

## What is emotion?

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### Abstract

There is no consensus in the literature on a definition of emotion. The term is taken for granted in itself and, most often, emotion is defined with reference to a list: anger, disgust, fear, joy, sadness, and surprise. This article expands on a thesis that motivational states can be compared to each other by means of a common currency (Philos. Trans. Roy. Soc. Lond. 270 (1975) 265–293). I have previously argued that this common currency is pleasure. Such a conclusion is based not on introspective intuition, as with early pre-scientific psychology (Mill (1869)), but on experimental methods. As a follow-up to a definition of consciousness (Neurosci. Biobehav. Rev. 20 (1996) 33–40) as a four-dimensional experience (quality, intensity, hedonicity, and duration), I propose here that *emotion is any mental experience with high intensity and high hedonic content* (pleasure/displeasure).

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‘The importance of clearly defining (and redefining) terms that describe behavioral processes as our knowledge of the underlying physiological mechanisms advances has repeatedly been emphasized’ (White, 1989).

White’s above statement has been applied to reward and reinforcement (White, 1989), to physiological psychology (Milner and White, 1987), to

sensation (Cabanac, 1994), and to consciousness (Cabanac, 1996). It also seems applicable to emotion. A definition of emotion is needed (Griffiths, 1997), ‘Although an enormous literature exists on the psychobiology of affect, there is no singular or even preferred definition of emotion’ (Chapman and Nakamura, 1998). In 1981 Kleinginna and Kleinginna listed 92 different definitions of emotion, plus their own, and nine skeptical statements compiled from the literature on emotion (Kleinginna and Kleinginna, 1981).

Emotion has been defined as a ‘sudden trouble, transient agitation caused by an acute experience

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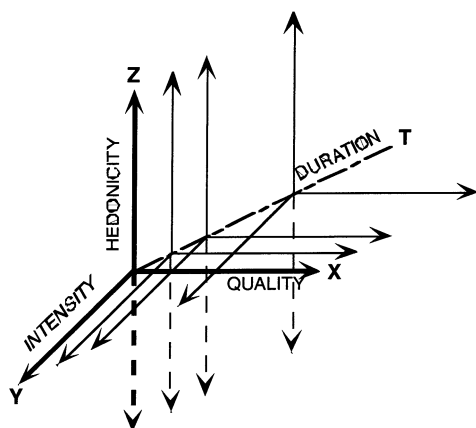


Fig. 1. A four-dimensional model of consciousness. *X*, identifies the nature of the mental object present in consciousness (sensation, memory recall, etc.). *Y*, is a measure of its intensity (barely experienced, faint, clear, loud, intense, etc.). *Z*, is the amount of pleasure or displeasure experienced, from extreme displeasure (negative), to extreme pleasure (positive); N.B. this dimension can be nil (indifference). *T*, is time and describes the duration of the mental experience.

of fear, surprise, joy, etc.’ (Larousse Dictionary, 1990), or a ‘mental feeling or affection (e.g. pain, desire, hope, etc.) as distinct from cognitions or volitions’ (Oxford English Dictionary, 1987). The Dictionary of Cognitive Psychology (Oatley, 1994) does not formally define emotion, but an operative definition emerges from its five pages devoted to emotion: emotion is a mental state. This is not trivial, since emotion has been considered to be merely a somatic response (Cannon, 1927).

Following Cannon, several authors see as being intrinsic of emotion the physiological responses that take place in emotionalized subjects. For example:

‘Although emotions have long been categorized as purely cognitive, it is now clear that the mental representation of an emotional experience includes motor and visceral components as well as cognitive ones’ (Dantzer, 1989).

Schachter and Singer (1962) define emotion as ‘a state of physiological arousal and of

cognition appropriate to this state of arousal.’

Whether the James–Lange or the Cannon concept of emotion is preferred, a common factor emerges from these various sources: emotion is a mental state, even when somatic signals participate in this mental experience. For example, according to Scherer (1993) all cognition participates more or less in emotion and Griffiths (1997) considers emotion as an ‘irruptive motivational complex in higher cognition’ (p. 243). Problems begin when one tries to define further; dictionaries and specialists overcome the difficulty simply by adding a list of emotions: anger, disgust, fear, joy, sadness, and surprise (e.g. Lazarus, 1991; Smith and Lazarus, 1993).

I shall limit myself to the *description of the mental experience* taking place in consciousness (Baars’ 1994 ‘global workspace’) during emotion, i.e. to what is experienced during emotion and the descriptive verbal analyses of the mental experience of emotion. A good defense of this type of approach to mental objects is found in (Searle, 1998). Therefore, I shall be only marginally concerned with the corollary problems of:

- 1) the neural structures of the brain where emotion takes place and the neurotransmitters involved (Dantzer et al., 1996). We may accept that emotion, like other mental experiences is the result of nervous activity, taking place in the brain.<sup>1</sup> Further neuropsychological analyses may be found in: Panksepp (1991), Parrott and Schulkin (1993), Scherer (1993), Rolls (1994), Damasio (1995), LeDoux (1996), Lane et al. (1997, 1998), Phillips et al. (1998), Watt (1998).
- 2) what causes the emotions, the role of peripheral responses and the James–Lange relationship between response and consciousness, (e.g. Zajonc, 1980; Ekman et al., 1983; Pecchinenda and Smith, 1996); and also what are, in turn,

<sup>1</sup> Until the 17th century, the heart was considered to be the seat of the soul and emotion (Coop-Phane, 1998), probably because emotional tachycardia is felt during some emotions.

the somatic responses to emotion. For Ekman et al., 1983 six different kinds of emotions produce different somatic patterns;

- 3) the specific roles of emotions. Presumably emotions have evolved through their adaptive value in life tasks (Smith and Lazarus, 1990; Ekman, 1992; Parrott and Schulkin, 1993), and in particular their part in communication (Oatley and Johnson-Laird, 1987; Kappas, 1991).
- 4) the phylogeny of emotion. We are concerned here only with human emotion. Presumably, emotion was maintained by natural selection from some remote ancestors of ours, down to us. This is treated elsewhere (Cyrułnik, 1998; Cabanac, 1999).

## 1. Starting point

In 1979 I have proposed that sensation should exhibit four-dimensions (see Eq. (1) and Fig. 1).

$$\psi = f(x[t], y[t], z[t]) \quad (1)$$

$\psi$ , is the mental experience and the four-dimensions are duration (axis  $T$ ), quality (axis  $X$ ), intensity (axis  $Y$ ), and pleasure/displeasure<sup>2</sup> (axis  $Z$ ). If we accept that sensation was the origin of all consciousness, this model should apply to all forms of mental experience (Cabanac, 1996). One may reach this conclusion by introspection alone, or by deduction:

- 1) according to evolutionary psychology, natural selection operates on consciousness.

