and desperation if the event happened in the past and if power and adjustment are low
- 0.5 for irritation and anger if power and adjustment are high
- 0.3 for joy, desperation, fear, and anger if the intensity of the emotion is rated above 4 on a 6-point scale

The nature of the adjustments and the size of these increments or decrements of the distance value computed on the basis of the comparison of the input vector with the prediction vectors are based on rules of thumb and are subject to change in future versions of the system.

TABLE 3
Questions Posed by the Expert System and their Correspondence to the Stimulus Evaluation Checks (SECs)

1. Did the situation that elicited your emotion happen very suddenly or abruptly? [SEC1-NOVELTY]

(0) not pertinent (1) not at all (2) a little (3) moderately (4) strongly (5) extremely

2. Did the situation concern an event or an action that had happened in the past, that had just happened or that was to be expected for the future? [see text]

(0) not pertinent (1) the event had happened a long time ago
(2) it happened in the recent past (3) it had just happened at that moment
(4) it was to be expected for the near future (5) it was to be expected in the long run

3. This type of event, independent of your personal evaluation, would it be generally considered as pleasant or unpleasant? [SEC2-INTRINSIC PLEASANTNESS]

(0) not pertinent (1) very unpleasant (2) rather unpleasant (3) indifferent
(4) rather pleasant (5) very pleasant

4. Was the event relevant for your general well-being, for urgent needs you felt, or for specific goals or plans you were pursuing at the time? [SEC3-RELEVANCE]

(0) not pertinent (1) not at all (2) a little (3) moderately (4) strongly (5) extremely

5. Did you expect the event and its consequences before the situation actually happened? [SEC3-EXPECTATION]

(0) not pertinent (1) never in my life (2) not really (3) I did not exclude it
(4) a little (5) strongly

6. Did the event help or hinder you in satisfying your needs, in pursuing your plans or in attaining your goals? [SEC3-CONDUCIVENESS]

(0) not pertinent (1) it hindered a lot (2) it hindered a little (3) it had no effect
(4) it helped a little (5) it helped a lot

7. Did you feel that action on your part was urgently required to cope with the event and its consequences? [SEC3-URGENCY]

(0) not pertinent (1) not at all (2) a little (3) moderately (4) strongly (5) extremely

(Continued)

TABLE 3
(Continued)

8. Was the event caused by your own actions—in other words, were you partially or fully responsible for what happened? [SEC4–CAUSATION]

(0) not pertinent (1) not at all (2) a little, but unintentionally
(3) somewhat, but I was unaware of the consequences
(4) quite responsible, I knew what I was doing
(5) fully responsible, I absolutely wanted to do what I did

9. Was the event caused by one or several other persons—in other words, were other people partially or fully responsible for what happened? [SEC4–CAUSATION]

(0) not pertinent (1) not at all (2) a little, but unintentionally
(3) somewhat, but he/she/they were unaware of the consequences
(4) quite responsible, he/she/they knew what they were doing
(5) fully responsible, he/she/they absolutely wanted to do what they did

10. Was the event mainly due to chance? [SEC4–CAUSATION]

(0) not pertinent (1) not at all (2) a little, but human action was the decisive factor
(3) somewhat, but human action contributed to it (4) strongly (5) exclusively

11. Can the occurrence and the consequences of this type of event generally be controlled or modified by human action? [SEC4–CONTROL]

(0) not pertinent (1) not at all (2) a little (3) moderately (4) strongly (5) extremely

12. Did you feel that you had enough power to cope with the event—i.e. being able to influence what was happening or to modify the consequences? [SEC4–POWER]

(0) not pertinent (1) not at all (2) a little (3) moderately (4) strongly (5) extremely

13. Did you feel that, after having used all your means of intervention, you could live with the situation and adapt to the consequences? [SEC4–ADJUSTMENT]

(0) not pertinent (1) not at all (2) with much difficulty (3) somewhat (4) quite easily
(5) without any problem at all

14. Would the large majority of people consider what happened to be quite in accordance with social norms and morally acceptable? [SEC5–NORM COMPATIBILITY]

(0) not pertinent (1) certainly not (2) not really (3) probably (4) most likely
(5) certainly

15. If you were personally responsible for what happened, did your action correspond to your self-image? [SEC5–SELF COMPATIBILITY]

(0) not pertinent (I was not responsible) (1) not at all (2) not really (3) somewhat
(4) strongly (5) extremely well

The emotion with the smallest overall distance measure is suggested to the user as diagnosis of the experienced emotional state. If the user does not accept the diagnosis as valid, the emotion with the vector that shows the second smallest distance is proposed as a second guess. If the user rejects this one also, he or she is prompted to provide the correct response in the list of the 14 emotions contained in the standard version of the system. If the user identifies one of these 14 emotions as correct, the respective prediction vector is changed in the direction of the empirical input vector (using an adaptable weighting function) to establish an empirically updated prediction matrix *for this particular user*. The user can indicate that none of the 14 emotion labels proposed corresponds to the real emotion that was felt. He or she then has the possibility to enter a freely chosen verbal label for that particular state. This label, together with the input vector, is then added to the personalised prediction matrix. In this manner, an unlimited number of new emotions can be added to the personalised knowledge base of a user. It should be noted that the personalised knowledge base for a particular user no longer represents pure theoretical predictions because the prediction vectors have been adapted to fit the empirical input. After prolonged usage by a particular user, the prediction matrix may actually represent a true empirical knowledge base—at least for that particular user.

The system stores all the information provided by the user in two separate data files, one which contains the complete protocol of the session and one that contains the personalised vector matrix.

Procedure

The system has been designed in such a fashion that it does not require any intervention by an experimenter. Users are expected to start the program and follow instructions on the screen which should be self-explanatory. In the following, a brief summary of the typical procedure is given.

Following a title page and the entry of a user code that permits repeated access and establishes a personalised data base, the user is requested to remember a situation that has produced a strong emotional response:

> Please recall a situation in which you experienced a strong emotional feeling. The emotion might have been elicited by an event that happened to you or by the consequences of your own behaviour. This might have happened recently or quite some time ago.
>
> I will ask you a certain number of questions concerning this situation and will then attempt to diagnose the emotion you felt at that time.
>
> Before continuing, please recall the situation as best as you can and try to reconstruct the details of what happened.

