A SPECIAL ISSUE

Cognition & Emotion

Pleasure

Edited by James A. Russell

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Introduction: The return of pleasure

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The call for submissions stated our topic simply as "pleasure." I did not know what to expect from this call, or even whether "pleasure" was the best word to use. To be sure, pleasure is the most neglected topic in psychology, at least in relation to claims about its importance. Under various names and guises *(satisfaction, happiness, hedonic tone, utility, positive emotiori),* pleasure has been advanced as the final criterion for human morality, as the basis of economic decisions, as, indeed, the ultimate goal of human action. There is Wundt's pleasantness dimension as a feature of all conscious human experience. And there is Freud's pleasure principle at the core of the unconscious mind. Yet, pleasure has been a shunned or even tabooed topic, as is evident by scanning the index of any introductory textbook in psychology. (A colleague not that long ago had told me of being forced to cut a chapter on happiness out of a textbook he had written because reviewers had said the topic was unscientific.)

As manuscripts and, a few months later, reviews started to arrive on my desk, an interesting story began to unfold. In the first place, a fair number of papers arrived. Pleasure is being taken seriously and is coming in for scientific treatment. Further, manuscripts arrived from researchers in diverse disciplines (from business to medicine to neuroscience to kinesiology to evolutionary, cognitive, social and personality psychology). As well, manuscripts covered diverse topics. Each was fascinating, but how were they related to each other? Reviewers then raised further important questions. (The articles in this Special Issue benefited from these exchanges with reviewers, as did I, for which I am grateful to all the reviewers and authors. I find it unfortunate that such interesting discussions must remain behind the scenes.)

Piecing together a special issue on pleasure was not going to be easy. Indeed, if you think that pleasure is simple—perhaps the good feeling that occurs when things go well and that makes you smile—then the articles that follow raise some fascinating questions. Questions about the possibility of unconscious pleasure, about multiple brain mechanisms involved, about the evolutionary origin of pleasure, about whether smiles and laughs are really signals ofpleasure, about the

functions of pleasure, and, ultimately, about the very natureof pleasure: Is pleasure really one thing (the unity view) or is "pleasure" just alabel for a broad collection of qualitatively different things (the multiplicityview)? When I wrote above that satisfaction, happiness, and the rest were different names or guises for the same thing, I expressed a common assumption,but is that assumption correct?

At first blush, the diversity of topics included here favours the multiplicity view. No two papers seemed to address the same topic and reviewers often wondered: "1s this article really about pleasure?" Authors used a variety of additional names besides pleasure, including *liking, affect, valence, pleasantness, approach,* etc. Are these just more names for the same thing? Or, are these new types of events, but with pleasure somehow a part of each one? Might some of these events even have to be broken down into qualitatively different phenomena (even more multiplicity)? To illustrate, consider the current upsurge of interest in "positive emotions". Keltner and Haidt examine one largely forgotten positive emotion, awe, and suggest that there is a primitive form of awe plus various derivative forms. Their suggestion raises this question: If awe in some form is primitive, does it share anything with other positive emotions? Do all positive emotions share a common denominator—presumably pleasure— or are they qualitatively different from one another and merely grouped together as "positive"?

In contrast to the seeming multiplicity of topics and terms, theoretical analyses favour the unity view. The assumption of unity occurs in Johnston's evolutionary analysis of pleasure, according to which novel events can acquire a pleasant tone through classical conditioning; thus the pleasant tone remains the same although attached to qualitatively different stimuli. On another analysis, pleasure remains the same whatever the stimulus modality, because the function of pleasure is to provide a common metric whereby disparate events within and across modalities can be compared and contrasted. Thus, pleasure is a means of ordering stimuli of qualitatively different kinds, and unity is presupposed in the function of pleasure. (See Cabanac, 1990, and Shizgal & Conover, 1996, for a formulation of this view.) Unity is also assumed when, for example, hedonic tone is said to be an attribute of every conscious experience whatever its nature. Dubé and Le Bel provide an enlightening discussion of multiplicity and unity. They also offer a conceptual analysis that brings these seemingly contradictory views into alignment. In doing so, they present a series of studies on the lay concept of pleasure.

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In part, of course, these are matters of definition. Although no one offered a definition of pleasure, most felt the need to discuss issues of terminology and definition. The articles here take the right approach, I think, which is not (yet) to argue about definitions, but to try to be clear on how terms are being used in the specific article. Nonetheless, bringing nine articles together on the topic of pleasure shows that matters of terminology and definition must soon be addressed.

Related to the problem of conceptual definition is that of operational definition. Although much research relies on simple verbal rating scales ("How pleasant was that, on a scale from 1 to 10?"), there are serious and subtle issues involved. Ekkekakis reviews many of these. For example, one issue on which much progress has been made recently (although a final resolution eludes us) is whether the verbal scale is best anchored at the opposite end by neutrality or by extreme displeasure. Berridge and Winkielman showed that verbal ratings can be complemented with a behavioural measure. Ruiz Belda, Fernandez-Dols, Carrera, and Barchard address the prevalent notion that smiles might serve as an operational definition of pleasure. Smoski and Bachorowski's article evokes similar questions about laughter. They pursue an account informed by evolutionary thinking according to which laughter serves to induce pleasure in the listener. If so, laughter might correlate with pleasure, not because laughter expresses pleasure, but because of reciprocal affect induction in face-to-face interaction.

Many of the authors consider pleasure from an evolutionary perspective. Carver and Smoski and Bachorowski search for pleasure's adaptive value. Pinkerton, Cecil, Bogart, and Abramson focus on pleasure as a key component in the mechanism that evolved to produce sexual behaviour—the adaptive value of which is clear enough. In doing so, they offer a model for the role that pleasure plays in behaviour in general. Another evolutionary notion is Keltner and Haidt's proposal of a primordial emotion (in their case, primordial awe), which is then elaborated in different ways in different cultural contexts. Rozin (1999) had proposed a primordial pleasure in primitive sensory systems, which was extended to aesthetic, mastery, and social pleasures during the subsequent course of evolution. He invoked the notion of pre-adaptation to suggest how the system evolved. Incidentally, as Rozin noted, this hypothesis of pleasure extending to new systems offers insight to the multiplicity/unity issue: There is unity on the output side (the pleasure response), but multiplicity on the input side (what can produce pleasure). Johnston focuses directly on the evolution of pleasure. He argues that an evolutionary perspective speaks against various widespread beliefs, such as that the brain is essentially like a computer; that sensations, perceptions, cognitions, and feelings are "representations" of the external world; and that consciousness (such as a conscious sensation of pleasure) is a mere epiphenomenon, lacking in function. Instead, pleasure has been honed through evolution to serve as a code for adaptive value. What is pleasant and what is

unpleasant matter a great deal. As Johnston points out: "If toxins tasted sweet, and sugar evoked a bitter taste, then survival would be in jeopardy" (p. 13).

Several authors guide their psychological analyses by what is known about specific brain mechanisms involved in pleasure. Carver cites current empirical and theoretical work linking pleasure to the cortex (the left hemisphere, specifically). Berridge and Winkielman offer a most interesting discussion of this idea, pointing out that although cortical structures are involved, they are unlikely to be the direct substrate of pleasure. They do not make pleasure happen, whereas subcortical structures do.

Another question consistent with an evolutionary perspective is the function of pleasure. An event's functions are those of its consequences that played some role historically in creating that event. For example, a table's function of holding objects led designers to make tables the way they did: flat and stable. Pleasure's consequences led to its nature through natural selection. But what are those consequences? On this question, the articles here present a broad range of proposals. Pleasure functions as a signal of the adaptive value of a stimulus (Johnston); as a goal or motivator of action (Pinkerton et al.); to chart the return to homeostasis (Ekkekakis); and as a regulator of behaviour by shifting priorities among goals (Carver). Carver pursues the interesting idea that pleasure is the part of a feedback loop that signals progress toward a goal: Far from a "go" signal, however, pleasure leads to coasting, that is, to putting less effort toward the particular goal one is pursuing and thereby freeing attention for other matters.

One time-honoured scientific response to these different proposals is to treat them as competing hypotheses. Doing so would stimulate research, resulting in a beneficial cycle of revised formulations and new research. Another approach would be to treat them as complementary statements, with the potential to be integrated into one framework. For example, a step toward integration comes from recognising that each proposal focuses on a different part of the whole. Johnston focuses on the occurrence of a stimulus, prototypically something out of the blue. Carver focuses on the case when that stimulus signals progress toward a goal. Pinkerton et al. focus on instrumental action, and especially its aftermath. Ekkekakis focuses on the accompanying disruption of and the return to homeostasis. Thus, different writers focus on different parts of, or different temporal points in, the unfolding of an action sequence. I would add that pleasure also occurs in a free-floating form (such as finding oneself in a chipper mood for no known reason), the existence of which suggests that the source of pleasure is not always known but perhaps must be inferred (Russell, in press).

These different proposed functions can perhaps be united by listing the various components of and temporal points in an action sequence and by distinguishing pleasure as remembered, as currently experienced, and as anticipated. The beginning and end of an action sequence are perhaps arbitrary, but the following set of steps illustrates how this approach might work. In the first step, the action sequence begins, triggered by the occurrence of a stimulus, by internal changes

(circadian cycles, build up of needs), or by the passage of time. This initiating event brings with it pleasure or displeasure (Johnston). In the second step, the person selects a goal and formulates a plan to reach that goal. Here, remembered and anticipated pleasure enter into the calculations (Pinkerton et al.). In the third step, the person carries out the set of planned acts. Each such act evokes environmental feedback, pleasure from which serves to monitor progress toward the goal (Carver). In the fourth step, the goal is achieved (or not) and consumption occurs. Here occurs experienced pleasure (Johnston). During this entire sequence, homeostasis is disrupted and restored (Ekkekakis) and the person undergoes changes in mood (or core affect, as I prefer to call it). This formulation highlights the different functions pleasure might serve, but raises a further question how these different roles are kept straight. (Multiplicity returns.)

As worthy as the individual contributions to this Special Issue are, and they are very worthy, the whole of this special issue is greater than the sum of its nine parts. Each article advances the field in a unique way, but if they had been published separately, the reader would miss the questions that emerge from their proximity. For example, one challenge to the assumption of unity comes not from any one article but from the diversity of topics that are addressed in different articles and that authors supposed fit under the term "pleasure". And the reader would miss the ideas that emerge from combining different proposals. The clearest example of this, to me, is the way all pleasure's various proposed functions nicely fit together in a way that shows pleasure appearing at various (every?) points in a behavioural sequence. Perhaps our call for submissions used the right word after all.

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The origin and function of pleasure

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Currently, most cognitive scientists view the brain as a general-purpose computer and the processes of mind as software algorithms running on this neural architecture. From this perspective, conscious feelings, like pleasure, play no functional role in controlling human behaviour. This paper proposes that such computational theories are based on a false premise; namely, that the external world is full of light, sounds, smells, and tastes that can be detected through our senses. An alternative viewpoint, evolutionary functionalism, considers the world to be composed of energy/matter and views conscious experiences, like pleasure, as evolved emergent properties of biological tissue. From this perspective, natural selection has favoured conscious experiences that serve as evaluations of (feelings), or discriminations among (sensations) those aspects of the physical and social world that are biologically relevant. Over generations, it is the functional usefulness of these emergent properties that has shaped the neural architecture that underlies them.

At a recent conference on consciousness (in Tucson 2000), one poster invited participants to complete the following sentence: "Consciousness is...". The answers varied from the evaluative (those annoying experiences between naps), to the humorous (un-American), to the enigmatic (matter looking at itself). Despite the whimsical nature of this endeavour, the variety of answers reflects a more serious concern; namely, the need to deflne terms such as consciousness and feelings before theorising about the function of conscious pleasurable feelings. In the current paper, consciousness is defined as the private subjective aspect of experience. This is similar to the definition proposed by David Chalmers (1996). It encompasses the wide variety of vivid sensations that we call colours, aromas, or sounds, the broad range of feelings that we describe as sadness, anger, or pain, and the difficult to specify fleeting experiences that we

characterise as thinking or self-reflection. In essence, this definition includes all the different sensations, thoughts, and feelings that make up our private subjective experiences.

The word "feeling" also requires a precise definition. Often, the quality of any conscious experience is described as its feeling. In this paper, however, the term "qualia" will be used to characterise the qualitative nature of subjective experiences, and feeling will be used in a more restrictive manner. In other contexts, the term "feeling" has been used in the very narrow sense of a somatosensory experience, such as the rough feeling of a surface. In the current paper, however, feelings are defined as qualia that evoke a pleasant or unpleasant hedonic tone. From this perspective, sourness, and bitterness are both sensory feelings (affects) that have an unpleasant hedonic tone. Love and fear are also feelings (emotions) that evoke pleasant and unpleasant hedonic tones, respectively. In contrast, redness and blueness are sensations with different qualia, but because they lack hedonic tone they would not be classified as feelings. (As will be discussed later, however, associative learning mechanisms can give rise to sensations that evoke different feelings in different individuals.)

Using these definitions, this paper outlines a functional theory of human feelings. The theory addresses such central issues as why pleasant and unpleasant feelings exist, where they come from, why we possess many different kinds of feelings, why they are conscious experiences, and the possible role they play in regulating learning and reasoning. In order to contrast this theory, evolutionary functionalism, with the currently popular computational viewpoint, it will be useful to examine how each theoretical perspective would describe and explain the process of seeing a red apple. This simple scenario will contrast these two materialistic views of the human mind, and reveal their relative strengths, weaknesses, and predictive power. Consider first how the process of seeing a red apple would be described from a computational perspective.

When white light strikes a red apple, the pigments in the skin of the apple absorb all colours except those in the red portion of the electromagnetic spectrum. This reflected red light then enters the eyes, strikes the cones of the retina, and ultimately generates nerve impulses that travel to the brain. Within the brain these inputs activate a complex neural circuit that serves as a symbolic representation of the red apple.

In this description, the connection between the physical world and the mental world is explained by drawing an analogy between the human brain and a

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computer. Inside a computer, pictures or sounds are represented as different states of transistors and these stored patterns can then be acted on by a variety of computer programs. Drawing on this computer metaphor, it is relatively easy to believe that nerve cells within the brain can play a similar role to the transistors of a computer. That is, when the image of the red apple enters our eye it is immediately converted into a pattern of nerve impulses and the software programs of our visual system can then process this pattern. Like a computer, neural states represent the attributes of objects in the external world and cognitive processes, like perceiving or thinking, are computational procedures that act on and manipulate such symbolic representations.

This computer metaphor is highly seductive. Many cognitive scientists now view the brain as a general-purpose biological computer than can implement a wide variety of software programs. Furthermore, because the same computer algorithms can be carried out on many different computer architectures, it is often argued that the physical structure of the brain is of little importance for understanding mental processes. In the parlance of cognitive science, the brain is equivalent to the hardware of a computer and the processes of the mind, like seeing, thinking, or feeling, are equivalent to sophisticated programs executed by this hardware. Indeed, when Marr (1982) proposed computer algorithms for processing visual information and Chomsky (1986) uncovered the universal rules of grammar, it soon became widely accepted that all cognitive processes could be viewed as computational procedures.

In his popular book, *How the Mind Works,* Steve Pinker has embraced this computational view of the human mind (Pinker, 1997). Pinker states that the environment "gives off patterns of sounds, sights, smells, tastes, and feels that the senses are designed to register". The attributes of the world are represented as symbols and "a symbol is connected to its referent in the world by our sense organs". Symbols have meaning, according to Pinker, because they can become connected to and activate other symbols and because some symbols are connected to the world through our senses. In essence, this computational theory of mind rests on the belief that inside the brain there is a world of symbols and symbol interactions that mirror the external world, and that the processes of mind "are a kind of computation".

In the hands of cognitive psychologists and practitioners of artificial intelligence, this viewpoint has yielded impressive results. Industrial robots now make intelligent decisions about their workplace, procedures for understanding language continue to improve, and chess-playing machines generate moves with the flare and expertise of grand masters. The startling fact in all of this is not the progress, which is in itself impressive, but the realisation that this is all possible without any role whatsoever for conscious experiences of any kind. Consciousness is not easily incorporated within a computation theory of mind because computers do not have sensations and feelings, and they do not appear to be necessary for the performance of even the most complex robots. When viewed

from this perspective, conscious experiences appear to be irrelevant events that play no functional role: they are epiphenomena.

For some cognitive philosophers, a computational theory of mind is best served by totally eliminating qualia from the discussion. Dennett (1991), for example, states that it is: "Far better, tactically, to declare that there simply are no qualia at all". Pinker (1997) arrives at a similar conclusion. He concedes that sentience does exist but: "As far as scientific explanation goes, it might as well not exist. It's not just that claims about sentience are perversely untestable; it's that testing them would make no difference to anything anyway". Like Pinker, most cognitive scientists now believe that conscious sensations like "redness" are generated within the nervous system, but insist that such qualia are irrelevant because they play no functional role. The "redness", from this viewpoint, would be similar to the hum of a computer; it is generated by the activity of the brain but it really does not matter because it is nerve cells and their programmed interactions that do all the work. That is, a zombie who lacked consciousness, but had the same neural organisation, would be equally functional. Indeed, for many cognitive scientists, attributing any function whatsoever to consciousness is equivalent to embracing dualism.

A simple thought experiment, "the inverted spectrum", bolsters this epiphenomenal view of consciousness. Imagine two individuals, John and Mary, who always agree on the colour names of objects. However, when Mary looks at a red apple she experiences what John would call blue, and although they both describe the sky as blue, Mary's subjective experience corresponds to what John would call red. Compared to John, Mary experiences an inverted spectrum of colour qualia, but because they both agree on the colour names of objects there are no behavioural consequences of their different conscious experiences. The fact that their conscious sensations appear to be irrelevant suggests that they could be eliminated from any theory of the human mind. This proposition conflicts with common sense but so does quantum mechanics, one of the most successful theories in the physical sciences. The value of a theory lies in how well it explains and predicts how nature behaves; so emotional appeal or common sense should be regarded with scepticism.

A very different view on human consciousness arises from experiments in the biological sciences. Here, it has been shown that almost every aspect of consciousness can be altered through lesions, brain stimulation, or chemical modification of the human brain (Delgado, 1969). Brain stimulation can produce hunger or thirst, a dose of Prozac may relieve years of depression, and a few molecules of LSD could fill a conscious mind with an amazing variety of thoughts, feelings, and emotions. It is clear that conscious experiences are closely tied to the physical structure and chemistry of the human brain, and disconnecting the hemispheres of the brain can result in two independent minds, each with its own conscious experiences (Gazzaniga, 1992). Even more puzzling and revealing is the brain's ability to generate the nightly hallucinations that we call dreams. Dreams can occur without any sensory input from the external

environment so they must be arising from the activity of nerve cells. If we see a red apple in our dream then, unless we ascribe to dualism, this conscious experience must be an emergent property of our nervous system.

Emergent properties of matter are not mystical or mysterious phenomena, for they are part of our daily experience. Two simple gasses, oxygen and hydrogen, can combine to produce water which possesses properties that do not exist in either gas. Water flows from the faucet and, unlike oxygen and hydrogen, it can freeze to form snowflakes or ice. An emergent property is simply an attribute that arises as a consequence of the arrangement and interactions among individual components. More complex arrangements of more complex components give rise to more complex emergent properties. Imagine all the parts of a car lying in a random heap. Each has its own properties; it may be hard and smooth, brittle and clear, or volatile and fluid. However, when these pieces are correctly assembled the resulting car has new properties, none of which were present in the original components. The car possesses such new attributes as "acceleration", and "cornering ability", that depend upon the complex arrangement and interactions among many components. In a similar manner, conscious experiences can be viewed as emergent properties resulting from the arrangement and chemical communication between nerve cells. Although it is not yet known how a biological brain can generate an emergent property like redness, the fact that such a conscious sensation can occur during a dream clearly indicates that it must be an emergent property of the brain.

However, once it has been accepted that conscious sensations are a property of biological tissue, we are now confronted with a very difficult paradox. Is redness an emergent property of biological tissue or is it a property of a particular frequency of electromagnetic radiation? It is clear that we can experience redness during a dream when no electromagnetic radiation is impinging on our senses, and it is also clear that the brain does not generate any such frequency of electromagnetic radiation. It does not matter whether we view the redness during a dream to be a memory or not, the point is that when we are experiencing redness in a dream no such radiation is present, so it must be a product of biological tissue. However, if redness exists in the external world then it must be a property of a particular frequency of electromagnetic radiation. It is possible that a complex attribute like "redness" could be a property of two completely different physical substrates, biological tissue and electromagnetic radiation? The paradox, of course, is much broader than this. Are sounds properties of air pressure waves or biological tissue? Is sweetness a property of sugar molecules or the interactions among nerve cells? It seems impossible to believe that all of these attributes are properties of two completely different physical substrates; so one interpretation must be discarded. Dennett (1991) has discarded subjective qualia, but it may be much more productive to abandon naive realism and recognise that although conscious sensations and feelings may be evoked by energy impinging on our senses, all such qualia are exclusively properties of biological tissue. That is, they do not exist in the external environment in the absence of a

conscious mind. Here is a description of the world without consciousness (Johnson, 1999):

> The darkness is a bubbling cauldron of energy and vibrating matter locked in the incessant dance of thermal agitation. Through shared electrons or the strange attraction of unlike charges, quivering molecules, not free to roam, absorb and emit their characteristic quantal packages of energy with the surrounding fog. Free gas molecules, almost oblivious to gravity but buffeted in all directions by their neighbors, form swirling turbulent flows or march in zones of compression and expansion according to the dictates of oscillating substrates. A massive solar flux and cosmic radiation from events long past, crisscross space with their radiant energy and silently mix with the thermal glow of living creatures whose hungry metabolic systems pour their infrared waste into the chaotic milieu. But within the warmth of their sticky protein bodies the dim glow of consciousness is emerging to impose its own brand of organization on this turbulent mix of energy/matter. The active filter of consciousness illuminates the darkness, discards all irrelevant radiation, and in a grand transmutation it converts and amplifies the relevant. Dead molecules erupt into flavors of bitterness or sweetness, electromagnetic frequencies burst with color, hapless air pressure waves become the laughter of children, and the impact of a passing molecule fills a conscious mind with the aroma of roses on a warm summer afternoon.

Of course, many philosophers have abandoned naive realism, but few have noted the importance consequences that arise from this perspective. When conscious experiences are viewed as malleable emergent properties of biological tissue, and not rigid properties of the external world, then they can evolve over generations. This has profound implications for understanding the nature and function of consciousness. To expose these implications, it is useful to consider how the emergent properties of cars would change if they were subjected to the evolutionary process.

Imagine a population of cars that possess, to different degrees, the emergent properties of acceleration and cornering ability. Now let us enter these cars into a "race of life" where to succeed they must make many sharp turns, accelerate up hills, and eventually complete the course. (In this thought experiment all drivers are equally competent.) Generation after generation, blind robots construct new generations of cars by combining the designs of the successful ones from the previous generation. What would happen under these circumstances? Some cars would crash because of inadequate "cornering ability" and yet others would fail because of "poor acceleration". Evolution is underway, and it is the emergent properties of cars that are dictating which ones survive and contribute to the design of future generations. A variety of physical designs, such as engine size and placement, carburettor design, body contours, etc., may contribute to these

emergent characteristics. In the evolutionary paradigm, however, survival depends upon the emergent properties, and the physical design of future cars will be a consequence of the functional emergent characteristics that allowed cars to complete the course. After several generations it is apparent that although it is certainly true that the physical components do all the work, their arrangement—how they got to be organised the way they are—is a consequence of the emergent properties arising from this arrangement. By analogy, nerve cells are certainly the active agents in the nervous system but their organisation depends upon the survival value of the emergent properties that arise from that organisation. Over the long course of evolution, it is the functional attributes of the mind that have been responsible for shaping the physical and chemical structure of brains.

Consider a more biological example, the evolution of the haemoglobin molecule. This molecule has a particular structure and a specific function, its oxygen-carrying capacity. Now imagine an initial population of animals that have different alleles of the haemoglobin gene and therefore different variations of this molecule. Over generations it is the oxygen-carrying capacity of haemoglobin that dictates which animals survive and reproduce, and it is their genes that increase in frequency in future generations. As a consequence, the structure of haemoglobin will change over generations because in the evolutionary paradigm, function dictates structure. Similarly, of all the different emergent properties that could arise from the neural organisation of a human brain, only a subset will be selected; that subset which ensures the survival of DNA that can design brains that possess such emergent properties. Rather than creating a general-purpose computer, this iterative design process ensures that the attributes of mind acquire a very special function: Gene survival. Furthermore, these attributes, rather than being independent of their biological underpinnings, as cognitive theories suggest, are selected because they help to preserve and perpetuate the biological substrate to which they owe their very existence. Relentless selection slowly but inexorably leads to adaptive or at least "satisficing", functional design. This simple premise has profound implications for understanding the nature and origin of all conscious experiences. More specifically, the design and significance of human feelings now become apparent.

Do rotten eggs smell bad? Is sugar sweet? Does tissue damage cause pain? The answer to these questions is "No". There is no foul smell hidden inside hydrogen sulphide gas, there is no sweetness concealed in a molecule of sugar, and there is no pain waiting to escape from the point of a pin as it enters the skin. It is brains that have evolved to generate pleasant or unpleasant feelings to those aspects of the environment that were a consistent benefit or threat to gene survival in ancestral environments. An individual need not be aware of the relationship between a foul odour and bacterial contamination, a sweet taste and the manufacture of ATP, or tissue damage and infection; the relationship between these emergent conscious experiences and gene survival has already

been established by natural selection. The discomfort that we experience at high or low temperatures, or the unpleasant smell of our waste products, are evolved emergent properties evoked by environmental events that reliably and repeatedly posed a threat to biological survival in ancestral environments. It is certainly not a coincidence that our most intense pleasurable feelings, orgasms, are evoked when we are closest to perpetuating our genes and yet we are often oblivious to such relationships. In this respect we are semi-conscious creatures. We are aware of our proximate design, our sensations and feelings, but we seldom recognise how these emergent properties are related to gene survival, our ultimate design.

The observation that qualitatively different conscious feelings are evoked by the many different kinds of environmental circumstances that had an impact on gene survival in ancestral environments is a compelling argument for adopting an evolutionary viewpoint on the nature of consciousness. If conscious feelings were epiphenomena, as the alternative viewpoint suggests, then there would be no reason why their pleasantness or unpleasantness should in any way be related to environmental benefits or threats to gene survival, respectively. That is, if the conscious aspect of feelings was irrelevant then sugar could have a foul taste or the death of our lover could evoke happiness rather than sadness. But this is not the case. Indeed, all human feelings, affects, and emotions, appear to be closely related to the host of physical and social circumstances that influence survival to reproductive age (Cabanac, 1992), reproduction, survival of offspring, kin selection, and reciprocal altruism (Johnston, 1999); all factors that are known to modify biological fitness.

The strength of evolutionary functionalism rests not only in its ability to account for these observed relationships, but also in its ability to generate specific hypotheses that can be experimentally evaluated. That is, if human feelings evolved to reflect the nature, magnitude, and direction of factors that influence gene survival, then they should vary with an individual's age, sex, and reproductive status. More specifically, because sexual reproduction using anisogamy and internal fertilisation produces predictably different threats and benefits to the reproductive success of males (microgamete producers) and females (macrogamete producers), these differences should be reflected in the factors that evoke feelings in men and women. A male's jealousy, for example, should be more aroused by the threat of sexual than emotional infldelity, whereas the reverse pattern is predicted for a female. Using both behavioural and physiological measures, Buss, Larsen, Westen, and Semmelroth (1992), have confirmed these predictions, and their findings have been replicated across cultures (Buss et al., 1999; Buunk, Angleitner, Oubaid, & Buss, 1996). Behavioural and physiological experiments examining the perceived beauty of men and women have also shown predictable sex differences (Cunningham, Roberts, Barbee, Druen, & Wu, 1995; Johnston, 2000; Johnston & Franklin, 1993; Johnston & Oliver-Rodriguez, 1997; Singh, 1993) and demonstrated biologically adaptive changes in these preferences with reproductive status

(Johnston, Hagel, Franklin, Fink, & Grammer, 2001; Penton-Voak & Perrett, 2000).

It is only when we abandon naive realism that the functional design of our conscious experiences becomes apparent. For example, if sensations, like redness and greenness, are considered to be properties that already exist in the external world then conscious experiences are reduced to nonfunctional epiphenomena. But if the external world is viewed as pitch dark, silent, tasteless, and odourless, then our evolved sensations acquire a whole new function. To elucidate this functional design, consider the fact that in the external world, the physical difference in wavelength between "red" and "green" is a mere 150 billionths of a metre; they are essentially identical. Inside human heads, however, our evolved brains generate one subjective experience "redness" when we are exposed to one wavelength, and an entirely different conscious experience, "greenness", when exposed to the other. Animals that make such discriminations simply survive better than those that do not. Over the course of evolution, what might have started as slightly different "glimmers", have now become vibrant conscious colours. If this is the case, then the design of colour vision should exhibit the unmistakable fingerprint of natural selection.

The adaptive nature of colour vision is apparent in the observation that both scotopic (rod) and photopic (cone) systems are centred on, and exhibit maximum sensitivity to, the wavelength of electromagnetic radiation reflected by the chlorophyll molecule. We appear to have evolved "green" cones, and a vivid conscious experience, greenness, for detecting the molecule responsible for the foundation of our food chain. However, in order to detect this source of photosynthesis under the different incident radiation conditions that commonly occur on our planet (reflected "blue-light" from the sky, and scattered "red-light" at sunrise and sunset) we have evolved "blue" and "red" cones that respond to and can correct for these persistent conditions. Our colour-constancy mechanism appears to have evolved in response to the very specific and perhaps unique problems encountered by diurnal animals that depend on a chlorophyllbased food chain on a planet that possesses particular atmospheric conditions. The specificity of this adaptive design can be seen in the failure of our colour-constancy mechanism when sodium lamps are used as the source of incident radiation (Shepherd, 1992).

Understanding the function of conscious sensations casts a new light on the inverted spectrum thought experiment. It is possible to invert the subjective colour spectrum without behavioural consequences simply because the discrimination made possible by colour sensations is still maintained under the inverted condition. It would not, however, be possible to invert feelings, like sweetness and bitterness, without encountering life-threatening consequences. Unlike sensations, feelings are evaluative qualia whose pleasantness or unpleasantness has evolved to reflect benefits or threats to gene survival. If toxins tasted sweet, and sugar evoked a bitter taste, then our survival would be in jeopardy.