<sup>2</sup> I formerly used the word affectivity. On reading a recent article by Watt (1998), I realized that I have been misled by similar cognates in French and English and have used erroneously for years the words 'affective' and 'affectivity' when I meant 'pleasurable' and 'pleasure'. In French, my most familiar language, 'affect' means elementary feeling of attraction or repulsion (i.e. I like or I dislike) and 'affectivité' is the area of consciousness dealing with affect. I discover only now that in English 'affective' means pertaining to the emotions (Oxford English Dictionary). In the present article I shall use 'hedonic' and 'pleasure/displeasure' for what I call 'affectif' and 'affectivité' in French.

- 2) this leads to the following postulate: consciousness evolved from sensation.
- 3) with a corollary: consciousness should exhibit the four-dimensional structure of sensation.

The four-dimensions are largely independent from one another. If the  $X$ -,  $Y$ -, or  $T$ -dimensions are multiplicative, i.e. if any of them is nil, there is no conscious experience. But the  $Z$ -dimension, pleasure/displeasure, can be nil. This article is an attempt to verify whether the four-dimensions apply to the special case of consciousness as constituted by emotion.

## 2. First proposition

Having accepted that emotion is a mental experience, the following will examine only whether the four-dimensional mathematical description of consciousness applies to emotion also. Roy (1998) stated that the usefulness of a theory or hypothesis lies in its predictive value. If emotion takes place in consciousness, it should also possess the four-dimensions of sensation and consciousness.

I shall examine emotion from this point of view, one axis at a time.

## 3. The qualitative dimension ( $X$ -axis)

In *consciousness* this dimension identifies the nature of the mental event, in the same way that it identifies the nature of various stimuli felt by the subject. An idea, like a sensation, is a mental representation, or model, of reality. The  $X$ -axis, the quality of mental experience, has no bearing for the purposes of this discussion on the anatomical support of consciousness in the brain. This dimension is non-parametric and is made of an infinite number of discrete items: on this axis, we can find various sensations, and all possible mental objects. There is no limit in the number of potential items on this axis. The highest level of complexity on this axis, in normal human subjects, is probably self-awareness. A useful discussion on

this point is found in Baars (1994) and Baars and Newman (1994).

### 3.1. Does this dimension apply to emotion?

The usual list of various emotions—anger, disgust, fear, joy, sadness, and surprise—can take place obviously on this axis. In addition contempt has been proposed as a basic emotion (Ekman and Friesen, 1986). This short list contains only words from folk-psychology and might depend on the speaker's language. A classic case where a concept is absent due to a lack of words is ancient Greek, which uses the same word for heat and temperature. In the case of emotions, the example of *amae* is particularly eloquent. In Japanese *amae* describes the emotion of warm bonding to a parent, or an institution: it is a deeply gratifying sense of childlike dependency on a person or institution, a feeling of belonging (Morsbach and Tyler, 1986). It is not too surprising to find no such word in English, a language that evolved in a society dominated by the nuclear family model, while *amae* is used in a country of *famille souche* (Todd, 1990). Another example is happiness (Ekman et al., 1983) sometimes used as synonymous with joy. I have proposed elsewhere (Cabanac, 1986) that joy is a dynamic, transient, and pleasant experience whereas happiness is a stable indifference; the same dual semantics, and ambiguity, is encountered in temperature sensation with the words pleasure and comfort.

Consequently, when it comes to identifying emotions, joy should be preferred to happiness.

Other mental objects are often referred to as emotions: hope, desire, pain, sadness, sorrow, jealousy. Each of these emotions can be characterized as a mental object in response to a stimulus. In all these cases, emotion may be described as a mental model of some stimulus or event occurring either in the subject's environment, within the subject's body, or purely mental. A stimulus can result from perception, or imagination. For example the sound of a predator, the odor of a meal, the vision of a sexual rival may be considered to be qualitative signals on the *X*-axis. The imaginary

evocation of a crash while flying on an airplane, or the outcome of an academic examination by a student, may be considered to be taking place on the *X*-axis.

What these 'emotions' have in common is that they are all aroused by exposure of the subject to situations more or less related to motivation, either positive or negative but all resulting in a behavior oriented towards, or away from, the stimulus. All these motivations have strong hedonic dimensions on the hedonic axis *Z*, as will be recognized in the following. For now, we may accept that they are all mental responses to various stimuli. Thus, emotion is a response to a stimulus that can be sensorial i.e. originating from any afferent nervous pathway (Cabanac, 1994), or mental, resulting from the subject's imagination or memory. Thus the qualitative *X*-axis variable can depict an infinite number of stimuli as potential producers of emotion. Each different stimulus will arouse a different qualitative emotion. Such a way of looking at emotion incorporates all emotions into a single category. Different emotions are simply responses to different stimuli.

## 4. The intensive dimension (*Y*-axis)

In *consciousness*, this *Y* dimension, identifies the intensity of the mental experience in the same way that it identifies the magnitude of a sensation's stimulus. The intensive dimension is easy to understand in the case of sensation, but less so in the case of consciousness. Contrary to the qualitative dimension above, the intensive dimension is a parametric variable with a continuum from zero intensity (absence of consciousness) to the highest levels of intensity. Thus, a gradation of intensity exists among mental experiences. Intensity is independent of quality, hedonicity, and duration, but may co-vary with these variables.

Many authors have pointed out before that consciousness can be analyzed as a structure with several levels of intensity. Here are a few examples: For Taylor et al. (1998), the state of consciousness requires neural support involving a connected

network of many brain areas at differing levels. At the lowest level is non-aware processing, of which there is no direct awareness. There are also modules involved in processing with awareness but without focused attention. Finally, there must be a set of modules involved in directing attention in a controlled manner (Taylor et al., 1998). For Baars and Newman (1994), the most intense idea or conscious event at a given time occupies the forefront of consciousness, hiding the other less intense ones, e.g. the existence of selective attention. Cowey (1997) proposed a list of seven kinds of consciousness (Table 1). This list, however, does not appear homogenous: items 2–6 may be considered to be different categories and should appear on the *X*-axis, quality of consciousness. Thus the four-dimensional model is useful for discriminating between quality and intensity. Indeed, items 1, 3, and 7 fit well on the *Y*-axis, the intensity of consciousness and confirm a graded intensity in consciousness. The items ‘unconscious’, ‘coma’, and ‘deep sleep’ would qualify for consciousness intensity zero, and higher awareness for high intensity consciousness.

#### 4.1. *It is easy to see that this axis is especially appropriate to emotion*

The intensity of the mental experience may even be a prerequisite for emotion (Nash, 1989). Griffiths (1997) considers emotion to be an ‘irruptive motivational complex in higher cognition’ i.e. with a strongly intensive component.

Table 1  
Cowey’s list of varieties of consciousness

Unconscious, coma, deep sleep
Unconscious, dream sleep
Simple awareness of sensory stimuli: light, sounds smells, etc.
Awareness of symbolic representations: we identify the stimuli, e.g. your home
Awareness of conditions: hunger, thirst, fatigue, etc.
Conscious recall of events or knowledge, imagery, voluntary selective attention
Higher awareness: reasoning, self-control, etc.