The program then pauses until the subject confirms to now recall a situation very vividly by pressing a key. He or she is then asked to type a brief description of the situation on the keyboard. To ensure anonymity and privacy, the text typed is not shown on the screen. Then, the 15 questions shown in Table 3 are presented consecutively. The questions are always presented in the order given in Table 3 because the underlying theory predicts that this is the natural micro-genetic appraisal sequence. It is hypothesised that following the original sequence of the appraisal in assessing the different checks may help the subject to recall the appraisal process faster and with fewer errors. The subject is then asked to enter the intensity with which the emotion was felt on a 6-point scale from very weak to extremely strong, as well as his/her age group and gender. Then, the subject is presented with the following message:

> I have now completed a first diagnosis of the affective state elicited by the situation you described and I am about to present you with a label that I consider to be a good description of the emotion you experienced. Please remember that, at the time, you may not have been conscious of all aspects of your emotional experience. Therefore, it is quite possible that the verbal label you normally use to describe your feelings in that situation does not exactly correspond to the term I will suggest in my diagnosis. If that is the case, please consider the possibility that the diagnosis which I suggest might reflect some part of what you felt in the situation—possibly without realising it.

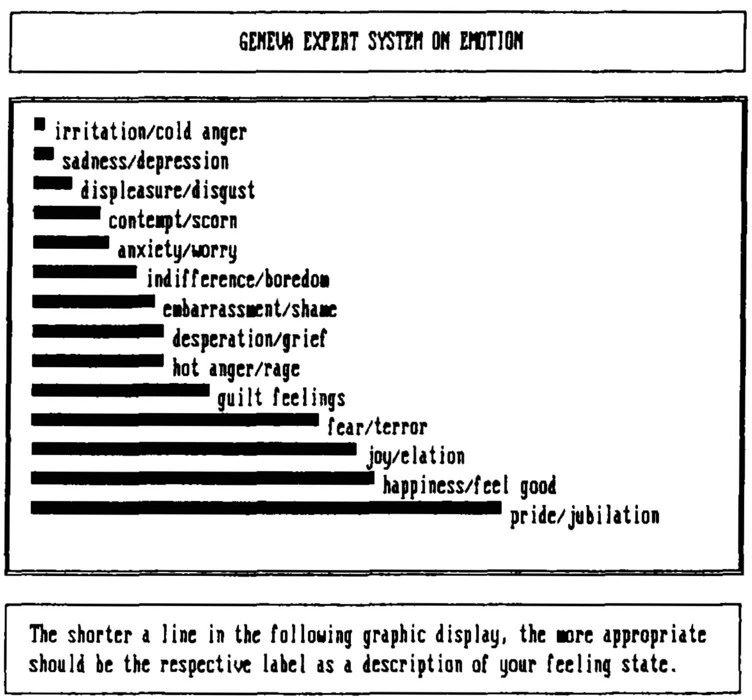


FIG. 1. Feedback screen showing relative distances of input vector to predicted vectors for different emotion concepts.

The system then presents the first diagnosis or suggested hypothesis and asks the user to indicate whether it is correct or not. If the user enters "incorrect", a second diagnosis is presented. If that is again incorrect, the user is presented with the list of 14 emotions and asked to indicate the correct emotion. Following either of these three cases the user is presented with feedback on the diagnostic process in form of a graph showing the relative distances of the various emotion concepts to the situation described (see Fig. 1).

If the subject indicates that none of the 14 emotion labels in the list describes the felt affect accurately, he or she is given the opportunity to enter a new concept:

> Aha, something new!?
> Do you really want to teach me a new emotion? It will change your personal knowledge base!
> Your decision—[y = yes/n = no followed by the new concept]

After each of the four possible options: (1) first diagnosis correct; (2) second diagnosis correct; (3) correct emotion identified in list; (4) new concept entered, the user is given the possibility to enter a new situation or to exit.

Administration

This expert system was used in a number of pilot studies, using English, German, and French versions. The French version was used for a first major study of the accuracy of the expert system in diagnosing emotional states on the basis of theoretically predicted appraisal patterns.

The program was inserted in a batch-file environment that allows automatic administration. After each user completes a session, the system returns to a title screen inviting potential users to test the power of the system to diagnose emotional states. To avoid the possibility that users would start a session and leave in the middle, a time limit for the responses to each screen was set. If the time limit is exceeded the system returns automatically to the title page.

A personal computer (Olivetti M240) on which this batch-file system had been installed, was placed in the exhibition of the University of Geneva at the 1990 Geneva book fair (Salon du Livre). This is a large international bookshow with exhibitors and visitors from different countries, mostly French speaking. Posters positioned around the PC invited passers by to test the GENESE emotion expert system. During three days of the exhibition, 201 persons used the system entering generally one, but sometimes two or three situations. In addition, 35 first year students in psychology at the University of Geneva (in their first 2 months of study) used the system as part of a course exercise (also in a completely automatised fashion). In all, 236 persons entered the data for a total of 282 emotional situations in this manner.

Data Analysis

A major concern for the analysis is the possibility that some users may have entered nonsensical information while just playing with or trying to mislead the system. However, there were very few cases where the text entered suggested that this was the case. In some cases no text was entered and it was difficult to decide whether the input vector constituted a serious trial or not. To avoid biasing the data by subjective judgement of the "seriousness" of the entry it was decided to retain all situations, assuming that nonsensical entries should work against finding accurate diagnoses and thus lead to a conservative estimate of the power of the system.

Data were excluded only in the following, clearly discernible cases: In some situations there was virtually no variability in the responses to the questions, e.g. a user responding with 1 to all questions. Fifteen situations in which 13 or more of the answers had the same numerical value were excluded. In 14 cases of the total of 282 situations entered, users neither judged any of the diagnoses as correct nor identified any of the 14 emotion labels suggested as the correct response. In these cases new concepts were entered. Because the number of such cases was small, and because in some cases strange concepts like "le spleen total" were entered, it was decided to exclude these cases from analysis.

After having excluded these cases, a total of 253 situations were analysed with respect to the number of hits and misses and the correlation between the predicted and the empirically obtained appraisal profiles for the 14 emotions studied.