It could be argued that natural selection "cannot see" such internal subjective feelings, but it can see their causal consequences. The downward causation of emergent properties is real and indisputable. Using our car analogy, acceleration plays a causal role in high-speed accidents, worn tyres, and low gas mileage. Similarly, our emergent feelings appear to play a causal role in learning and reasoning. These two adaptive mechanisms allow humans and other animals to modify their behaviour as a consequence of their unique environmental experiences. Learning enables animals to acquire and store new behaviours for interacting with aspects of the environment that may change over generations, but remain fairly consistent within an individual's lifetime. Reasoning empowers them with the ability to predict future changes based on this stored information. Such complex adaptive processes, however, would not have evolved unless they reliably contributed to the biological survival of organisms that possessed them. To be adaptive, organisms should learn and reason about those aspects of their environment that are biologically relevant, and it is feelings that dictate when such circumstances exist. Feelings appear to define both the rewards and deterrents that regulate learning, and the utility functions necessary for reasoning. It is these adaptive mechanisms that elevate our ephemeral conscious feelings to a role of paramount biological importance.

From the viewpoint of evolutionary functionalism, it is not surprising that the well-established learning mechanisms, classical and operant conditioning, result in the storage of new associations when environmental circumstances or behaviours are coupled with events that evoke human feelings. The primary outcome of classical or Pavlovian conditioning is that an arbitrary environmental object can acquire the ability to evoke a pleasant or unpleasant feeling when it reliably associated with an event that inherently evokes such feelings. Humans begin life with a repertoire of inherited feelings that are initially evoked by important nutrients (e.g., salt or sugar) contaminated food (e.g., sour milk or rotten eggs), tissue damage (e.g., pains or burns), loud noises (e.g., animal roars), etc. Now, if an inherently unpleasant event (e.g., pain) is repeatedly and reliably associated with an arbitrary object (e.g., a piece of fur), then the latter will soon evoke a feeling with an unpleasant hedonic tone, in this case fear. In a comparable manner, an object that has no initial value, like money, can acquire the ability to elicit a positive feeling through association with events that have inherent positive value. This simple mechanism permits the intrinsic hedonic tone evoked by a small set of environmental circumstances that have remained stable over many generations, to be aroused by a much larger array of events that vary within individual lifetimes and may differ significantly among individuals. Nevertheless, these learned values are not arbitrary since they were acquired as a consequence of faithful associations with the primary value system. Once established, this expanded set of events that evoke pleasant or unpleasant feelings can be used within the behavioural learning paradigm known as operant conditioning.

It is the common hedonic dimension of feelings that enables them to play a collective role in behavioural learning and reasoning mechanisms (Cabanac, 1992; Johnston, 1999). Shifts in a positive direction, evoked either by events that elicit pleasant feelings or the removal of events that evoke unpleasant feelings, correspond to what psychologists label as positive or negative reinforcements, respectively. A behaviour will be learned if followed by the presentation of a reward (positive reinforcement) or the removal of a deterrent (negative reinforcement). Such learned behaviours are stored in memory and have an increased probability of occurring at a future time under similar conditions. Alternatively, a behaviour will decrease in probability if it is followed by a deterrent, or by the loss of an event that elicits a pleasant hedonic tone. In both cases, the behaviour has now become associated with an expected hedonic outcome.

Behaviours are invariably learned in the presence of an external and an internal context. That is, when an animal learns a behaviour in one environment, it is likely to exhibit that behaviour when it finds itself in the same or a similar situation. This is possible because a sensory representation of the external environmental is present in the brain at the time of learning and these contextual cues are stored as an integral part of every newly learned association. The qualitative aspect of feeling states, like the qualitative perceptions of the external world, supplies the important internal context that is also present at the time of learning. Like external context, this internal context is also stored as an integral part of every newly learned association. That is, behaviours learned in one feeling state, such as hunger or fear, are more likely to be recalled in a future similar state. The outcome of this associative mechanism is the formation of a genuine semantic, or meaningful, memory whereby events in the physical world are no longer arbitrary incidents, but are now connected to an animal's biological survival through both the internal context and the expected hedonic outcome.

In his computational theory of mind, Pinker (1997) has proposed an alternative method whereby symbols could acquire meaning by virtue of their "causal" and "inferential" roles. He argues that symbols can stand for things when "the unique pattern of symbol manipulations triggered by the first symbol mirrors the unique pattern of relationships between the referent of the first symbol and the referents of the triggered symbol". Of course, a symbol cannot acquire meaning by triggering other symbols if the latter have no meaning in the first place. Pinker uses a "causal" argument to provide meaning for such meaningless internal symbols. This argument states, "a symbol is connected to its referent in the world by our sense organs". Here, Pinker implies that the meaning of an internal symbol can be supplied by its relationship to events in the external world. The problem, however, is that meaning cannot be acquired in this manner because there is no inherent meaning in any such events and no purpose or intention in the laws of physics or chemistry that govern their behaviour. That is, in a world governed by physics and chemistry there is nothing "bad" about death and nothing "good" about life, for both processes are perfectly lawful physical/

chemical events. The sting of death is in the fear, not the physics. Indeed, all such evaluations only exist as emergent properties of biological brains. So, even if the physical-chemical processes of the brain were totally isomorphic with the physical-chemical processes in the external world, they would still be devoid of any meaning. Meaning can only arise from the evolved "yuck or yum" feelings of biological brains and new events can only acquire meaning through their learned association with these "omens" of our reproductive success.

Without feelings, the world around us is a meaningless conglomerate of energy/matter that cannot provide the source of meaning required for a computational theory of mind. Indeed, this is the central problem with all computational theories of mind and treat the human brain as a general-purpose computer. Computers merely change states according to programmed algorithms but unless a conscious programmer assigns a meaning to these states, then no computation is possible. Searle (1992) has convincingly argued that the molecules in a wall are probably executing a wide variety of algorithms but all such operations are meaningless without an interpretation of these states by a conscious mind. Algorithms define processes not properties. Hence, a nonbiological robot might behave as if it sees red or feels pleasure, but it could not possess the emergent properties of redness or pleasure. Processes are independent of their physical substrate, but properties are attributes that belong to their physical substrate.

In his seminal paper, "Facing up to the problem of consciousness," David Chalmers (1995) has characterised the "hard problem" of consciousness in the following manner: "It is widely agreed that experience arises from a physical basis, but we have no good explanation of why or how it so arises". Evolutionary functionalism offers a possible answer to the why question. Without conscious feelings there is only a world of physical and chemical happenings that take place inside and outside the brains of living creatures. These events have no meaning in and of themselves, they just are. It is the emergent properties of neural pathways, shaped by the life and death of our ancestors, that provide meaning to these otherwise insignificant physical-chemical events. Of course, different animals may experience the same events in an entirely different manner from a human being; the unpleasant smell of dung may evoke great pleasure in a dung beetle. Such conscious experiences are neither "true" nor even accurate representations of the world around us for they are the result of a single functional constraint, gene survival. In this respect our conscious experiences are illusions, but they are remarkably adaptive illusions. They alone are responsible for illuminating the darkness and adding light, love, and meaning to the silent void of being.

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What is an unconscious emotion? (The case for unconscious "liking")

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Ever since William James, psychologists of emotion have tended to view affective states as intrinsically conscious. We argue that nonconscious affect also exists, and focus specifically on the possibility of unconscious "liking". We present evidence that positive and negative affective reactions can be elicited subliminally, while a person is completely unaware of any affective reaction at all (in addition to being unaware of the causal stimulus). Despite the absence of any detectable subjective experience of emotion, subliminally induced unconscious "liking" can influence later consumption behaviour. We suggest that unconscious "liking" is mediated by specific subcortical brain systems, such as the nucleus accumbens and its connections. Ordinarily, conscious liking (feelings of pleasure) results from the interaction of separate brain systems of conscious awareness with those core processes of unconscious affect. But under some conditions, activity in brain systems mediating unconscious core "liking" may become decoupled from conscious awareness. The result is a genuinely unconscious emotion.

We begin with apologies to William James for having stolen the title of our paper from his classic article, "What is an emotion" (James, 1884). Worse still, by inserting "unconscious" as a modifier, our title distorts his concept of emotion in a way that renders it almost nonsensical. This is because an unconscious emotion was a contradiction in terms, according to James' (1884) definition. For James, emotion was a conscious experience or subjective feeling belonging to the “aesthetic sphere of the mind, its pleasure and pains, and itsemotions” (p. 188). The subjective feeling of emotion has remained an essentialpart of its definition for many psychologists ever since.

In this paper we recognise the reasons for viewing emotion as subjective feeling, but also present theoretical and empirical arguments why an unconscious emotion may actually exist. As the topic of this journal issue is about *pleasure,* we focus especially on the possibility of unconscious "liking".

Before we start, a few clarifications are in order. We use the term *emotion* throughout the paper primarily to refer to stimuli, processes, or responses that involve *affect,* or *the property of being good/bad* (Zajonc, 1998). We acknowledge that particular emotions, such as hope, love, or envy, are differentiated and based in elaborated appraisals, and we do not propose to talk about their unconscious forms. Rather, we will restrict our discussion to more general unconscious affective reactions, such as "liking" and "disliking". We return to definitional issues later in the paper.

Traditional view: Emotion defined as subjective experience

James' famous treatise dealt with the *causation* of emotion, based upon feelings of sensory feedback from involuntary reactions to events. By emotion itself, however, James made clear that conscious "feelings of pleasure and displeasure" caused by bodily changes were the essence of an affective state. His famous phrase, *"that our feeling of the same changes as they occur IS the emotion"* (pp. 189–190, original italics, James, 1884), captures this essential subjectivity of the feeling as well as its hypothesised causation in bodily changes.

That feelings were necessarily conscious was further emphasised by James in the thought experiment he posed to eliminate emotionality from subjective experience: "If we fancy some strong emotion, and then try to abstract from our consciousness of it all the feelings of its characteristic bodily symptoms, we find that we have nothing left behind, no 'mind-stuff' out of which the emotion can be constituted…" (p. 193, James, 1884). In the taxonomy of emotions, "Rapture, love, ambition, indignation, and pride, considered as feelings, are fruits of the same soil with the grossest bodily sensations of pleasure and of pain" (p. 201).

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Emotions all were feelings, on a continuum with sensory pleasures. By definition, all feelings were subjectively felt.

Contemporary scholars of James have reopened the issue of emotional causation, but have kept the identiftcation of emotion itself with conscious feeling. For example, in a centennial analysis of cognitive appraisal in James' classic paper, Ellsworth reassessed the causation sequence that led to a consciously felt emotion: "He was never very clear on whether the physiological feedback was a cause or a component of the emotion; he seemed to argue that the *bodily sensations create a feeling,* which is different from the sensations themselves, and that *this feeling is the emotion"* (Ellsworth, 1994b; italics added). Then and now, the traditional Jamesian theory of emotion is viewed as asserting that "feeling is the emotion".

Contemporary re-evaluation: Conscious experience remains key

Modern cognitive theorists of emotion have continued to focus primarily on *conscious experience* as affect's defining feature. A straightforward common-sense definition of affect has been offered by Frijda." 'Affect' here primarily refers to hedonic experience, the experience of pleasure or pain" (p. 194, Frijda, 1999). Many cognitive theorists who view emotion as information take a similar position on the intrinsic subjectivity of emotional processes (Clore, 1994; Ellsworth, 1994a; Ellsworth & Scherer, in press). Although cognitive appraisals of events are granted to sometimes be unconscious, the emotions that result from those appraisals are typically viewed as necessarily conscious. As Clore put it in a chapter entitled "Why emotions are never unconscious", "In agreement with Freud, I would argue that it is not possible to have an unconscious emotion because emotion involves an experience, and one cannot have an experience that is not experienced" (p. 285). And "emotions cannot be unconscious because they must be felt, and feelings are by definition conscious" (p. 290, Clore, 1994).

Other cognitive appraisal theorists of emotion have been more willing to entertain at least the possibility of unconscious emotion, even if unsure as to its actual existence. For example, Ellsworth, while noting that, "I have always found the idea of unconscious emotions extremely difficult to think about… (as) in most definitions of emotion…a subjective experience of feeling is an essential component" (Ellsworth, 1995, p. 214), nonetheless, explicitly left open the possibility for future examination. Similarly, Ellsworth and Scherer declined to close the door entirely on unconscious emotion: "Most appraisal theorists would probably agree with Frijda that 'one knows, generally that one has an emotion', and have reserved the vexing question of unconscious emotions for future exploration. While many appraisal theorists may in fact be agnostic on the question of unconscious emotions, their initial goal was to account for the person's subjective experience of emotion at the time it is felt" (Ellsworth & Scherer, in press). This position suggests that a focus on conscious experience by

contemporary appraisal theorists has been one of explanatory priorities rather than definitional necessity and that an unconscious emotion might still be possible.

Implicit emotion and unconscious affect

A new look at the question of unconscious emotion is prompted by recent developments regarding other unconscious psychological processes in cognition, perception, etc. The "cognitive unconscious" has been suggested by Kihlstrom as a label to subsume a variety of psychological phenomena where cognitive processes demonstrably occur in the absence of conscious awareness (Kihlstrom, 1999). One of the most studied manifestations of the cognitive unconscious is implicit memory, as revealed, for example, by the effect of previously encountered words on participants' performance on a word stem completion task without any explicit memory of those words (Clark & Squire, 1998; Schacter, 1996). Another well-documented manifestation of the cognitive unconscious is implicit perception, such as blindsight, the ability to make visual discriminations among stimuli that are not consciously seen (Weiskrantz, 1996). Similarly, Bargh and colleagues and others have described a number of automaticity phenomena, in which behaviour is influenced by automatic reaction to masked stimuli in the absence of conscious awareness (Bargh, Chen, & Burrows, 1996; Tiffany & Carter, 1998). Related phenomena involving unconscious perception of evaluative aspects of social stimuli also have been discussed under the label of implicit attitudes (Greenwald & Banaji, 1995; Wilson, Lindsey, & Schooler, 2000).

Just as "cognitive unconscious" refers to implicit cognitive operations, Kihlstrom has suggested "emotional unconscious" and "implicit emotion" as corresponding labels for unconscious *affective* reactions (Kihlstrom, 1999; Kihlstrom, Mulvaney, Tobias, & Tobis, 2000). As Kihlstrom puts it, "paralleling the usage of these descriptors in the cognitive unconscious, 'explicit emotion' refers to the person's conscious awareness of an emotion, feeling, or mood state; 'implicit emotion', by contrast, refers to changes in experience thought or action that are attributable to one's emotional state, independent of his or her conscious awareness of that state" (p. 432, Kihlstrom, 1999).

But what exactly constitutes an unconscious emotional state? There are various degrees of being unaware. Some weak instances merely involve inaccurate *labelling* of the exact nature of one's emotion, as when one angrily denies that one is angry (Ellsworth & Scherer, in press). Other weak instances are mere errors of attention, as when one realises only later that one had been gripped by an emotional state at an earlier time. But in such cases one is fully conscious of events that cause the emotion, and one may be conscious of many effects of the emotion. Moreover, the actual emotional state is presumed *capable of being made conscious* if only the person's full attention is directed to the emotional experience, and the right label is provided. Instances of mistaken or unnoticed

emotion are by no means unconscious in a strong sense of unconscious affect. These are not intrinsically inaccessible.

Unconscious affect requires a much stronger demonstration of implicitness. The strongest type of unconscious affect would be an exact parallel to strong implicit memory or implicit perception. That is, *truly implicit affect* would require the demonstration of *an affective reaction of which one was simply not aware, even upon introspection*. Does truly implicit affect exist? Kihlstrom and colleagues suggest that this question has not yet been settled (Kihlstrom, 1999; Kihlstrom et al., 2000). They conclude that no convincing evidence has yet been demonstrated for implicit emotion in the strongest sense of an affective reaction that is not experienced at the moment of its occurrence. Still, Kihlstrom proposes, it is possible that real implicit emotion exists: "But while the hypothesis of unconscious emotional states has not yet garnered convincing support, it can no longer be rejected out of hand. If we are willing to speak of implicit percepts, memories, and thoughts that are dissociated from their explicit counterparts, then we must be willing to speak of implicit emotions in the same terms" (p. 433, Kihlstrom, 1999).

Unconscious causes of emotion: Zajonc, Oehman, and colleagues

Among the strongest formulations of unconscious emotion are those from studies by Robert Zajonc and colleagues (Zajonc, 1980, 1998, 2000). In the mere-exposure effect, repeated presentation of an object increases subsequent liking for it even when participants are completely unaware of the repetition (Kunst-Wilson & Zajonc, 1980; Moreland & Zajonc, 1977; Monahan, Murphy, & Zajonc, 2000). Similarly, in subliminal affective priming, preference ratings for an object can be influenced by unconsciously (e.g., 10 ms) presented affective stimuli, such as smiling or angry faces (Murphy & Zajonc, 1993; Winkielman, Zajonc, & Schwarz, 1997). Zajonc and colleagues have interpreted such results as demonstrating the operation of unconscious affective processes. In a recent review of 20 years of work, Zajonc recounts that: "In seeking to establish the independence of affect and cognition, I relied on the assumption that emotions are often unconscious…" (p. 32, Zajonc, 2000).

It is worth noting, however, that Zajonc only has asserted the *causation and assignment* of affect to be unconscious. The elicited *affective state* itself is always assumed to be *consciously* experienced (Zajonc, 2000). Providing a prototypical example, Zajonc asks, "What happens when we induce nonconscious affect?" He answers: "Nonconscious affect has been recognized in clinical psychology in the form of the phenomenon of free-floating anxiety. Free-floating anxiety is a state—a feeling—a mood, in which the person has no idea of the origin of the feeling. It is a sort of fear, but the person does not know what he or she is afraid of, and has no idea of how to escape it. It is diffuse and nonspecific" (pp. 47–48, Zajonc, 2000). In other words, in Zajonc's prototypical example, a

free-floating anxiety is a conscious fear—the person experiences ordinary subjective anxiety, but is unaware of its cause, and is afraid of "everything".

More systematically, Zajonc has defined unconscious emotion in this partly implicit sense as possession of three features (Zajonc, 2000). First, it is *caused by an unconscious event,* such as a subliminal stimulus. Second, unconsciously caused affect is experienced as *diffuse*. Third, unconsciously caused affect *can be assigned to any target* that comes along, such as a visual ideograph or the person's own mood (Kunst-Wilson & Zajonc, 1980; Monahan et al., 2000; Murphy & Zajonc, 1993; Winkielman et al., 1997). These aspects of the emotion are unconscious, but the emotion itself remains a felt feeling.

Oehman and his colleagues make a similar use of the term "unconscious emotion" to refer primarily to unconsciously caused occurrences of conscious affective states (Oehman, Flykt, & Lundqvist, 2000). They express the similarity of their use to Zajonc's view of unconscious emotion in a recent review: "In this chapter we address *unconscious emotion in the sense that emotion can be activated without conscious recognition of the eliciting stimulus*. This may happen when an emotionally relevant stimulus, which is presented outside conscious attention, automatically redirects attention to become its focus, or when a stimulus that is prevented for reaching conscious awareness through backward masking nonetheless elicits psychophysiological responses suggesting emotional activation. These lines of evidence suggest that emotions can be activated independently of consciousness, much as in Zajonc's (1980) slogan that 'preferences need no inferences'" (p. 298, emphasis ours, Oehman et al., 2000). Thus, for both Zajonc and colleagues and Oehman and colleagues, unconscious emotion is most generally expressed as an unconsciously caused emotion that is nonetheless consciously felt. The positions of Zajonc and Oehman do not rule out unconscious emotion in an even stronger sense of an unfelt affective reaction. They merely do not go so far as to assert that implicit emotion exists in this strongest sense.

Unremembered subliminal feelings: Unconscious or forgotten?

Given that a consciously felt feeling seems to be virtually everyone's criterion of emotion, it is not surprising that there has not been much research on unconscious emotion in the strongest sense of an unfelt affective reaction. Yet there is some evidence. In one attempt to probe whether subliminally induced affective reactions were unconscious, Winkielman and colleagues asked participants to evaluate Chinese ideographs that were preceded by subliminal happy or angry facial expressions, and warned them that their conscious feelings might be influenced by external factors, such as "hidden pictures" or background music (Winkielman et al., 1997). This warning was meant to alert participants to attend to their own affective responses, and lead them to discount the subliminally induced reactions in their preference ratings, as suggested by the feeling-as-information hypothesis (Schwarz, 1990). But, in fact, warnings did

not protect the participants from subliminal affective priming effects on their ratings. Further, when asked afterwards, participants strongly denied experiencing any conscious affective reactions during the experiment.

However, failure to discount or remember is not conclusive evidence for unconscious affect, and could have been due to errors of attention, motivation, or memory. Participants may simply have failed to notice their subtle, but conscious affective reactions, because they were focused on the task of rating the ideographs (Gasper & Clore, 2000; Lane et al., 1998). Further, participants may have failed to discount the "subliminally caused" affective reactions because they did not care about the unimportant Chinese ideographs (Tetlock & Lerner, 1999). Perhaps most important, retrospective reports of hedonic experiences are often simply wrong (Kahneman, Fredrickson, Schreiber, & Redelmeier, 1993; Kahneman & Snell, 1992; Mook & Votaw, 1992; Redelmeier & Kahneman, 1996; Wilson & Schooler, 1991). Participants might have experienced a conscious affective change the moment after presentation of a subliminal affective stimulus, but simply failed to remember it later.

Genuine unconscious affect: On-line demonstration

Let us be clear on what is needed to demonstrate true unconscious emotion. Our view on criteria is essentially that of Kihlstrom and colleagues (Kihlstrom et al., 2000). For an emotion to be unconscious, people must not be able to report their emotional reaction at the moment it is caused. Yet there must be clear evidence of the emotional reaction either in their behaviour, or physiological response, or subsequent subjective impressions of an affect-laden event.

We believe we have produced such a demonstration in recent experiments (Winkielman, Berridge, & Wilbarger, 2000). In two studies, we asked participants to *rate their momentary feelings of subjective emotional experience* (subjective emotion) immediately after exposure to a series of subliminal happy or angry emotional facial expressions (rather than at the end of the experiment). If participants do not report any change in subjective emotion at the moment right after the subliminal stimulus, it is hard to argue their failure is due to deficits of attention, motivation, or memory, especially if they subsequently go on to demonstrate behavioural and judgemental consequences of their emotional reaction.

In Study 1 of this research, we also wished to provide evidence that an unconscious emotional reaction can control *actual consumption behaviour* in a real-life situation (i.e., not just control preference ratings or autonomic reactions). We gave participants a pitcher of fruit-flavoured drink, which they could physically interact with, pour and actually consume, after subliminal exposure. We wondered if participants' behaviour would be influenced by the valence of subliminal primes, even if their self-reports failed to reveal evidence of any conscious emotion.

In more detail, in Study 1 participants were first exposed to eight subliminal exposures of happy, neutral, or angry facial expressions (Winkielman et al., 2000). Conscious perception of the subliminal stimulus was prevented by showing it for only 16 ms. Further, the emotional expression was masked by an immediately following second photograph of a neutral face shown for 400 ms, long enough to be seen consciously. Participants were told that their task was to guess the gender of the neutral face. That gave them something to concentrate upon and provided a plausible cover story. This procedure succeeded in keeping emotional presentations subliminal; later people denied having ever seen the emotional expressions, and performed at chance in a forced-choice task of face recognition. Immediately after the subliminal exposure to happy, neutral or angry facial expressions, participants rated their own subjective emotion at that moment on a 10-point hedonic scale ranging from "very unpleasant" to "very pleasant". Then they were presented with a pitcher of fruit-flavoured drink, and asked to pour themselves as much as they wanted, to drink it, and to evaluate it (the order of subjective emotion ratings and of drink presentation was counterbalanced for another group of subjects).

Subliminal control of consumption behaviour with no subjective change

Our results showed that subliminal emotional expressions controlled people's pouring and drinking behaviour, but in a way that depended on participants' thirst. Subliminal exposure to happy facial expressions actually caused thirsty participants to *pour roughly 50% more* of the fruit-flavoured drink into their own cup than if they had seen only neutral facial expressions (Figure 1). Thirsty participants also *drank about 50% more* of what they poured after being exposed to subliminal happy expressions than after neutral expressions. By contrast, subliminal angry expressions caused thirsty participants both to pour less into their cup and to drink less of it than participants primed with subliminal neutral expressions. Thus, the effect of subliminal affective stimuli on real behaviour toward the drink was bivalent in that consumption could be driven either up or down by subliminal happy versus angry stimuli. Importantly, thirsty participants reported no conscious awareness of any intervening change in their subjective emotion even when asked before receiving the drink (Figure 1). Nonthirsty participants did not show any of these effects.

Willingness to pay and subjective wanting to drink without subjective emotion

In Study 2, we presented people with the same series of subliminal happy or angry faces embedded in the gender identification task. After the primes, some participants first reported their subjective emotion on an expanded 20-question PANAS mood rating scale (Watson, Clark, & Tellegen, 1988). Other

participants, however, were first given just a single sip of the fruit beverage, and asked to rate immediately how much they liked it, how much they wanted to consume, and how much they would be willing to pay for a hypothetical can of the beverage (again the order of drink presentation and mood ratings were counterbalanced). Subliminal emotional expressions altered these subjective ratings of the drink for thirsty participants in bivalent directions, and again had no effect on nonthirsty participants. For example, in answer to the question "How much would you pay for a can of this drink?", thirsty participants were willing to pay nearly double after seeing subliminal happy expressions than after seeing subliminal angry expressions (about 40 vs. 20 US cents per can). They also gave higher ratings to the question: "How much of this drink do you want to drink right now?" after the happy versus angry subliminal stimulus. Again, no changes in subjective emotion were produced in these thirsty participants, even when assessed by the sensitive 20-item PANAS questionnaire. Interestingly, however, a slight mood shift was found for *nonthirsty* subjects who never showed changes in their consumption behaviour or ratings of the drinks. Thus, the results provide a double dissociation (i.e., A occurs without B, and B occurs without A). Subliminal emotional expressions controlled drink evaluation but not subjective emotion ratings for thirsty participants, whereas they impacted subjective emotion ratings, but not drink evaluation for nonthirsty participants.

Although the ability of thirst to channel subliminal affective reactions is of interest itself, our focus here is on the implications of the lack of conscious emotion in thirsty people right after their subliminal exposure. Overall, happy subliminal faces did not create a conscious positive affective state in thirsty people, nor did subliminal angry faces create in them a conscious negative affective state. Instead, the subliminal stimuli altered their behaviour and evaluation of the affect-laden beverage they encountered later, without altering intervening ratings of subjective emotion.

Thus, we consider this pattern of findings a demonstration of *unconscious affective reaction*. It meets the criteria for a strong sense of truly implicit emotion. That is, a behaviourally demonstrable affective reaction of which the person is simply not aware, even when that person deliberately introspects and reports in detail on his/her own conscious emotional state. Our thirsty participants were unaware not only of the subliminal facial stimuli, but also of their own emotional reaction to those stimuli. Further, our results demonstrate that both positive affect as well as negative affect can be unconscious, as revealed in bivalent shifts from a neutral baseline.

Unconscious emotion vs. unconscious information?

An alternative to the unconscious emotion interpretation of the above results would be to posit that the effects of subliminal stimuli were purely cognitive. Such a rhetorical move would allow an "emotion is always conscious" theorist to argue that our thirsty participants did not report an affective change is because

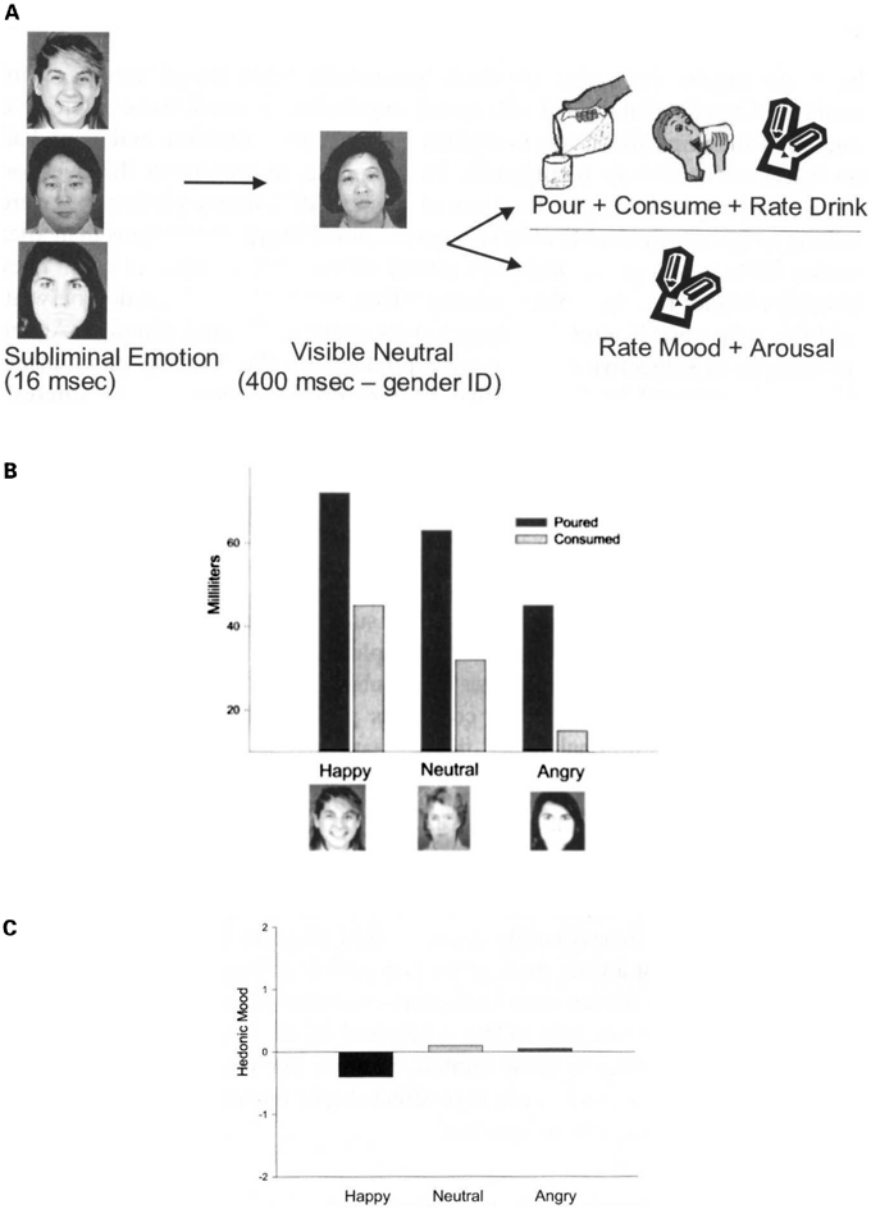

Figure 1. Unconscious subliminal affective reaction controls consumption behaviour. (A) Summary of experimental procedure: (1) subliminal emotional exposure; (2) gender identification task; and then (3) emotion self-report; and (4) behavioural consumption of drink (3 and 4 in balanced order). (B) Pouring and drinking behaviour by thirsty men and women was changed after subliminal exposure to happy facial expressions, neutral facial expressions, or angry facial expressions (amount poured of a fruit-flavoured drink, and amount actually consumed). (C) Ratings of subjective mood were not changed after same subliminal stimuli ("How do you feel right now at this moment, 10-point hedonic scale). (From Winkielman et al., 2000.)

there was no affective change to be aware of. However, such a position is inconsistent with research showing that subliminal facial expressions elicit genuine affective changes, as revealed in a variety of physiological and behavioural effects, including activation of the amygdala and substantia innominata (Morris, Oehman, & Dolan, 1998; Whalen et al., 1998), spontaneous mimicry (Dimberg, Thunberg, & Elmehed, 2000), and skin conductance responses (Oehman et al., 2000).