Table 2  
Sonnemans and Frijda intensities of emotions

Duration of the emotion and delay of its onset and peak
Perceived bodily changes and strength of felt passivity
Recollection and re-experience of the emotion
Strength and drasticness of action tendency
Belief changes and influence upon long-term behavior
Overall felt intensity

Sonnemans and Frijda (1994) recognized six factors of the intensity of emotion (Table 2). Arguably, item 1 would fit more with duration, the *T*-axis, as defined in the present article, items 2 and 3 with the qualitative *X*-dimension, items 4 and 5 apply to the motivation to act and would fit better with the hedonic *Z*-axis as defined below. Sonnemans and Frijda (1995) also hypothesized that four groups of feelings determine the subjective intensity of emotion: concern, appraisal, regulation, and individual differences. Any of these events or stimuli, if at a low intensity, would unlikely arouse emotion. On the contrary, it may be accepted that high intensity is a prerequisite for emotion as pointed out by Sonnemans and Frijda. Yet, the reverse is not true; an intense experience may be related to sensation or to problem solving, without being emotional. Finally, Ekman’s (1992) distinction between basic emotions and more subtle emotions may find its place on this intensive *Y*-axis.

The relation of intensity with emotion has already been recognized by several authors. According to the ‘New (Pure) Cognitive Theory,’ emotional thoughts are believed or desired more intensely than normal. Thus, any thought can arouse an emotion; it is the intensity of the mental event that makes the emotion (Nash, 1989). I believe, however, that intensity is a necessary but not sufficient condition. If this mental event is neither pleasant nor unpleasant, it does not qualify as an emotion. Thus, surprise, classified sometimes as an emotion (Ekman et al., 1983) should be considered as such only when clearly pleasant or unpleasant, as will be seen in the following.



## 5. The hedonic dimension (Z-axis)<sup>3</sup>

In *consciousness* we find little difficulty in accepting that a mental experience is either unpleasant, indifferent, or pleasant, in the same way as sensation is. Young (1959) defined the hedonic process from its three attributes: sign (pleasant or unpleasant), intensity, and duration. Intensity and duration would appear on the *Y*- and *T*-axes; pleasant/unpleasant on the *Z*-axis. Duncker (1940–1941) listed four types of causes of pleasure (Table 3). Thus, he hinted that various mental experiences could be listed on the same hedonic dimension. Like the quantitative dimension, the hedonic dimension of consciousness is a continuum where the following landmarks merge into one another: distress, extreme displeasure, acute displeasure, slight displeasure, indifference, slight pleasure, acute pleasure, delight, rapture. The hedonic dimension can be nil, in which case the mental experience is indifferent.

The *Z*-axis is that of motivation and decision making. To prioritize the multiple motivations that compete for access to the behavioral final common path, the brain needs a common currency (McFarland and Sibly, 1975; McNamara and Houston, 1986). Pleasure serves as the common currency for the trade-offs that take place in the mind to rank priorities and ensure that the most urgent motivation has first access to the behavioral final common path (Cabanac, 1992). Thus, this hedonic axis defines the desire for a stimulus or a goal, but the intention to act depends on the algebraic sum of several simultaneous positive and negative desires on this axis. Indeed, a common currency for motivations as different from each

Table 3

Dunker's four types of causes of pleasure

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1. Sensory enjoyment (or displeasure) i.e. to enjoy the stimulus or the consequences of behavior
  2. Aesthetic enjoyment i.e. to strive for a better understanding
  3. Desire (e.g. for a steak, a book, a love, etc.), not a reaction but the fulfillment of a need
  4. Pleasure in achievement, dynamic joy of succeeding, in victory
- 

other as those of Duncker's four categories is necessary to permit competition and trade off for access to behavior. Therefore, physiological, ludic, social, esthetical, moral, religious motivations can be compared to one another according to the amount of pleasure and displeasure they arouse.

The main properties of sensory pleasure should also belong to consciousness. Sensory pleasure is contingent, is transient, indicates useful stimuli, and motivates behavior. One can easily recognize that the hedonic dimension of mental events is contingent (what I have called alliesthesia, Cabanac, 1971, 1979). Normally I am indifferent to my keys. If I discover at work that I have lost them, my thoughts of them are unpleasant. If I find my keys on my way home, my thoughts of them are now quite pleasant.

Pleasure is transient, a quality that we can recognize in global consciousness. Happiness is considered generally to be the aim of life. Yet, the pursuit of happiness is fallacious if one does not know what happiness is. Just as there are two different elements in sensation-sensory pleasure, highly positive but transient, and comfort, indifferent but stable—it is possible to recognize two elements in the pleasure/displeasure of global consciousness: positive and transient joy, and indifferent but stable happiness (Cabanac, 1986).

Knowing that sensory pleasure indicates the physiological usefulness of a stimulus, the corollary of the postulate that consciousness evolved from sensation entails that joy indicates useful mental event. The relationship of joy to usefulness may become more complex with the increased complexity of mind processes. Yet, simple situations show that joy occurs during optimal mental functioning (Cabanac et al., 1997) a pattern similar

<sup>3</sup> Some authors, especially economists, in an attempt at objectivity reject mentalistic vocabulary and concepts and use the word utility rather than the word pleasure. As pointed out by Kahneman et al. (1997), 'utility' is ambiguous as the word can refer to a stimulus as well as the mental experience of a stimulated subject. To remove the ambiguity they propose to use 'experienced utility' for the mental event and 'decision utility' for the stimulus attribute. I find simpler and less jargonic to use the vernacular vocabulary and, in the present article, will call a spade a spade; therefore I shall use the words 'pleasure' for the mental experience and 'pleasantness' for the attribute of a stimulus.

to the occurrence of pleasure during useful behaviors (Cabanac, 1992).

The final property of sensory pleasure is its capacity to motivate behavior. Seeking maximizing sensory pleasure results in a stimulus-seeking behavior. Does this apply to joy? Philosophers generally accept this. Duncker (1940–1941) has sorted the philosophers into hedonists for whom pleasure (joy) is the motivation to behave and hormists for whom pleasure (joy) is the outcome of behavior. In both cases pleasure (joy) is one way or another both the goal and the drive. It even may be hypothesized that the pursuit of pleasure/joy for its own sake has been the driving force of the evolution towards complexity of the human mind, because this Z-axis defines the desire for a stimulus or a goal. The intention to act depends on the algebraic sum of several simultaneous positive and negative desires. Thus this Z-axis is the seat and the source of permanent pre-rational computation and the locus of motivation to consume or reject, to achieve or avoid (Cabanac, 1992; Cabanac et al., 2002).

### 5.1. Does emotion follow the same pattern?

‘The basic postulate, adhered to consistently throughout this study, is that emotion is a disruption or disorganization of the total individual, and not an integrated process’ (Young, 1943).