RESULTS

Tables 4 and 5 show the major results of the analyses. In Table 4, the first column contains the total number of situations that were entered for each of the 14 emotions (using the final indication of a correct diagnosis or the user correction as a criterion). Column 2 shows in how many of these cases the first diagnosis was correct, and Col. 3 in how many cases the second diagnosis was correct. Column 4 shows the total number of misses. However, some of the latter cases can be considered as "dubious misses" as the input vectors not only deviate strongly from the predicted vectors but also from the empirically obtained mean vectors for each of the emotion (as shown in Table 5). It is highly probable, then, that the

TABLE 4
Results of Expert System Runs for 253 Emotion Situations

Emotion	*Total Situat*	*1st Hit*	*2nd Hit*	*Total Misses*	*Dubious Misses*	*% Correct*	*Marked Diff*	*Profile Correl*
Happiness/Feel good	27	21	1	5	2	88.0	3	0.76
Joy/Elation	34	30	3	1	1	100.0	3	0.63
Displeasure/Disgust	10	4	3	3	1	77.8	1	0.60
Contempt/Scorn	3	3	0	0	0	100.0	2	0.51
Sadness/Depression	34	19	3	12	3	71.0	2	0.24
Desperation/Grief	58	49	8	1	1	100.0	2	0.75
Anxiety/Worry	19	2	0	17	5	14.3	4	0.13
Fear/Terror	19	2	2	15	4	26.7	10	0.61
Irritation/Cold anger	11	3	4	4	1	70.0	3	0.30
Hot anger/Rage	19	10	4	5	1	77.7	6	0.74
Indifference/Boredom	3	1	0	2	0	33.3	3	0.36
Embarrassment/Shame	4	1	0	3	1	33.3	4	0.23
Guilt feelings	3	1	0	2	1	50.0	9	−0.10
Pride/Jubilation	9	6	0	3	1	75.0	6	0.75
Totals	253	152	28	73	22	77.9		

Notes: ***Total Situat***, total number of situations clearly categorised by respondents; ***1st Hit***, number correctly recognised on first attempt; ***2nd Hit***, number correctly recognised on second attempt; ***Total misses***, number missed as shown by user correction; ***Dubious Misses***, cases in which the deviation of the input profile from the mean empirical profile exceeded half a standard deviation; ***% Correct***, percentage of total hits (first plus second) on the basis of total number of situations minus dubious misses; ***Marked Diff***, marked difference between predicted and empirically obtained vectors; ***Profile Correl***, Pearson r between the mean empirical input profile and the theoretically specified prediction profile over $N = 15$ questions (0 in prediction vector treated as missing observation).

appraisal information was not provided in the correct manner. Twenty-two situations were considered dubious because the absolute value of the sum of the differences (deviations) obtained by deducting the individual values for each question from the mean value—Row 1 in Table 5 exceeded the value corresponding to a standard deviation for all difference scores. Column 5 shows the number of these "dubious misses" per emotion. Column 6 shows the percentage of correct diagnoses (excluding the "dubious misses" which are considered to be the result of incorrect input).

Table 5 lists, for each of the 14 emotions, the mean input vector (Row 1), the theoretically predicted SEC vector as represented in the knowledge base (Row 2), the difference between the two (Row 3), and the standard deviations of the empirical values in the input vector (Row 4). This table allows to compare the theoretically predicted SEC vectors in the knowledge base with the empirically obtained input vectors. Thus it permits to determine the stimulus evaluation checks for which the empirical values greatly differ from the predicted value and for which, in consequence, a revision of the prediction might be required (if there is reason to believe that the input value does not represent artifacts or errors). For this decision, the standard deviations of the empirical values are useful: High discordance of the values entered for a particular stimulus evaluation check can be taken to indicate that there may not be a standard appraisal pattern (or that the respondents did not understand the question).

The data in Table 5 generate a large number of interesting issues to be explored. A detailed discussion of these points would exceed the space available in this paper. However, some general trends can be inferred by doing a rough analysis of the size of the difference between theoretical and empirical patterns across stimulus evaluation checks and across emotions.[3] Counting the number of cases in which a difference score exceeds the value of 1 (absolute) for different emotions yields an indication of where the predicted patterns deviate most strongly from the empirically obtained patterns (these values are shown in Col. 7, Table 4). Another way of evaluating the fit between theoretical and empirical patterns is to correlate the two vectors for each emotion. Column 8 in Table 4 shows the mean Pearson correlation coefficients (over respondents) between the predicted profile or vector in the knowledge base, and the empirically obtained input vectors for each of the emotions across the 15 appraisal criteria (as shown in Table 5).

At first observation, although not directly pertinent to the questions outlined earlier, concerns the relative frequency of the different emotions which were presented to the expert system (Col. 1, Table 4). The categories mentioned most frequently are sadness/depression and desperation/grief, both of which are closely linked to some kind of permanent loss. Positive emotions, happiness/feel good and joy/elation are also mentioned relatively frequently. Anxiety/worry and fear/terror, both related to apprehension about impending dangers, are in third position with respect to frequency. Anger states (irritation/cold anger and hot anger/rage) are mentioned the least frequently of the four major fundamental emotion types. The remaining emotions are all relatively low in occurrence.

The most important question concerns the accuracy of the expert system in diagnosing the emotional state descriptions entered by the users. Column 6, Table 4 shows the percentage of correct diagnoses on either the first or second guess. The data in Cols 2 and 3 show that first hits are generally much more frequent (84.4% of all correct diagnoses) than second guesses. The accuracy percentage in Col. 6 is based on a comparison of all

[3] It should be noted that the differences should not be interpreted in cases in which the theoretical prediction is 0—not pertinent—as the difference score is not interpretable. Also, as explained in the description of the expert system design, the quantitative prediction vectors are based on but not identical to the patterns in the published prediction tables.

TABLE 5
Empirically Obtained and Theoretically Predicted Appraisal Vectors for 14 Emotions