But suppose for a moment that a subliminal smile or frown functions purely in a semantic fashion, just like a positive or negative subliminal word prime (Clore & Ortony, 2000). If so, the facial expression might elicit a "free-floating" cognitive belief that something good or bad is happening, and thus influence the interpretation of subsequent stimuli, via mechanisms discussed in the literature on knowledge accessibility (Higgins, 1996). If a "free-floating belief" can be assigned to any relevant object, including the drink, then one could argue that for thirsty participants, who may have been thinking about drinks, a subliminal happy expression led to their interpretation of the drink as "good", leading to the increased consumption. On the other hand, for nonthirsty subjects, who were not thinking about the drink and might be thinking about themselves, a subliminal smile expression led to interpretation of one's own subjective state as good, thus accounting for the difference in reports of mood. In short, the "emotion-is-always-conscious" theorists may try to account for findings like ours by viewing them as phenomena of unconscious cognition rather than unconscious affect (Clore, personal communication).

Although such a cognitive view might accommodate some of our findings, it cannot accommodate all. Most importantly, right after subliminal exposure some participants were asked to first focus their attention on themselves (subjective emotion rating) whereas other participants were asked to first focus their attention on the external stimulus (drink). If attention-driven *assignment of the free-floating belief* was the primary factor, then order of testing should have strongly determined which measure was influenced by the prime. Specifically, subjective emotion reports should have been influenced most for participants who were first asked to introspect about how they felt. That did not happen. Instead, the appetite state (thirst) was the overwhelming factor.

To us, the powerful role of the thirst appetite state suggests an explanation in terms of more basic motivational or affective mechanisms. Specifically, the initial appetite state (thirst) may directly enhance the initial value of the relevant affective stimulus (drink), as revealed by the fact that our thirsty participants found the drink generally more desirable (i.e., the phenomenon of alliesthesia, Cabanac, 1971). This enhancement in the initial drink value allows subliminal facial expressions to control consumption behaviour and ratings of thirsty participants while having no effects on nonthirsty participants, except for slight changes in mood. This interpretation is consistent with biopsychological theories of how physiologically based appetite states modulate perceptions of relevant reward stimuli (Berridge, 2001; Cabanac, 1971; Toates, 1986).

What determines conscious manifestations of subliminally elicited emotion?

Interestingly, a recent study by Monahan et al. (2000) found a different result in that subliminal stimuli led to shifts in *conscious* mood. It is worth examining some differences between their study and ours, and highlight factors that may influence whether subliminally elicited emotion manifests in subjective experience.

Monahan and colleagues' study was based on the "mere exposure" phenomenon (Zajonc, 1968). Participants were subliminally presented with a series of 25 drawings, each for 5 ms, and followed by a 1 s mask of grey dots. Participants were then asked to rate their mood on a verbal or pictorial 5-point scale. Participants who had been presented with a subliminal series of five identical drawings repeated five times each gave reliably higher mood ratings than subjects who had been presented with 25 distinct drawings (Monahan et al., 2000). Monahan and colleagues interpreted their results to indicate that repeated exposure of the same subliminal stimulus elicited a diffuse and positive affective state, which was experienced consciously even though its causation was unconscious (similar to interpretations by Zajonc discussed above).

Why were mood effects reliably found in participants studied by Monahan and colleagues (2000), but not in thirsty participants studied by Winkielman and colleagues (2000)? The difference may be due to several factors. One factor already mentioned are appetite states such as thirst. In the study by Winkielman et al. (2000), only nonthirsty participants showed mood effects, whereas only thirsty participants showed changed reactions to drinks. This suggests that physiologically based appetite states can modulate the channelling of subliminal effects, perhaps similar to the way anxiety has been suggested to facilitate extraction of the valence of subliminal stimuli (Oehman & Soares, 1994). Appetite states may also determine whether the valence cues conveyed by subliminal affective stimuli will automatically influence action (e.g., for thirsty people, change consumption behaviour without concurrent subjective emotion), or whether it will become consciously available (for nonthirsty people, change subjective emotion without changing consumption) (Mandler & Nakamura, 1987).

Second, the nature of eliciting stimuli might be important. Subliminal presentation of emotional facial expressions activate subcortical limbic circuits (Whalen et al., 1998), and might be more potent than simple abstract drawings at influencing action via unconscious core affective processes (Winkielman & Cacioppo, 2001).

Finally, procedural differences, such as the masking task, could be crucial. For example, Monahan et al. (2000) masked subliminal drawings with a visual dot pattern, which participants passively watched. In contrast, Winkielman et al. (2000) masked subliminal facial expressions with a consciously seen neutral face, and asked participants to actively identify its gender identification. Any "extra" conscious affect might have been screened out by the active task, or absorbed by

the neutral face (Niedenthal & Showers, 1991), without dissipating the underlying affective core process that changed consumption behaviour. Such possibilities deserve to be addressed by future studies.

It is important to note that our conclusion from the Winkielman et al. results is not that subliminal stimuli *never* influence conscious experience of emotion (see, e.g., Robles, Smith, Carver, & Wellens, 1987). Instead, it is that *changes in subjective emotion need not be related to the strength of subliminally induced changes in affective reactions to subsequent events*. The double dissociation between the effects of subliminal emotional expression on subjective experience (only in nonthirsty subjects) versus behavioural and evaluative reaction to drinks (only in thirsty subjects) indicates changes in subjective emotion did not mediate changes in affective reactions to the drinks. The change in affective reaction to the drink and in consumption behaviour was essentially unconscious, in that it was unrelated to the subjective component of emotion (feeling ratings) at the moment it was caused. That behaviourally expressed-but-unfelt change reflected an unconscious core affective process.

Unconscious core affective processes

It is easier to illustrate the existence of unconscious affect than to provide a comprehensive definition. Empirical studies, not a priori definition, will offer the best way to an accurate understanding of core emotional processes. However, below we discuss some critical features of unconscious core affective processes, contrast them with conscious emotions, and address their relation to brain systems. In our discussion, we focus especially on the relation between unconscious "liking" and conscious pleasure. We do not pretend that our ideas are complete, but we hope that they might be useful in framing the issue.

Unconscious core affective processes can be basically defined as valenced good/bad reactions that occur in the absence of conscious awareness (Berridge, 1999; Kihlstrom et al., 2000). These reactions can be triggered unconsciously, and, once triggered, can persist and unconsciously influence perception and behavior to value-laden events. How can an unconscious core affective process be recognised? Primarily, by features it shares with ordinary conscious emotion (Kihlstrom et al., 2000). First, these include *stimuli* for elicitation (e.g., emotional facial expressions) that ordinarily induce conscious affective feelings. Second, they include valence in *reaction* direction (e.g., reaction to stimulus as good vs. bad). [In passing, we note debate exists regarding whether good and bad valenced reactions can both exist simultaneously or are mutually exclusive (e.g., Berridge & Grill, 1984; Cacioppo, Gardner, & Berntson, 1999; Russell & Carroll, 1999; Tellegen, Watson, & Clark, 1999; Winkielman, Berntson, & Cacioppo, 2001). For our purposes here, it is enough that either good, bad, or both be manifest to count as an affective reaction].

Third, the valenced process must *persist* for at least a short time after the eliciting stimulus and be *expressed* later either behaviourally, physiologically

(e.g., galvanic skin response), or neurally (e.g., fMRI) in response to a value-laden event. Fourth and last, in order to be considered "unconscious", of course, an affective core process must not be accessible to subjective reports at the moment it is caused. For example, in the Winkielman study, all these criteria were met: affective behavioural reactions were triggered by subliminal happy or fearful faces, they caused participants to later drink either more or less of the fruit beverage, and they could not be subjectively reported by participants at the moment of causation.

The above discussion makes clear that our view of unconscious emotional reactions is similar to that of several other psychologists and affective neuroscientists who have argued that the essential purpose of emotional processes is to influence perception and action, and that these effects can be distinguished from changes in subjective awareness (Berridge, 1999; Cosmides & Tooby, 2000; Damasio, 1999; Ekman, 1999; Frijda, 1999; Lane et al., 1998; Lang, 1993; LeDoux, 1996; Oehman & Soares, 1998; Shevrin et al., 1992; Zajonc, 1998). For example, regarding unconscious fear processes, Le Doux writes: "When we use the term 'fear', we are naturally inclined to think of the feeling of being afraid. [But] As important as subjective feelings like fear are to our lives, it seems likely that these were not the functions that were selected for in the evolution of the fear systems or other emotion systems" (p. 130, LeDoux, 2000).

Most discussions of the possibility and evolutionary significance of unconscious affective reactions has usually been limited to negative affect. However, we would apply similar arguments to *positive* affect, especially liking. In fact, one could argue that as important as conscious pleasure is to our lives, it was not the primary reason for evolution of brain liking systems (cf. Cabanac, 1996). Rather, evolutionary pressures primarily acted to shape appropriate behavioural reactions to positive events. Accordingly, Berridge and Robinson and colleagues have introduced the apostrophic terms "liking" and "wanting" to refer to unconscious core processes of affect and motivation generated by the brain, which influence behaviour towards incentives—without necessarily being felt. The apostrophes around "like" and "want" denote the difference between these intrinsically unconscious affective core processes versus the ordinary subjective sense of liking and wanting as conscious pleasure and conscious desire (Berridge, 1999; Robinson & Berridge, 1993). [For clarity, in this paper we use the unmodified *word pleasure* to denote only *conscious liking*. However, just as it makes sense to talk about unconscious *"liking",* it makes sense to talk about *unconscious "pleasure"*.]

As is the case with mechanisms underlying unconscious negative affects (LeDoux, 1996), most of the experimental work on core "liking" and "wanting" systems has been conducted in animals (Berridge, 1999, in press b). However, we propose that these distinctions bear on human reactions involved in pleasure. Specifically, we suggest that an unconscious "liking" (and "dis liking") is indicated by our finding that subliminal emotional faces modified positive (and negative) behavioural reactions to drinks in the absence of any conscious

intervening effect of the faces on subjective experience of emotion (Winkielman et al., 2000). Related instances of an unconscious affective core process modifying behaviour without conscious awareness have been observed in certain clinical examples. For example, drug addicts will work for drug rewards even when the drug dose is so low that they do not experience it as consciously pleasurable (Fischman & Foltin, 1992; Lamb et al., 1991).

What is a conscious emotion?

Although core affective processes are intrinsically unconscious, they may in turn cause conscious emotions by acting on other processes of conscious representation. Conscious pleasure and unconscious "liking", for example, are by no means mutually exclusive. Unconscious core "liking" can typically cause conscious liking—but the two are not identical. An analogy to visual sensation may be useful here. When one is consciously aware of a visual sensation, activation of core visual sensory processes causes in turn the subjective event. The core process is not sufficient by itself to cause a corresponding conscious experience, as is exemplified by the phenomenon of blindsight in human patients after brain damage to occipital cortex (Weiskrantz, 1996). An additional mechanism of conscious awareness, requiring sufficient occipital cortex participation in the case of vision, must take the core process as its input and transform it into subjective awareness. Perhaps related, the clinical condition of alexithymia has been described by Lane and colleagues as a form of emotional blindsight (blindfeel), in which people are unable to describe emotional feelings even when they have strong physiological reactions to events (Lane, Ahern, Schwartz, & Kaszniak, 1997).

The difference between an unconscious core affective process, such as "liking", and a conscious affective experience, such as subjective pleasure, thus is similar to the difference between blindsight and conscious vision. Both unconscious "liking" and conscious pleasure are affective processes, just as blindsight and a conscious visual perception are both visual processes. The difference in both cases is a *difference of conscious awareness* (involving mechanisms of consciousness)—not a difference in the underlying emotional or visual process (involving core processes of affective reaction or of visual processing).

Relation of unconscious core processes to conscious emotions

Importantly, unconscious core affective processes need not always bear a one-to-one relation to conscious emotions (Berridge, 1999). Although some core affective processes may be specific to a particular conscious emotion (e.g., negatively valenced fear reactions, Esteves, Dimberg, & Oehman, 1994; LeDoux, 2000), others may be more general in function, such as "liking" for diverse sensory pleasures (Cabanac, 1992).

Perhaps less intuitively, some core processes may participate in several different subjective emotions. For example, conscious desire and conscious fear may both share a similar core process of incentive salience or "wanting", involving brain mesolimbic dopamine systems and nucleus accumbens (Berridge, 1999; Reynolds & Berridge, 2001). Attribution of incentive salience to cues for "liked" events causes those cues to become attractive, sought after, and able to trigger pursuit of the "liked" reward (Berridge & Robinson, 1998; Wyvell & Berridge, 2000). However, hyperpolarisation of other accumbens neurons, near those that attribute attractiveness to perceived cues, may cause cues to instead be perceived as frighteningly salient, and trigger defensive behavioural reactions instead of approach (Reynolds & Berridge, 2001). Thus, a similar mesolimbic core process may cause either a positive or a negative motivated response, combining aspects of both appetitive motivation and fear into one psychological core process and the same brain structure (Berridge, 1999; Gray, Young, & Joseph, 1997; Horvitz, 2000; Reynolds & Berridge, 2001; Salamone, 1994). If so, it means that the same psychological core process is used as a building block to construct two emotional reactions that are consciously experienced as opposite to each other (negative fear vs. positive desire). This position seems related to psychological composite theories and appraisal theories, which allow a single subjective emotion to contain multiple components (Clore & Ortony, 2000; Ellsworth & Scherer, in press; Russell & Barrett, 1999).

Brain mechanisms of conscious vs. unconscious core processes

Any attempt to distinguish brain substrates for unconscious emotional core processes versus conscious emotion is necessarily speculative. However, we will sketch some possibilities below.

Many parts of the brain are activated by emotional events. These include several regions of the *neocortex,* such as the ventromedial or orbitofrontal parts of prefrontal cortex, anterior cingulate cortex, parietal cortex, and temporal cortex. The emotional brain also includes important *subcortical structures* beneath the neocortex, such as amygdala, nucleus accumbens, mesolimbic dopamine system, ventral pallidum, hypothalamus, and structures deep in the brainstem. For reviews of brain systems of affect and emotion see (Berridge, in press, a, b; Damasio, 1999; Davidson, Jackson, & Kalin, 2000; Everitt, Cardinal, Hall, Parkinson, & Robbins, 2000; LeDoux, 1996; Panksepp, 1998a; Rolls, 1999; Shizgal, 1999).

Both neocortex and subcortical structures participate in affective processes, but cortical and subcortical systems may play very different causal roles (Berridge, in press a; Damasio, 1999; LeDoux, 1996; Rolls, 1999; Stone, 1999). A detailed description is beyond the scope of this article, but evidence indicates that although neural activation in *cortical* structures is often *correlated* to pleasant affective reactions, it may be relatively unimportant in *causing* them (Berridge,

in press b). By contrast, changes in activity in *subcortical* structures are more likely to *cause* basic affective reactions.

Although cortical structures, such as orbitofrontal and cingulate areas, show activation to emotional stimuli in human neuroimaging studies and animal electrophysiological recording studies (Damasio, 1999; Davidson et al., 2000; Rolls, 1999), brain damage in those cortical regions typically does not *abolish capacity for an emotional reaction.* Nor can *activation* of these cortical regions generally suffice to *produce* a strong emotional response. Instead, damage to those cortical regions alters cognitively mediated emotional anticipation, decisions, and action strategies based on emotion, as well as subtle aspects of the cognitive representation of emotion (e.g., Bechara, Damasio, & Damasio, 2000; Damasio, 1999). This suggests that when the cortex participates in basic affective reactions, it does not function as their primary cause, but rather does something more hierarchical in nature (Berridge, in press a; Hughlings-Jackson, 1958). Specifically, the cortex might mediate *conscious experience of emotions* and other psychological processes by hierarchically monitoring and re-representing lower core processes. Further, cortical causation might be restricted to cognitive aspects of emotion induction, cognitive decisions based on emotion, and to voluntary regulation of emotional state via modulation of lower brain structures that more directly cause affective reactions (Bechara et al., 2000; Damasio, 1999; Davidson et al., 2000; Rolls, 1999).

Subcortical brain mechanisms cause core processes of emotion

By contrast, much evidence indicates that manipulations of *subcortical* brain systems are highly effective at *causing* basic affective reactions themselves (Berridge, in press a, b; Damasio, 1999; LeDoux, 1996; Panksepp, 1998a). The ability to *cause* an affective reaction, whether conscious or unconscious, is exactly the property we expect to be possessed by any brain structure that mediates a core process of emotion. Subcortical brain structures may therefore be the best candidates to mediate unconscious core affective processes.

Similar suggestions for subcortical mediation of unconscious core emotional processes have been made by Le Doux and by Damasio, Bechara and their colleagues (Damasio et al., 2000; LeDoux, 1996). For example, LeDoux distinguishes between basic fearful reactions (i.e., an emotional core process) and the conscious feeling of fear, and suggests that the unconscious reaction component of fear is mediated by the subcortical amygdala (LeDoux, 1996, 1998). His proposition is based on many studies showing that damage to amygdala disrupts basic fearful reactions, such as behavioural freezing, startle responses, etc. (Davis & Shi, 1999; Everitt et al., 2000; Kagan & Schulkin, 1995; Killcross, Robbins, & Everitt, 1997; LeDoux, 1992, 1998; Maren, 1999). Similarly, Damasio, Bechara, and colleagues suggest that deep brain structures participate in generating an unconscious stage of fear, anger, happiness, and

sadness reactions (Bechara, 2000, personal communication; Damasio, 1999; Damasio et al., 2000).

How the brain generates *pleasure* has traditionally received less attention than fear in affective neuroscience. That is in part because there are fewer recognisable *positive affective reactions* to pleasant sensations available for study than there are fearful reactions to frightening stimuli. However, brain mechanisms of positive affective reaction and reward have recently received increasing attention (Berridge, 1996; Davidson et al., 2000; Everitt et al., 2000; Panksepp, 1998a; Rolls, 1999; Shizgal, 1999). Just as for fearful reactions, the evidence available indicates that basic core "liking" reactions to pleasant sensations are caused primarily by subcortical brain structures.

Infant/animal affective reactions reveal core "liking" for pleasant tastes

Understanding unconscious core "liking" takes us into the affective neuroscience of positive affective reactions to pleasant events. First, it is helpful to note a useful behavioural measure that has been employed in some affective neuroscience studies of core "liking" reactions, namely, affective facial expression to the sensory pleasure of taste. For example, a newborn human infant has distinct positive versus negative patterns of affective facial reactions to tastes (Steiner, 1973; Steiner, Glaser, Hawilo, & Berridge, 2001). Sweet elicits positive facial reactions from newborns, whereas bitter elicits negative reactions, even on the first experience (Figure 2). The positive reaction to pleasure includes tongue protrusions and lip sucking movements, plus facial relaxation, and the occasional smile. By contrast, the negative facial reaction to bitter comprises a very different pattern of gapes, nose wrinkling, and head shaking (Steiner, 1979; Steiner et al., 2001).

Positive facial reactions to sweetness might plausibly be accompanied by conscious feelings of pleasure for normal human infants. But there are reasons to think that the facial reaction to pleasure reflects a core process of "liking" rather than the consciousness *per se* of the pleasant sensation. One reason is that positive affective facial reactions also occur in infants whose consciousness status may be more suspect, such as "anencephalic" infants (Steiner, 1973). Anencephalic infants are born with a brainstem but no cortex and little else of the forebrain, due to a birth defect that prevents prenatal development of forebrain structures (i.e., no amygdala, hippocampus, nucleus accumbens, thalamus, etc.). Yet sweet tastes still elicit strong positive facial reactions. Although core "liking" and conscious liking both might be reflected in the positive affective facial expression of a normal newborn infant, that of an anencephalic might arguably reflect only the unconscious core process of "liking"—without full felt feeling of normal subjective pleasure. Such examples provide further basis for a distinction between "liking" and liking. It also provides a relatively direct

way to measure "liking" for a basic sensory pleasure in infants and animals: Watch the face (Berridge, 2000).

No one would use human infants in an affective neuroscience experiment. But animals also have affective reactions to pleasant tastes, which are similar in both facial pattern and evolutionary origins. For example, chimpanzees, orangutans, and gorillas have facial reactions to sweet versus bitter tastes that are highly similar to those of human babies (Steiner et al., 2001). Old World monkeys (primate relations which evolved in Africa and Asia), and New World monkeys (more distant primate relations which evolved in South America), have slightly less similar behavioural affective reactions tastes (Steiner et al., 2001). Finally, even rats have affective reactions to taste related to those of primates, such as tongue protrusions to pleasant sweetness and gapes and headshakes to unpleasant bitterness (Grill & Norgren, 1978a). The similarity across species of these affective reactions to pleasure permits one to use them to gain insight into underlying brain mechanisms of sensory pleasure (Berridge, 2000). Affective neuroscience studies in our laboratory have used the basic affective reactions of rats to identify the brain systems that generate positive "liking" reactions to pleasant tastes (Berridge, in press b).

Subcortical forebrain site causes positive affective core process: Nucleus accumbens shell

Perhaps the most intriguing brain system of "liking" identified so far is in the nucleus accumbens. The nucleus accumbens lies at the front base of the brain, just below the prefrontal cortex, and contains two parts, the shell and the core. A recent affective neuroscience study in our laboratory showed that activation of neural circuits in the accumbens shell can cause "liking" for a pleasant taste (Peciña & Berridge, 2000). Specifically, a sweet taste elicited extra "liking" reactions from rats after a selective activation of opioid neurotransmitter receptors inside their nucleus accumbens shell. The selective activation was caused by microinjections of morphine (a drug that activates opioid receptors) directly into the brain structure (painless because the brain cannula had been implanted a week earlier while the rats were anaesthetised).

A few minutes after the morphine microinjection, a bittersweet taste was infused into the rat's mouth and its behavioural affective reactions were video recorded (Peciña & Berridge, 1995, 2000). The rats responded behaviourally with a distinct shift towards positive affective reactions after the morphine microinjection, which indicated it made them "like" the taste more. Interest ingly, the morphine microinjection also caused the rats to eat more of a tasty food than they ordinarily would. This suggests that the accumbens shell activation may increase "wanting" for food, as a consequence of enhancing "liking" for it (Peciña & Berridge, 2000).

The nucleus accumbens is well positioned for crosstalk between unconscious core processes of "liking" and conscious feelings of liking. It receives extensive

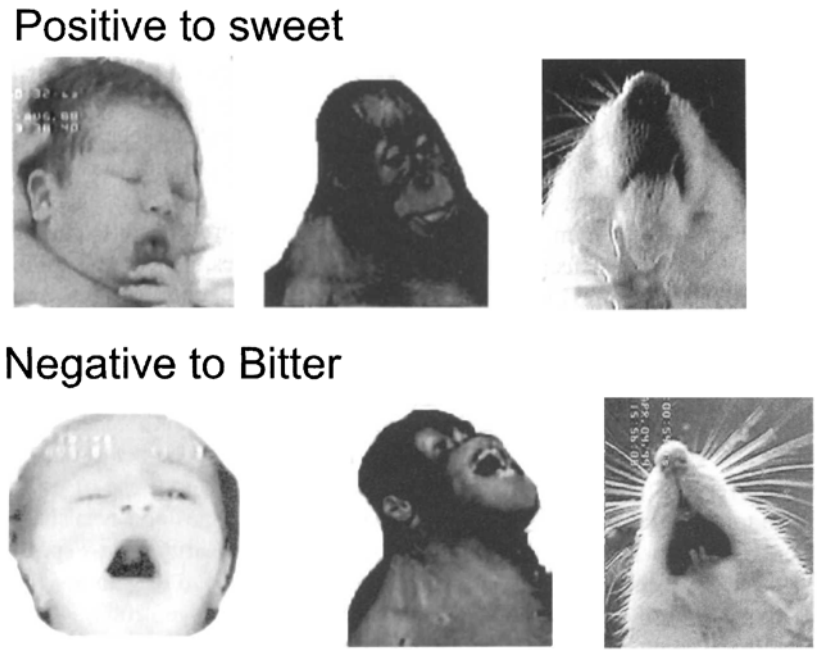

Figure 2. "Like" vs. "dislike" reactions to tastes. Positive affective facial reactions to pleasure of sweetness elicited from a human infant, an orangulan, and a rat (top). Displeasure reactions to bitterness (bottom). Human infant and orangutan photos from (Steiner et al, 2001). (Modified from Berridge, 2000.) To view this figure in colour, please see the online version of the journal.

inputs both from deep subcortical systems that send ascending signals directly to it, and from prefrontal cortex regions involved in cognitive emotional appraisals (Kalivas & Nakamura, 1999; Zahm, 2000).

How does this research bear on the subliminal affective reactions to drinks in adult humans found by Winkielman and colleagues? We speculate that activa tion patterns in the shell of the human nucleus accumbens might well be altered by a subliminal happy facial expression. It is known that subliminal facial expressions activate brain structures closely connected to the accumbens (Morris, et al., 1998; Whalen et al., 1998). Emotional subcortical circuits are also activated by fear-related facial expressions even in blindsight patients (de Gelder, Vroomen, Pourtois, & Weiskrantz, 1999; Morris, DeGelder, Weiskrantz, & Dolan, 2001). Altered neuronal activity in the nucleus accumbens (constituting unconscious "liking") and related brain structures could then change the human affective reaction to a drink, just as morphine microinjection into a rat's shell of accumbens enhances its affective reaction to sweetness and leads to a behavioural reaction of greater "liking".

Further, to the degree that *conscious* feelings of pleasure might be influenced in turn by opioid activation in accumbens, the subjective feeling could be caused

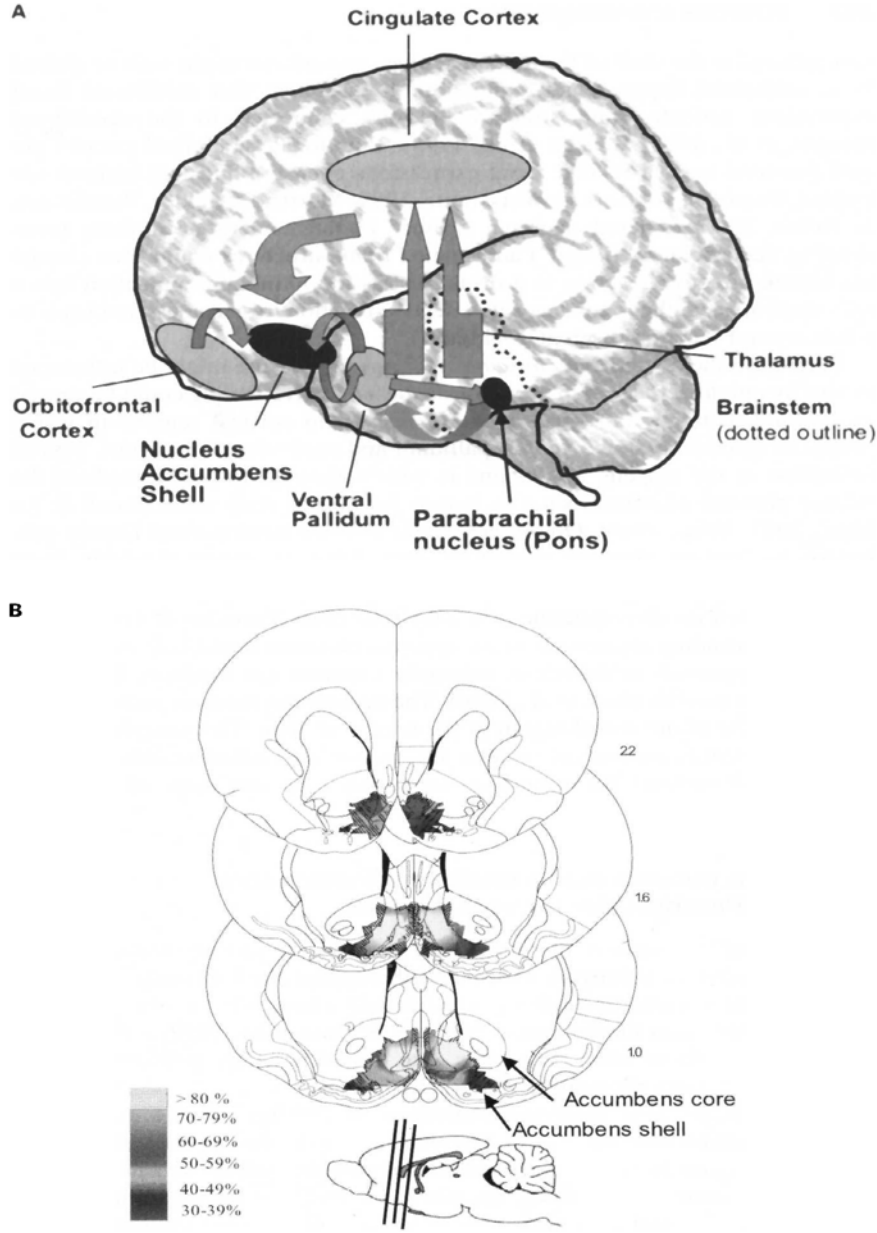

Figure 3 (opposite). (A) Brain sites that mediate core processes of sensory pleasure. The nucleus accumbens is in the bottom of the subcortical forebrain, and the parabrachial nucleus is in the pons portion of the brainstem. (Modified from Berridge, in press b.) (B) Opioid site in nucleus accumbens shell for "liking" and "wanting" taste pleasures, identified by map of morphine microinjections. Site shown in coronal slices (face on view). Position of slices shown by saggital brain in profile below. (Modified from Peciña & Berridge, 2000.) To view this figure in colour, please see the online version of the journal.

by accumbens-to-cortex signals that are relayed to cortical regions in just a couple of synapses, via the ventral pallidum and mediodorsal thalamus. Opioid activation in the nucleus accumbens is widely thought to partly mediate the intense pleasure of stimuli such as heroin for human drug users (Koob & Le Moal, 2001; Wise, 1998). Opioid activation also mediates normal human subjective feelings of pleasure caused by tasty food, as opioid-blocking drugs reduce the conscious pleasure (though the entire brain also is affected in such studies, which involve systemic drug administration; Yeomans & Gray, 1997). Finally, descending projections in the opposite direction might help explain how cognitive appraisals or deliberate voluntary intention can modulate basic emotional reactions (Davidson et al., 2000). The accumbens receives massive inputs back from the orbitofrontal region of the prefrontal lobe. This completes a loop between potential subcortical systems for unconscious affective core processes and cortical systems for cognitive, conscious representations of emotional events.