Contrary to that view, emotion is now seen as an integrative response the biological function of which is primarily homeostatic (e.g. see Plutchik, 1965; Stanley-Jones, 1966; Lang et al., 1998). Because pleasure is a sign of usefulness, one would expect emotion to be highly hedonic, either positively or negatively.

As mentioned above, several authors have underlined the hedonic experience of emotion: Ekman et al. (1983) have considered disgust, sadness, anger, fear, and happiness as emotions. These categories would fit particularly well on the hedonic Z-axis, with clear pleasure/displeasure components. Sonnemans and Frijda (1994) cate-

gories 4, strength and drasticness of action tendency, and 5, (belief changes and influence upon long-term behavior), (Table 2) are obviously motivational in nature.

Oatley and Johnson-Laird (1987) have proposed five basic emotions: happiness, sadness, anger, fear, disgust which occur with the achievement of sub-goals, loss of a goal, frustration of a goal (or plan) by another person, conflict of goals (including conflict with self preservation), perception that something is noxious or toxic. Thus, they insist on the pleasure/displeasure involved in emotion. Although they were not labeled ‘hedonic’ by these authors, one can easily recognize hedonicity in these emotions, and their outcomes, and thus their motivational nature.

Damasio (1995) has convincingly argued that impairment of the emotional process undermines the patient’s capacity to make decisions. Such a statement is in line both with this present article that emotion exhibits four-dimensions, and with the contention that pleasure/joy is the dimension of consciousness that motivates the subject towards useful behaviors. When the hedonic dimension is lost, or is severed from its normal function in the conscious process, one would expect as well to find emotional impairment and impediment of decision making, as discovered by Damasio.

*A-contrario* evidence of the Z-axis’ primordial role of pleasure/displeasure, in emotion may be found in alexithymia. Patients suffering from this syndrome were considered to be simply unable to put emotion into words (alexia); however it has recently been proposed that they actually suffer from an impoverished mental experience of emotion (Lane et al., 1997). Indeed, alexithymia is characterized by a decreased capacity to experience pleasure (Prince and Berenbaum, 1993). If so, we could say that these patients have lost the Z-axis, pleasure/displeasure dimension of their consciousness. These subjects may suffer from a deficit in their ability to make decisions. Actually, Lane et al. (1997) indicate that these patients express their discomfort with uncertainties and complexities, a symptom described by Damasio (1995) also in patients with emotion deficit. This would be in line with the hedonic axis of consciousness being the motivational dimension, especially active in emo-

tion. The lack of pleasure/displeasure impairs emotion *and* motivation.

Chevalley and Belzung (2002) pinpointed the paradox that emotion ‘often if not always emerge as a contingent process.’ The same stimulus or situation may arouse different emotions at different times. In that regard, emotion follows narrowly the pattern of sensory alliesthesia where a given stimulus can arouse pleasure or displeasure depending on signals from the body core (Cabanac, 1971).

If we return to the dictionary definition of emotion as a simple list including: surprise, fear, anger, love, hope, desire, pain, contempt, sadness, disgust, joy, sorrow, and *amae*, we may recognize that the elements of this list fall into three categories according to their polarity, but they are all strongly hedonic:

- desire and surprise can be unpleasant or pleasant, depending on the nature of the stimulus or event expected or presented;
- fear, anger, desire, pain, sadness, disgust, sorrow, contempt, and jealousy all possess a strong negative hedonic dimension;
- love, joy, hope, and *amae* possess a strong positive hedonic dimension.

Thus, no emotion from the list is hedonically indifferent.

I accept, therefore, that all emotions possess a strong hedonic dimension, either positive (pleasure) or negative (displeasure). In all these cases emotion may be described as a ‘mental model of some stimulus or event occurring either in the subject’s environment, or purely mental’. What these ‘emotions’ have in common is that they are all intense mental events aroused by exposure of the subject to situations more or less related to motivation, either positive or negative but all resulting in a behavior oriented to, or away from, the stimulus. Without this dimension the mental experience does not qualify as emotion. It may be proposed, therefore, that this hedonic dimension is what pathognomonically defines emotion.

Such a conclusion would be consistent with emotion as intentional experience (Kenny, 1963)

with the primacy of pleasure/displeasure in emotion (Zajonc, 1980), with the proposition that emotion is motivational and includes strong desires (Marks, 1982), and with the notion that ‘emotions can usefully be considered as states produced by reinforcing stimuli’ (Rolls, 1994). From experimental results, Watson et al. (1999) were led to distinguish two main axes in motivational consciousness: arousal and pleasure. Thus, they identified two sorts of pleasure: pleasure with high arousal and pleasure with low arousal. I am tempted to see in arousal the intensity (*Y*-axis), and in pleasure the hedonicity (*Z*-axis). Therefore, their results would tend to show that hedonicity and intensity lie on different axes and can vary independently.

## 6. The time dimension of consciousness (*T*-axis)

The notion that any mental event has a limited duration should raise no other problem than the existential problem of time itself (*T*-axis of Fig. 1).

Similarly, we may accept without further discussion that emotion is limited in the time following the stimulus that aroused it. A further study of the duration of emotion in relation to a stimulus is found in Sonnemans and Frijda (1994).

## 7. Second proposition: a definition of emotion

Taking for granted that:

- 1) emotion is a mental experience,
- 2) emotion possesses the four-dimensions of all mental objects, and
- 3) that any mental object possesses already a nature and a duration, I propose that:

*Emotion is any mental experience with high intensity and high hedonicity.*

According to this definition a mental experience that is either of low intensity or low hedonicity is not an emotion. For example, surprise qualifies as



an emotion only if highly pleasant or unpleasant. Also, an emotion can have short or long duration. Finally, any mental experience may be considered as emotion, if it is intense and strongly positively or negatively hedonic. Thus, emotion can result from sensation, perception, memory recall, reckoning (assessment), and imagination. According to this definition, intense pain and sexual orgasm are emotions. Both are accompanied by the autonomic responses, facial expression, tachycardia, and sweating usually considered to be signs of emotion.

## 8. Discussion

### 8.1. The four-dimensional model

‘Research on emotion is difficult’ (Lazarus, 1991). The reason for this pessimistic statement might lie in the fact that emotion is often ill defined, as we have seen above. In this regard I find the four-dimensional model to be helpful and believe that it may have heuristic value.

‘A hypothesis about mental structure cannot be proved merely by producing an adaptive scenario in which that mental structure would be advantageous. An empirical demonstration that the mind is actually structured in that way is also required’ (Griffiths, 1997).

The four-dimensional model for emotion proposed here cannot be proven strictly speaking and, therefore, remains largely axiomatic. Direct evidence of its validity, however, can be found in the fact that the four axes can be tested independently from one another. The model is not adaptive but rather conceptual and facilitates understanding. Watt (1998) has offered a similar proposal.