Emotion	*Nov*	*Time*	*Plea*	*Rele*	*Expec*	*Condu*	*Urgen*	*EgoC*	*OthC*	*ChaC*	*Cont*	*Power*	*Adjus*	*Ext*	*Int*
Enjoy	2.59	2.19	4.41	2.70	3.59	2.96	1.52	3.11	3.41	2.19	3.22	2.37	3.33	3.85	2.93
	2.00	2.00	4.00	3.00	4.00	4.00	1.00	2.00	3.00	2.00	0.00	0.00	5.00	0.00	0.00
	−0.59	−0.19	−0.41	0.30	0.41	1.04	−0.52	−1.11	−0.41	−0.19	•	•	1.67	•	•
	1.18	0.86	0.70	1.57	0.88	0.87	0.95	1.38	1.29	1.06	1.55	1.20	1.21	1.09	1.44
Joy	3.29	2.97	4.26	3.76	2.85	3.97	2.62	3.12	2.97	2.71	3.32	2.59	3.53	3.97	2.88
	4.00	3.00	3.00	4.00	1.00	5.00	2.00	3.00	3.00	3.00	0.00	0.00	4.00	0.00	0.00
	0.71	0.03	−1.26	0.24	−1.85	1.03	−0.62	−0.12	0.03	0.29	•	•	0.47	•	•
	1.30	0.93	0.99	1.30	1.16	0.98	1.39	1.24	1.44	1.24	1.40	1.26	1.14	0.93	1.56
Disgus	3.10	2.30	1.70	1.60	1.90	2.40	2.40	2.00	2.70	3.30	2.30	1.70	2.20	2.70	1.50
	3.00	3.00	1.00	2.00	2.00	3.00	3.00	1.00	3.00	3.00	3.00	2.00	4.00	3.00	0.00
	−0.10	0.70	−0.70	0.40	0.10	0.60	0.60	−1.00	0.30	−0.30	0.70	0.30	1.80	0.30	•
	1.68	1.44	0.98	0.92	0.90	1.20	1.60	1.20	1.30	1.10	1.36	0.84	1.36	1.56	1.60
Contem	2.33	1.00	1.67	1.67	2.33	1.00	2.67	2.00	4.00	1.00	2.33	1.33	3.67	3.00	1.00
	2.00	2.00	2.00	2.00	2.00	3.00	2.00	1.00	5.00	1.00	3.00	4.00	4.00	2.00	0.00
	−0.33	1.00	0.33	0.33	−0.33	2.00	−0.67	−1.00	1.00	0.00	0.67	2.67	0.33	−1.00	•
	1.11	1.33	0.89	0.89	1.11	0.67	1.11	0.67	0.67	0.00	1.78	0.89	0.89	0.67	1.33
Sad	3.06	2.21	1.85	2.44	2.65	2.38	2.26	2.15	2.62	2.21	3.12	1.71	2.26	2.26	1.56
	2.00	2.00	2.00	4.00	2.00	2.00	2.00	2.00	3.00	3.00	3.00	0.00	2.00	0.00	0.00
	−1.06	−0.21	0.15	1.56	−0.65	−0.38	−0.26	−0.15	0.38	0.79	−0.12	•	−0.26	•	•
	1.24	1.15	0.97	1.58	1.39	0.94	1.27	1.07	1.46	1.25	1.59	0.91	0.87	1.17	1.12
Desper	4.12	2.74	1.79	2.90	2.17	2.00	3.34	1.95	2.53	2.38	2.52	1.50	1.69	1.90	1.47
	4.00	3.00	2.00	5.00	1.00	1.00	3.00	1.00	2.00	3.00	3.00	0.00	1.00	0.00	0.00
	−0.12	0.26	0.21	2.10	−1.17	−1.00	−0.34	−0.95	−0.53	0.62	0.48	•	−0.69	•	•
	0.88	0.91	1.05	1.98	1.07	0.93	1.51	0.98	1.42	1.53	1.41	0.72	0.54	1.27	1.27

Emotion	*Nov*	*Time*	*Plea*	*Rele*	*Expec*	*Condu*	*Urgen*	*EgoC*	*OthC*	*ChaC*	*Cont*	*Power*	*Adjus*	*Ext*	*Int*
Anxi	2.42	2.74	1.26	3.05	3.16	3.00	2.79	2.32	2.11	2.16	2.95	2.42	2.68	3.05	1.68
	2.00	5.00	2.00	3.00	2.00	2.00	3.00	1.00	4.00	3.00	3.00	2.00	3.00	0.00	0.00
	−0.42	2.26	0.74	−0.05	−1.16	−1.00	0.21	−1.32	1.89	0.84	0.05	−0.42	0.32	•	•
	1.43	1.10	0.49	1.42	1.11	0.74	1.51	1.28	1.39	1.25	1.64	1.07	0.58	1.41	1.35
Fear	4.32	2.79	1.42	2.79	2.05	2.11	3.53	2.11	2.11	2.37	3.42	2.26	1.47	1.00	1.58
	5.00	4.00	2.00	5.00	1.00	1.00	5.00	1.00	4.00	4.00	2.00	1.00	2.00	0.00	0.00
	0.68	1.21	0.58	2.21	−1.05	−1.11	1.47	−1.11	1.89	1.63	−1.42	−1.26	0.53	•	•
	0.94	1.05	0.71	1.80	0.82	0.88	1.44	0.99	1.20	1.48	1.30	1.36	0.97	0.84	1.51
Irrit	3.27	2.64	2.18	2.73	3.45	2.36	3.09	2.55	3.36	1.55	3.55	2.45	2.91	3.00	2.27
	3.00	2.00	3.00	3.00	2.00	2.00	3.00	2.00	4.00	3.00	4.00	3.00	4.00	2.00	2.00
	−0.27	−0.64	0.82	0.27	−1.45	−0.36	−0.09	−0.55	0.64	1.45	0.45	0.55	1.09	−1.00	−0.27
	1.21	1.19	1.02	1.70	0.96	0.76	1.02	0.96	0.76	0.69	1.21	1.14	0.84	0.91	1.16
Anger	2.63	2.05	1.32	2.79	2.11	2.21	3.26	1.53	2.89	1.63	4.21	2.68	2.42	1.74	2.11
	4.00	3.00	2.00	4.00	1.00	1.00	4.00	1.00	4.00	2.00	4.00	4.00	3.00	1.00	0.00
	1.37	0.95	0.68	1.21	−1.11	−1.21	0.74	−0.53	1.11	0.37	−0.21	1.32	0.58	−0.74	•
	1.37	1.10	0.60	1.51	1.08	1.13	1.09	0.93	1.39	1.15	1.00	1.17	0.88	1.01	1.29
Indiff	3.67	3.67	2.33	2.67	3.67	2.33	1.67	0.67	2.67	1.67	3.67	1.67	3.67	2.33	2.33
	1.00	3.00	3.00	2.00	5.00	3.00	1.00	0.00	0.00	0.00	3.00	3.00	4.00	0.00	0.00
	−2.67	−0.67	0.67	−0.67	1.33	0.67	−0.67	•	•	•	−0.67	1.33	0.33	•	•
	0.44	0.44	0.89	1.56	1.78	0.44	0.89	0.44	1.56	0.44	0.44	0.44	1.78	1.56	1.11
Shame	4.50	2.75	1.50	2.00	1.50	2.50	1.25	4.00	2.75	1.50	3.50	2.50	2.50	3.00	3.75
	2.00	3.00	2.00	4.00	2.00	2.00	2.00	4.00	2.00	1.00	2.00	2.00	3.00	2.00	2.00
	−2.50	0.25	0.50	2.00	0.50	−0.50	0.75	0.00	−0.75	−0.50	−1.50	−0.50	0.50	−1.00	−1.75
	0.50	0.38	0.50	2.00	0.50	1.50	0.38	1.00	1.25	0.75	1.50	1.50	1.25	1.00	0.75