Brainstem contributes to positive affective core process: Parabrachial nucleus of pons

Core "liking" for sensory pleasure is not contained in just one brain structure, but is mediated by a network distributed throughout the subcortical brain. For example, the nucleus accumbens is intimately connected to other structures extending deep into the brainstem (Kalivas & Nakamura, 1999; Zahm, 2000). Activation of those other structures also produces more positive affective reactions to sensory pleasure (Berridge, in press b).

Among these deep brainstem structures of "liking" is the parabrachial nucleus —located near the top of the pons, which is the upper portion of the hindbrain (Figure 3). In rats, the parabrachial nucleus receives signals ascending from many sensory modalities, including visceral signals regarding internal bodily functions, and also taste sensations from the tongue (Norgren, 1995). Interestingly, in humans, the same brainstem parabrachial nucleus has been suggested to participate in generating what Damasio calls the "protoself" an unconscious but coherent representation of the momentary state of the body (Damasio, 1999). Damasio's protoself has several functions in common with our notion of unconscious core psychological processes. Both involve representations of significant stimuli that remain unconscious, and both can support generation of appropriate reactions. In addition, Damasio suggests that damage to the parabrachial region of the brain can impair consciousness itself. For example, deficits in awareness of extreme Alzheimer's disease, and the coma that follows certain brainstem damage, both involve disruption of this region of the brain (Damasio, 1999).

Specifically regarding pleasure, activation of a neurotransmitter receptor in the parabrachial nucleus causes increased "liking" reactions to a pleasant taste, just as does opioid activation of the nucleus accumbens. In this case, the specific

receptors are called benzodiazepine receptors, and help facilitate the impact of an inhibitory amino acid neurotransmitter called gamma-aminobutyric acid or GABA. A recent study in our laboratory found that a microinjection of a benzodiazepine drug into the parabrachial nucleus caused enhanced "liking" for a sweet taste (Söderpalm & Berridge, 2000). The rats emitted more positive affective reactions than usual to a bittersweet taste after the benzodiazepine microinjection into their parabrachial nucleus. Our discovery of a core "liking" enhancement caused by parabrachial nucleus is consistent with earlier findings that similar microinjections cause enhanced eating behaviour of food. In other words, parabrachial receptor activation leads rats to also "want" the food it has made them "like" (Higgs & Cooper, 1996; Peciña & Berridge, 1996).

Perhaps not surprisingly, the parabrachial nucleus sends signals up to the nucleus accumbens. And the parabrachial nucleus can receive signals in turn from the nucleus accumbens, via a single synapse in the lateral hypothalamus (Zahm, 2000). Thus, the brainstem parabrachial nucleus is firmly embedded in a larger brain circuit for a core process of affective reaction to sensory pleasure, which loops recursively throughout the brain.

Affective brainstem: Conscious affect or unconscious core process?

Clearly, the brainstem makes an important contribution to core processes of sensory pleasure, at least for taste "liking". Some theorists have suggested that *conscious* affective feelings arise from brainstem substrates too. For example, Panksepp argued, "the most basic form of conscious activity…arises from the intrinsic neurodynamics of the PAG…" (p. 314, Panksepp, 1998a). The PAG is the periaqueductal grey area, an opioid-rich site in the midbrain portion of the brainstem. He suggested, "It is the PAG that allows creatures to first cry out in distress and pleasure" (p. 314, Panksepp, 1998a). In a related paper on brain mechanisms of consciousness, Panksepp pointed out that he does not suppose the PAG can "explain higher forms of human consciousness", but stipulates that: "However, it might begin to explain the fundamental nature of e-qualia, the distinct affective states that arise from the arousal of the basic emotional systems of the brain" (p. 569, Panksepp, 1998b).

Panksepp's suggestion that the brainstem generates the most basic forms of conscious pleasure follows from his conviction that all true emotional reactions must be intrinsically conscious (similar to the position of many psychologists discussed earlier). For example, for identifying brain systems of emotion, Panksepp suggests "the basic criterion that emotional systems should be capable of elaborating *subjective feeling states* that are affectively valenced…" (p. 48, italics added, Panksepp, 1998a).

Interestingly, in this respect Panksepp's proposal for an affectively conscious brainstem is similar to the most strictly conscious cognitive appraisal view of affect and emotion, as represented for instance by Clore (Clore, 1994). Both

views agree that "emotion is never unconscious". An emotional reaction, for both Panksepp and Clore, is necessarily a conscious reaction (although these two views of emotion might agree on little else). The idea that deep brainstem activity might suffice for affective consciousness also seems to underlie the controversial but intriguing recent suggestion that anaesthetics should be routinely given to organ donors who are clinically brain dead (Young & Matta, 2000). Thus, there appear to be practical consequences of these theoretical positions.

That brainstem circuits themselves are capable of generating real consciousness remains a logically possible alternative, but it is *not* our suggestion here. Instead, as a working hypothesis we posit that subcortical brain circuits are truly affective, but only as unconscious core processes contained within ordinary emotion. Those unconscious affective processes do not give rise to conscious feelings by themselves. They are not even directly accessible to conscious introspection in a normal brain (as evidenced by people's inability to report subliminally induced emotional processes that later cause them to drink more of a fruit drink).

By this view of unconscious affective core processes, only an unconscious "like" or "dislike" is revealed when an anencephalic human infant, born without a forebrain, smiles to pleasant sweetness or gapes to bitterness (Steiner, 1973). And similarly, no more than unconscious "liking" is signified by positive affective reactions to sweet tastes of a decerebrated rat, whose brain has been surgically transected behind the hypothalamus (Berridge, 1988; Grill & Norgren, 1978b). The isolated brainstem is capable by itself of unconscious "likes" and "dislikes", which it reflects behaviourally in these cases, but not of conscious likes or conscious dislikes.

It is difficult to find evidence by which to choose conclusively between such hypotheses, and we acknowledge the case is not closed. On the one hand, as others and we have suggested, it might be that subcortical brain systems generate only unconscious core affective processes. Other (perhaps cortical) brain systems must then elaborate those basic reactions into consciousness. On the other hand, it is conceivable that even deep subcortical brain systems participate directly in the generation of conscious feelings. If that were so, then the mechanism determining whether emotional processes were conscious or unconscious would be more subtle and complicated than a simple neuroanatomical division of labour between cortex and lower brain structures. Instead, the same neural structures might be capable of supporting both conscious and unconscious modes of emotional reaction. Still, it seems plausible that the ratio of conscious versus unconscious emotional representation might decline as one descends the brain.

In either case, the existence of unconscious "likes" and "dislikes" seems demanded by examples such as the subliminal priming of affective reactions to a drink we found in people who reported no emotional experience at the moment their reaction was caused (Winkielman et al., 2000). And the existence of unconscious emotional processes demands a generative explanation in terms of brain systems. The psychological difference between conscious feelings and

unconscious emotional reactions should correspond to a difference in affective neuroscience terms. The nature of that difference remains to be elucidated.

CONCLUSION

William James' (1894) theory defined subjective feeling as the essence of emotion. Yet he posited that conscious emotional feeling depended on an unconscious prior cause, namely, the bodily reaction to the emotional stimulus. That immediate neurobehavioural reaction was automatic, but shared certain features with the conscious emotion it enabled, such as the eliciting stimulus and a valenced response. This Jamesian reaction seems to encompass several features of what we have called unconscious core processes of emotion. Perhaps, after all, it is not such a contradiction of William James to ask: "What is an unconscious emotion?".

Although the contemporary psychology of emotion has tended to emphasise the view of emotion as intrinsically conscious, we propose that unconscious emotions also exist. To mediate unconscious emotion, there appears to be a subcortical network available to generate core "liking" reactions to sensory pleasures. In normal adults under some conditions, core "liking" reactions may influence a person's consumption behaviour later, without a person being able to report subjective awareness of the affective reaction at the moment it was caused. When the brain generates an affective response of which the mind is unaware, as we have described here, there exists a truly unconscious emotion.

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Pleasure and displeasure from the body: Perspectives from exercise

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The affective changes associated with acute exercise have been studied extensively in exercise and health psychology, but not in affective psychology. This paper presents a summary of the relevant findings and a tentative theoretical model. According to this model, affective responses to exercise are jointly influenced by cognitive factors, such as physical self-efficacy, and interoceptive (e.g., muscular or respiratory) cues that reach the affective centres of the brain via subcortical routes. Furthermore, the balance between these two determinants is hypothesised to shift as a function of exercise intensity, with cognitive factors being dominant at low intensities and interoceptive cues gaining salience as intensity approaches the individual's functional limits and the maintenance of a physiological steady-state becomes impossible.

A large and continuously expanding research literature in the areas of exercise and health psychology and behavioural medicine shows that single bouts of exercise are commonly associated with what has been called a “feel better" response (Tuson & Sinyor, 1993; Yeung, 1996). Although the possible link between exercise-induced changes in the body and affect is an issue of great theoretical interest, this research has been almost exclusively descriptive, focusing on the practical implications for public health. Although the public health implications should not be overlooked, the absence of theory is striking and could hamper further progress (Ekkekakis & Petruzzello, 1999).With the exception of a series of studies by Thayer and his co-workers, in which moderate exercise was shown to be one of the factors that contribute positively to the self-regulation of mood (Thayer, 1987a, b; Thayer, Peters, Takahashi, & Birkhead-Flight, 1993), the exercise-associated “feel better" phenomenon has received little attention in other areas of psychology. In the few studies that involved exercise treatments, exercise was assumed to produce a state of high arousal,

devoid of any form of pleasure or displeasure, essentially serving as an analogue to the injections of epinephrine in Schachter's experiments (e.g., Anderson, Deuser, & DeNeve, 1995; Isen, Daubman, & Nowicki,1987; Sinclair, Hoffman, Mark, Martin, & Pickering, 1994; Zillman & Bryant,1974; Zillman, Katcher, & Milavsky, 1972).

In general, there are conflicting assumptions about the relationship between exercise and affect. One of the goals of this paper is to show that some of these assumptions are contradicted by empirical evidence and all tend to be monolithic, not recognising that the relationship is in fact multifaceted and dynamic. Another goal is to highlight that exercise can serve as a useful model for the investigation of one of the most controversial components of many theories of affect, namely the role of bodily input. To accomplish these goals, this paper will provide (a) definitions of the main terms that are used, (b) a note on measurement issues, (c) a review of empirical findings on the exercise-affect relationship showing that at least flve distinct phenomena may be involved, and (d) an outline of a new "dual-mode" conceptual model for this relationship, accompanied by a synopsis of preliminary supporting evidence.

Distinguishing basic affect from emotions

The literature on the exercise-affect relationship has not been immune to problems of inconsistent or inappropriate use of terminology. It is, therefore, imperative to define the main terms used in this paper.

Emotion and *affect* are viewed here as occupying different levels along an evolutionary continuum (also see Ekkekakis & Petruzzello, 2000). The simplest and most phylogenetically and ontogenetically primitive response is *basic affect*. This term refers to the intrapersonal or experiential core of all valenced (i.e., positive or negative, pleasant or unpleasant) responses, including, but not limited to, emotions and moods. The concept is similar to what Russell and Feldman Barrett (1999) called *core affect*. Affect is described as "basic" or "core" because it is considered an "irreducible" (Frijda, 1993, p. 383) or the "most elementary" (Russell & Feldman Barrett, 1999, p. 806) component, the nucleus or essential ingredient of all the phenomena that make up the global affective domain (i.e., the broad domain that encompasses basic affect, emotions, moods, and other related phenomena). In the same sense, other authors have characterised affect as a "broader" (Ortony, Clore, & Foss, 1987, p. 343) or the "most general" of the

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concepts in this domain (Batson, Shaw, & Oleson, 1992, p. 298). Along similar lines, I follow Scherer (1984) in using *affective states* as a "generic term" (p. 298) that refers to all varieties of states that contain the ingredient of basic affect. Importantly, although basic affect (such as pleasure or displeasure, tension or relaxation, sluggishness or excitement, etc.) can exist as a component of emotions, there can also be basic affective responses to specific stimuli that occur independently of emotions. As an example from the context of exercise, when an individual reports feeling "exhilarated", it is possible that this sense of exhilaration is a component of an emotion (e.g., pride for having completed a challenging bout of exercise) or just that—pure exhilaration.

As alluded to in the previous paragraph, *emotions* are considered here to be more complex phenomena compared to basic affect (Ekkekakis & Petruzzello, 2000). In addition to their basic affective core, emotions may also comprise other components, such as attention directed toward the eliciting stimulus, a cognitive appraisal of the meaning of that stimulus for the survival and wellbeing of the individual, behavioural expressions or action tendencies, coping responses, a multitude of physiological changes, etc. Emphasis here is placed specifically on the process of *cognitive appraisal* as a *necessary* antecedent of emotions (Lazarus, 1991; Ortony et al., 1987). The term *cognitive appraisal* refers to an inferential process by which information from the internal or external environment is *evaluated* regarding its potential *meaning* for the survival, the well-being, and the goals of the individual (Lazarus, 1991). In agreement with Lazarus (1982), I do not assume that cognition in the context of emotion-antecedent appraisals implies "anything about deliberate reflection, rationality, or awareness" (p. 1022). The distinction between rapid, automatic, unreflective, and unconscious appraisal on the one hand and slow, deliberate, reflective, and conscious on the other is not pertinent to this analysis. Finally, as used here, the term refers only to a subset of the phenomena typically subsumed under the general rubric of *emotion* by many authors in neuroscience (e.g., Damasio, 1995; LeDoux, 2000a).

Measurement issues

As a reflection of the confusion regarding the conceptual distinctions between affective phenomena, the measurement and operationalisation of affective responses to exercise has become a major source of controversy over the years (Ekkekakis & Petruzzello, 1999, 2000). In most studies, the selection of measures was not guided by which construct was the genuine target of investigation, but rather by what measures were available or popular for use with non-clinical samples, regardless of their exact content and without any prior psychometric evaluations in the context of exercise. After three decades of research, the present situation is strikingly similar to that in the area of research dealing with the affective changes associated with drugs, as described by Russell (1989). Most studies report changes in several distinct affective states, but it

remains impossible to integrate this information and, thus, identify the nature of the most salient changes or pinpoint the effects of moderating variables.

Several reviews and empirical studies published in the 1990s began to call some of the traditional measurement practices into question. Some of the most oft-cited problems were the overemphasis on negative states and the floor effects resulting from measuring negative emotions, such as state anxiety, in studies that did not involve trait-anxious participants or the induction of state anxiety. From a theoretical standpoint, the most important issue that surfaced was that certain measures were shown to confound exercise-induced changes in perceived activation with emotional changes. For example, items from the state anxiety scale of the State Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1970) referring to cognitive antecedents of anxiety, such as worry, show decreases with exercise, whereas items that reflect perceived activation show increases during and decreases after vigorous exercise, mirroring changes in autonomic activation and self-reports of perceived activation (Ekkekakis, Hall, & Petruzzello, 1999a; Rejeski, Hardy, & Shaw, 1991).

As a way of addressing these problems, some researchers turned to the development of exercise-specific measures (Gauvin & Rejeski, 1993; McAuley & Courneya, 1994). This approach consisted of asking young, healthy, and physically active respondents to indicate whether they experience various affective states when they exercise and grouping the states found to be "relevant" to exercise into scales. However, this approach is also problematic, since (a) it is atheoretical, (b) it was developed in the absence of evidence that the affective domain is uniquely transformed in the context of exercise, (c) retrospective reports from a single demographic group have limited generalisability, and (d) there is a potential for bias when measures that were tailored to reflect only responses to exercise are used to assess responses to sedentary comparison or control conditions (Ekkekakis & Petruzzello, 2001a,b).

The measurement approach used in the research that our group has conducted is different and is based on a dimensional model of affect, namely the circumplex (Russell, 1978, 1980; see Larsen & Diener, 1992 for a critical review; see Figures 1 and 2 for examples). The reasons for selecting this model were that (a) it targets basic affect, the simplest and broadest concept in the affective hierarchy, (b) as a dimensional model, it offers unparalleled parsimony, allowing the integration of findings within the global affective space, (c) it is domain-general, and (d) it is based on a strong theoretical and empirical foundation (Ekkekakis & Petruzzello, 2000, 2002). Typically, both the "unrotated" (i.e., affective valence and activation) and the 45° rotated dimensions (extending from high-activation pleasant to low-activation unpleasant affect and from high-activation unpleasant to low-activation pleasant affect, respectively) are assessed. Valence and activation are commonly assessed by two single-item scales, the Feeling Scale (FS; Hardy & Rejeski, 1989) and the Felt Arousal Scale (FAS) of the Telic State Measure (Svebak & Murgatroyd, 1985), respectively. The rotated dimensions are assessed by the Activation Deactivation Adjective

Check List (AD ACL; Thayer, 1989). Specifically, the *Energetic Arousal* scale of the AD ACL (ranging from *Energy* to *Tiredness)* is used to tap the dimension that extends from high-activation pleasant to low-activation unpleasant affect and the *Tense Arousal* scale (ranging from *Tension* to *Calmness)* is used to tap the dimension that extends from high-activation unpleasant to low-activation pleasant affect (Yik, Russell, & Feldman Barrett, 1999).

Targeting basic affect and assessing it from a dimensional perspective has several advantages for research in the context of exercise (Ekkekakis & Petruzzello, 2002), but there are still some challenges. One such issue is of particular interest here given its relevance to the subsequent discussion and its implications for the controversial issue of the relationship (i.e., independence vs. bipolarity) between positive and negative affect. In exercise, especially among trained and physically fit individuals, a commonly used expression is that vigorous exercise "hurts so good". Although this may be seen as supporting the notion of independence, an alternative interpretation is that these apparently conflicting responses originate from different levels of the affective hierarchy. The "hurt" may reflect the inherent unpleasantness of the bodily sensations that accompany strenuous physical effort (i.e., basic affect), whereas the "good" feeling may reflect a sense of pride (i.e., an emotion) sparked by the thought that, by exercising, one is doing something good for his or her health, fitness, or physical appearance. For example, in a study involving middle-aged women, participation in a maximal treadmill test resulted in increases in both fatigue and self-esteem (Pronk, Crouse, & Rohack, 1995). The distinction between responses that may originate from different levels of the affective hierarchy is extremely important from a theoretical standpoint, but still outside the reach of available measures.

Affective responses to exercise: One phenomenon or many?

Despite the fact that most writings on the relationship between exercise and affect give the impression that we are dealing with a unitary phenomenon (i.e., "exercise makes people feel better"), there is evidence that the relationship is in fact considerably more complex. Based on the nature of affective changes, the inter-individual variability of changes, and the patterns of relationships with relevant variables, at least five distinct phenomena can be identified.

First, there are positive affective responses during and for a short time following bouts of physical activity of mild intensity and short duration. This has been a relatively controversial finding. Based on a few earlier studies showing that low-intensity and short-duration exercise had no significant effects on state anxiety, some authors argued that such "small doses" of activity are not sufficient to produce significant affective changes and, instead, speculated that exercise intensity and duration should exceed certain relatively vigorous thresholds before significant changes can occur (Dishman, 1986; Raglin & Morgan, 1985). However, studies that have examined variables other than state anxiety have

produced different results. For example, research using the AD ACL (Thayer, 1989) has shown that walks at a self-chosen pace lasting for as little as 4 to 10 min were associated with increases in Energy (Thayer, 1987a,b; Thayer et al., 1993) and decreases in Tension and Tiredness (Saklofske, Blomme, & Kelly, 1992; Thayer, 1987a; Thayer et al., 1993). In a recent series of studies, Ekkekakis, Hall, Van Landuyt, and Petruzzello (2000) found that short (10 to 15 min) self-paced walks were consistently associated with increased activation and improved valence. Post-walk recovery for 10 to 15 min was associated with a return to a low-activation pleasant state (see Figure 1). This pattern was robust across different self-report measures of the circumplex dimensions, across ecological settings (outdoors and in the laboratory), across two walks on different days, and across four samples.

Although the pattern of responses appears to be reliable, the mechanisms underlying the positive responses to low-intensity, short-duration exercise have received virtually no research attention and remain elusive. It is noteworthy that in healthy, normally ambulatory adults, the intensity of physical effort involved is very low (15–22% of age-predicted maximal heart rate reserve in the studies by Ekkekakis et al., 2000). At this level of intensity, the afferent signals from peripheral physiology are weak and perceived exertion on Borg's (1998) scale is rated as "very light" or "fairly light". This raises the possibility, as suggested by an earlier hypothesis (Morgan, 1985), that the positive changes occur not because of the exercise stimulus *per se* but rather because exercise provides a distraction from daily stressors. This hypothesis was prompted by findings that exercise led to decreases in state anxiety that were comparable to those following periods of quiet rest and meditation (Bahrke & Morgan, 1978). However, in the studies by Ekkekakis et al., walking led to high-activation pleasant affect, whereas periods of rest led to decreased activation with little change in valence. Therefore, the "distraction" hypothesis does not seem tenable. It is also noteworthy that low-intensity, short-duration exercise performed in noncompetitive settings (such as taking a short walk for recreation) is generally not perceived as physically challenging in disease-and pain-free individuals. Thus, variables such as self-efficacy that have been found to be related to affective responses to more challenging types of exercise have not been shown to be related to affective responses to low and moderate-intensity exercise (e.g., Treasure & Newbery, 1998, but see McAuley, Blissmer, Katula, & Duncan, 2000, for an exception in a study of older and previously sedentary adults).

One possibility that remains in the realm of speculation is that the positive affective responses to low-intensity, short-duration exercise reflect a reward mechanism, part of a biological system that has evolved to maintain a healthy balance between energy intake and expenditure (similar to mechanisms underlying pleasant and unpleasant responses to taste or thermal sensations; Cabanac, 1971, 1979, 1995). Rowland (1998) has discussed several indications from animal and human studies that such a system (creatively named "activity-stat") may exist. If this is true, it is possible that the tendency to "go for a walk"

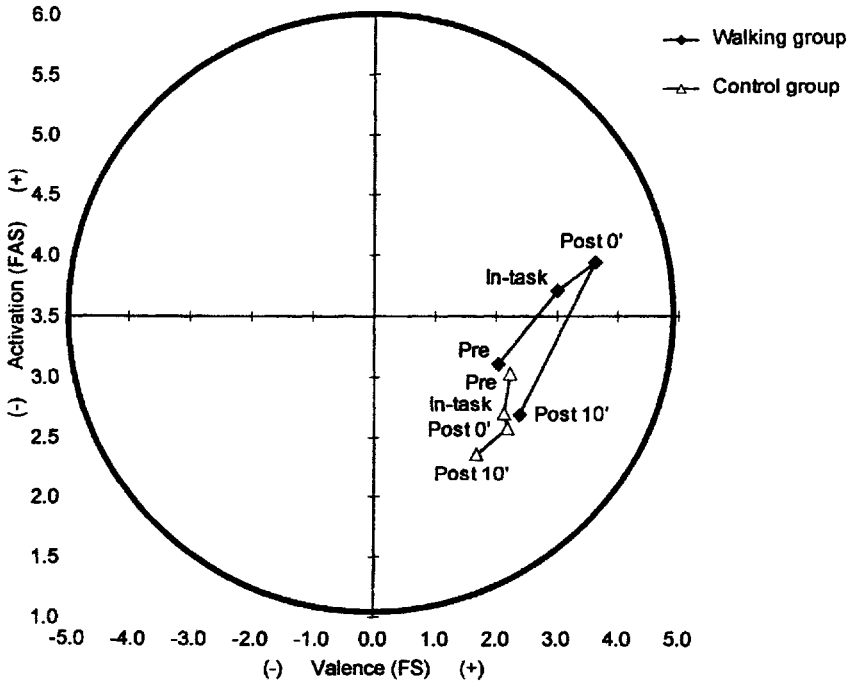

Figure 1. Affective responses to a 15-min walk on a treadmill at a self-selected intensity and a 10-min post-walk recovery period. (Data from Ekkekakis et al., 2000.)

is partly motivated by the subconscious need to expend energy and that the positive affective changes associated with such activities are the manifestations of a mechanism that has evolved to reward and, thus, promote this behaviour. After all, although the physiological responses to this level of activity are minor, this information does reach the (subcortical) areas of the brain responsible for internal regulation (Craig, 1996). The problem is that the links between exercise, energy regulation, and affect will likely remain speculative, as direct evidence is very difficult to obtain in humans.

Second, affective responses during moderately vigorous exercise are characterised by marked inter-individual variability, with some individuals reporting positive and some reporting negative changes. The traditional assumption in exercise science has been that moderately vigorous exercise provides an optimal stimulus for positive affective change (Ojanen, 1994; Raglin & Morgan, 1985). Thayer (1989) has also described the amount of exercise that is likely to lead to increases in Energetic Arousal as "moderate". One problem with these suggestions is that the amount of exercise described as *moderate* has not been specified. The percentages of maximal capacity that have been assumed to provide the "optimal" dose (e.g., 60–70% of maximal aerobic capacity;

Dishman, 1986; Raglin & Morgan, 1985) are essentially arbitrary, as they are not supported by conceptual reasoning or empirical evidence. A second problem is that these suggestions are based on examinations of affective change from pre-to various time points post-exercise, which are typically positive, although evidence from studies examining responses during exercise have shown a much more diverse pattern (Ekkekakis & Petruzzello, 1999).

In general, although the role of individual and situational variability is not entirely discounted, there has been a tendency to assume that the relationship between exercise intensity and affective responses is unitary. Therefore, it is often assumed that "moderate" exercise will produce positive affective responses in all or most individuals. For example, Morgan (1997) asserted that, although individual physiological and psychological profiles should be taken into account, it may still "be possible to defend a single exercise prescription for all individuals (e.g., 70% [of maximal aerobic capacity])" (p. 11). Based on this assumption, the majority of applied research to date has employed exercise stimuli within the "moderate" range, namely between 60% and 70% of maximal capacity and for 20–30 min. In a study designed to examine whether an exercise bout in this range (i.e., 30 min on a stationary cycle at 60% of estimated maximal aerobic capacity) leads to the assumed universally positive affective changes, Van Landuyt, Ekkekakis, Hall, and Petruzzello (2000) found that, although 97% of the participants reported either an increase or no change in activation during exercise, 44% reported a progressive improvement in valence whereas 41% reported a progressive decline. As a result of these divergent trends, the average valence responses appeared unchanged during exercise. Interestingly, this variability during exercise was followed by a convergence toward improvement after exercise. Thus, it seems that, contrary to the assumption of universality, valence responses during exercise can vary considerably between individuals.

The challenge is to identify the sources of this variability. Although the size of the relevant literature remains limited, a number of variables, primarily from social-cognitive theories, have been shown to be related to affective responses to moderate exercise. These variables include attributions, goal orientations, and others, but the one that has been studied most extensively and has been shown to be consistently associated with affective responses in a variety of samples is self-efficacy (e.g., McAuley & Courneya, 1992; McAuley, Talbot, & Martinez, 1999; Treasure & Newbery, 1998).

An important question that is receiving increasing attention is whether the variance in affective responses accounted for by self-efficacy changes as a function of exercise intensity. This question is particularly relevant to affective responses associated with moderate exercise, because it has been suggested that self-efficacy becomes a salient moderator of affect when the intensity of exercise presents an appreciable challenge (e.g., 70% of maximal heart rate; McAuley & Courneya, 1992), but, if the intensity is too high, its influence is weakened because "physiological cues…override cognitive processing" (McAuley et al., 2000, p.

352). However, the data on this issue are inconsistent. Treasure and Newbery (1998) showed that self-efficacy was related to physical exhaustion when the intensity was 70–75% but not when it was 45–50% of heart rate reserve. Conversely, Tate, Petruzzello, & Lox (1995) found that selfefficacy was related to scores on the Tense Arousal scale of the AD ACL during exercise performed at 55%, but not at 70% of maximal aerobic capacity. Finally, in a study of older adults, McAuley et al. (2000) found that changes in selfefficacy were unrelated to changes in affect in a moderate exercise intensity condition, but were related to changes in affect in a light and in a maximal exercise intensity condition. As in much of this research, the inconsistency in the findings may be due to differences in the age and physical condition of the participants, the measures of affect, and the exercise loads. To examine the relationship between self-efficacy and affective valence across a greater range of intensities, Ekkekakis, Hall, and Petruzzello (1999b) used an exercise protocol in which the speed and grade of a treadmill were increased every minute, from a slow jog to the point of volitional exhaustion. Consistent with the hypothesis that the relationship should be stronger at moderate levels of intensity, the results showed significant positive correlations between self-efficacy and affective valence near the middle of the range, but not in the early stages or at the point of volitional exhaustion.

A noticeable void in this literature is the absence of studies on the role of personality. This is partly due to the fact that the standard measures of relevant personality traits (i.e., extraversion, sensation seeking, behavioural activation/inhibition, etc.) emphasise social behaviour over responses to somatosensory stimuli, making it difficult to find significant relationships with affective responses to exercise. Nevertheless, individual differences are likely to play an important role. For example, in a preliminary series of studies on the role of exercise-specific sensory modulation, Ekkekakis, Hall, and Petruzzello (2001) found that preference for and tolerance of exercise intensity accounted for approximately 25% and 20%, respectively, of the variance in valence during moderate exercise. In general, affective responses to moderate exercise can vary considerably between individuals. Social-cognitive variables and some individual differences may account for substantial portions of this variability.

Third, responses immediately following moderately vigorous exercise are almost uniformly positive, regardless of whether the responses during exercise were positive or negative. The robustness of this post-exercise positive change is remarkable. It is a phenomenon that seems to transcend modes of exercise, exercise environments, types of participants, and measures of affect. It quickly eradicates any divergent trends that might have occurred during exercise (Ekkekakis & Petruzzello, 1999). Although compared to assessments made during exercise, activation begins to drop, average valence ratings improve. This improvement is more dramatic among those who report a deterioration during exercise, but it is noticeable even for those who report an improvement during exercise (Ekkekakis et al., 1999a). Compared to pre-exercise, the average postexercise state is characterised by higher (although gradually decreasing)

activation and improved valence. During post-exercise recovery, this state is progressively transformed into a low-activation pleasant state.

For those individuals who report a positive change immediately post-exercise, following a negative trend during exercise, Solomon's (1980, 1991) opponent process model (to be discussed shortly) may provide a possible explanation. On the other hand, for those individuals with already positive trends during exercise, the continued positive changes in valence after exercise may be a reflection of at least some of the same mechanisms that produced the positive changes during exercise. The overlap, however, is unlikely to be complete because the post-exercise positive changes are accompanied by decreases in activation, whereas the during-exercise positive changes are accompanied by increases. No research exists on this issue.