Among the various definitions of emotion, Kleinginna and Kleinginna (1981) discerned four primary characteristics and within them ten categories of emotions. Their first characteristic put emphasis on the subjective experiential aspect of emotion; the above definition includes this aspect. Their second characteristic fits S–O–R paradigm;

the above definition covers this aspect, as any external stimulus or physiological response that can arouse a strong and hedonic sensation is the source of an emotion. Their third characteristic is based on the functional consequences of emotion, disruptive or adaptive. As was discussed above, the hedonic dimension of consciousness is the motivational and adaptive one; the above definition making the hedonic dimension a prerequisite for emotion covers this aspect therefore. Finally their fourth characteristic is based on the scope of the definition, multiaspects and motivational; as any mental experience may become an emotion provided it possesses strong intensity and hedonicity, the above definition is especially well suited to this characteristic. Finally, Kleinginna and Kleinginna insisted on the difficulty to differentiate emotion from motivation; the above definition lumps both in a single category.

I believe that the four-dimension model of consciousness is useful in the case of emotion because:

- a) it incorporates into one concept the notion that emotion is multidimensional, as expressed explicitly or implicitly by several other authors,
- b) it renders more evident the paramount importance of intensity and pleasure/displeasure,
- c) it provides a simple definition of emotion, and finally
- d) it is homologous with the other mental objects that are part of consciousness.

### 8.2. Previous propositions that emotion is multidimensional

The description of emotion with a multidimensional model has been proposed before explicitly or implicitly. Schachter and Singer (1962) have suggested that emotion might be produced by the interaction of two components, a non-specific arousal caused by the activation of the sympathetic nervous system and a perception resulting from one’s attribution of the cause of the arousal to the stimulus that provoked it. A similar conclusion has been reached by Leventhal and Scherer (1987), and by Parrott and Schulkin (1993), but

none of them has proposed a model or identified the various dimensions. Their definitions of emotion would fit with the *X*-qualitative, and *Z*-hedonic axes, but would ignore the intensity that I believe a prerequisite of emotion. Plutchik (1970) has proposed a tri-dimensional model as an inverted cone with intensity (e.g. distinction between fear and panic), similarity to each other (e.g. shame and guilt), and polarity (e.g. joy as the opposite of sadness), which can be a matter of degree. Russell (1980) has proposed a model of emotion with two dimensions combining in a spiral: sleepiness-arousal and misery-pleasure (*Y*- and *Z*-axes of the present article). Smith and Lazarus (1993) have described emotion as a bi-dimensional phenomenon with knowledge or belief, corresponding to quality (*X*) and appraisal with respect to significance, corresponding to pleasure/displeasure (*Z*) of the present article, although they did not propose a specific mode. Rolls (1994) has proposed a bi-dimensional description of emotion (his Figure 72-1) with two axes for negative reinforcement vs. positive reinforcement which I incorporate in the *Z*-axis of Fig. 1 above. Griffiths (1997) after Nash (1989) defined emotion as an ‘irruptive motivation in higher cognition’; such a definition would fit with the notion that emotion contains one dimension of intensity (irruptive, axis *Y*) and another one of pleasure/displeasure (motivation, axis *Z*). Finally, in a study of the perception of emotion in facial expression Russell and Fehr, (1987) plotted their results on a two-dimensional diagram with pleasure in abscissa and arousal in ordinate. Thus, they described emotion in terms of hedonicity and intensity.

There seems to exist, therefore, a rather large consensus for the multidimensional nature of emotion, but albeit with marked differences on the nature of the variables involved. Yet, intensity and hedonicity emerge—although not frequently linked to the ensemble just reviewed.

### 8.3. The motivational dimension

In the 1960’s emotion began to be thought of as an adaptive reaction to events in the life of the individual (Plutchik, 1965; Stanley-Jones, 1966).

Furthermore, the notion that emotion is useful has recently emerged from a number of publications (Oatley and Johnson-Laird, 1987; Johnson-Laird and Oatley, 1992) and has clearly been hypothesized by Damasio (1995) as the important adaptive factor in human decision-making. Knowing the fundamental role of pleasure as a mental signal of usefulness (Cabanac, 1971, 1992), a useful emotion suggests that pleasure/displeasure is essential in decision making. There are good reasons for accepting that pleasure is the common currency that allows the brain to make trade-offs among various motivations (Cabanac, 1992) and that pleasure is the sign that an efficient/optimal behavior has been chosen (Cabanac, 1996; Cabanac et al., 2002). The hedonic axis of consciousness in the model of Fig. 1, is where pleasure/displeasure takes place. Pleasure/displeasure is the mental index of usefulness. A pleasant stimulus that arouses pleasure is useful and an unpleasant one that arouses displeasure is useless or noxious. Thus, maximization of pleasure leads to well-oriented and efficacious behavioral responses. If emotion is useful, the axis that models this usefulness is the hedonic *Z*-axis. Reciprocally, emotion being defined in terms of hedonicity is synonymous to usefulness. Pleasure/displeasure is the motivation once a behaving agent does not operate only in a reflex mode. The hedonic dimension, in response to an intense stimulus is the characteristic of emotion. This has been recognized by several authors (Oatley and Johnson-Laird, 1987; Rolls, 1994; Watt, 1998).

The concept that emotion is useful and that its usefulness sits on the hedonic axis of consciousness can be discerned in the writings of several authors. Emotion is useful when it leads to rational decisions and behaviors (DeSousa, 1987). Emotions often lead people to behave in ways that conflict with calculated rationality (Frank, 1988) and emotional response can be also independent from rational evaluation (Ekman, 1980; p. 151), thus making emotion a basic, archaic mechanism where pleasure/displeasure is the pre-rational decision-maker. Taylor (1984) identified two kinds of emotions, ‘appetitive’ and ‘possessive.’ Without entering into that discussion, let us consider both types to be motivational in nature. Attitudes

towards foods can be better adapted if they are based on emotion than on cognition (Dubé and Cantin 2000). Finally, cultivating positive emotions optimizes health and well being (Fredrickson, 2000).

Ovsich (1998) also has proposed recently that motivation for any behavior lies on the hedonic Y-axis of consciousness, which is the decision-maker, a thesis that is virtually the same as that defended in the present article. This is also in line with Mellers et al. (1997) decision affect theory, according to which emotional experiences are associated with the outcomes of decisions. This theory incorporates utilities, expectations, and counterfactual comparisons into hedonic responses. The choices between risky options can be described as the maximization of expected emotional experiences, as predicted by decision affect theory. That is, people choose the risky options for which they expect to feel better on average (Mellers et al., 1997). For example, in a gambling situation the best strategy is to maximize the subjective emotion of expectation, or long run pleasure, associated with gambling (Mellers et al., 1999). Finally attitudes, which bear clear hedonic content, orient visual attention and categorization processes in a useful manner. Both of these ease decision making and enhance the quality of ultimate decisions and leave more resources available for coping with other stressors; an attitude (to the extent that it is accessible from memory) ‘provides a ready aid in ‘sizing up’ objects and events in the environment, which yields a number of benefits for the individual’ (Fazio, 2000).