(Continued)

TABLE 5
(Continued)

Emotion	*Nov*	*Time*	*Plea*	*Rele*	*Expec*	*Condu*	*Urgen*	*EgoC*	*OthC*	*ChaC*	*Cont*	*Power*	*Adjus*	*Ext*	*Int*
Guilt	3.33	3.33	1.67	0.33	1.33	1.67	3.33	3.33	2.33	1.00	3.00	2.00	1.67	3.67	2.33
	2.00	2.00	3.00	4.00	2.00	3.00	3.00	4.00	1.00	1.00	2.00	2.00	3.00	2.00	1.00
	−1.33	−1.33	1.33	3.67	0.67	1.33	−0.33	.067	−1.33	0.00	−1.00	0.00	1.33	−1.67	−1.33
	1.56	0.44	0.44	0.44	0.44	1.11	1.56	0.44	1.78	0.00	2.00	1.33	1.11	1.11	1.11
Pride	1.11	1.67	4.44	3.67	3.67	2.78	2.00	3.44	1.89	1.33	4.00	2.89	3.11	3.56	3.33
	2.00	3.00	4.00	4.00	4.00	4.00	2.00	5.00	2.00	2.00	4.00	4.00	5.00	4.00	5.00
	0.89	1.33	−0.44	0.33	0.33	1.22	0.00	1.56	0.11	0.67	0.00	1.11	1.89	0.44	1.67
	0.62	1.26	0.99	1.56	1.19	2.02	1.33	1.85	1.85	0.81	1.11	1.70	1.65	1.38	1.56

Note: First row: Mean empirical input vector. Second row: Theoretical predicted vector. Third row: Difference between empirical and theoretical vectors. Fourth row: Standard deviation for values in empirical vector. • signifies cases in which difference score is not meaningful because prediction is "0—not pertinent or open".

Abbreviations: *Nov*, novelty; *Time*, when did the event happen; *Plea*, intrinsic pleasantness; *Rele*, relevance; *Expec*, expectation; *Condu*, goal conduciveness; *Urgen*, urgency; *EgoC*, self as causal agent; *OthC*, other(s) as causal agent; *ChaC*, chance as causal agent; *Cont*, control; *Power*, Power to cope; *Adjus*, capacity to adjust; *Ext*, external; *Int*, internal.

hits with true misses (excluding the dubious misses because there is a very high probability that the information on the appraisal criteria was entered incorrectly). As shown in the row for the totals, the overall percentage of hits is 77.9% (180 first and second hits compared to 51 true misses). However, averaging the accuracy percentages in Col. 6 across all emotion categories yields a mean accuracy percentage of only 65.5%. This difference between the total accuracy percentage and the average percentage across the different categories is due to marked differences in the number of situations per category. Because the accuracy percentage is rather low in some of the categories containing a small number of cases, the average percentage drops. It is difficult to decide whether this lower accuracy is due to the small number of cases or to greater difficulties in predicting the respective categories. One has to assume that the true accuracy of the present version of GENESE lies somewhere between 65% and 80%. In view of the fact that with 14 emotion alternatives one would expect 7.14% accuracy if the system operated on chance level, this result seems quite respectable.

Closer inspection of the accuracy percentages for the individual emotions shows that the average across the emotion categories is reduced by very low percentages for anxiety/worry and fear/terror, on the one hand, and indifference/boredom, embarrassment/shame, and guilt feelings, on the other. With respect to the latter group, it is difficult to evaluate the lack of precision in the diagnoses, because only very few cases are involved and the results may not be very stable. However, it is possible that the low performance for indifference/boredom is due to the fact that the SEC profile for this state is not highly differentiated across the different stimulus evaluation checks (see Table 4). Shame and guilt are among the most complex human emotions and the current prediction profiles might well be too simplistic to differentiate these emotions. The comparatively low correlations between predicted and actually obtained profiles (shown in Table 4, Col. 8) suggest important divergences between prediction and empirical means. In consequence, it is not too surprising to find low accuracy for these emotions.

In contrast, the abnormally low accuracy percentages for anxiety and fear are quite unexpected. One possible explanation is the rapidity with which fear situations tend to change—particularly due to the occurrence of events that eliminate the danger or due to a re-evaluation of an event or stimulus as less dangerous. Because of the low accuracy in the anxiety and fear cases, the individual data files and particularly the input profiles were closely scrutinised. This qualitative analysis showed that in many cases subjects entered appraisal results from *both* the danger anticipation *and* the resolution part of the emotion process.

A concrete example may demonstrate this phenomenon: A man between 41 and 60 years of age describes a situation in which his daughter leaned over a burning candle in such a way that her hair started to catch fire. The input vector constituted by the answers to the SEC-based questions and the predicted fear vector are reproduced below (see Table 3 for the exact text of the questions corresponding to the vector entries):

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Criterion	nov	tem	ple	rel	exp	con	urg	ego	oth	cha	con	pow	adj	ext	int
Input	5.0	3.0	1.0	0.0	1.0	0.0	5.0	1.0	1.0	5.0	4.0	4.0	4.0	0.0	0.0
Prediction	5.0	4.0	2.0	5.0	1.0	1.0	5.0	1.0	4.0	4.0	2.0	1.0	2.0	0.0	0.0
Difference	0	−1	−1	*	0	*	0	0	−3	1	2	3	2	*	*

The comparison between the input and prediction vectors shows that for the first 10 questions there is rather good correspondence (the difference for "other responsibility"—question 9—is due to the cause of the event being exclusively seen in chance factors, which is of course possible in the present case). However, the answers concerning coping potential (control, power, and adjustment) are clearly related to a phase in the continuous appraisal process in which the danger has already passed (e.g. the flames having been extinguished) and the situation is under control. Otherwise it would be difficult to understand that "very intensive" fear results in spite of the strong ability to control and master the event (an input of 4—"strongly" for both control and power) and it being "quite easy" (4) to adjust to the cosequences of the situation. In this situation, fear was probably quickly followed by relief after realising that no serious consequences had ensued. Yet, the total situation was stored and referred to under the most prominent and distinctive label—in this case fear. Given that the appraisal results reported by the subject are likely to come partly from the fear phase and partly from the relief phase of this emotion episode, it is not surprising that the expert system does not correctly diagnose the target emotion—in this case fear.