Fourth, affective responses during strenuous exercise unify into a negative trend as the intensity of exercise approaches each individual's functional limits. In several studies in which the intensity of exercise was gradually increased to levels that approached the participants' physical limits, valence ratings showed a progressive decline with each increase in intensity (Acevedo, Rinehardt, & Kraemer, 1994; Hardy & Rejeski, 1989; Parfitt & Eston, 1995; Parfitt, Eston, & Connolly, 1996; Parfitt, Markland, & Holmes, 1994). Furthermore, as exercise intensity increased, the negative correlations between valence and various indices of metabolic strain (heart rate, ventilation, respiratory rate, oxygen consumption, blood lactate) increased in magnitude (Acevedo et al., 1994; Hardy & Rejeski, 1989), suggesting an increasingly stronger link between valence and interoceptive afferents.

In two studies, we examined whether the negative shift in affective valence is specifically linked to an important metabolic event, namely the transition from aerobic to anaerobic metabolism. This is perhaps the single most important landmark in the entire range of exercise intensity from an adaptational standpoint. This is because, although the energy resources that are available for aerobic metabolism are vast, the resources that are available for anaerobic metabolism are limited. As a result, one can continue to exercise for only a brief period of time at this level of intensity before the energy resources are depleted and exhaustion sets in. The determination of the level of exercise intensity that corresponds to the transition from aerobic to anaerobic metabolism is done by continuously collecting the expired gases, analysing them for oxygen and carbon dioxide, and determining the so-called ventilatory threshold, the point at which there is a systematic increase in the ventilatory equivalent of oxygen without a corresponding increase in the ventilatory equivalent of carbon dioxide. In the first study (Hall, Ekkekakis, & Petruzzello, 2002), we examined minute-byminute ratings of valence and activation as exercise intensity (the speed and incline of a treadmill) was gradually increased until each participant reached the point of volitional exhaustion. The results showed that, during the early stages, affective change was characterized primarily by an increase in activation, with little change in valence. After the transition to anaerobic metabolism, however,

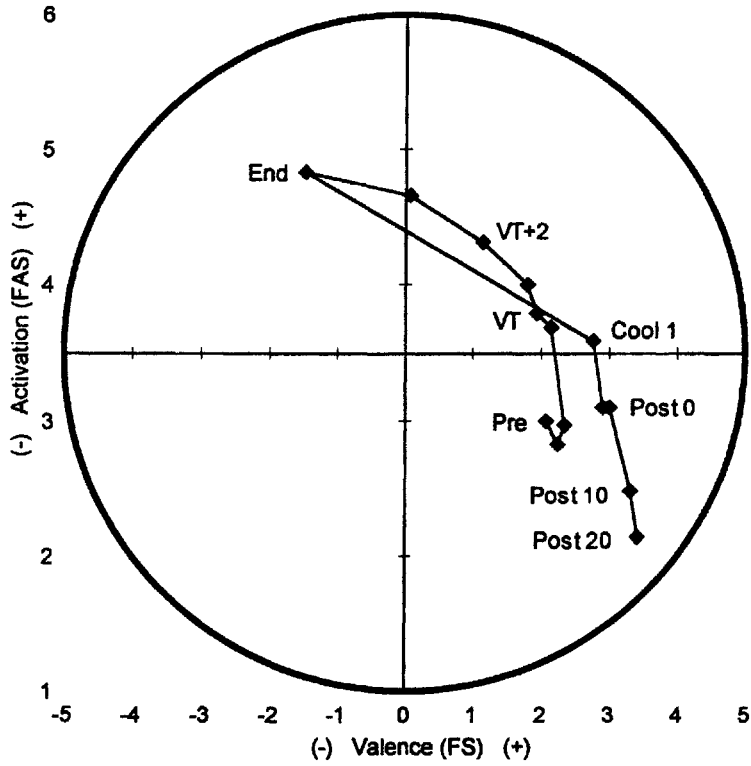

Figure 2. Affective responses to a graded treadmill test performed until volitional exhaustion and a 20-min recovery period. (*Note:* VT: ventilatory threshold; VT+2 min 2 after the VT; Cool 1: min 1 of the cool-down). (Data from Hall et al., 2002.)

the continued increase in activation was coupled with a substantial shift toward negative valence (see Figure 2). Furthermore, an examination of the interindividual variability in minute-to-minute changes in valence showed that, despite large variability during the early stages, starting with the minute following the ventilatory threshold and until exhaustion, the valence ratings of most participants exhibited a relatively homogeneous pattern of decline. Similar results were obtained in a second study (Ekkekakis, Hall, & Petruzzello, in press), in which the participants ran at a constant pace for 15 min at three intensities, one below, one at, and one above the ventilatory threshold. Again, with increasing intensity, there were larger increases in activation and declines in valence. Particularly during the run above the ventilatory threshold, the pattern of decline in valence fit a quadratic trend, indicating a more rapid rate of decline over time compared to the intensities below and at the ventilatory threshold. Analyses of inter-individual variability in changes in valence over the course of the runs also showed less variability above the ventilatory threshold.

Furthermore, in both studies, physiological variables showed strong negative relationships with ratings of affective valence at intensities above the ventilatory threshold (these results are reported in Ekkekakis et al, 1999b, Ekkekakis, Hall, & Petruzello, 2002). During the incremental treadmill test, the respiratory exchange ratio (the ratio of carbon dioxide produced to oxygen consumed) accounted for less than 10% of the variance in valence below, but for approximately 30–50% above the ventilatory threshold and until exhaustion. During constant-pace exercise (during which ventilatory data were not collected), above the ventilatory threshold (when there was no physiological steady state), the correlation between valence and the percentage of maximal heart rate was gradually strengthened from .08, to −.45, whereas no relationship was found during the runs below and at the ventilatory threshold. Therefore, it seems that strenuous exercise, particularly at an intensity that exceeds the ability of the metabolic system to supply energy through purely aerobic means, leads to declines in affective valence that exhibit limited inter-individual variability. Furthermore, a substantial portion of the variance in valence ratings at this level of intensity is accounted for by physiological variables.

Fifth, there is a homogeneous positive shift in affective valence immediately following strenuous exercise. In Hall et al. (2002), affective valence was assessed at the point of volitional exhaustion and one and two minutes later, as the participants were cooling-down by walking on the treadmill at a slow pace. Within just the first minute of the cool-down, affective valence had returned to the level it was before and during the first few minutes of the incremental exercise protocol. Furthermore, the patterns of inter-individual variability of changes in valence for all the stages of the test showed that the dramatic improvement that followed the termination of the test was the least variable response, even more homogeneous than the negative change during the last minute before volitional exhaustion.

The mechanisms that underlie the instantaneous improvement in affective valence that follows the negative response to exhaustive exercise are, again, unclear. Descriptively, the pattern of responses resembles what Solomon (1991) described as the *affective contrast* phenomenon. He proposed that this pattern of responses might be driven by an affective opponent process (Solomon 1980, 1991; Solomon & Corbit, 1974). Specifically, Solomon proposed that, in response to certain stimuli, including exercise that exceeds a critical threshold of intensity, affective responses are the algebraic sum of two processes that carry opposite valence signs. He attributed this function to a hypothetical affect summator, which determines the quality of the affect experienced at any given moment. Therefore, although the affect may be co-determined by two distinct processes, the experience is unitary. In this regard, Solomon's notion is consistent with the philosophical view that, although conscious experience may be determined by multiple spatially distributed and specialised assemblies of neurons in the brain, consciousness itself is unitary at each moment in time (e.g., Greenfield, 1995). According to Solomon, the primary process, the so-called *a-*

process, is an unconditioned response aroused by the onset of the stimulus. It closely tracks the intensity of the eliciting stimulus and disappears shortly after the termination of that stimulus. The appearance of the *a*-process, after a short delay, leads to the elicitation of a secondary process, the so-called *b*-process, which has the opposite valence. Not only is the *b*-process slower to appear than the *a*-process, but it also has a slower build-up and a slower decay. As a result, the effects of the *b*-process persist for a period of time following the termination of the eliciting stimulus. Thus, what Solomon (1991) called the "standard pattern of affective dynamics" in response to a relevant stimulus, such as exercise, is characterised by two consecutive states. State A is the period of time during which the eliciting stimulus is present and affect is the result of the algebraic summation of the *a*- and *b*-processes. State B is the period that follows the cessation of the eliciting stimulus, during which affect depends solely on the *b*-process, since the *a*-process ends almost immediately after the removal of the stimulus. The strength of the *b*-process is hypothesised to increase with repeated exposures to the stimulus. Solomon has argued that, in the case of exercise, the *a*-process is charged with negative affective valence, whereas the b-process is charged with positive valence. Thus, although during exercise (particularly in physically unconditioned individuals participating in exercise for the first few times), the responses may be negative, following exercise, the response is positive.

Although the predictions of the opponent process model are consistent with the patterns of affective responses to exercise typically reported in the literature, the possible substrates of the *a*- and *b*-processes have not been explored systematically. Given that, according to Solomon (1980, 1991), the a-process is activated only in response to stimuli that exceed a critical level of intensity, then tracks the intensity of the eliciting stimulus, and finally disappears upon the termination of that stimulus, it is possible that what drives the a-process in the context of exercise are the interoceptive signals that carry information from receptors stimulated by the chemical, circulatory, mechanical, and other peripheral physiological changes that take place during strenuous exercise. As noted earlier, the declines in affective valence with increasing intensity, particularly following the transition from aerobic to anaerobic metabolism, are related to physiological variables (Acevedo et al., 1994; Ekkekakis et al., 2002; Hardy & Rejeski, 1989). On the other hand, Solomon (1980) speculated that the b-process might be driven by the endogenous opiate system. The hypothesis that the socalled "exercise high" or "runner's high" is linked to the known increases in peripheral opiates during vigorous exercise has been frequently cited in the popular press, but research evidence is mixed (Hoffmann, 1997). What may hold some promise, however, is a hypothesis by Hatfield and Landers (1987) that *central* opiates in particular may be linked to the positive post-exercise affective changes through their role in returning peripheral physiological activity toward baseline (i.e., reducing heart rate and blood pressure, slowing respiration, etc.; Vaccarino & Kastin, 2000) and, thus, alleviating the symptoms of exertion.

Opiate levels in several brain regions have been reported to increase in response to acute exercise, including areas involved in cardiovascular and respiratory regulation. Decreases in heart rate, blood pressure, and respiratory activity induced by opiate agonists are reversed by naloxone, an opiate antagonist that crosses the blood-brain barrier. However, the hypothesis by Hatfield and Landers has yet to be tested directly, as most relevant studies have concentrated instead on whether opiates are related to changes from pre-to post-exercise rather than immediately following strenuous exercise.

A synthesis and a proposed dual-mode conceptual model

As shown in the foregoing review, the affective responses associated with physical exercise constitute a complex and multifaceted phenomenon. There are pleasant and unpleasant responses, periods of low and high activation, patterns of individual variability and homogeneity, and multiple correlates whose strength of association with affective responses varies. Integrating this information into a conceptual model is a challenging task which is made more difficult by a number of factors, including the relatively small number of studies that have gone beyond mere description to the test of specific theory-driven hypotheses, the costly and laborious nature of metabolic assessments that limit sample sizes, and the inability to benefit from modern brain imaging methods due to the susceptibility of this technology to movement artifacts. At present, most of the information on the possible moderators of the exercise-affect relationship comes from correlational research and most of the information on the brain structures involved comes from animal studies or from research with somatic stimuli other than exercise (e.g., pain, visceroception). Although this situation makes speculation inevitable, the potential benefits from formulating even a tentative conceptual model make this effort worthwhile.

The first step in attempting to understand the substrates of affective responses to exercise is to examine exercise itself from an adaptational standpoint. As noted in the review, the intensity of exercise plays a critical role in influencing both the valence of the affective responses and the nature of their primary correlates. Analyses of the metabolic responses across the entire range of exercise intensity reveal three distinct domains of intensity (Gaesser & Poole, 1996). The first domain encompasses the lower range of intensities, in which an adequate supply of energy can be produced through aerobic metabolism. In this range, a physiological steady-state can be maintained for a long time and there is no accumulation of lactate (an acid by-product of the metabolism of glucose). The second domain begins at the point at which the ability of the metabolic system to provide an adequate supply of energy through aerobic means is exceeded and the process must be supplemented by anaerobic metabolism. In this domain, lactate begins to appear at a rate that exceeds the rate of removal, leading to an accumulation of lactate known as the “lactate threshold”. However, if the rate of accumulation is not too rapid, over time there may be a new

stabilisation of lactate, but this time at increased levels of concentration. The intensity that corresponds to this "maximal lactate steady-state" is the upper limit of this domain. Another important change in this domain is that the rate of oxygen uptake cannot be stabilised and, instead, there is a gradual increase in oxygen cost per unit of work. In this range of intensity, there is a potential threat to homeostasis since the maintenance of a physiological steady-state is no longer possible and the production of energy depends in part upon the limited resources available for anaerobic metabolism. The final domain of intensity extends from the higher level at which lactate can be stabilised to the point of maximal exercise capacity. In this range, neither oxygen uptake nor lactate can be stabilised. Both rise continuously until exercise is terminated due to exhaustion.

The adaptational implications of this typology are fairly clear. In the low range of intensity, activity can be continued for a long time while in a physiological steady-state. This situation poses no threat to homeostasis and the physiological adjustments that occur remain largely outside awareness. Then, there is a range of intensity in which the maintenance of a steady-state is threatened. In this range, the amount and intensity of interoceptive information increases exponentially, as the accumulating lactate stimulates free nerve endings, respiration becomes quicker and deeper, and additional (nonoxidative) muscle fibres are recruited disrupting coordination patterns. Since this situation presents a potential challenge, good adaptational sense dictates that the possibility of a critical homeostatic perturbation should enter consciousness. As several authors have noted, affect provides the primary means by which information about critical disruptions of homeostasis enters consciousness (Cabanac, 1995; Damasio, 1995, 1999, 2000; Panksepp, 1998a,b; Schulze, 1995). Finally, above the maximal lactate steady-state, the energy supply system is overwhelmed and the maintenance of a steady-state is impossible. At this point, if the intensity of the activity is not reduced or the activity is not stopped, the available energy stores will soon be depleted and the muscles will go into rigor. What prevents this from happening is a strong and unambiguously negative affective "message" from the body.

The second step in attempting to gain insight into the mechanisms underlying the affective responses to exercise is to examine their correlates. Although research is still at an early stage, it appears that there are two main classes of correlates. On the one hand, there are several cognitive constructs (of which self-efficacy is the one that has been studied most extensively). On the other, there are physiological variables that reflect the level of metabolic strain. The results show that the variables in the latter category exhibit increasingly negative relationships with valence across increasing levels of exercise intensity (Acevedo et al., 1994; Ekkekakis et al, 1999b; Hardy & Rejeski, 1989). The information on how the relationship between the cognitive variables and affective valence changes as a function of exercise intensity is more scarce and less clear. The studies that have focused on self-efficacy have yielded conflicting results (McAuley et al., 2000; Tate et al., 1995; Treasure & Newbery, 1998). However, in the only

study that took into account the balance between aerobic and anaerobic metabolism, the relationship between self-efficacy and valence was shown to be weak below the aerobic-anaerobic transition and at the point of exhaustion, but stronger around the point of transition, when the challenge to participants was presumably appreciable but not overwhelming (Ekkekakis et al., 1999b).

A crucial question is whether and how the cognitive and peripheral physiological influences on affect interact across the domains of exercise intensity. At this step, examining the structure of the brain mechanisms involved in the processing interoceptive information and the generation of affective responses can provide valuable insight. As is the case with the mechanisms involved in the processing of other types of somatosensory stimuli, afferent signals associated with exercise, such as signals from chemoreceptors, mechanoreceptors, articular nociceptors, thermoreceptors, baroreceptors, and various visceroceptors in the heart, lungs, and internal organs, reach areas with an increasingly complex network of connections as they ascend from the spinal cord to the cerebral cortex. This hierarchical organisation is assumed to be the result of an evolutionary process and to serve an adaptive function (Berntson, Boysen, & Cacioppo, 1993; Berntson & Cacioppo, 2000). Although adaptational problems could be solved by the complex and polysynaptic higher processing levels, those problems that have remained invariant and had to be solved reliably during the evolutionary history of the human species can also be solved by simpler, oligosynaptic, lower processing levels. In fact, solving such invariant adaptational problems through simpler mechanisms may not only represent a more efficient use of limited resources, but may also offer a considerable adaptational advantage. Oligosynaptic mechanisms may lack response flexibility but are fast and reliable (Berntson & Cacioppo, 2000; Griffiths, 1990). There are situations in which rigid, obligatory responses are preferable to responses from systems that could enter a multitude of factors into the equation, some of which may be impertinent or downright maladaptive. The wisdom of the hierarchical design is that it can allow the priority in the control of behaviour to shift between the higher and lower processing levels to fit varied adaptational needs (Berntson & Cacioppo, 2000).

LeDoux (1986, 1989, 1995, 1996, 2000a,b) has proposed a model of affective responses that is consistent with the notion of shifting control between higher and lower levels of the brain. The model was initially based on neuroanatomical evidence that the amygdala, which LeDoux considers to be the center of integration of affective information, receives sensory input via two routes. One pathway, the “low road,” carries sensory data directly from the sensory thalamus. This information is crude as its features have not been elaborated by the sensory cortex and its implications have not been analysed by the frontal cortex. The processed version of this information is fed into the amygdala by the other pathway, characterised as the “high road”. Thus, the activity of the amygdala and the ensuing responses reflect the constantly updated balance between these two inputs. According to LeDoux, the “low road” appears to be involved in the

processing of "relatively simple sensory cues" (LeDoux, 1989, p. 274) whereas the "high road" may be involved in processing more complex stimuli and "cognitive information" (p. 276) from the hippocampus and the cortex.

Although LeDoux's work has concentrated on visual and auditory stimuli, he has pointed out that the amygdala also receives extensive interoceptive inputs (LeDoux, 1989). In fact, there is extensive evidence that respiratory and cardiac activity, blood pressure fluctuations, stimulation of baroreceptors and chemoreceptors, and various modalities of noxious somatosensory stimulation are reflected in the activity of the amygdala, suggesting that its involvement during exercise is highly likely. This was supported in a study in rats, in which exercise led to increases in glucose utilisation by 56% in the central nucleus, 33% in the lateral nucleus, and 18% in the medial nucleus of the amygdala (Vissing, Andersen, & Diemer, 1996). Importantly, in addition to extensive corticoamygdala connections from the somatosensory cortices (McDonald, 1998), interoceptive cues reach the amygdala via multiple subcortical routes (i.e., multiple "low roads"). In addition to the thalamo-amygdala pathway, there are projections from other areas, including the nucleus of the solitary tract (Ottersen, 1981; Ricardo & Koh, 1978), the parabrachial nucleus (Bernard, Alden, & Besson, 1993), and a spinal projection (Burstein & Potrebic, 1993). Further-more, the amygdala receives input about the internal state of the body from several subcortical areas known to be involved in cardiovascular, respiratory, and endocrine regulation during exercise, including the ventrolateral medulla (Roder & Ciriello, 1993) and hypothalamic nuclei (Ottersen, 1980).

A critical issue, and one that has stimulated criticism toward LeDoux's model, is identifying the mechanism that determines whether information about a sensory event should reach the amygdala via the "low road" as opposed to the "high road". The challenge from a theoretical standpoint is that the determination of whether the adaptive advantage is to be had by responding to a given stimulus on the basis of the quick but crude input of the "low road" or the slow but enriched input of the "high road" almost begs the invocation of a homunculus at the subcortical level. Clore and Ortony (2000) argued that, for the amygdala to be activated via the thalamo-amygdala route when seeing a snake on the ground, as LeDoux has suggested, some recognition and evaluation of the adaptational significance of the snake must take place but these functions constitute cognitive processing. It is important to recognise that, although this may be a relevant point of contention in the case of exteroceptive stimuli, whose form must be distinguished from other forms and their symbolic meaning must be appraised, the scenario may be simpler in the case of interoceptive stimuli such as those associated with exercise. This is because perhaps most of the adaptational significance of interoceptive cues may already be encoded in their intensity. Research on the physiology of interoceptors suggests that the intensity or severity of the stimulus is reflected in the pattern of firing of different classes of interoceptors (Cervero, 1994). Thus, the information that is essential for survival, namely the degree of dysregulation of the internal state, can be reflected

in the pattern of activation of the interoceptive neurons. This information does not need to undergo recognition or evaluation in the sense implied by cognitive models of emotion. Instead, the determination of the significance of these cues for survival can be made on the basis of their intensity by nuclei that act as gates, allowing only the flow of impulses that exceed a critical level of intensity. In addition to the sensory thalamus, other nuclei may also serve a gating function, including the lateral nucleus of the amygdala, the entry point of most sensory input into the amygdaloid complex (Lang & Pare, 1998). Theoretically, these gates could be responsible for directing interoceptive impulses toward the cortex or directly toward the amygdala, depending on their intensity. Preliminary evidence is consistent with this possibility. In rats, stimulation using an air-puff resulted in an average delay of 61 ms until the response of the lateral nucleus of the amygdala (Uwano, Nishijo, Ono, & Tamura, 1995), whereas the corresponding value using an electric foot shock was only 17 ms (Romanski, Clugnet, Bordi, & LeDoux, 1993). This difference could indicate that the impulse from the more intense foot shock reached the amygdala via a shorter route, bypassing the cortex.

Based on the preliminary evidence from exercise studies and the information from neuroscience, it is reasonable to speculate that affective responses to exercise are the products of the continuous interplay between two general factors, both of which have access to the affective centres of the brain (i.e., the amygdala, but also other areas not discussed here, such as the anterior cingulate and insula): (a) relevant cognitive processes originating primarily in the prefrontal cortex and involving such processes as appraisals of the meaning of exercise, goals, self-perceptions including self-efficacy, attributions, and considerations of the social context of exercise and (b) interoceptive cues from a variety of receptors stimulated by exercise-induced physiological changes, which reach the affective centres of the brain via oligosynaptic subcortical pathways. Because of the assumed dual influences on affective responses, this conceptualisation is referred to as the *"dual-mode" model*. Neither mode is likely to have complete control over affective responses to exercise. Instead, the relative salience of the two types of influences is likely to change as a function of exercise intensity. In healthy humans, the cognitive factors probably remain as the most salient influence on affective responses through the larger part of the functional range of exercise intensity. Because these cognitive processes are shaped to a large extent by experience and depend on individual developmental histories, affective responses that rely on cognitive processes are likely to vary from individual to individual. On the other hand, when exercise intensity precludes the maintenance of a physiological steady state and begins to pose a threat, the balance is likely to shift, so that interoceptive cues become the primary source of influence. Because of the limited plasticity of the subcortical pathways that carry interoceptive information to the affective centres of the brain compared to cognitive mechanisms, the inter-individual variability of affective responses that depend primarily on interoceptive influences is likely to be limited. Interoceptive

influences on affective responses are also likely to be salient for a short period immediately following intense exercise. During this period, inter-individual variability in affective responses is again likely to be limited. I hypothesize, based on Solomon's (1980, 1991) opponent-process model, that, during this period, the removal of the noxious interoceptive cues associated with strenuous exercise (i.e., Solomon's a-process) allows the effects of the already activated endogenous opiates on respiratory and cardiovascular functions to manifest themselves (i.e., Solomon's b-process), beginning the return of the organism to a state of biological and affective equilibrium. In essence, the activation of the endogenous opiate system during exercise is viewed here as playing a role analogous to that which they have been known to play in stimulation-or stress-induced analgesia. In response to the stimulation or stress of exercise, the endogenous opiates may, in addition to analgesia (Droste, 1992), facilitate the process of returning physiological parameters such as respiration and blood pressure to normalcy. As in the case of stimulation-or stress-induced analgesia, this function may be controlled by the connection between the amygdala and the periaqueductal gray (Rizvi, Ennis, Behbehani, & Shipley, 1991).

The dual-mode model is primarily intended to stimulate new research into the relationship between exercise and affect. The process of designing studies to formally test the various aspects of the model is only now getting under way. The preliminary supporting evidence comes from three sources, namely (a) correlations of valence with cognitive and physiological variables across increasing levels of exercise intensity, (b) patterns of interindividual variability in affective responses, and (c) correlations of affect with indices of frontal cortical activity.

First, in two recent studies, we determined the levels of exercise intensity that were used in relation to the ventilatory threshold, as an index of the point of transition from aerobic to anaerobic metabolism (Ekkekakis et al., 1999b, 2002). These are also the only known studies that included assessments of physiological parameters and of a cognitive correlate of affective responses to exercise, namely self-efficacy. As noted in the review of the literature, in the study by Ekkekakis et al. (1999b), in which the speed and grade of the treadmill was increased every minute until the participants reached the point of volitional exhaustion, self-efficacy was significantly correlated with affective valence near the middle of the range of exercise intensity (from one minute before the ventilatory threshold to one minute before exhaustion), but not in the early stages or at the point of volitional exhaustion. On the other hand, the correlation between the respiratory exchange ratio and affective valence reached statistical significance from the first minute after the ventilatory threshold and until the point of exhaustion. Entering both self-efficacy and the respiratory exchange ratio data into a hierarchical regression (with self-efficacy first), showed that, below the ventilatory threshold, self-efficacy was responsible for almost all (approximately 80–100%) of the total accounted variance in affective valence (total R^2 between 12% and 23%). On the other hand, at intensities above the ventilatory threshold,

the respiratory exchange ratio began to account for increasingly larger amounts of variance. From the second minute after the ventilatory threshold and until exhaustion, the respiratory exchange ratio was responsible for most (approximately 65–80%) of the total accounted variance in affective valence (total R^2 between 34% and 55%). In another study (Ekkekakis et al., 2002), which involved running at a constant speed at three levels of intensity, below, at, and above the ventilatory threshold, self-efficacy and the highest percentage of maximal heart rate attained during exercise jointly accounted for approximately 30% of the variance in changes in affective valence over the course of each of the three runs (note that the percentage of maximal heart rate is generally a weaker correlate of affective valence compared to the respiratory exchange ratio, but respiratory data were not collected in this study). Although self-efficacy accounted for approximately two thirds and nearly all of this variance at the intensities below and at the ventilatory threshold, respectively, it only accounted for less than half at the intensity above the ventilatory threshold. Although these are interesting results, they are limited in several respects, including the correlational nature of the studies and the relatively small sample sizes (N=30 in both studies). Furthermore, the range of exercise intensities in these studies did not include intensities as low as those found in our studies on walking (Ekkekakis et al., 2000). As noted earlier, the mechanisms behind the positive changes associated with walking remain unexplored. Given the very low level of physiological activation involved, it is possible that these responses may be influenced by some yet unknown cognitive factors. At the same time, the possibility that these positive affective responses are the manifestations of a biological mechanism that has evolved to reward and, thus, promote physical activity and, through that, the maintenance of a healthy balance between energy intake and expenditure (Rowland, 1998) should not be discounted. For instance, it is intriguing that lesions of the amygdala in young rats lead to decreases in spontaneous play activity (Panksepp, Siviy, & Normansell, 1984).

Second, some insight about the substrates of affective responses to exercise of different intensities and during different stages of an exercise bout may come from examining changes in patterns of inter-individual variability in valence ratings. As noted earlier, high inter-individual variability may be interpreted as an indication that the responses are influenced primarily by cognitive processes, whereas low inter-individual variability may be an indication that the responses are driven primarily by the evolutionarily more ancient and less plastic connections between interoceptive pathways and the affective centres of the brain. Responses that depend on these lower brain processes are generally characterised as rigid, stereotypical, or obligatory (Berntson & Cacioppo, 2000). This line of reasoning, of course, is not without some risk, as it is possible that, under certain conditions, most individuals simply make the same cognitive appraisal via higher brain processes. Nevertheless, these analyses may still be informative in conjunction with other types of evidence. Examination of the patterns of inter-individual variability in changes in affective valence shows that

variation is higher when exercise intensity is low to moderate and during recovery from exercise (Ekkekakis et al., 2000, Hall et al., 2002). Particularly during moderate-intensity exercise, valence responses can vary greatly from individual to individual, not only in terms of magnitude but also in terms of direction, with some individuals exhibiting improvements and others declines (Van Landuyt et al., 2000). On the contrary, inter-individual variation in valence responses are minimised as exercise intensity approaches the physical limits of individuals (in which case, valence changes are almost universally negative) and during the first minute after the terrain ation of strenuous exercise (in which case, valence changes are universally positive; Hall et al., 2002). If these differences in the patterns of inter-individual variability indicate shifts between the two postulated sources of influence on valence responses, these results would seem consistent with the dual-mode model.

A third and final line of evidence that affective responses to exercise of different intensities may engage different mechanisms comes from a series of studies examining the relationships between the asymmetric activation of the brain's prefrontal lobes (assessed through electroencephalography, or EEG) and affective responses. According to Davidson's (1995) model, frontal asymmetry is a biological marker of approach versus avoidance dispositions. These dispositions manifest themselves as propensities for positive and negative affective responses, respectively. Specifically, more right-activated individuals may tend to respond to affective stimuli in a more negative or less positive manner, whereas, conversely, more left-activated individuals may respond in a more positive or less negative manner. Davidson and Fox (1988) have noted that "precisely what the frontal asymmetry represents will require additional research", but "appraisal and coping are two subcomponents that may be related to the frontal asymmetries" (p. 204). If that is so, frontal asymmetry can be interpreted as reflecting primarily cognitive processes involved in affective responses. The studies that have been conducted in the context of exercise have shown that baseline frontal asymmetry is related to affective responses (in these cases, changes in the Energetic Arousal scale of the AD ACL; Thayer, 1989) when exercise intensity is moderate (70–75% of maximal aerobic capacity), but not when it is low or high (Hall, Ekkekakis, Van Landuyt, & Petruzzello, 2000; Petruzzello, Hall, & Ekkekakis, 2001; Petruzzello & Landers, 1994; Petruzzello & Tate, 1997). Again, the interpretation of these results as supporting the dual-mode model rests on the assumption that frontal asymmetry reflects primarily cognitive processes, such as appraisal and coping.

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Pleasure as a sign you can attend to something else: Placing positive feelings within a general model of affect

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Positive feelings are considered within the framework of a general model of origins and functions of affect. This model treats affect as reflecting the error signal of a feedback loop managing rate of incentive-seeking (and threat-avoidant) behaviour. In this view, positive feelings represent a sign that things are going better than necessary and are presumed to induce coasting. A tendency to coast is seen as facilitating the shift of attention and effort to other behavioural domains, where they may be needed more or where unforeseen opportunities have arisen. Such a function for positive feelings would permit the person both to maintain satisfactory standing with regard to multiple goals and to take advantage of unforeseen opportunities, thus providing adaptive value. Comparisons are made to other recently developed ideas concerning the functions of positive feelings.

What are positive feelings? Do they have a purpose? How do they arise? In this paper I consider these questions from the perspective of the theoretical model of affect proposed by Carver and Scheier (1990; elaborated in Carver & Scheier, 1998, chapters 8 and 9). Several other views share similarities of one sort or another with this one (particularly Higgins, 1996, 1997 and Hsee & Abelson, 1991; see also Clark, Watson, & Mineka, 1994; Cloninger, 1988; Frijda, 1986, 1988; Ortony, Clore, & Collins, 1988; Roseman, 1984). However, for the sake of simplicity, I frame my arguments here in terms of the version with which I am most familiar.