If we accept that emotion is useful, it is of interest to examine briefly this notion from the point of view of evolutionary psychology proposed by Cosmides et al. (1992). After careful review of experimental evidence, Ramos and Mormède (1998) proposed recently that the concept of multidimensional nature of emotionality be extended to animals; thus, they accept it for humans. When in phylogeny did emotion begin? Briese and deQuijada (1970) have provided a tool to explore animal emotion when they showed that the core temperature of rats rises during an emotional stress. As an open-loop response this fever is more specific to emotion than Cannon’s tachycar-

dia because it is independent from exercise<sup>4</sup>. According to this criterion all mammals and birds know emotion and the evolutionary threshold for it is likely to be between amphibians and reptiles (Cabanac, 1999). If emotion is as ancient as reptiles, its retention by natural selection over millions of years argues strongly for its usefulness.

On the other hand thinking machines may be excluded from the range of emotion experiencing creatures. They indeed possess the axes X, Y, and T, but not the axis Z of consciousness. A view shared with Johnston (1999) who has explicitly stated that the human brain is different from a computer because it has the property of consciousness, with the fundamental dimension of pleasure.

#### 8.4. Emotion and the behavioral final common path

As we have seen above, for Baars and Newman (1994), the most intense idea or mental event at a given time occupies the forefront of consciousness, hiding the other less intense ones e.g. selective attention. This is perfectly coherent with the notions of ‘final common path’ and of ‘common currency’ developed in ethology (McFarland and Sibly, 1975; McNamara and Houston, 1986). These notions can be recognized, again explicitly or implicitly, in the writings of several authors.

Mellers et al. (1997) ‘decision affect theory’ implies that all sorts of signals are incorporated to reach a decision; this is in line with the notion of behavioral final common path and is consistent with the hypothesis that pleasure is the common currency. We may find additional support for the theory in Plutchik’s work as well as in more recent papers. Plutchik and Ax (1967) have convincingly argued that motivations compete with one another thus creating mixed states for emotional stresses and showing the necessity of various signals to ‘talk to one another’. The same concept has been empirically tested by Frederickson and Levenson (1998) who showed that positive emotions accelerate recovery from the cardiovascular sequels of negative emotions. Fredrickson (2000) has hy-

<sup>4</sup> The higher core temperature is indeed a fever i.e. the resetting of the body’s thermostat at a higher temperature.

pothesized further that positive emotions not only counteract negative emotions, but also broaden one's mode of thinking, thus implying that there is one common mental pathway. Ovsich (1998) has proposed the notion that 'Pleasantness of the Condition of a Subject' is the sum of all vectorial components of the stream of consciousness, and thereby accepts the concepts of behavioral common pathway and of common currency. In his words, 'pleasantness plays the role of a common and integrating orientational measure.'

### 8.5. A definition of emotion

Throughout a thorough and enlightening book on emotion, Griffiths (1997) expresses some doubts on the usefulness of the concept of emotion: 'The general concept of emotion is unlikely to be a useful concept in psychological theory' (p. 14), 'the research surveyed in this book suggests that the general concept of emotion has no role in any future psychology'. 'But as far as understanding ourselves is concerned, the concept of emotion [...] can only be a hindrance' (p. 247). A cause of such pessimism might be the lack of an appropriate definition of emotion. The definition that I proposed above should fill the semantic vacuum found in dictionaries. The new definition replaces the dictionary list of emotions. It is simpler than this list, but does not contradict it.

We saw above that Watson et al. (1999) in a way quite similar to that of Russell and Fehr (1987), were led to distinguish two main axes in motivational consciousness: arousal and pleasure. Thus, they considered that there are two sorts of pleasure: pleasure with high arousal and pleasure with low arousal.

The new definition (of emotion) is in accordance with the concept that any cognition can be a source of emotion (Scherer, 1993). It should clear up several controversies: whether emotion is primary, independent of cognition (Cannon, 1927; Lazarus, 1982, 1984), or secondary always dependent on cognition (James, 1890; Zajonc, 1980, 1984). The definition also solves the nature-nurture conundrum (see Damasio, 1998) since any mental event can arouse an emotion, provided it is intense and hedonically polarized;

'It should not be assumed that everything which counts as an emotion must involve the activation of ancient, pan-cultural, involuntary responses. In particular, higher cognitive activity need not trigger affect program responses in order to be counted as emotional.' (Griffiths, 1997).

The proposed new definition would incorporate 'attitudes', which play a broad role in decision-making and usually improve its efficacy (Fazio, 2000), such as with emotions with low intensities.

Finally, the definition inverts Watt (1998) relationship between emotion and consciousness: rather than emotion being a central organizing process leading to consciousness, emotion would be one element among others in the global workspace of consciousness.

## 9. Conclusion

The scientific study of consciousness and of all conscious experience must remain axiomatic: what proof do I have that my neighbor experiences the same color as me when he looks at what both of us call blue? In this realm of knowledge it is possible to falsify a hypothesis, but it is impossible to prove it. To remove reasonable doubts, one must bear only on correlative evidence. Roy (1998) reminded us that a useful theory is a theory that generates true predictions. The present article is an attempt to verify whether the four-dimensional model I proposed previously for sensation, then for consciousness would predict the structure of emotion (Cabanac, 1994, 1996). The present essay does not contradict the hypothesis, which can be accepted as predictive of the structure of emotion. Panksepp has proposed that a definition of emotion should be the result of research rather than its start (Panksepp, 1986). This is what has been attempted here, i.e. the result being the proposed definition of emotion, namely, as *any mental experience with high intensity and high hedonic content* (pleasure/displeasure). Intensity explains the 'disarray of the mind' classically admitted by the philosophers and well described by Chevalley and Belzung (2002). Hedonicity makes emotion a motivational experi-

ence. In turn, this definition predicts that any mental experience with high intensity and hedonicity should be accompanied with the usual objective somatic signs of emotion, such as tachycardia and fever.