Many other similar examples for the anxiety and fear cases could be listed. This probably reflects a tendency of the subjects to respond with respect to the *total situation* which may be characterised by a rapid change in the type of emotion—especially in the case of fear which has been empirically shown to be of very brief duration (Frijda, Mesquita, Sonnemans, & van Goozen, 1991; Scherer & Wallbott, submitted; Scherer, Wallbott, Matsumoto, & Kudoh, 1988; Scherer, Wallbott, & Summerfield, 1986; Wallbott & Scherer, 1986).

In consequence, some of the lack of accuracy may well be due to the respondents' tendency to report appraisals from *different phases* of an emotion situation rather than responding to all SEC appraisal questions with respect to a singular and well-defined slice of time. In addition, further refinement of the prediction profiles is required to improve the predictions for fear and anxiety. The correlation between predicted and obtained profiles is comparatively low for fear and particularly anxiety which would account for low accuracy. It is possible, then, that the theoretically predicted profiles for fear and anxiety are quite unrepresentative of reality and require major changes. Alternatively, it is possible that anxiety/worry situations, in particular, are very variable in their appraisal patterns which would imply that no clear-cut prototype profile can be defined. In this case, it could be one or more central criteria which determine the special nature of this emotion (one or all of which might be missing from the list of stimulus evaluation checks). Thus, the differentiation might hinge on one or more very central criteria which may not be contained in the list of stimulus evaluation checks or imperfectly measured by the questions.

This might imply the need for a revision in the theoretical underpinnings of GENESE, i.e. the list of stimulus evaluation checks. At present, the second question in the system (see Table 3) requires the subject to indicate whether the emotion-inducing event happened in the past, is about to happen, or is likely to happen in the future. This is not based on a particular stimulus evaluation check but is part of the facets of situations which are part of component process theory (see Scherer, 1984a). This particular facet was added to the prediction profile precisely because of the need to differentiate anxiety and fear, which imply threats of negative outcomes in the future, from other negative emotions. However, it may be necessary to go beyond the straightforward timing issue and include dimensions such as certainty (Frijda, 1987; Roseman, 1984, 1991; Smith & Ellsworth, 1985, 1987; see also Reisenzein & Hofmann, 1990). Although "outcome probability" was added to the prediction table in Scherer (1988) this check was not implemented as a question in the expert system (due to the reasons given above in the description of the expert system design). The present results could be interpreted to show that this appraisal dimension might be a major discriminating factor for fear and anxiety and thus needs to be added to the prediction vectors in the expert system.

These considerations demonstrate one of the major uses of the GENESE expert system, providing impetus and direction for theory development. The comparison between predicted and actual appraisal, as well as the precision of diagnosis, should help to identify the points where emotion-specific appraisals are badly represented in the theoretical predictions or where appropriate appraisal criteria are still lacking.

CONCLUSIONS

This paper illustrates how an empirical expert system approach to the study of emotion-antecedent appraisal can go beyond the established paradigms of obtaining correlational evidence between self-report of verbally labelled emotional experiences and inferred appraisal dimensions. In particular, the study examined the feasibility of using an expert system to empirically test the author's predictions on emotion differentiation as based on a limited number of stimulus evaluation checks. The results of a first major study reported here demonstrated an accuracy of *post hoc* diagnosis that substantially exceeds chance for many of the emotions studied and that lends support to the specific appraisal theory suggested by the author.

The present results might well underestimate the actual capacity of the system (and the support for the SEC predictions) as there is some evidence for incorrect input by some users. One particular problem is the reporting of appraisal results from different points in time during the emotional episode which may reflect different emotions (e.g. fear and relief). Because most real-life emotion episodes seem to consist of rapid sequences of changing emotional states (see also Scherer & Tannenbaum, 1986), it is necessary to make the requirement that appraisal reports need to be focused on one clearly defined point or time slice in the emotion episode more apparent to the users of the expert system. One possibility would be to ask the users to segment the recalled emotion episode into several clearly distinguishable segments and to report the appraisal process separately for each of these segments. In this case, GENESE could attempt to diagnose a sequence of emotions rather than an overall state.

One of the major sources for possible errors in reporting the recalled appraisal results is the wording of the questions. For example, even the use of the word "consequence" might have the effect of focusing the respondent's attention on the aftermath of the emotion episode rather than the crucial period of appraisal at the onset of an emotion-eliciting event. This would obviously lead to a reporting of appraisal results from totally different time periods in the emotion episode (and thus render an accurate expert system diagnostic impossible). This problem is one that the expert system approach shares with all other research paradigms in appraisal research that attempt to elicit verbal report of appraisal processes via questionnaires or interviewing. The process of appraisal is clearly non-verbal and probably occurs largely outside of awareness. Thus, the attempt to obtain a verbal report of many fine details from recall of a process that generally occurs in a split second is obviously fraught with many dangers. A particular problem is the conceptualisation of some of the major appraisal dimensions. In the process of developing GENESE it became clear that many subjects had great difficulty in understanding the concept of goal conduciveness (even in the simple formulation used in question 6, Table 3). In the further development of GENESE much attention will have to be paid to this problem. Providing copious HELP screens that the respondent can call up to get more information about a particular question are part of such efforts to avoid noise in the data that is due to incorrect responding to the questions.

The discussion of the results has attempted to show how the expert system approach yields precise suggestions as to where the theoretical assumptions need sharpening or modification. For example, the low accuracy for anxiety and fear clearly indicated the need to add a dimension or check likely to capture the future orientation of the respective appraisals. In consequence, the check of "outcome probability" (or certainty) has been added to the revised version of GENESE (and is given strong weight). First informal observation of some trial runs seem to show that the accuracy of GENESE in diagnosing these emotions has improved quite dramatically. Further studies like the one described here will be necessary to fine tune the prediction vectors with respect to the question of how many and which specific types of appraisal dimensions are required, and how they should be weighted, to satisfactorily diagnose the emotional states reported by the users of the system (see also Frijda & Swagerman, 1987).

Obviously, the expert system approach could provide a principled way of comparing rival appraisal theories and bring about further convergence. The requirement for using this approach in critical experiments opposing different theories is that pertinent questions for the hypothesised appraisal dimensions or criteria can be formulated and that explicit, quantified predictions for an overlapping set of emotion concepts are made by each of the respective theories. In principle, these requirements could be met by most, if not all, of the appraisal theories reviewed in the introduction. Although the present version of GENESE is based on the determination of Euclidian distance in a vector space, it is certainly feasible to implement a configurational, rule-based algorithm if that were to be preferable for a comparison between theories.