My main points are these: I believe that positive affects constitute important information for the people who experience them (cf. Clore, 1994) and play an important regulating function in the flow of behaviour. In my view, positive feelings are readily understood in the framework of at least some general viewsof emotion. On the other hand, I believe some effects of positive feelings

areunexpected and counterintuitive. Finally, although I think the ideas presentedhere are useful, I do not mean to assert that they account for all consequences ofpositive affect.

A few words at the outset about the terms "affect", "feeling", and "emotion": Sometimes these terms are used interchangeably (e.g., Isen, 2000), sometimes they are distinguished from each other (e.g., Russell & Feldman Barrett, 1999; Fredrickson, 2001). I focus here on affect, by which I mean the experience of valence, a subjective sense of positivity or negativity arising from an experience (Russell & Carroll, 1999). Although I occasionally use the word "emotion", it is with that sense in mind. As Frijda (2000) put it: "For many theorists, the essence of emotion is feeling, and notably 'affect', here used in the sense of a feeling of pleasure or pain…" (p. 63). I tend to use the word "emotion" less frequently because it often has connotations of physiological change that can accompany hedonic experiences, and 1 have little to say about those changes.

CONCEPTUAL BACKGROUND: BEHAVIOUR AND AFFECT

I begin by outlining the general view on behaviour that underlies my position on affect. I believe that behaviour is organised for moving toward desired goals, or incentives, and for avoiding undesired "anti-goals", or threats. My inclination is to view these approach and avoidance processes in terms of discrepancy-reducing and discrepancy-enlarging feedback loops, respectively (Carver & Scheier, 1998, 1999), although that is certainly not the only way such processes can be viewed.

The idea that behaviour is organised around approaching incentives and avoiding threats is not new (cf. Miller, 1944; Miller & Dollard, 1941). However, it has enjoyed renewed popularity in recent years, in a family of motive theories with roots in neuropsychology and conditioning. A system managing incentive motivation and approach has been postulated, variously called the behavioural activation system (Cloninger, 1987; Fowles, 1980), behavioural approach system (Gray, 1981, 1987, 1994), and behavioural facilitation system (Depue & Collins, 1999). A system managing aversive motivation and withdrawal or avoidance has

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been called the behavioural inhibition system (Cloninger, 1987; Gray, 1981, 1987, 1994), and withdrawal system (Davidson, 1984, 1992a, 1995, 1998).

A secondary theme of these models concerns affective experience. Specifically, the two motive systems are believed to be the sources of the affect qualities that are relevant to approach behaviour and avoidance behaviour, respectively.

Affective states and frontal lobe activation

Work that focuses on neural substrates of emotional experience is an important source of support for this latter idea (for reviews see Davidson, 1995, 1998; Davidson & Sutton, 1995; see also Watson, Wiese, Vaidya, & Tellegen, 1999, pp. 829–831). Most of this work examines regional activity (by EEG or functional neuroimaging) in areas of the cerebral cortex in response to affect-inducing stimuli (or individual differences in activation relating to temperamental susceptibility to particular affects).

On the basis of a considerable accumulation of findings, Davidson (e.g., 1992a, 1995, 1998) has argued that portions of the specialised neural substrates for approach and withdrawal (and for affects relevant to approach and withdrawal) are lateralised in the left and right anterior regions of the cerebral cortex, respectively. This general view on behaviour—that approach and withdrawal and concomitant affects are managed by two distinct systems—has much in common with the ideas described in the prior section. However, work on neural substrates of affect links the ideas about neural systems and behaviour explicitly to subjective affective experiences.

Affect as an indicator of effectiveness in ongoing action

The sources discussed thus far suggest that two distinct systems manage two aspects of behaviour and create affects that are relevant to them. To this I now add Carver and Scheier's (1990, 1998) argument about processes by which affect comes to exist. The general sense of the argument is that certain feedback systems monitor not approach and avoidance actions *per se,* but rather the *effectiveness* of such actions over time. These systems are assumed to take an input signal that corresponds to "rate of progress" and compare it against a reference rate. The "error signal" of these loops (reflecting any discrepancy detected) is manifest subjectively as affective valence. If the rate of progress is below the criterion, negative affect arises. If the rate is high enough to exceed the criterion, positive affect arises. If the rate is not distinguishable from the criterion, no affect arises.

In essence, the argument is that feelings with a positive valence mean you are doing better at something than you need to, and feelings with a negative valence mean you are doing worse than you need to (for more detail, including a review of evidence on the link between this "velocity" function and affect, see Carver &

Scheier, 1998, chapters 8 and 9). One implication of this argument is that the affective valences that might potentially arise regarding any given action domain should fall along a bipolar dimension. That is, for a given action, affect can be positive, neutral, or negative, depending on how well or poorly the action is going.

On the other hand, the idea that there are distinct approach and avoidance systems (and thus distinct approach and avoidance behaviours) suggests the basis for a difference. Specifically, affects may differ as a function of which system—approach versus avoidance—is managing the behaviour and thus underlies the affect. Both approach and avoidance have the potential to induce positive feelings (by doing well); both also have the potential to induce negative feelings (by doing poorly). But doing well at moving *toward an incentive* is not quite the same as doing well at moving *away from a threat.* Thus, the two positives may not be quite the same, nor the two negatives quite the same.

Based on this line of thought, and drawing on insights from Higgins and his collaborators (e.g., Higgins, 1987, 1996), Carver and Scheier (1998) argued for two bipolar affect dimensions (Figure 1). One dimension relates to the system that manages approach of incentives, the other to the system that manages avoidance of or withdrawal from threat (see also Carver, 2001). The approach related dimension ranges (in its "purest" form) from such affects as elation, eagerness, and excitement to sadness and dejection. The avoidance related dimension relating to the latter system ranges (in its "purest" form) from fear and anxiety to relief, serenity, and contentment.[1]

Affect and action

This view treats the systems that regulate action and affect as a simultaneously functioning two-layered array (Carver & Scheier, 1998, 1999). The layers are analogous to position and velocity controls in a two-layered engineering control system (Clark, 1996). Such an organisation permits high response speed while minimising oscillation (thus not impairing accuracy; Carver & Scheier, 1998, p. 144). There is reason to believe the simultaneous functioning of two layers of control has the same effects on human behaviour. A person with very reactive emotions overreacts and oscillates behaviourally; a person who is emotionally nonreactive is slow to respond even to urgent events. A person whose emotional reactions are between the two extremes responds quickly but without undue overreaction and oscillation.

Earlier, I described affect as reflecting the error signal of a loop that takes rate of progress as its input. The output thus would be an adjustment in rate of progress. What does it mean to adjust rate of progress? Consider the case of inadequate progress—being behind. Sometimes adjusting to being behind means, literally, going faster. But the rates of many behaviours of interest to personality-social psychologists are manifested in choices among actions, even *programmes* of action. For example, increasing rate of progress on a work

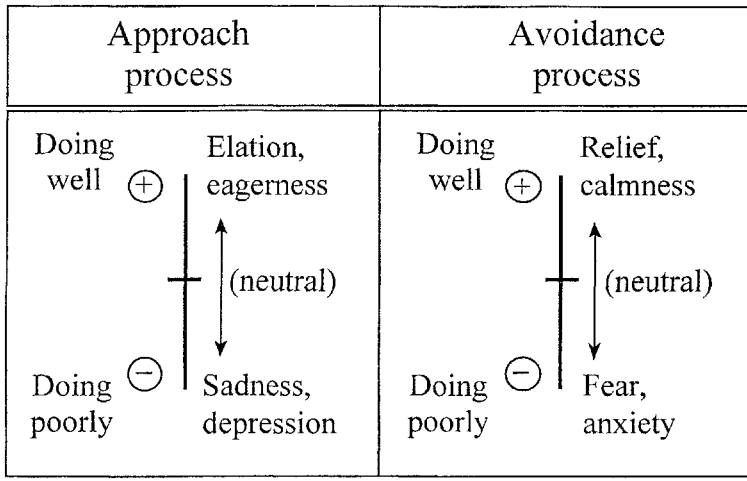

Figure 1. Two behavioural systems and poles of the affective dimensions held by Carver and Scheier (1998) to relate to the functioning of each. In this view, approach processes yield affective qualities of sadness or depression when progress is very poor; they yield such qualities as eagerness, happiness, or elation when progress is very high. Avoidance processes yield anxiety or fear when progress is very poor; they yield relief, calmness, or contentment when progress is very high. (Adapted from C.S.Carver and M.F.Scheier, *On the self-regulation of behavior,* Copyright 1998, Cambridge University Press. Used with permission.)

assignment may mean deciding to spend a weekend working rather than boating. Increasing the rate of "kindness" may mean choosing to initiate an action that reflects kindness. Thus, adjustment in rate must often be translated into other terms, such as concentration or reallocation of time and effort.

Despite this complexity in implementation, it should be clear that action and velocity systems are seen here as working in concert. Both are involved in the flow of action, though they influence different aspects of the action. Thus, this view assumes explicit links between behaviour and affect.

[1] Let me note explicitly that Figure 1 ignores several further issues. With respect to approach, for example, it does not distinguish between eagerness and satisfied basking (both of which are approach-related and positive, but which clearly differ both in the subjective experience and in what phase of approach they are most likely to occur). Nor does it incorporate frustration or anger, which are also approach-related affects (cf. Harmon-Jones & Sigelman, 2001). Although these and other issues are important, they are beyond the scope of this article (for broader treatment see Carver, 2002).

A CLOSER LOOK AT POSITIVE FEELINGS

The model just described has a number of implications for positive feeling. One has already been touched on, concerning diversity among positive affects. Positive feelings might be seen as equivalent, in the sense that all are positive. But this model distinguishes among positive feelings according to the class of action within which they emerge. Some positive feelings arise while pursuing incentives—feelings such as eagerness, happiness, joy. Other positive feelings arise in the context of escaping or avoiding threats—feelings such as relief, calmness, and tranquility. These sets of feelings are both positive in valence, but in other ways they differ. There is also evidence linking them uniquely to the two classes of experience just mentioned—attainment of an incentive versus avoidance of a threat (e.g., Higgins, Shah, & Friedman, 1997, study 4).

Sometimes two sets of positive feelings roughly equivalent to these are differentiated by the fact that one set has higher activation, the other has lower activation (Fredrickson, 1998; Russell, 1980; Russell & Carroll, 1999; Watson & Tellegen, 1999). Although this may be descriptively accurate, I think it misses the point. I do not think that a feeling of being calm turns into a feeling of being happy or eager by the addition of a nonspecific activation. I think that the activation involved in eagerness arises very specifically from the engagement of an approach system.

Consequences of construing affect as arising from a feedback process

The idea that affect reflects the error signal from a comparison process in a feedback loop has some counterintuitive implications, which are key to everything else I will say here. If affect reflects the error signal in a feedback loop, affect therefore is a signal to adjust rate of progress. This would be true whether the rate is above the mark or below it—that is, whether affect is positive or negative.

For negative feelings, this model is intuitive. Negative feelings point to a rate that is too low. The first response to negative feelings usually is to try harder. (I disregard here the possibility of giving up effort and quitting the goal, though that possibility clearly is important—Carver, 2002; Carver & Scheier, 1998.) If the person tries harder—and assuming more effort (or better effort) increases the rate of intended movement—the negative affect diminishes or ceases.

What is counterintuitive concerns positive feelings. In this view, positive feelings arise when things are going better than they need to. But they still reflect a discrepancy (albeit a positive one), and the function of a feedback loop is to minimise discrepancies. Thus, the system “wants” to see neither negative nor positive affect. Either quality (deviation from the standard in either direction)

would represent an "error" and lead to changes in output that would eventually reduce it.

This view argues that people who exceed the criterion rate of progress (i.e., who have positive feelings) will reduce subsequent effort in this domain. They are likely to "coast" a little (cf. Frijda, 1994, p. 113)—not necessarily stop, but ease back such that subsequent rate of progress returns to the criterion. The impact on subjective affect would be that the positive feeling is not sustained for very long. It begins to fade. The fading may be particularly rapid if the person turns from this activity to another domain of behaviour (Erber & Tesser, 1992).[2]

Let me be clear that the responses just described—expending greater effort to catch up, and coasting—are presumed to be specific to the goal domain to which the affect is attached. Usually (although not always), this is the goal that underlies the creation of the affect (for exceptions see Schwarz & Clore, 1983). We do not argue that positive affect creates a tendency to coast *in general,* but rather a tendency to coast with respect to this specific activity.

Cruise control model

This arrangement has functional properties that resemble those of a car's cruise control. Cruise control works like this: You come to a hill, which slows you down; the cruise control responds by feeding the engine more fuel, which brings velocity back up. You come over the crest of a hill and roll downhill too fast; the system decreases the fuel, which gradually drags velocity back down.

The model we have proposed for affect has several things in common with this. If a person is going too slowly toward a goal, negative affect arises. The response is to feed more effort, trying to enhance performance, which then removes the negative affect. If a person is going faster than needed, positive affect arises. The person then diminishes effort—coasts—which removes the positive affect, although not necessarily right away.

The analogy is intriguing in part because both sides of it incorporate an asymmetry in the consequences of deviating from the set point. That is, in a cruise control system and in behaviour, going too slow calls for the investment of greater effort and resources. Going too fast calls only for cutting back on resources. That is, the cruise control simply reduces the fuel—it does not engage the brake. Thus, if the hill is steep, the car may exceed the cruise control's set point all the way to the valley below. Similarly, people experiencing positive feelings do not usually invest resources to dampen the feelings (although there are special cases—Martin & Davies, 1998). They simply pull back temporarily on the resources devoted to the domain in which the affect has arisen. Depending on the circumstances, the positive feelings may be sustained for a long time, as the person coasts down the subjective analogue of the hill. Eventually, though, the withdrawal of resources would cause the positive affect to diminish. Under normal circumstances, then, the system would prevent great amounts of pleasure, as well as great amounts of pain.

Coasting

The idea that positive affect leads to coasting, which would eventually result in reduction of the positive affect, strikes some people as unlikely at best. Many believe that pleasure is instead a sign to continue what one is doing or even to immerse oneself in it more deeply (cf. Fredrickson, 2001; Messinger, 2002). On the other hand, the latter view creates something of a logical bind. If pleasure increases engagement in the ongoing activity, leading thereby to more pleasure and thus more engagement, when and why would the person would ever cease that activity?

The notion that positive feelings induce coasting may seem unlikely, but we are not the only ones to have suggested such a thing. In discussing joy, Izard (1977) wrote: "If the kind of problem at hand requires a great deal of persistence and hard *work, joy may put the problem aside before it is solved*... If your intellectual performance, whatever it may be, leads to joy, the joy will have the effect of *slowing down performance* and removing some of the concern for problem solving. This change in pace and concern may postpone or in some cases eliminate the possibility of an intellectual or creative achievement… If excitement causes the 'rushing' or 'forcing' of intellectual activity, *a joy-elicited slowing down* may be exactly what is need to improve intellectual performance and creative endeavor" (p. 257, emphasis added). More recently, Izard and Ackerman (2000) wrote, "Periodic joy provides *respite from the activity* driven by intense interest" (p. 258, emphasis added).

Does positive affect lead to coasting? I am not aware of data that bear unambiguously on the question (though see Mizruchi, 1991, for suggestive evidence). To do so, a study must assess coasting with respect to the same goal as underlies the affect. Many studies have created positive affect in one context and assessed its influence on another task (e.g., Isen, 1987, 2000; Schwarz & Bohner, 1996). Those who conduct such studies typically work hard to make the two contexts appear unrelated. In earlier writings (e.g., Carver & Scheier, 1998), I interpreted one such study (Melton, 1995) as support for the coasting hypothesis, but that was erroneous on my part. Because the target performance was on a task unrelated to the one on which the affect arose, the finding does not bear on the hypothesis; nor do other studies using dual-context paradigms. The question seems to remain open.

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[2]This is not the same point as the concept of "hedonic treadmill" (Brickman & Campbell, 1971), in which a given attainment loses its ability to create positive affect because people adapt to it (see also Kahneman, 1999). That phenomenon involves a longer-term process of resetting the reference value to a higher setting (for further discussion see Carver & Scheier, 2000).

Coasting and multiple concerns

One reason for scepticism over the idea that positive affect induces coasting is that it is hard to see what reason could there possibly be for people to have built-in a process that limits—and even reduces—positive feelings. We believe a basis for the adaptive value of such a tendency lies in the fact that people have multiple concerns (Carver & Scheier, 1998; Frijda, 1994). Given multiple concerns, people usually do not optimise their performance on any one of them, but rather "satisfice" (Simon, 1953)—do a good enough job on each to deal with it satisfactorily.

A tendency to coast virtually defines satisficing regarding that particular goal. A tendency to coast would also foster satisficing regarding a set of several goals. That is, if progress toward goal attainment in one domain exceeds current needs, a tendency to coast in that domain (satisficing) would make it easy to shift to another domain, at little or no cost. This would help ensure satisfactory goal attainment in the other domain and ultimately across multiple domains.

Continued pursuit of the present goal without let-up, in contrast, has potential adverse consequences. Continuing a rapid pace here may sustain positive affect here, but by diverting resources from other goals it also increases the potential for problems elsewhere. This would be even more true of an effort to *intensify* the positive affect, as doing so would entail further diverting resources from other goals. Indeed, a single-minded pursuit of yet-more-positive feelings in one domain can even be fatal, if it results in the disregarding of threats looming elsewhere.

A pattern in which positive feelings lead to easing back and an openness to shifting focus would minimise such adverse consequences. Note that this view does not *require* that people with positive feelings shift goals. It simply holds that openness to a shift is a potential consequence—and a potential benefit—of the coasting tendency. This pattern would, however, begin to account for why people do eventually turn away from what are clearly pleasurable activities.

A provocative finding, in this regard, is that smiling infants who are engaging in face-to-face interactions with their mothers periodically avert their gazes from their mothers, then stop smiling. The infants are more likely to do this (and avert their gaze longer) when they are smiling intensely than when the smiles are less intense (Stifter & Moyer, 1991). This pattern hints that their happiness creates an openness to shifting focus, or at least a tendency to coast with respect to the interaction with mother, letting the affect diminish before returning to the interaction.

The line of argument just outlined begins to implicate positive feelings in a broad function within the organism: Shifting from one goal to another as focal in behaviour. Let us take a closer look at this function.

PRIORITY MANAGEMENT AS A KEY ISSUE IN SELF-REGULATION

Simon (1967) pointed out that an entity pursuing many goals needs a way to rank them for pursuit and a mechanism to change the rankings as necessary. Most of our goals are largely out of awareness at any given moment. Only the one with the top priority has full access to consciousness. Sometimes events that occur during the pursuit of that top-priority goal create problems for a second goal that has lower priority. Indeed, the mere passing of time sometimes creates a problem for the second goal, because the passing of time may be making its attainment less likely. If the second goal is important, emerging problems for its attainment need to be registered and taken into account If the situation evolves enough to seriously threaten the second goal, some mechanism is needed for changing priorities, so that the second goal replaces the first one as focal.

Simon (1967) reasoned that emotions represent calls for reprioritisation. He suggested that emotion arising with respect to a goal that's out of awareness eventually causes people to interrupt their behaviour and give that goal a higher priority than it had. The stronger the emotion, the stronger is the claim being made that the unattended goal should have higher priority than the presently focal goal. The affect is what pulls the out-of-awareness into awareness. (Simon did not address negative affect pertaining to the focal goal, but the same principle seems applicable: Negative affect in that case seems to be a call for even greater investment of resources and effort in that focal goal.)

Simon's analysis is applied easily to negative feelings such as anxiety. If you are following driving instructions that take you into a dangerous part of town, the focal goal is getting to your destination. Anxiety that arises concerns a second issue—a threat to your safety. If you promised your spouse you would go to the post office this afternoon and you have been too busy to go, the creeping of the clock toward closing time can cause an increase in anxiety—concerning the second issue of an angry spouse. Anxiety arises when a threat is coming closer, whether the threat comes from ongoing action (e.g., entering a bad area of town) or through the passage of time. The greater the threat, the stronger the anxiety, and the more likely it is that the anti-goal it stems from will rise in the priority list until it comes fully to awareness and becomes itself the focal influence on behaviour.

Positive feelings and reprioritisation: Theory

Simon's discussion of shifting priorities focused on cases in which a nonfocal goal demands a higher priority and *intrudes* on awareness. By strong implication, his discussion dealt only with negative affect. However, there is another way priority ordering can change: The currently focal goal can *relinquish its place*. Simon noted this possibility obliquely, by noting that goal completion

results in termination of pursuit of that goal. However, he did not consider the possibility that an unattained goal might also yield its place in line.

Consider the possibility that positive feelings represent a cue regarding reprioritisation, but a cue to *reduce* the priority of the goal to which the feeling pertains. This construal appears to do no violence to the sense of Simon's scheme. Rather, it simply suggests a functional symmetry between affects of opposite valences. Positive affect regarding avoidance (relief or tranquility) indicates that a threat has dissipated, no longer requires much attention, and can assume a lower priority. Positive feelings regarding approach (happiness, joy) indicate that an incentive is being attained. If it has *been* attained, effort can cease, as Simon noted. If it is not yet attained, the affect is a signal that you could temporarily put this goal aside—that is, that this goal can assume a lower priority.

If a focal goal diminishes in priority, what follows? In principle, this situation is less directive than is the case of increasing priority of a nonfocal goal (which is very specific about what goal should receive attention). What happens next in this situation depends partly on what else is waiting in line; it depends partly on whether the context has changed in any important way while you were busy with the focal goal. That is, opportunities sometimes appear unexpectedly. People often put aside their plans to take advantage of such unanticipated opportunities (Hayes-Roth & Hayes-Roth, 1979; Payton, 1990). It seems reasonable that people should be most prone to shift goals at this point if something else needs fixing or doing (regarding a next-in-line goal or a newly emergent goal) or if an unanticipated opportunity for gain has appeared.

Sometimes, the next item in line is of fairly high priority in its own right. Sometimes, the situation has changed and a new goal has emerged for consideration. On the other hand, it is often the case that nothing has changed enough to present a new goal for serious consideration, and that no goal waiting in line is pressing. If so, *no change in goal would occur,* because the downgrade in priority of the now-focal goal does not take it below the priorities of the salient alternatives. Thus, positive feeling does not *require* that there be a change in direction. It simply sets the stage for such a change to be more likely.

Given the nature of the argument being made, it seems to follow that when the priority of the focal activity drops there ensues a scanning for potential next actions (cf. Vallacher & Kaufman, 1996). Such scanning would use information about goals waiting in line, but also information from the environment. Without the latter, there would be no chance to recognise and act on unexpected opportunities. Such scanning would seem to entail, in part, a broadening of attentional focus.

Evidence that positive affect promotes shifting to areas in need of repair

Aspects of the preceding line of reasoning have a good deal in common with ideas recently proposed about circumstances under which people do and do not engage in self-esteem-protective behaviour. Maintaining self-esteem is an important human goal (e.g., Tesser, 1988). When people are in good moods, however, self-esteem-enhancement becomes less likely (Tesser, Crepaz, Collins, Cornell, & Beach, 2000). Tesser et al. argued from this that self-esteem maintenance follows the principle of satisficing: It does not happen all the time. As long as the self-image is above a threshold of positivity, there is no effort to build it higher. Only if it falls below the threshold is effort engaged to prop it back up (cf. Reed & Aspinwall, 1998).

This line of argument, although speciflc to self-evaluation maintenance, is consistent in theme with my position on coasting and shifting as a way of satisficing with respect to multiple concerns. The effects Tesser et al. discussed appear very much like the behaviours of people who are doing well enough for the time being with respect to one important goal (self-esteem), and are free to turn to something else that might benefit from their attention.

Indeed, a variety of other evidence appears to fit the idea that positive feelings make people more open to alternate goals, particularly desired goals that seem threatened. Trope and Neter (1994) had participants completed two ostensibly unrelated sessions. The first involved inducing positive affect or not. In the second session, participants took a social sensitivity test and were told they performed well on two parts of it but poorly on a third. They then indicated their interest in reading more about their performances on the various parts of the test. Positive-mood participants showed more interest in the part they had failed than did controls. I see this as indicating that the positive feeling (arising from a behavioural context unrelated to the target task) rendered people more open to fixing a problem that needed fixing—the poor performance on the target task.

Trope and Pomerantz (1998) conceptually replicated this effect. In a first session participants experienced either success or failure. In an ostensibly unrelated second session they were offered feedback about their ability to attain life goals that varied in self-relevance. The feedback would pertain to either selfassets or self-liabilities. After success, self-relevance of the goal related to greater interest in feedback about self-liabilities pertaining to that goal.

Reed and Aspinwall (1998) also conceptually replicated the effect. Participants completed a measure on which they had an opportunity to affirm their kindness (or a control measure). They then had an opportunity to read information that either asserted or discounted a potential health threat from caffeine. The key finding occurred among participants who were high caffeine users, and thus had the greatest reason to be threatened by the threat-assertion. The prior affirmation of positive self-image (kindness) made these persons more open to the information about how caffeine poses a health threat.

These studies all represent cases in which people confronted a personally relevant situation that was in need of repair. Other research has created situations in which someone else needed help. A substantial body of research shows that people in good moods are more willing to help another than are people who are in less good moods (Isen, 1987, 2000). In my view, this reflects a tendency to fix a salient problem. It has also been found that people who know that helping would make them feel depressed were less likely to help if they were in good moods than if not (Isen & Simmonds, 1978). My interpretation of this is that helping in this case would be fixing a problem for someone else at the expense of creating a problem for yourself. It thus is less likely.

Another illustration of the tendency to take care of salient problems comes from subsidiary analyses in a study by Isen, Rosenzweig, and Young (1991). Third-year medical students were to determine which of six hypothetical patients most likely had cancer, on the basis of nine pieces of information about each. Subsidiary analyses found that participants who had had a success on an unrelated task were more likely to go beyond the assigned task (deciding which patient had cancer) to considering probable diagnoses of the other patients and potential treatment plans.

Psychological resource models

Effects such as these have contributed to the emergence of the view that positive experiences represent psychological resources. Trope and Pomerantz (1998) wrote that experiences such as a success or a positive mood often serve as means to other ends, rather than as ends themselves. Reed and Aspinwall (1998) suggested that positive self-beliefs and experiences (e.g., self-affirmation) act as resources that permit people to confront problematic situations such as health threats (see also Aspinwall, 1998; Isen, 2000; Tesser et al., 2000; for even broader resource models see Hobfoll, 1989; Muraven & Baumeister, 2000).

This line of thought is not quite the same as the one that underlies the position I am taking, but some of its connotations are very similar. The end result of either line of thought is that when the present situation seems to be in reasonably good shape in the focal domain (via a success, or a self-affirmation, or recall of good times, or positive feelings), the person is more likely to take on a salient problem in another domain.

Although the findings just described are consistent with this line of reasoning, most of those studies were conducted to investigate self-protective tendencies in particular, rather than shifts in goal or task. My line of reasoning holds that such shifts should be observable for a wide range of alternate activities, rather than just those related to self-improvement, health maintenance, helping, or the like (although repairing problems for oneself would certainly be very high priority targets for such shifts).

Opportunistic shifting

On the other hand, the idea that positive feelings act as psychological resources need not be limited to cases in which resources allow people to turn to problems or threats. For example, secure infant attachment is widely seen as a resource that promotes exploration (Bowlby, 1988). Such a view also seems implicit in Fredrickson's (1998) position that positive feelings promote play.

The idea that positive affect serves as a resource for exploration resembles in some ways the idea that positive feelings open people to noticing and taking advantage of emergent opportunities, to being distracted into enticing alternatives (i.e., to opportunistic behaviour). There is some evidence consistent with this idea. Kahn and Isen (1993) reported studies in which people had opportunities to try out choices within a food category. Those in whom positive affect had been induced switched among choice alternatives more than did controls. Isen (2000, p. 423) interpreted this as indicating that positive affect promotes "enjoyment of variety and a wide range of possibilities", which seems almost a description of opportunistic foraging.

Another source of evidence worth brief mention, although there are also reasons to view it with caution, is the behaviour of persons in manic or hypomanic states. Mania is characterised by positive feelings, and also by a high degree of distractibility (American Psychiatric Association, 1994). This pattern is consistent with the idea that the positive feelings render these persons especially susceptible to cues indicating opportunities for gain that lie outside the framework of their current goal pursuit.

FURTHER COMPARISONS

A variety of people have taken positions on the phenomena discussed in this article that differ from the position I am taking. I close this paper with a few more comparisons between views.

Positive affect broadens attention

Drawing on a review by Derryberry and Tucker (1994), Fredrickson (1998) suggested that positive emotions cause (among other things) a broadening of attentional focus. This is in opposition to the effects of negative emotions such as anxiety and anger, which narrow attention. It is generally believed that the narrowing of attention by negative emotions occurs in order to process selectively information regarding the threat at hand. But why would positive feelings broaden attention?

Fredrickson (1998) proposed that the broadening of attention is a reflection of a more diverse broadening of cognitive and behavioural responses, which facilitate actions that have valuable long-term consequences. Positive feelings can lead to exploration and play (which presumably reflect a broadened attentional focus),

and these activities lead to development of both intellectual resources and physical skills, which have survival value. Sharing pleasure with another person creates a social bond, which also has survival value. Fredrickson argued that such side-effects of the broadening of cognitive and behavioural responses (including but not limited to broadening of attention) confer adaptive advantage, resulting in the retention of genes that support such tendencies.

I would not quarrel with the value of the outcomes on which Fredrickson focuses. However, I do not think it necessary to appeal to those indirect and longer-term consequences to find a reason why positive affect might broaden attention. As argued earlier, a simpler reason derives from the core organismic function of priority management.

Negative affects such as anxiety and anger narrow attention because they point to a specific threat or problem to be resolved. Resolving that problem requires focusing on the domain of the problem to the relative exclusion of other things—thus narrowing attention. My view of why positive affect would broaden attention follows from my argument that positive affect induces an openness to considering possibilities other than the goal currently being pursued. Positive affect means there is *no* problem here requiring attention, thereby freeing the person to turn elsewhere, to where there may be a need for repairs or an unexpected opportunity.

Thus, my view of the adaptive value of broadening of attention derives from its immediate consequences. A broadening of focus helps people notice deficiencies (e.g., evidence of self-liabilities—cf. Trope & Pomerantz, 1998—a lack of food in the cupboard, the need to replace a burned out tail-light). Noticing and doing something about small deficiencies can help avoid larger problems later on. This would seem to be an adaptive advantage. Broadening of focus also facilitates detection of unexpected opportunities (e.g., a fruit tree or freshwater spring you did not know about, an unadvertised sale at Macy's). The ability to notice, and take advantage of, unforeseen opportunities (in the relative absence of threat) would also seem to confer a basic adaptive advantage.