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## References

- Baars, B.J., 1994. A global workspace theory of conscious experience. In: Revonsuo, A., Kamppinen, M. (Eds.), *Consciousness in Philosophy and Cognitive Neuroscience*. Lawrence Erlbaum Associates, Hillsdale, New Jersey, pp. 149–171.
- Baars, B.J., Newman, J., 1994. A neurobiological interpretation of global workspace theory. In: Revonsuo, A., Kamppinen, M. (Eds.), *Consciousness in Philosophy and Cognitive Neuroscience*. Lawrence Erlbaum Associates, Hillsdale, New Jersey, pp. 211–226.
- Briese, E., deQuijada, M., 1970. Colonic temperature of rats during handling. *Acta Physiol. Latinoam* 20, 97–102.
- Cabanac, M., 1971. Physiological role of pleasure. *Science* 173, 1103–1107.
- Cabanac, M., 1979. Sensory pleasure. *Quarterly Rev. Biol.* 54, 1–29.
- Cabanac, M., 1986. Du confort au bonheur. *Psychiat. Fr.* 17, 9–15.
- Cabanac, M., 1992. Pleasure: the common currency. *J. Theoret. Biol.* 155, 173–200.
- Cabanac, M., 1994. What is sensation? In: Wong, R. (Ed.), *Biological Perspectives on Motivated Activities*. Ablex, Norwood, New Jersey, pp. 409–428.
- Cabanac, M., 1996. On the origin of consciousness, a postulate and its corollary. *Neurosci. Biobehav. Rev.* 20, 33–40.
- Cabanac, M., 1999. Emotion and Phylogeny. *J. Consc. Stud.* 6, 176–190.
- Cabanac, M., Guillaume, J., Balaskó, M., Fleury, A., 2002. Pleasure in decision making situations. *Biomed. Central* <http://www.biomedcentral.com/1471-244X/2/71>
- Cabanac, M., Pouliot, C., Everett, J., 1997. Pleasure as a sign of efficacy of mental activity. *Eur. Psychol.* 2, 226–234.
- Cannon, W.B., 1927. The James–Lange theory of emotions: a critical examination and an alternation. *Am. J. Psychol.* 39, 106–124.
- Chapman, C.R., Nakamura, Y., 1998. A bottom up view of emotion. ASSC Seminar <http://server.phil.vt.edu/assc/watt/chapman1.html>.
- Chevalley, C., Belzung, C. Emotional behaviour as the result of stochastic interactions: a process crucial for cognition. *Behav. Proc.*, 2002.
- Coop-Phane, C., 1998. L'âme au coeur. *Med. Sci.* 14, 1089–1096.
- Cosmides, L., Tooby, J., Barkow, J.H., 1992. Introduction: evolutionary psychology and conceptual integration. In: Barkow, J.H., Cosmides, L., Tooby, J. (Eds.), *The Adapted Mind*. Oxford University Press, New York, pp. 3–15.
- Cowey, A., 1997. Current awareness: spotlight on consciousness—The 1996 Ronnie Mac Keith Lecture. *Dev. Med. Child Neurol.* 39, 54–62.
- Cyrlunik, B., 1998. Ethology of anxiety in phylogeny and ontogeny. *Acta Psychiat. Scand.* 98 (Suppl. 393), 44–49.
- Damasio, A.R., 1995. *L'erreur de Descartes*. Paris, Éditions Odile Jacob.
- Damasio, A.R., 1998. Emotion and consciousness. ASSC Seminar <http://www.phil.vt.edu/assc/esem.html>.
- Dantzer, R., 1989. *The Psychosomatic Delusion*. The Free Press, New York.
- Dantzer, R., Bluthé, R.M., Aubert, A., Goodall, G., Bret-Dibat, J.L., Kent, S., 1996. Cytokine actions on behavior. In: Rothwell, N.J. (Ed.), *Cytokines in the Nervous System*. R.G. Landes Co, Austin Texas, pp. 117–144.
- DeSousa, R., 1987. *The Rationality of Emotion*. MIT Press, Cambridge, Massachusetts.
- Dubé, L., Cantin, I., 2000. Promoting health or promoting pleasure? A contingency approach to the effect of informational and emotional appeals on food liking and consumption. *Appetite* 35, 251–262.
- Duncker, K., 1940. On pleasure, emotion, and striving. *Philos. Phenomenol. Res.* 1, 391–430.
- Ekman, P., 1980. *The Face of Man*. Garland, New York.
- Ekman, P., 1992. An argument for basic emotions. *Cognit. Emot.* 6, 169–200.
- Ekman, P., Friesen, W.V., 1986. A new pan-cultural facial expression of emotion. *Motiv. Emot.* 10, 159–168.
- Ekman, P., Levenson, R.W., Friesen, W.V., 1983. Autonomic nervous system activity distinguishes among emotions. *Science* 221, 1208–1210.
- Fazio, R.H., 2000. Accessible attitudes as tools for object appraisal: their costs and benefits. In: Maio, G.R., Olson, J.M. (Eds.), *Why We Evaluate: Functions of Attitudes*. Lawrence Erlbaum Associates, Mahwah, New Jersey, pp. 1–36.
- Frank, R.H., 1988. *Passions within Reason: The Strategic Role of the Emotions*. Norton, New York.
- Frederickson, B.L., Levenson, R.W., 1998. Positive emotions speed recovery from the cardiovascular sequelae of negative emotions. *Cognit. Emot.* 12, 191–220.
- Fredrickson, B.L., 2000. Cultivating positive emotions to optimize health and well being. *Prevent. Treatment* 3, 1–19.
- Griffiths, P.E., 1997. *What Emotions Really Are*. The University of Chicago Press, Chicago.