The automatic computer-based administration of GENESE allows for easy and economical administration of the procedure to large numbers of subjects, providing a high degree of anonymity. In consequence, the system seems to be well suited to collect large sets of data that would allow to base predictions at least in part on stable empirical patterns. Although some scholars in this area seem convinced that theoretical predictions should be made totally independently of empirical evidence, the present author believes that theory development and refinement must occur in a constant interactive process with empirical data collection. Thus, the predictions made on the basis of the stimulus evaluation check notion of the component process model (Scherer, 1984a,b, 1986, 1988) will change as a result of continuous empirical research. Concretely, the empirically found input patterns (as aggregated over many respondents) for the emotions reported in the study above, in so far as errors in answering the questions can be excluded, will be used to modify the theoretical prediction vectors in the standard version of GENESE.

The development and use of the expert system as a tool for refining theory has just started and new ways of making use of the information provided by the system are being explored. Although at present only the experienced intensity of the emotion is to be judged, future versions of the system will contain additional questions on the duration of the emotion episode and expressive and psychophysiological responding. This should allow to examine the relationship between appraisal patterns on the one hand and specific response patterning on the other. One possible use of this procedure might be to determine to what extent theoretical predictions only work in situations characterised by particular response profiles.

Such refinement may also help to study the issue of pure vs. blended emotions. More generally, GENESE might allow an empirical access to the issue of whether there are basic or fundamental emotions and how many there are of these. Users can specify new emotion concepts not contained in the "knowledge base" if neither of two attempts at a diagnosis have provided a satisfactory classification. The name given to this state is then associated with the input vector provided for the respective appraisal. One can determine, once a large number of such added emotion concepts has been obtained, which states (as defined by highly similar appraisal vectors) reoccur very frequently and ought to be added to the basic version of the system. In addition, these data allow to study the labelling used for specific appraisal patterns in a more inductive fashion.

GENESE also allows us to study individual differences in the appraisal process. Because information about age and gender is obtained, it will be possible, given a large number of respondents, to investigate the effect of these variables on the appraisal patterns reported for specific emotional experiences. More background information could be obtained to refine this kind of analysis. Even more importantly, as the system is able to learn, i.e. modify the appraisal vectors on the basis of the empirical input (see section on the design of GENESE earlier), it is also possible to determine user-specific emotion appraisal patterns. For example, a group of users could be asked to use the system repeatedly over a period of some months, entering each week some of the major emotions that occurred. It would then be possible to compare the resulting matrices, having been adjusted to the empirical appraisal pattern input for each situation in order to find interindividual differences in emotion-antecedent appraisal. This might provide interesting insights into the issue of habitual emotionality and may even lead to a better understanding of moods or affective disturbance.

Manuscript received 23 March 1992
Revised manuscript received 15 August 1992

REFERENCES

Arnold, M.B. (1960). *Emotion and personality*. Vols 1 and 2. New York: Columbia University Press.

De Rivera, J. (1977). A structural theory of the emotions. *Psychological Issues, 10* (4), Monograph 40.

Ekman, P. (1984). Expression and the nature of emotion. In K.R. Scherer & P. Ekman (Eds), *Approaches to emotion*. Hillsdale, NJ: Lawrence Erlbaum Associates Inc, pp. 319–344.

Ekman, P. (1992). An argument for basic emotions. *Cognition and Emotion, 6*, 169–200.

Ellsworth, P.C. & Smith, C.A. (1988). From appraisal to emotion: Differences among unpleasant feelings. *Motivation and Emotion, 12*, 271–302.

Folkman, S. & Lazarus, R.S. (1985). If it changes it must be a process: Study of emotion and coping during three stages of a college examination. *Journal of Personality and Social Psychology, 48*, 150–170.

Frijda, N. (1986). *The emotions*. Cambridge University Press.

Frijda, N.H. (1987). Emotion, cognitive structure, and action tendency. *Cognition and Emotion, 1*, 115–143.

Frijda, N.H., Kuipers, P., & ter Schure, E. (1989). Relation among emotion, appraisal, and emotional action readiness. *Journal of Personality and Social Psychology, 57*, 212–228.

Frijda, N. & Swagerman, J. (1987). Can computers feel? Theory and design of an emotional system. *Cognition and Emotion, 1*, 235–258.

Frijda, N.H., Mesquita, B., Sonnemans, J., & van Goozen, S. (1991). The duration of affective phenomena, or emotions, sentiments and passions. K. Strongman (Ed.), *International review of emotion and motivation*. New York: Wiley, pp. 187–225.

Gehm, Th. & Scherer, K.R. (1988) Relating situation evaluation to emotion differentiation: Nonmetric analysis of cross-cultural questionnaire data. In K.R. Scherer (Ed.), *Facets of emotion: Recent research*. Hillsdale, NJ: Lawrence Erlbaum Associates Inc, pp. 61–78.

Izard, C.E. (1977). *Human emotions*. New York: Plenum.

Johnson-Laird, P.N. & Oatley, K. (1989). The language of emotions: An analysis of a semantic field. *Cognition and Emotion, 3*, 81–123.

Lazarus, R.S. (1968). Emotions and adaptation: Conceptual and empirical relations. In W.J. Arnold (Ed.), *Nebraska Symposium on Motivation*, Vol. 16. Lincoln, NE: University of Nebraska Press, pp. 175–270.

Lazarus, R.S. (1984a). Thoughts on the relations between emotion and cognition. In K.R. Scherer & P. Ekman (Eds), *Approaches to emotion*. Hillsdale, NJ: Lawrence Erlbaum Associates Inc, pp. 247–257.

Lazarus, R.S. (1984b). On the primacy of cognition. *American Psychologist*, 39, 124–129.

Lazarus, R.S. & Smith, C.A. (1988). Knowledge and appraisal in the cognition-emotion relationship. *Cognition and Emotion, 2*, 281–300.

LeDoux, J.E. (1987). Emotion. In F. Plum & V. Mountcastle (Eds), *Handbook of physiology. Nervous system*, Vol. 5. *Higher functions*. Washington, DC: American Physiological Society, pp. 419–459.

LeDoux, J. E. (1989). Cognitive-emotional interactions in the brain. *Cognition and Emotion, 3*, 267–289.