Cognitive benefits from positive affect

The idea that positive feelings broaden attention is one aspect of a more general argument that positive feelings facilitate diverse cognitive functions (see Isen, 2000, for review). Some of the findings of that literature appear to be interpretable in terms of broadening of attention per se—an enhanced openness to possibilities. For example, the finding that people in good moods make creative, divergent, and unusual associations seems compatible with such a view (Isen, 2000), as does the finding that good moods enhance performance on secondary tasks (Bless et al., 1996).

However, not all the flndings of this literature are that simple. Isen (1987, 2000) has argued that positive affect promotes seeing unusual ways in which information can be fitted together and applied, aspects of ideas not otherwise

noticed. She believes positive affect induces elaboration of material in memory, yielding better and faster decisions. Positive affect may help people recognise both similarities and differences, and may enhance the ability to take other people's perspectives. Isen (2000) reviewed a great many studies in which positive mood created in one context enhanced performances in other contexts, characterising the effects as a group as showing increased cognitive flexibility. Although some of the findings seem readily interpreted as reflecting broadened attention, not all do (see Isen, 2000, for mechanisms she believes underlie the effects).

On the other hand, that literature also has resonances to points made in this article regarding the kind of goals people in positive moods adopt. I raised two possibilities. One possibility was seizing on unanticipated opportunities for gain. This possibility is fully consonant with Isen's model, though her construal might differ from mine. Isen would note that positive affect makes positive information more accessible and readily processed; thus the emergent opportunity may be more apparent to the person who is in a good mood. She would also likely say that pursuit of a new opportunity helps maintain the positive mood, and she regards mood maintenance as a key motive.

The second possibility I raised is that people may turn to a domain where a problem of some sort exists. At first glance this seems contrary to Isen's model, because such a shift seems to conflict with the desire to maintain the positive mood. Isen says, however, that people will turn to thinking about negative material "if doing so is useful or necessary" (Isen, 2000, p. 423). Doing so appears to be useful or necessary when it will forestall or eliminate a problem. Isen views this turning to the negative as reflecting increased cognitive flexibility. I see it instead as a reflection of satisficing for diverse goals. Yet, just as in the preceding paragraph, our views predict the same shift.

As noted earlier, this literature is one in which positive affect is created in one context and its effects are measured in another. This raises two questions. If positive feelings arose in one context and the person remained in the same context, would there still be increased creativity and cognitive flexibility? If so, would such a finding create a problem for the principles I have advocated?

The passage quoted earlier in the article from Izard (1977) suggests that such beneficial effects would indeed still occur. However, the same passage simultaneously suggests a tendency to coast with respect to the goal being pursued. Indeed, Izard appeared to argue that something about the easing back of effort actually works to the benefit of creativity. The possibility that both phenomena—coasting and enhanced cognitive flexibility—derive from positive feelings, in mutually supportive ways, surely deserves further attention.

Positive feelings in emotion-general theories

A final issue I want to raise is whether positive feelings can be understood meaningfully in the context of broad-scale, general theories of emotion.

Fredrickson (1998, 2001) has argued that they do not fit well in such theories and therefore should be treated separately. However, her conclusion seems to rest in part on her equating "broad-scale" theory with "discrete-emotions" theory (e.g., Izard, 1977; Levenson, 1994, 1999). In the latter, each emotion has a specific function and is linked to a specific action tendency. In a strong version of this viewpoint, a specific action readiness is virtually a defining feature of an emotion.

Although negative feelings such as fear and anger fit that view easily, many positive feelings do not. As Fredrickson pointed out, Frijda (1986) linked contentment to inactivity. He described joy as aimless—a readiness to take up whatever behavioural possibility presented itself (a depiction that is quite consistent with the position taken here). Fredrickson (1998) concluded from this lack of specific action readiness that emotion-general theories are not helpful in dealing with positive feelings.

It appears, however, that that conclusion applies only if emotions are defined as incorporating *specific* action readinesses. Not every view of emotion has such a requirement. The view I take is intended to bear on "emotions in general" analysing feelings by reference to the functioning of two broad regulatory systems (Carver, 2001; Carver & Scheier, 1998; see also Cacioppo, Gardner, & Berntson, 1999; Davidson, 1992b; Watson et al., 1999). The affects addressed by this view range widely, including happiness and relief but also such feelings as fear, guilt, sadness, frustration, and anger (Carver, 2002; Harmon-Jones & Sigelman, 2001). Some of these affects relate to speciflc kinds of action readiness, others relate to *diffuse* kinds of action readiness. Although diffuse, the latter pertain to functions that are critical to a multitasking entity—ceasing one activity and choosing a good candidate to pursue next. In short, I believe that general models of emotion address positive as well as negative emotions in meaningful ways. In the long run, we have to fit the pieces together into an integrated model of human functioning. I do not think it is too soon to be trying to do so.

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The content and structure of laypeople's concept of pleasure

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Five studies were conducted to map the content and structure of laypeople's conceptions of pleasure. Instances of the pleasure concept collected in Study 1 consisted predominantly of objects, events or persons described as sources of pleasure. Content analysis suggested that the pleasure category, like emotional response categories, might be formed at an implicit level where various pleasure antecedents are grouped based on common phenomenological qualities of the affective experience. Studies 2 and 3a showed that the pleasure category possesses a graded structure and fuzzy boundaries. Results further revealed that, either when explicitly presented with labels (Study 3b) or left to their own implicit categories during a sorting task (Study 4), laypeople represented pleasure as a hierarchical concept in which differentiated pleasure types (i.e., intellectual, emotional, social and physical) were subsumed under a higher level unitary form of pleasure. In this structure, unitary and differentiated pleasures shared a set of common affective qualities but were also distinguishable by unique and distinctive affective characteristics (Study 5). Ties to prior theories of pleasure and implications for decision making and behavioural research are discussed.

Just as to the man who wants money to spend, it is all the same whether the gold was dug out of the mountain or washed out of the sand, provided it is everywhere accepted at the same value, so the man who cares only for the enjoyment of life does not ask whether the ideas (which he enjoys) are of the understanding or of the senses, but only how much and how great pleasure they will give for the longest time.

(Kant, 1788/1948, p. 110)

A product like gold emancipates itself from, and exists independently of, its source. Is the pleasure separable from the flavor in the same sense? Clearly not. The experience of pleasure remains dependent upon the experience of the flavor (or whatever source it may have).

(Duncker, 1941, p. 399)

Is pleasure of one kind? Like gold and money, a currency reducible to its quantity regardless of its quality, as suggested by Kant? Or, is pleasure inseparable from its antecedents and experiential qualities, as implied by Duncker? These opposite philosophical perspectives rest on very different conceptualisations of pleasure and they have divergent implications for modern research on decision making and behaviour. On the one hand, Kant's position suggests that pleasure is a unitary phenomenon, independent of its source and subjective experience. Thus, units of pleasure are simply added to a mental counter, integrated at some level, regardless of kind, in much the same way a bank account integrates money regardless of its source or what may be purchased with it. The bulk of modern research on decision making and behaviour adheres to such a unitary view of pleasure. On the other hand, pleasures of different kinds may be inseparable from their respective antecedents and from the nuances of their subjective experience, and therefore not so straightforwardly integrated into a single account, as suggested by Duncker. This differentiated perspective on pleasure has appeared across eras in various disciplines.

We believe that to achieve a more comprehensive understanding of the nature of pleasure, including its unitary and differentiated aspects, and its impact on decision making and behaviour, it is critical to begin to map the psychological reality of pleasure as it is represented in people's mind. As argued by Shaver and his collaborators, the "structure of representation necessarily reflects the gross structure of reality, or at least the distinct features of reality that are most important for human transactions within the world" (Shaver, Schwartz, Kirson, & O'Connor, 1987, p. 1062). To our knowledge, there has been no systematic study of the concept of pleasure, either to test the unitary and differentiated views, or

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simply to explore its content and structure. The present research consists of a series of five studies that was designed to provide a systematic empirical exploration of the lay concept of pleasure. First, we review the literature on the nature of pleasure. Then, building on prior research on emotions as categorical concepts, we examine the content and the internal structure of the lay concept of pleasure. Based on our findings, we propose that the unitary and differentiated views may simply be two levels at which pleasure is represented as a hierarchical concept.

THE NATURE OF PLEASURE

Pleasure has been conceptualised as either a unitary or a differentiated phenomenon and strong support can be summoned for each position. Consider flrst the view of pleasure as a unitary phenomenon. Within this perspective, pleasure has also been named valence, hedonic tone, utility, or approach response. Regardless of the label, unitary pleasure is akin to a summary judgement of how good it feels to interact with an object. The experiential quality of this summary is independent of its antecedents and the various sensations and emotions that compose its phenomenology. This view of pleasure is captured in the first definition of pleasure in the *Oxford English Dictionary*." 1. a. The condition of consciousness or sensation induced by the enjoyment or anticipation of what is felt or viewed as good or desirable" (Simpson & Weiner, 1989, p. 1031). The unitary perspective of pleasure can be found in various scientific fields of enquiry. For instance, in psychology, pleasure is a basic, pancultural dimension underlying human emotional experience (Russell, 1991). In decision science, pleasure has been equated with experience utility and much theorizing relies on the axiom that individuals make decisions and behave to maximise such utility (Kahneman, Wakker, & Sarin, 1997). Utility-maximising decisions are believed to be independent of the sources from which pleasure arose and the affective qualities that were associated with its experience. In physiology, Cabanac (1971, 1992) defined pleasure as the pleasant sensation that arises when hunger, bodily comfort, or other visceral drives are satisfied, thereby re-establishing homeostasis. Cabanac further argued that it is the intensity of such pleasant sensation that guides choice between alternative, sometimes conflicting courses of action.

Contenders of the unitary view do not challenge that pleasure may result from different antecedents and be associated with a variety of affective experiences. However, they assume that capturing such components in an organised fashion is doubly useless because antecedents and experiential qualities are idiosyncratic and untractable, and get distilled anyway into a Good/Bad summary, which ultimately drives decision making and behaviour (Kahneman, 1999). For instance, Bentham (1781/1988), whose ideas have fuelled modern utility theory, recognised the diversity of hedonic experiences when he outlined no less than 14 different kinds of pleasures, such as pleasures of sense, wealth, skill, and

memory. As another sign of nuances between pleasures, he listed nine subtypes under the "pleasures of the senses" category. However, neither Bentham, nor the behavioural economists and decision scientists whose work he inspired, have integrated any of this experiential richness in their theoretical formula for computing the utility derived from different hedonic experiences.

As for the differentiated perspective, there is no shortage of expressions to describe varieties or types of pleasure, ranging from those provided by Greek philosophers to the diverse qualities and properties assigned to pleasure by artists of all times (see Bailey, 1928; Dissanayake, 1996; Gaskin, 1995; Le Bel & Dubé, 1997). For example, among Greek philosophers whose influence has inspired modern thinking on pleasure, Plato, Aristotle, and Epicurus all distinguished the pleasures of the body from those of the soul. In the Platonic tradition, sensations were deemed fallible and only led to false pleasures while true pleasure resided in the domain of the soul. For Plato, these two types of pleasures clearly were not of the same nature. For Aris totle, and even more so for Epicurus, the operation of reason and consciousness could raise simple pleasures born of sensations to the status of higher pleasures. Although pleasures of the mind could be derived from the simpler pleasures of the body via the operation of reason, both types of pleasure were clearly differentiated.

Modern thinkers have recently proposed various typologies of pleasure, again largely based on theoretical arguments. For instance, Duncker (1941) sidestepped the body-soul dichotomy and proposed three types of pleasure: *sensory pleasures,* for which the immediate object of pleasure is the nature of a sensation (e.g., the flavour of the wine, the feel of silk); *aesthetic pleasures,* derived from sensations expressive of something, offered by nature, or created by man (e.g., sunsets, music); *accomplishment* pleasures represent the emotional, pleasant consciousness that something valued has come about (e.g., mastery of a skill, sport performance). The latter type of pleasure is conceptually close to Csikszentmihalyi's (1990) concept of flow, although for Csikszentmihalyi pleasure is limited to sensations, as "beyond that, it becomes enjoyment" (Seligman & Csikszentmihalyi, 2000, p. 12). Kubovy (1999) recently returned to the distinction between pleasures of the body and those of the mind. Interestingly, he defined pleasures of the mind as collections of emotions distributed over time. He also acknowledged the pleasures of nurture and of belonging to a social group as additional varieties of pleasure. Kubovy's typology parallels the sociological account offered by Tiger (1992) who identified four pleasure types: physio-pleasures (sensations or physical impressions obtained from eating, drinking, lying in the sun), socio-pleasures (borne of the company of others), *psycho-pleasures* (satisfaction from individually motivated tasks or acts), and ideo-pleasures (borne of ideas, images, and emotions privately experienced). Tiger's typology, like previous ones, has never been tested empirically.

As of today, the literature on unitary pleasure includes no test of the assumption that all pleasures of equal intensity lead to the same approach response regardless of their antecedents and emotional qualities of their

experience, against an alternative differentiated view. Conversely, the literature on the differentiated nature of pleasure still only consists of broad theoretical arguments and typologies awaiting empirical validation. As suggested earlier, a prerequisite for a clearer understanding of the motivational power of pleasure and its various forms of expressions is to proceed with a systematic empirical investigation of the concept of pleasure in the layperson's mind, as a means to map its psychological experience. In contrast to the dearth of empirical studies on the lay concept of pleasure, a considerable amount of work has been done on this topic in the domain of emotions. Because pleasure and emotions share a common affective nature, we now build on the literature on emotions and offer a conceptualisation of pleasure that can accommodate both the unitary and differentiated perspectives.

THE CATEGORICAL CONCEPT OF PLEASURE

Research on emotions has shown that people are highly knowledgeable about various facets of their affective experiences and that it is possible to elicit memory representations of such experiences (Fehr & Russell, 1984, 1991; Fitness & Fletcher, 1993; Russell & Fehr, 1994; Shaver et al., 1987). Based on the robust evidence of categorisation in the domain of emotions, it is reasonable to expect that laypeople are also able to articulate their representations of pleasure and that the content of such representation has evolved into a categorical concept. In the present research, we explore the concept of pleasure in three ways. First, we address the nature of instances that form the content of the pleasure category. We then explore whether internal structure and membership in the pleasure category is defined according to the principles of classical concepts or according to those of prototype theory. Finally, we provide the theoretical and empirical bases for a proposition that pleasure is a hierarchical concept in which differentiated pleasure types are subsumed under a higher level unitary form of pleasure. In this structure, unitary and differentiated pleasures share a set of common affective qualities but are also distinguishable, as they each possess unique and distinctive affective characteristics.

Category content

If the concept of pleasure is categorically organised, what is the nature of the "members" or "instances" contained in the category? Robust evidence shows that emotions form taxonomic categories at both the general domain of emotions (Fehr & Russell, 1984; Shaver et al., 1987) and at the level of specific emotions, like anger (Russell & Fehr, 1994) and love (Fehr, 1988). For instance, studies by Fehr and Russell (1984) and by Shaver et al. (1987) found that the general emotion category differentiates itself at a lower level into specific types of emotions like love, joy, anger, fear, sadness, etc. At the level of specific emotions, Russell and Fehr (1994) found that laypersons' concept of anger was

differentiated into a constellation anger-like emotional states, such as frustration, irritation, rage, etc, that vary in typicality as instances of anger. Thus, if the pleasure concept were also a taxonomical category, its various instances would consist of subtypes of pleasure. As with emotions, a general category could be formed at the level of unitary pleasure and distinct taxonomic categories could be formed at the more specific level, one for each possible differentiated pleasure such as perhaps "intellectual", "social", etc.

One may argue, however, that a taxonomic structure may not be the only representation of pleasure as a categorical concept. Individuals could have a hard time articulating the explicit rules of coherence necessary to form abstract representations of the type of pleasure to which various instances might belong. Recently, Niedenthal, Halberstadt, & Innes-Ker (1999) proposed and demonstrated that things, events, and persons that evoke the same emotional response may be categorised together and may be treated as the "same kind of things", even when such things are otherwise perceptually, functionally, and theoretically diverse. They labelled such groupings "emotional response categories" because these are formed on the basis of a common affective experience triggered by members of the category. As evidence of such categorisation, Niedenthal and her collaborators (Niedenthal & Halberstadt, 1995; Niedenthal et al., 1999; Niedenthal, Halberstadt, & Setterlund, 1997) found that recognition of conceptually and perceptually dissimilar emotion antecedents was facilitated by emotion congruence: Happiness priming favoured recognition of happiness antecedents, sadness priming favoured recognition of sadness antecedents. Such categorisation effects were not observed in the neutral, control conditions.

Note that the actual memory representation of these emotional response categories remains an empirical question as Niedenthal et al.'s work has thus far been limited to the categorisation *process per se,* with no explicit exploration of the memory representation of such categories. However, Niedenthal and her collaborators proposed that the content of emotional response categories is probably not abstract as it is the case in taxonomic categories of emotions. Instead, they suggested that objects, events, or persons that are antecedents of specific emotional experience might simply be stored as exemplars (Niedenthal et al., 1999). Niedenthal et al.'s flndings and theorising suggest that the pleasure category may not necessarily contained "types of pleasures" in a taxonomic category, but instead, may be composed of various objects, persons, or events grouped, similar to an emotional response category, on the basis of a common pleasurable or affective experience. Building on prior work on the categorisation of emotions, we propose that pleasure may be represented in the layperson's mind in one of two ways: either as a taxonomy composed of various subtypes of pleasure, or as an emotional response category grouping diverse pleasure antecedents. At this point, there is no basis on which we can argue for one over the other alternative and this issue will be empirically explored in Study 1.

Internal structure and category membership

Whether the concept of pleasure emerges as a taxonomy or as an emotional response category, it remains to be determined whether its internal structure and category membership follows the classical rules of concept formation, with membership being clearly defined by a set of necessary and sufficient features, or alternatively, if it follows the rules of prototype theory, with graded structure and fuzzy boundaries. We suspect the emergence of pleasure as a classical category to be unlikely because graded structure in support of prototype theory has been observed even for concepts that one might intuitively expect to be classically defined such as odd/even numbers (Armstrong, Gleitman, & Gleitman, 1983). Moreover, there is robust evidence that emotion categories reflect graded structure and fuzzy boundaries (Fehr & Russell, 1991; Russell & Fehr, 1994; Shaver et al., 1987). Therefore, we expect the internal structure and category membership of the pleasure category to conform to prototype theory and reveal signs of graded structure and fuzzy boundaries. This proposition is explored in Studies 2 and 3.

Hierarchical structure

The two aspects of the pleasure category addressed thus far (i.e., their content and the principles guiding structure formation) are applicable to both the unitary and the differentiated views of pleasure. Under the unitary view, the pleasure category would be structured around a general representation of pleasure, akin to the general emotion category observed in prior research (Fehr & Russell, 1984; Shaver et al., 1987). Under the alternative differentiated view, differentiated pleasures correspond to distinct psychological realities, and distinct categories would emerge around specific pleasure types, such as "intellectual", and "social", to use some descriptors previously suggested in the literature. Such a differentiated categorisation has been observed for specific emotions like anger (Russell & Fehr, 1994) and love (Fehr, 1988). Yet, neither view is satisfactory. On the one hand, the well-accepted and universal approach-inducing power of pleasure relies on the unitary aspect of pleasure for successful and adaptive decisions and actions to be made when interacting with the environment (Damasio, 1999; Higgins, 1997). On the other hand, viewing pleasure strictly from a general approach tendency perspective is too restrictive and prevents a richer understanding of human behaviour that could accrue from a closer examination of the affective qualities of the experience of diverse pleasurable instances (Damasio, 1999; Higgins, 1997).

Between the unitary and differentiated views of pleasure, we propose that the pleasure category is structured as a hierarchy, with a general, unitary representation of pleasure at the highest level. We further propose that this higher level unitary pleasure differentiates itself into meaningful subgroups of pleasure instances, either explicitly labelled as subtypes of pleasures or implicitly

grouping antecedents sharing some experiential affective qualities. This view of the pleasure concept as a hierarchical category is inspired by recent research that underscores the need to recognise the universal value of the approach-inducing power of pleasure in understanding human behaviour in general, while at the same time pressing to move beyond the notion that the complex modern world can simply be divided into stimuli that are to be approached or avoided based on how good or bad they make one feel. Higgins (1997), for instance, argued for a better understanding of the various facets of the psychological experience of pleasure and their relationship to approach-avoidance motivation. In Higgins, Shah, and Friedman (1997), it was reported that the affective qualities of pleasure derived from the achievement of different goals varied as a function of the regulatory focus of the goal. More specifically, achievement of a promotion goal (e.g., advancement and personal growth) was associated with pleasures of a cheerful quality while achievement of a prevention goal (e.g., protection and safety) procured pleasures of a quiescent emotional quality. Such findings suggest that the relationship between pleasure and behaviour may not be based solely on the intensity of the former but must somehow also be shaped by its antecedents and experiential qualities.

A similar argument in favour of differentiation and how it may improve the understanding of the various facets of affective experience accounts for the development of emotional response categories at the level of specific emotions, by opposition to the level of general positive-negative affect. Niedenthal and her collaborators argued that emotions have distinct behavioural tendencies that are more specific than the generalised approach tendency tied to general affect. For instance, joy is generally believed to trigger a tendency to act in a powerful and triumphant demeanour while warmth and affection generally leads to caressing (Davidson, 1992; MacLean, 1993; Plutchik, 1980). Support for this differentiated view of emotional response categories (over that of generalised affect) was found in a series of category learning experiments (Niedenthal et al., 1997, 1999). In these studies, the authors found emotion-specific and not valence-level facilitation effects: neither happiness priming/love recognition nor sadness priming/anger recognition showed facilitation effects while such effects were observed in all four emotion-specific priming/recognition contexts. By extension, unitary pleasure, not unlike general affect in Niedenthal et al.'s theorising, may well have evolved into something akin to emotional response categories with more differentiated types of pleasure capturing more precise information for approachavoidance decisions and behaviours.

In sum, we build upon these two lines of research to propose that pleasure is organised as a hierarchical category in which the representation of general, unitary pleasure is differentiated further into types of pleasure (by comparison to a category in which all instances relate directly to general pleasure). We believe that this structural arrangement is more functional, permits abstraction and inference to new instances (Rosch, 1975), and provides more specific information relevant to the person-stimulus interaction and behavioural

responses called for. We further propose that, because specific emotions are tied to specific behavioural tendencies and entail appraisal of various complexity, significant insights into the unitary and differentiated nature of pleasure as represented by laypeople can be gained by unravelling the commonalities and differences in the emotional qualities of pleasurable experiences represented at various levels in this hierarchy. The emotional or affective qualities that are common to unitary pleasure and to differentiated types of pleasure are likely to reflect clear approach tendencies and not to involve complex appraisal. By contrast, the affective qualities uniquely associated with differentiated pleasures may entail more diversified tendencies and appraisal, providing insight into the pheno menological qualities of these experiences and into the various ways in which they guide relationships with hedonic stimuli. These propositions, briefly explored in Study 3, are at the core of Studies 4 and 5.

OVERVIEW

Five studies were designed to map laypeople's concept of pleasure and to test the proposed hierarchical structure that we believe can accommodate unitary and differentiated views. In Study 1, a free elicitation task was used to explore the content of the pleasure category and ascertain whether it reflects evidence of pleasure as a taxonomic category grouping types of pleasures, or as an emotional response category, composed of exemplars of pleasure antecedents. Studies 2 and 3 were designed to determine whether the pleasure category is organised in a manner consistent with the classical view or with prototype theory. Participants in Study 2 provided typicality ratings of pleasure antecedents, whereas Study 3 was a test of category membership ("yes/no" decisions) designed to determine whether the pleasure category possesses fuzzy boundaries. In Study 3, we also started to investigate whether the pleasure category is organised simply around a representation of general unitary pleasure or whether pleasure representations show signs of further differentiation. The objective was to determine whether laypersons, whose pleasure category may not naturally be structured around types, were able to assign antecedents to differentiated pleasures when explicitly presented with them, or if instead they would prefer to group these antecedents under the general unitary level. Study 4 was designed to further explore the degree of differentiation of the pleasure category and consisted of a hierarchical cluster analysis of data from a sorting task conducted with pleasure antecedents. Finally, Study 5 was designed to explore the similarities and differences in the patterns of emotional qualities associated with the two levels in the pleasure hierarchy (i.e., the general unitary representation of pleasure and the differentiated pleasures). Participants in all studies were undergraduate students at a major Eastern Canadian university. No student took part in more than one study. Except for Study 4 where participants were enrolled in a lottery for a cash prize, participants received no incentive. Results for each study are presented and

then discussed briefly, and their meaning, validity, and limitations are elaborated in the general discussion section.

STUDY 1: FREE ELICITATION OF THE CONTENT OF THE PLEASURE CATEGORY

Participants were given the category of pleasure and were asked to list subcategories thereof. Following Russell and Fehr (1994), the frequency with which a subcategory was listed served as an index of its degree of membership.

Method

Participants (n=78) were given these instructions adapted from Fehr and Russell (1991) and Russell and Fehr (1994): "In this study, we're interested with *types* within a general category. For example, if we ask you to list types of the category CHATR, you might write: rocking chair, recliner, lawn chair, kitchen chair, stool, bean bag chair, and so on. The category we are interested in is PLEASURE. Please write down as many items as come to mind when you think of PLEASURE. Stop after a few minutes or 20 items or so. There are no right or wrong answers. We just want to know what comes to your mind when you think of PLEASURE".

Results and discussion

In all, 1127 units of information were collected and were coded independently by two coders, using a scheme adapted from emotion research (Fehr & Russell, 1984; Shaver et al., 1987). The coding scheme consisted of the following content codes: (1) *types of pleasure:* descriptors, adjectives, and other words used to qualify the word *pleasure* (e.g., physical, meaningful, intellectual); (2) *emotion words:* feelings or emotions associated with the experience of pleasure (also included arousal or other affective qualities associated with pleasure antecedents, e.g., relaxing, exciting, etc.); (3) *antecedents:* specific events, persons, places, or things that bring pleasure. Six items were deemed uncodable by both coders. Agreement between the two coders was 0.77 over the entire corpus of responses and discrepancies were resolved by discussion.

Table 1 presents the content of participants' freely elicited concept of pleasure. This comprehensive coding involved two types of aggregation of participants' accounts. First, units that shared a syntactical form were coded together. For instance, "relaxed" and "relaxing" were coded together, as were "excited" and "exciting" under the category "Emotion words". The second round of aggregation focused on semantic similarities between units of information. For instance, "food", "chocolate", "desserts", and "ice cream" were collapsed under "food". In such cases, the frequency of units mentioned at least twice and

aggregated under a broader heading is indicated in parentheses in Table 1. For example, "food" proper was mentioned 30 times, chocolate seven times, desserts and ice cream twice each, items mentioned only once make up the remaining five units under food for a total of 46 mentions.

Supporting our proposition that the layperson's mental representation of pleasure evolves into a categorical concept, no participants found the task nonsensical and most were able to provide rich and detailed accounts of their mental representation of pleasure with reasonable consistency. On average, each participant generated 14.45 information units. The content of participants' protocol suggests that the pleasure category may be organised as an emotional response category rather than as a taxonomic category. Antecedents were, by far, the largest content category (891 mentions or 79.1% of all units) with also a significant amount of emotion words (164 mentions, 14.6% of all units). In fact, only 66 units (5.9%) referred to types or qualifiers of pleasure, and of these, 45 were idiosyncratic mentions. The proportion of antecedents from this free listing task is much higher than what has been found in similar studies conducted in the domain of emotions (Fehr & Russell, 1984, 1991; Russell & Fehr, 1994). In these studies, the proportion of antecedent ranged between 5% (Fehr & Russell, 1984; Russell & Fehr, 1994) and 20% (Fehr & Russell, 1991).

What was the nature of antecedents composing the pleasure category as per the participants' accounts? As can be seen in Table 1, pleasure antecedents were highly diversified and related to all the various types of pleasures offered by the literature. However, as expected for categorical concepts, the list of pleasure antecedents reflected a reasonable degree of consistency across participants: The ten most frequently mentioned antecedents accounted for 36.8% (328 mentions) of all antecedents mentioned. At the other extreme, were 91 idiosyncratic antecedents, a proportion that is not higher than those obtained in studies on taxonomic emotion categories (e.g., Fehr & Russell, 1984, 1991). Between these two extremes, there was no clear break between popular and unpopular antecedents.

Was the emergence of pleasure as a taxonomic category given a fair chance? The last sentence of the instructions ("We just want to know what comes to your mind when you think of PLEASURE".) may have distracted participants from thinking about more abstract types of pleasure in favour of more easily available top-of-mind associations, like antecedents and experiential qualities. Therefore, we conducted a first follow-up study with 51 different participants, which was essentially a replication of Study 1, removing the last sentence of the instructions. Responses were coded by the same two coders using the same coding scheme. Agreement between the two coders was 0.82. Results were almost identical to those reported earlier: Antecedents were mentioned 555 times, emotion words 43 times, and various types of pleasure were mentioned 6 times. Types included: physical (2), intellectual (1), social (1), immoral (1), and virtual (1).