- James, W., 1890. *The Principles of Psychology*. Dover Publications Inc.
- Johnson-Laird, P.N., Oatley, K., 1992. Basic emotions, rationality, and folk theory. *Cognit. Emot.* 6, 201–223.
- Johnston, V.S., 1999. *Why We Feel: The Science of Human Emotions*. Perseus Books, Reading, Massachusetts.
- Kahneman, D., Wakker, P.P., Sarin, R., 1997. Back to Bentham? Explorations of experienced utility. *Quart. J. Econom.* 112, 375–405.
- Kappas, A., 1991. The illusion of the neutral observer: on the communication of emotion. *Cah. Linguist. Fr.* 12, 153–168.
- Kenny, A., 1963. *Action, Emotion, and Will*. Routledge and Kegan Paul, London.
- Kleinginna, P.R., Kleinginna, A.M., 1981. A categorized list of emotion definitions, with suggestions for a consensual definition. *Motivat. Emot.* 5, 345–379.
- Lane, R.D., Ahern, G.L., Schwartz, G.E., Kaszniak, A.W., 1997. Is alexithymia the emotional equivalent of blindsight? *Biological Psych.* 42, 834–844.
- Lane, R.D., Reiman, E.M., Axelrod, B., Yun, L.S., Holmes, A., Schwartz, G.E., 1998. Neural correlates of levels of emotional awareness: evidence of an interaction between emotion and attention in the anterior cingulate cortex. *J. Cogn. Neurosci.* 10, 525–535.
- Lang, P.J., Bradley, M.M., Cuthbert, B.N., 1998. Emotion, motivation, and anxiety: brain mechanisms and psychophysiology. *Biol. Psychiat.* 44, 1248–1263.
- Lazarus, R.S., 1982. Thoughts on the relations between emotion and cognition. *Am. Psychol.* 37, 1019–1024.
- Lazarus, R.S., 1984. On the primacy of cognition. *Am. Psychol.* 39, 124–129.
- Lazarus, R.S., 1991. *Emotion and Adaptation*. Oxford University Press, Oxford.
- LeDoux, J., 1996. *The Emotional Brain. The Mysterious Underpinnings of Emotional Life*. Simon and Schuster, New York.
- Leventhal, H., Scherer, K., 1987. The relationship of emotion to cognition: a functional approach to a semantic controversy. *Cognit. Emot.* 1, 3–28.
- Marks, J., 1982. A theory of emotions. *Philos. Stud.* 42, 227–242.
- McFarland, D.J., Sibly, R.M., 1975. The behavioural final common path. *Philos. Trans. Roy. Soc. Lond.* 270, 265–293.
- McNamara, J.M., Houston, A.I., 1986. The common currency for behavioural decisions. *Amer. Natur.* 127, 358–378.
- Mellers, B., Schwartz, A., Ritov, I., 1999. Predicting choices from emotions. *J. Exp. Psychol. G* 128, 332–345.
- Mellers, B.A., Schwartz, A., Ho, K., Ritov, I., 1997. Decision affect theory: emotional reactions to the outcome of risky options. *Psychol. Sci.* 8, 423–429.
- Mill, J., 1869. *Analysis of the Phenomena of the Human Mind*. Edited with additional notes of J.S. Mill. New York, Kelley.
- Milner, P.M., White, N.M., 1987. What is physiological psychology? *Psychobiology* 15, 2–6.
- Morsbach, H., Tyler, W.J., 1986. A Japanese emotion: *amae*. In: Harré, R. (Ed.), *The Social Construction of the Emotions*. Oxford University Press, London.
- Nash, R.A., 1989. Cognitive theories of emotion. *Nous* 23, 481–504.
- Oatley, K., 1994. Emotion. In: Eysenck, M.W. (Ed.), *The Blackwell Dictionary of Cognitive Psychology*. Blackwell, Oxford, pp. 129–134E.
- Oatley, K., Johnson-Laird, P.N., 1987. Towards a cognitive theory of emotions. *Cognit. Emot.* 1, 29–50.
- Ovsiich, A.J., 1998. Outlines of the theory of choice: attitude, desire, attention, will. <http://www.bu.edu/wcp/Papers/Acti/ActiOvsi.htm>.
- Panksepp, J., 1986. The anatomy of emotions. In: Plutchik, R., Kellerman, H. (Eds.), *Emotion: Theory, Research, and Experience*, vol. 3. Academic Press, Orlando, pp. 91–124.
- Panksepp, J., 1991. Affective neuroscience: a conceptual framework for the neurobiological study of emotions. In: Strongman, K. (Ed.), *International Reviews of Emotion Research*. Wiley, Chichester, UK, pp. 59–99.
- Parrott, W.G., Schulkin, J., 1993. Neuropsychology and the cognitive nature of the emotions. *Cognit. Emot.* 7, 43–59.
- Pecchinenda, A., Smith, C.A., 1996. The affective significance of skin conductance activity during a difficult problem-solving task. *Cognit. Emot.* 10, 481–503.
- Phillips, M.L., Young, A.W., Scott, S.K., Calder, A.J., Andrew, C., Giampietro, V., 1998. Neural responses to facial and vocal expressions of fear and disgust. *Proc. R. Soc. Lond. Ser. B—Biol. Sci.* 265, 1809–1817.
- Plutchik, R., 1965. What is an emotion? *J. Psychol.* 61, 295–303.
- Plutchik, R., 1970. Emotions, evolution, and adaptive process. In: Arnold, M.B. (Ed.), *Feelings and Emotions*. Academic Press, New York, pp. 3–24.
- Plutchik, R., Ax, A.F., 1967. A critique of ‘Determinants of Emotional State’ by Schachter and Singer. *Psychophysiology* 4, 79–82.
- Prince, J.D., Berenbaum, H., 1993. Alexithymia and hedonic capacity. *J. Res. Personal.* 27, 15–22.
- Ramos, A., Mormède, P., 1998. Stress and emotionality: a multidimensional and genetic approach. *Neurosci. Biobehav. Rev.* 22, 33–57.
- Rolls, E.T., 1994. A theory of emotion and consciousness, and its application to understanding the neural basis of emotion. In: Gazzaniga, M.S. (Ed.), *The Cognitive Neurosciences*. M.I.T. Press, Boston, pp. 1091–1105.
- Roy, J.R., 1998. *Les héritiers de Prométhée*. Québec, Presses de l’université Laval.
- Russell, J.A., 1980. A circumplex model of affect. *J. Personal. Soc. Psychol.* 39, 1161–1178.
- Russell, J.A., Fehr, B., 1987. Relativity in the perception of emotion in facial expressions. *J. Exper. Psychol. (General)* 116, 223–237.
- Schachter, S., Singer, J.E., 1962. Cognitive, social, and physiological determinants of emotional state. *Psychol. Rev.* 69, 379–399.

- Scherer, K.R., 1993. Neuroscience projections to current debates in emotion psychology. *Cognit. Emot.* 7, 1–41.
- Searle, J.R., 1998. How to study consciousness scientifically. *Brain Res. Rev.* 26, 379–387.
- Smith, C.A., Lazarus, R.S., 1990. Emotion and adaptation. In: Pervin, L.A. (Ed.), *Handbook of Personality: Theory and Research*. Guilford, New York, pp. 609–637.
- Smith, C.A., Lazarus, R.S., 1993. Appraisal components, core relational themes, and the emotions. *Cognit. Emot.* 7, 233–269.
- Sonnemans, J., Frijda, N.H., 1994. The structure of subjective emotional intensity. *Cognit. Emot.* 8, 329–350.
- Sonnemans, J., Frijda, N.H., 1995. The determinants of subjective emotional intensity. *Cognit. Emot.* 9, 483–506.
- Stanley-Jones, D., 1966. The thermostatic theory of emotion: a study in cybernetics. *Pror. Biocybernetics* 3, 1–20.
- Taylor, C.C.W., 1984. Emotions and wants. In: Marks, J. (Ed.), *Ways of Desire*. Precedent Publishing, Chicago.
- Taylor, J.G., Jancke, L., Shah, N.J., Nosselt, T., Schmitz, N., Himmelback, M., 1998. A three stage model of awareness: formulation and initial experimental support. *Neuroreport* 9, 1787–1792.
- Watson, D., Wiese, D., Waidya, J., Tellegen, A., 1999. The two general activation systems of affect: Structural findings, evolutionary considerations, and psychobiological evidence. *J. Personal. Soc. Psychol.* 76, 820–838.
- Todd, E., 1990. *L'invention de l'Europe*. Paris, Éditions du Seuil.
- Watt, D.F., 1998. Emotion and consciousness: implications of affective neuroscience for extended reticular thalamic activating system theories of consciousness. ASSC September/October <http://server.phil.vt.edu/assc/watt/default.html>.
- White, N.M., 1989. Reward or reinforcement: what's the difference? *Neurosci. Biobehav. Rev.* 13, 181–186.
- Young, P.T., 1943. *Emotion in Man and Animal*. Wiley, New York.
- Young, P.T., 1959. The role of affective processes in learning and motivation. *Psychol. Rev.* 66, 104–123.
- Zajonc, R.B., 1980. Feeling and thinking: preferences need no inferences. *Am. Psychol.* 35, 151–175.
- Zajonc, R.B., 1984. On the primacy of affect. *Am. Psychol.* 39, 117–123.