LeDoux, J.E., Farb, C., & Rugiero, D.A. (1990). Topographic organization of neurons in the accoustic thalamus that project to the amygdala. *The Journal of Neuroscience, 10*, 1043–1054.

Leventhal, H. & Scherer, K.R. (1987). The relationship of emotion and cognition: A functional approach to a semantic controversy. *Cognition and Emotion, 1*, 3–28.

Manstead, A.S.R. & Tetlock, P.E. (1989). Cognitive appraisals and emotional experience: Further evidence. *Cognition and Emotion, 3*, 225–240.

Mauro, R., Sato, K., & Tucker, J. (1992). The role of appraisal in human emotions: A cross-cultural study. *Journal of Personality and Social Psychology, 62*, 301–317.

Mees, U. (1985). Was meinen wir, wenn wir von Gefühlen reden? Zur psychologischen Textur von Emotionswörtern. *Sprache und Kognition, 1*, 2–20.

Ortony, A., Clore, G. L., & Collins, A. (1988) *The cognitive structure of emotions*. Cambridge University Press.

Reisenzein, R. & Hofmann, T. (1990). An investigation of dimensions of cognitive appraisal in emotion using the repertory grid technique. *Motivation and Emotion, 14*, 1–26.

Reisenzein, R. & Schönpflug, W. (1992). Stumpf's cognitive-evaluative theory of emotion. *American Psychologist, 47*, 34–45.

Roseman, I.J. (1984). Cognitive determinants of emotion: A structural theory. In P. Shaver (Ed.), *Review of personality and social psychology*, Vol. 5. *Emotions, relationships, and health*. Beverly Hills, CA: Sage, pp. 11–36.

Roseman, I.J. (1991). Appraisal determinants of discrete emotions. *Cognition and Emotion, 5*, 161–200.

Roseman, I.J., Spindel, M.S., & Jose, P. E. (1990). Appraisal of emotion-eliciting events: Testing a theory of discrete emotions. *Journal of Personality and Social Psychology, 59*, 899–915.

Scherer, K.R. (1981). Wider die Vernachlässigung der Emotion in der Psychologie. In W. Michaelis (Ed.), *Bericht über den 32. Kongreß der Deutschen Gesellschaft für Psychologie in Zürich 1980*. Göttingen: Hogrefe, pp. 304–317.

Scherer, K.R. (1982). Emotion as a process: Function, origin, and regulation. *Social Science Information, 21*, 555–570.

Scherer, K.R. (1983). Prolegomina zu einer Taxonomie affektiver Zustände: Ein Komponenten-Prozeß-Modell. In G. Lüer (Ed.), *Bericht über den 33. Kongreß der Deutschen Gesellschaft für Psychologie in Mainz*. Göttingen: Hogrefe, pp. 415–423.

Scherer, K.R. (1984a). On the nature and function of emotion: A component process approach. In K.R. Scherer & P. Ekman (Eds), *Approaches to emotion*. Hillsdale, NJ: Lawrence Erlbaum Associates Inc, pp. 293–317.

Scherer, K.R. (1984b). Emotion as a multicomponent process: A model and some cross-cultural data. In P. Shaver (Ed.), *Review of Personality and Social Psychology*, Vol. 5. Beverly Hills, CA: Sage, pp. 37–63.

Scherer, K.R. (1986). Vocal affect expression: A review and a model for future research. *Psychological Bulletin, 99*, 143–165.

Scherer, K.R. (1988). Criteria for emotion-antecedent appraisal: A review. In V. Hamilton, G.H. Bower, & N.H. Frijda (Eds), *Cognitive perspectives on emotion and motivation*. Dordrecht: Nijhoff, pp. 89–126.

Scherer, K.R. (1993). Neuroscience projections to current debates in emotion psychology. *Cognition and Emotion, 7*, 1–41.

Scherer, K.R. & Tannenbaum, P.H. (1986). Emotional experiences in everyday life: A survey approach. *Motivation and Emotion, 10*, 295–314.

Scherer, K.R. & Wallbott, H.G. (Submitted). *Evidence for universality and cultural variation of differential emotion response patterning*. University of Geneva.

Scherer, K.R., Wallbott, H.G., Matsumoto, D., & Kudoh, T. (1988). Emotional experience in cultural context: A comparison between Europe, Japan, and the USA. In K.R. Scherer (Ed.), *Facets of emotion: Recent research*. Hillsdale, NJ: Lawrence Erlbaum Associates Inc, pp. 5–30.

Scherer, K.R., Wallbott, H.G., & Summerfield, A.B. (Eds) (1986). *Experiencing emotion: A crosscultural study*. Cambridge University Press.

Smith, C.A. & Ellsworth, P.C. (1985). Patterns of cognitive appraisal in emotion. *Journal of Personality and Social Psychology, 48*, 813–838.

Smith, C.A. & Ellsworth, P.C. (1987). Patterns of appraisal and emotion related to taking an exam. *Journal of Personality and Social Psychology, 52*, 475–488.

Solomon, R.C. (1976). *The passions. The myth and nature of human emotion*. Garden City, NY: Doubleday.

Tesser, A. (1990). Smith and Ellsworth's appraisal model of emotion: A replication, extension, and test. *Personality and Social Psychology Bulletin, 16*, 210–223.

Tomkins, S.S. (1984). Affect theory. In K.R. Scherer & P. Ekman (Eds), *Approaches to emotion*. Hillsdale, NJ: Lawrence Erlbaum Associates Inc, pp. 163–196.

Wallbott, H. & Scherer, K.R. (1986). How universal and specific is emotional experience? *Social Science Information, 26*, 763–795.

Weiner, B. (1982). The emotional consequences of causal attributions. In M.S. Clark & S.T. Fiske (Eds), *Affect and cognition. The 7th Annual Carnegie Symposium on Cognition*. Hillsdale, NJ: Lawrence Erlbaum Associates Inc, pp. 185–209.

Weiner, B. (1986). *An attributional theory of motivation and emotion*. New York: Springer.

Zajonc, R.B. (1980). Thinking and feeling: Preferences need no inferences. *American Psychologist, 35*, 151–175.

Zajonc, R.B. (1984). On primacy of affect. In K.R. Scherer & P. Ekman (Eds), *Approaches to emotion*. Hillsdale, NJ: Lawrence Erlbaum Associates Inc, pp. 259–270.

Zajonc, R.B. & Markus, H. (1984). Affect and cognition: the hard interface. In C.E. Izard, J. Kagan, & R.B. Zajonc (Eds), *Emotions, cognition, and behavior*. Cambridge University Press, pp. 73–102.