Because the corpus of accounts from Study 1 was going to be used in the subsequent studies, we conducted a second follow-up to ensure that we elicited

TABLE 1

Content of freely elicited lay concepts of pleasure

Type of pleasure	*66*	Music(27)/concerts(2)/ disco(2)/CDs(2)/ other(1)	34	Freedom	4
Physical	5			Health	4
Erotic	2			Learning	4
Exotic	2	Family(17)/brother(2)/ parents(2)/other(2)	23	Saturday(2)/other(2)	4
Expensive	2			Summer(3)/spring	4
Free	2	Sleeping	23	Walk	4
Innocent	2	Movie	21	Water(2)/other(2)	4
Intense pleasure	2	Beach(16)/sand(2)/sea(2)	20	Conversation	3
Positive	2	Laugh	17	Going out/date	3
Sensory pleasure	2	Sun(13)/Heat(3)	16	Playing guitar(2)/other(1)	3
Idiosyncratic items	45	Vacation	16	Hug	3
		Money	15	Men	3
Emotion words	*164*	Watching TV(12)/other(3)	15	Play	3
Love	23	Alcohol(9)	15	Romance	3
Fun	23	Parties	14	Singing	3
Relaxing	19	Dining(6)/eating(5)/ other(1)	12	Wildlife	3
Happiness	16			Work	3
Warmth	11	Shopping(10)/grocery shopping(2)	12	1980s/1990s	2
Enjoyment	8			Activities	2
Satisfaction	6	Shower(6)/Bath(6)	12	Air condition	2
Exciting	4	Travelling	12	Art	2
Feelings	4	Performance	11	Beautiful/attractive	2
Fulfilled	4	Sensation(3)/touch(4)/ taste(3)/other(1)	11	Boating	2
Accomplishment	3			Body/arms	2
Achievement	3	Games(7)/computer games(3)	10	Camera	2
Content	3			Clubs	2
Crazy	3	Good grades	10	Compliments	2
Joy	3	Reading(8)/Literature(2)	10	Cooking	2
Lazy	3	Success	10	Experience	2
Feel good	2	Women	10	Gifts	2
Peaceful	2	Car(7)/Porsche(2)	9	Going to a café	2
Pleasing	2	Drugs(4)/ecstasy(2)/ rush(2)/other(1)	9	Hanging around/out	2
Relief	2			Holding hands	2
Soothing	2	Comfortable	9	Hotel rooms	2
Idiosyncratic items	18	Dancing	9	Knowledge	2
		Fragrance	9	Letters (writing/getting to/ from friends/family)	2
		Massage	9		
Antecedents	*891*	No exams/work	9	Life	2
Sports(14)/skiing(8)/ hockey(7)/ swimming(5)/ exercising(4)/ baseketball(3)/ rollerblading(2)/ snowboarding(2)/ other (9)	54	Clothes(6)/other(2)	8	Meeting new people	2
		Holiday	7	Passion	2
		Boyfriend/Girlfriend	6	Peace toward men on Earth	2
		Dream	6	Prestige	2
		Drinking	6	School	2
		Places	6	Snow	2
		Smile	6	Socializing	2
		Home	5	Tanning	2
Sex(44)/seduction(3)/ masturbation(2)/other(1)	50	Kissing	5	Telephone call (to/from friends/family)	2
		Smoking	5		
Food(30)/chocolate(7)/ desserts(2)/ ice cream(2)/other(5)	46	Birthday	4	Thinking	2
		Christmas	4	Materialism	2
		Driving	4	Wedding	2
Friends	40	Entertainment	4	Idiosyncratic items	91

as rich and detailed content of the pleasure category as possible. Emotional response categories are supposed to capture the phenomenal qualities of one's interaction with people, object, and events (Niedenthal et al., 1999) and yet, thus far, respondents have been asked to elicit types of pleasure only. Therefore, this follow-up study was designed to elicit the content of specific pleasurable episodes. Participants (n=69) were instructed to think of two recent pleasurable experiences, and to describe each one it in their own words, and to list what they felt in connection with each experience. Instructions for that study were adapted from Fehr and Russell (1984). In total, 124 "episodes" were coded (1.8 episode per participant) using the same scheme as for Study 1. Because the results of these two follow-up studies confirm those of the first one, they will not be fully discussed but only briefly outlined. The most frequently mentioned antecedents were sports (19 episodes), school (11 episodes), friends (11), and sex (9). The most frequently reported emotions were generally similar to Study 1: happiness (39), excitement (23), and joy (18). However, the emotional make-up of pleasurable experience elicited under experience-eliciting instructions contained more complex emotions, such as fulfilment (8), accomplishment (7), and relief (6) and a limited number of negative emotions: anxiety (4), fear(2), anger (2), and idiosyncratic mentions of sadness, revenge, greed, nervousness, and vulnerability. Other affective responses included: stress-free (8), energetic (4), peaceful (4), calm (3), horny (3), warm (3), and vulnerability (2).

The results of Study 1 and its two follow-up studies provide evidence that the content of the pleasure category is primarily composed of exemplars of various pleasure antecedents grouped into an emotional response category, rather than encompassing types of pleasures, that would have reflected formation of taxonomic categories. In addition, results of Study 1 did not suggest the existence of any necessary and sufficient features that would have implied that pleasure is a classical concept. Instead, regardless of the nature of information units, the frequency of mention of various instances showed no clear break, much in line with prototype theory. In Studies 2 and 3, we provide a more formal empirical exploration of the internal structure of the pleasure category. Sixty antecedents were chosen from the corpus of Study 1 and its two follow-up studies. Antecedents were chosen to cover the whole range of frequency of mention, including 13 idiosyncratic antecedents.

STUDY 2: GRADED STRUCTURE OF PLEASURE ANTECEDENTS

This study was designed to determine if the antecedents that composed the pleasure category displayed signs of graded structure consistent with prototype theory, or if instead, their typicality ratings produced the bimodal distribution reflecting the "yes/no" nature of category membership consistent with the classical view (Rosch & Mervis, 1975).

Method

Participants (n=58) were presented with the list of 60 pleasure antecedents and asked to rate each one in terms of its degree of membership in the category of pleasure. Instructions were patterned after Fehr and Russell (1991, study 2). Participants were asked to rate each item on a scale ranging from 1 *(extremely poor example of the kinds of things that bring me pleasure)* to 6 *(extremely good example of the kinds of things that bring me pleasure)*. Antecedents were presented in the same random order to each participant.

Results and discussion

The mean typicality ratings for the 60 antecedents are reported in Table 2. Guttman's split-half reliability coefficient was 0.79. The broad range of typicality ratings and their continuous distribution reflects the graded structure of pleasure antecedents. Very typical antecedents (mean of 5 or higher) included success, good grades, travelling, romance, boyfriend/ girlfriend, and sex. More atypical antecedents, such as prayer and snow, scored around 2 on the typicality scale. Antecedents between these two extremes produced a rather smooth and continuous distribution and included moderately typical activities like watching television, reading, telephone call to or from friends or family.

STUDY 3: CATEGORY MEMBERSHIP AND ASSIGNMENT TO UNITARY AND DIFFERENTIATED PLEASURES

According to Russell and Fehr (Fehr & Russell, 1984, 1991; Russell & Fehr 1994), beyond a graded structure, a key difference between classically and prototypically defined concepts concerns the categorisation of unclear cases. If category membership is determined by a set of defining, necessary, and sufficient features, then membership should be an easy "either/or" decision. Thus, in the classical view, people should agree on which events and which subcategories are and are not members of the pleasure category, even for less typical, idiosyncratic instances. By contrast, prototype theory predicts that agreement among participants will gradually vary from the clear cases indicated by a "yes" answer to the question "is X a true example of Y?" through the unclear cases, indicated by a "no" to the same question. This gradual shift should correspond to the graded structure and the degree of agreement on category membership should form a smooth continuum. In their study on anger, Russell and Fehr (1994), using a 90% agreement criterion, found consensus on fury, rage, aggravation, hate, and hostility as being subtypes of anger but they found no clear agreement on what was not anger. Fehr and Russell (1991) observed similar results in the domain of love and also found a high correlation between the probability of an item being judged a true case of love and its typicality rating.

TABLE 2

Pleasure antecedents by decreasing order of mean typicality

Antecedents	*Mean*	(SD)	*Antecedents*	*Mean*	(SD)
Success	5.41	(0.75)	Desserts	3.97	(1.12)
Good grades	5.28	(0.77)	Holding a baby	3.86	(1.28)
Travelling	5.17	(0.77)	Writing/receiving letters	3.84	(1.15)
Romance	5.17	(0.77)	to/from family/friends		
Boyfriend/Girlfriend	5.14	(0.77)	Birthday	3.84	(1.11)
Sex	5.0	(0.96)	Watching TV	3.69	(0.97)
Sun	4.97	(0.84)	Reading	3.67	(1.37)
Music	4.93	(0.75)	Telephone call to/from	3.52	(1.33)
Knowledge	4.84	(0.94)	family/friends		
Sleeping	4.83	(1.11)	Concerts	3.45	(1.36)
Beach	4.78	(1.06)	Sales	3.46	(1.43)
Money	4.76	(1.14)	Going to a café	3.45	(1.29)
Conversation	4.53	(0.91)	Drinking	3.21	(1.38)
Meeting new people	4.52	(0.98)	Masturbation	3.13	(1.43)
Clothes	4.5	(0.93)	Art	3.10	(1.27)
Food	4.47	(0.93)	Literature	3.09	(1.24)
Moving into my own apartment	4.45	(1.23)	Candles	3.05	(1.38)
Shower	4.45	(1.05)	Fireplace	3.02	(1.20)
Equality	4.34	(1.10)	Cooking	3.0	(1.17)
Peace on earth	4.34	(1.35)	Materialism	3.0	(1.10)
Movie	4.33	(1.01)	Solitude	2.93	(1.05)
Shopping	4.33	(1.07)	Cartoons	2.84	(1.20)
Dressing up	4.24	(0.93)	Ecstasy	2.76	(1.71)
Seduction	4.23	(1.12)	School	2.74	(1.10)
Sports	4.19	(1.46)	Aromatherapy	2.50	(1.15)
Popularity	4.16	(0.85)	Prayer	2.43	(1.54)
Parties	4.12	(1.03)	Grocery shopping	2.36	(1.22)
Learning	4.10	(1.18)	Computer games	2.23	(1.11)
Christmas	4.00	(1.32)	Drugs	2.16	(1.35)
Choculate	4.00	(1.28)	Snow	2.12	(1.19)
Exercising	3.98	(1.25)	Repetition	1.71	(0.74)

Study 3a was designed to determine whether pleasure antecedents displayed signs of fuzzy boundaries.

Thus far, we have used unitary, general pleasure as a referent in eliciting the category content and structure. In Study 3b, we explored the possibility that the general representation of pleasure differentiates itself into reliable and meaningful groupings in an implicit manner, even if participants were unable to explicitly label these groupings or to articulate the rules underlying their formation. Because emotional response categories implicate the phenomenal qualities of the person's experience, and not just the conceptual representation of their features, Niedenthal and her collaborators also believe that these categories may be formed at the subcortical level (Niedenthal & Halberstadt 1995), a level

at which much of emotional processing occurs in an implicit manner (i.e., without conscious, explicit knowledge that such categories are formed, LeDoux, 1993). This suggests that the content of the pleasure category and its hypothetical differentiation may be more or less accessible to introspection. Therefore, when explicitly given labels to do so, participants should be able to discriminate and identify the specific type of differentiated pleasure produced by various hedonic stimuli. After participants had assessed the category membership of various pleasure antecedents (Study 3a), we asked them to assign each antecedent to either a general pleasure category or to one of four more specific and differentiated types of pleasure. The four differentiated pleasures (i.e., physical, social, intellectual, and emotional) were selected as being lay terms that could capture the four types of pleasure most often offered by prior theorists (see Kubovy, 1999; Tiger, 1992).

Method

Study 3a. Participants (n=61) were presented with the 60 pleasure antecedents used in Study 2. Participants were asked to assess category membership by indicating whether each antecedent was or was not a true, genuine, case of pleasure. Instructions for category membership task were adapted from Fehr and Russell (1991). Participants were asked to indicate by a "Yes" or a "No" next to each antecedent their answer to the question "X is a true genuine case of pleasure".

Study 3b. After indicating their opinion on the "yes/no" category membership question, participants were asked to assign each antecedent to one of five pleasure categories. In order to verify that participants indeed possessed and were able to instantiate a mental representation of each type of pleasure when performing the category assignment task, they were first asked to indicate what they spontaneously associated with each type of pleasure. The 60 antecedents were then listed (in a different order from the previous page) in a column on the left-hand side, next to five columns headed by the label of one of the possible pleasure categories: "General pleasure, can't say which differentiated type", "physical pleasure", "social pleasure", "intellectual pleasure", and "emotional pleasure". Instructions were adapted from Fehr and Russell (1984, study 2). Participants were asked to indicate the dominant type of pleasure they associated with each antecedent by placing a check mark in the column with the label corresponding to their association.

Results and discussion

Category membership. Table 3 presents the percentage of participants who denied category membership for each of the 60 antecedents. Results show that the agreement on membership among participants is a matter of degree. Interestingly, the asymmetry between clear and unclear instances predicted by

classical theory did not emerged. There were a good number of cases that were clear instances of the category (12 items with 90% or higher agreement; 24 items with 80% or higher). Items with the highest agreement included the most typical pleasure antecedents unravelled in Studies 1 and 2. At the other extreme, possibly reflecting the diverse and idiosyncratic nature of pleasure antecedents, only one atypical antecedent (i.e., repetition) was clearly categorised as a nonmember using 80% and 90% agreement as consensus criteria. Between these two extremes, as expected, we observed a gradual shift in the degree of agreement. The probability of an antecedent being judged a true case of pleasure correlated .89 with the typicality rating obtained from Study 2; Fehr and Russell

TABLE 3
Percentage of participants denying membership in the pleasure category

Item	*%*	*Item*	*%*
Romance	1.6	Chocolate	26.2
Sex	1.6	Sports	26.2
Success	1.6	Christmas	27.9
Sun	3.3	Clothes	27.9
Music	4.9	Exercising	27.9
Travelling	4.9	Reading	29.5
Beach	8.2	Masturbation	29.5
Boyfriend/Girlfriend	8.2	Desserts	31.1
Knowledge	8.2	Art	31.1
Movies	8.2	Literature	34.4
Seduction	8.2	Watching television	36.1
Good grades	9.8	Solitude	36.1
Food	11.5	Going to a café	37.7
Sleeping	13.1	Telephone call to/from family/friends	37.7
Conversation	14.8	Drinking	39.3
Learning	14.8	Shopping	39.3
Parties	14.8	Aromatherapy	39.3
Peace on earth	14.8	Cooking	41.0
Meeting new people	16.4	Candles	41.0
Money	16.4	Cartoons	47.5
Shower	16.4	Ecstasy	52.5
Birthday	19.7	Sales	59.0
Concerts	19.7	Drugs	60.7
Moving into my own apartment	19.7	Computer games	62.3
Writing/receiving letters to/from		Prayer	62.3
family/friends	21.3	Materialism	67.2
Holding a baby	23.0	School	67.2
Equality	23.0	Snow	73.8
Dressing up	24.6	Grocery shopping	75.4
Fireplace	24.6	Repetition	90.2
Popularity	24.6		

(1991) obtained a correlation of .96 between membership probability and typicality rating for types of love.

Assignment to pleasure type. Participants' spontaneous associations with unitary and differentiated pleasures collected prior to the category assignment task were fully consistent with what might be expected for each type of pleasure. For instance, physical pleasure was associated primarily with sex (mentioned 20 times), but was also associated with other items that conveyed the bodily and sensory nature of that pleasure type: food and sports (each 4 mentions), massage (3), touch and taste (4). Similarly, intellectual pleasure was associated with cognitively demanding activities like reading (5 mentions), conversation (2), challenge (2), playing chess (2), and good grades (2). Social pleasure was associated primarily with friends (11 mentions). Emotional pleasure was associated with specific positive emotions: happiness (5 mentions), and love and peace of mind (each 2 mentions). As for general pleasure, the idiosyncratic antecedents along with the variety of emotion words listed under this category illustrated the catch-all nature of its mental representation and the lack of finergrained information on the source and nature of the experience. Antecedents mentioned in connection with the general pleasure category were idiosyncratic except for "pleasing experience" mentioned twice. Emotions associated with general pleasure and mentioned more than once were fun (5 mentions), excitement, happiness, satisfaction, joy, relaxing, and no stress (each with 2 mentions). Thus, the four differentiated types of pleasure were associated with antecedents and emotion words that form a profile consistent with their theoretical definition. In fact, of all items spontaneously associated with each type of pleasure, none were conceptually or domain-irrelevant.

Table 4 presents the number of participants who either assigned a pleasure antecedent to the general unitary pleasure category or assigned it to one of the (Continued) four differentiated pleasures. In Table 4, antecedents are sorted by the modal type of pleasure to which they were assigned and the number of participants who denied membership (from Study 3a) is indicated as well. Across all participants and all antecedents (61 participants x 60 item assignments), when participants were given the option between general pleasure and explicitly differentiated types of pleasure, they chose to keep the antecedents in the general pleasure category in only 1 out of 4 cases (884 times or 24.15% of all assignment decisions). As Table 4 shows, the General Pleasure category was the modal category for only 11 antecedents whereas for all other antecedents the modal category was one of the four differentiated types of pleasure. Specifically, the physical pleasure category accounted for 19.4% of the cases (711 mentions), as well as 776 mentions or 21.2% for the social pleasure category, 465 mentions or 12.7% for the intellectual pleasure category, and 750 mentions or 20.5% for emotional pleasure.

STUDY 4:
SIMILARITY SORTING OF PLEASURE ANTECEDENTS

It is conceivable that the imposition of the four pleasure types derived from the literature and explicitly provided in Study 3b could have biased participants' organisation and mental representations and therefore obscured their true pleasure categories. Study 4 was designed to test whether these four differentiated types of pleasure would also emerge as implicit groupings of pleasure antecedents in the absence of such a demand artifact. Moreover, as per our proposition that pleasure is a hierarchical concept, the possible differentiated pleasures were expected to emerge and be subsumed under a general, unitary representation of pleasure.

Method

Methodology, instructions, and analyses were patterned after Shaver et al. (1987). Participants (n=75) were tested individually and entered their names in a

TABLE 4

Number of participant assigning antecedents to pleasure type[a]

Antecedent	*Denied membership*	*General pleas.*	*Physical pleas.*	*Social pleas.*	*Intellectual pleas.*	*Emotional pleas.*
Moving into my own apartment	12	*32*	0	11	0	4
Peace on earth	9	*23*	1	1	5	20
Watching TV	22	*23*	2	6	3	4
Money	10	*22*	7	12	3	7
Christmas	17	*19*	1	15	0	8
Sex	1	3	*46*	0	0	9
Sleeping	8	3	*45*	0	0	4
Shower	10	4	*44*	0	0	2
Masturbation	18	1	*41*	1	0	0
Exercising	17	0	*39*	2	0	1
Sports	16	3	*36*	4	0	1
Food	7	14	*34*	3	0	3
Sun	2	13	*27*	1	1	16
Chocolate	16	11	*23*	1	0	20
Desserts	19	13	*21*	3	0	5
Beach	5	15	*18*	8	0	13
Meeting new people	10	0	0	*48*	2	1
Parties	9	2	2	*46*	0	2
Birthday	12	2	2	*41*	0	4

Antecedent	*Denied membership*	*General pleas.*	*Physical pleas.*	*Social pleas.*	*Intellectual pleas.*	*Emotional pleas.*
Conversation	9	1	1	*35*	9	4
Going to a café	23	3	1	*32*	0	2
Popularity	15	7	1	*31*	0	6
Travelling	3	10	4	*26*	5	13
Concert	12	6	3	*23*	4	12
Drinking	24	2	11	*22*	0	2
Dressing up	15	7	5	*20*	1	13
Movies	5	12	1	*20*	12	9
Equality	14	12	1	*19*	7	6
Shopping	24	7	3	*18*	0	7
Knowledge	5	0	0	4	*51*	1
Learning	9	0	1	3	*48*	0
Literature	21	1	0	0	*38*	1
Reading	18	2	0	0	*35*	6
Good grades	6	20	0	0	*30*	3
Art	19	5	2	1	*24*	10
School	41	0	0	3	*16*	1
Romance	1	0	2	7	0	*51*
Boyfriend/Girlfriend	5	3	2	4	0	*45*
Holding a baby	14	4	2	0	0	*39*
Music	3	5	1	9	7	*36*
Seduction	5	2	14	5	1	*34*
Writing/receiving letters to/from family/friends	13	1	0	15	1	*30*
Solitude	22	5	3	2	4	23
Success	1	7	1	13	15	*22*
Candles	25	9	5	1	0	*21*
Fireplace	15	9	12	4	1	*20*
Telephone call to/from family/friends	23	4	0	13	0	*20*
Prayer	38	2	0	0	4	*15*
Repetition	55	3	0	1	1	1
Grocery shopping	46	8	2	4	1	0
Snow	45	6	5	0	0	5
Materialism	41	6	3	7	0	4
Computer games	38	4	4	4	9	2
Drugs	37	3	13	5	0	3
Sales	36	12	0	6	3	3
Ecstasy	32	4	12	6	1	6
Cartoons	29	11	0	2	9	10
Cooking	25	12	6	11	3	3
Aromatherapy	24	9	18	1	0	9
Clothes	17	11	12	12	0	8

[a]Sorted by modal pleasure type. N=61, some rows may not add up to 61 because of missing responses.

lottery for cash rewards. The 60 antecedents used thus far were printed on 2.5 inch x 4 inch cue cards. Participants were informed that the words referred to instances of pleasure that had been elicited previously from a group of students like themselves. They were then asked to sort the words into piles such that items in a pile bore more similarity with each other than with items in other piles. No limit was placed on the number of piles allowed. For each participant, a 60 x 60 frequency of co-occurrence matrix was constructed, with 1 indicating that two antecedents were placed into the same category, 0 indicating that they were not. These individual matrices were added across the 75 participants to produce a 60 x 60 matrix in which cell entries ranged from 0 to 75. This last matrix was transformed into dissimilarity measures, which were then submitted to a hierarchical cluster analysis using SASs *proc cluster*.

Results and discussion

Participants took between 20 and 55 minutes to complete the task. Participants, on average, formed 10 categories. The maximum number of categories formed was 21, the minimum was 3 and 6 was the median. Thirty-three was the maximum number of items placed into a single category while 1 was the smallest, which occurred for two different items with two different participants. The results from the cluster analysis are shown in Figure 1 in the form of a dendrogram. The 60 antecedents appear along the bottom in clusters of strength equal to or greater than 35, the strength being indicated by the vertical scale. Thus, within each grouping at the bottom, the average number of respondents placing any two words together in a cluster was at least 35.

Inspection of Figure 1 reveals that the groups of antecedents at the bottom quickly merge into nine larger clusters. These clusters preserve some of the richness and detailed information of the original 60 antecedents. To correctly interpret and label these early clusters, a necessary step in understanding the later stages of agglomeration, we relied primarily on the measure of within-cluster centrality used by Shaver et al. (1987). For each word within a group, this measure is computed by subtracting the average number of co-occurrences with all words outside that cluster from the average number of co-occurrences with all other words within that cluster. This measure constitutes an indication of each word's defining role within a specific cluster. An asterisk indicates the item with the highest centrality measure within each of these first nine clusters. For instance, "good grades" has the highest centrality measure of the first cluster. The nine clusters later merge into four higher order groups that, albeit nonperfectly, match reasonably well the four differentiated pleasure types from Study 3b.

To explore further the nature of the four higher clusters, we computed the within-cluster centrality measures for the items now in those clusters. The most central items in the cluster "intellectual" were: good grades (20.9), knowledge (19.8), learning (19.2), school (19.2), and success (15.9). The emotional pleasure type was

defined by watching television (14.7), movies (13.6), cartoons (12.4), and art (11.0). In the social type, the centrality scores for most items fall at a moderate level (15 of the 21 items have a centrality score between 6 and 9) with "shopping" being the most central antecedent (9.8). Finally, physical pleasure was defined by sex (21.9), seduction (21.4), romance (18.4), and boyfriend/ girlfriend (18.4). In sum, the four types of pleasures that implicitly underlaid participants' sorting of pleasure antecedents in Study 4 were very much in line with the four differentiated pleasure types to which Study 3's participants were willing to assign pleasure antecedents. At a higher level, intellectual and emotional pleasures were grouped in a cluster (labelled A Figure 1) that could arguably be labelled as "pleasures of the mind". The other cluster to emerge at the same level (labelled B Figure 1) grouped the physical and social pleasures, a grouping that would not conform to "pleasures of the body" as per prior theories of differentiated pleasures. Therefore, in follow-up work, we considered the differentiated pleasures that emerged at the four-cluster rather than the two-cluster level. Ultimately, differentiated pleasures were subsumed under the general, unitary pleasure.

We conducted a follow-up study to provide a more formal test of the proposed hierarchical structure of the pleasure category and of the critical role of these four differentiated types of pleasure in structuring the pleasure category. Study 3b has shown that even though participants did not explicitly abstract types of pleasure in forming their memory representation of pleasure, they were nonetheless able to relate explicitly provided labels to their implicit organisation of the pleasure category. In this follow-up study, different participants (n=31) were asked to perform category membership judgment (yes/no decisions) as in Study 2, but this time on a list of 30 possible types of pleasure taken from the corpus of Study 1, including the four differentiated types of pleasure tested in Studies 3 and 4. These four types of pleasure emerged with the highest agreement: physical and intellectual pleasures were denied membership to the pleasure category by only one participant, social and emotional pleasures by three participants. The types of pleasure on which the highest proportion of denial of membership was observed were embarrassing pleasures, with 20 participants denying membership, and stressful pleasures with 24 participants denying membership. Between these extremes, we could observe a gradual shift in category membership agreement, as was the case for pleasure antecedents in Study 2.

STUDY 5: COMMON AND UNIQUE EMOTIONAL QUALITIES OF UNITARY AND DIFFERENTIATED PLEASURES

Results of Study 4 support the proposition that pleasure is a hierarchical concept with the general, unitary representation of pleasure differentiating itself into four types that laypersons recognise as the most typical of the category with a high level of agreement (i.e., intellectual, emotional, social, and physical). If affective

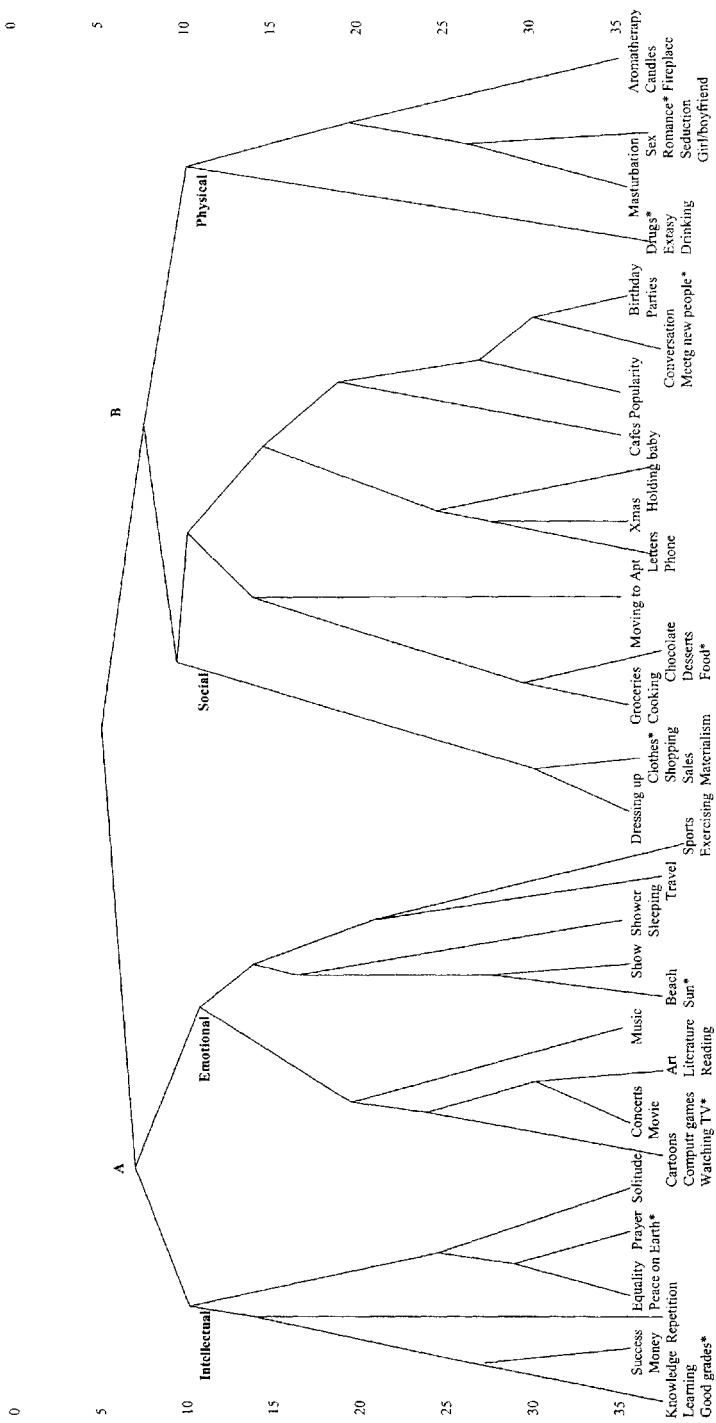

Figure 1. Results of a hierarchical cluster analysis of 60 pleasure antecedents.

qualities are key features in specifying hedonic experiences, significant insights into the representation of pleasure can be gained from identifying the emotional qualities that might be common to unitary and differentiated pleasures and those that might vary between the two levels in the hierarchy, or those that might be uniquely associated with specific differentiated types. Moreover, the discriminative role of affective qualities in hedonic experiences also suggests that unitary pleasure and the most typical types of pleasures would tend to be associated with a constellation of affective responses that does not characterise less typical pleasure types. In Study 5, participants provided typicality ratings for a set of affective qualities in the context of one of seven types of pleasure (i.e., the general pleasure, the four differentiated pleasures, and two atypical types of pleasure).

Method

Participants (n=172) were randomly assigned to one of seven pleasure "conditions". The pleasure conditions included the general pleasure level, each of the four differentiated pleasures (i.e., physical, emotional, social, intellectual), and the two types of pleasure conditions that emerged as the type of pleasures that were the poorest instances of the pleasure category in the follow-up study above (i.e., embarrassing and stressful). In each condition, participants were presented with the same list of 35 feelings and emotion words (same random order for each participant), chosen from the corpus of Study 1 and its two follow-up studies to include a broad range of frequencies of mention. The instructions were similar to those of Study 2, with minor modifications. Participants were asked to rate each emotion word on a scale from 1 *(extremely poor example of the kinds of emotions I have when experiencing____pleasure)* to 6 *(extremely good example of the kinds of emotions I have when experiencing____pleasure)*.

Results and discussion

Analysis of variance with type of pleasure as a between-participants factor was conducted on the typicality ratings of the 35 emotion words. Average typicality ratings and results of *post-hoc* comparisons using Fisher's LSD appear in Table 5 for general pleasure, the four differentiated subcategories (i.e., physical, social, intellectual, and emotional), and the two less typical pleasures (i.e., embarrassing and stressful). We use the general unitary pleasure level as the reference, and highlight in the table all typicality ratings that are significantly different from this reference. Other pairwise comparisons of interest are presented below.

Before analysing the unique affective makeup of the four differentiated pleasure types, it is informative to consider emotions that are common to all pleasurable experiences, including those that are less typical. As expected, very few affective qualities did not vary across all seven subcategories. These

consisted of anger, lazy and sleepy, figuring equally low typicality, with, in addition, surprise and heart-pounding, rated at a moderate level of typicality. When only unitary and the four differentiated pleasures were considered, common affective qualities entailed both highly typical positive emotions and highly atypical negative emotions. Positive affective qualities that were highly typical and common between unitary and the four differentiated pleasures were excitement, fulfillment, self-confidence, self-esteem, relaxed, ecstatic, bliss, stress-free, and content. Negative affective qualities were pain, vulnerability, fear, nervousness, and crazy feelings.

What unique emotional qualities distinguished, in the laypersons' mind, the experience of general unitary pleasure from the differentiated pleasures? Intellectual pleasure presented the largest number of different affective qualities when compared to the general unitary pleasure. The subjective experience of intellectual pleasure was characterised by more sadness and less of the following emotions and feelings: altruism, caring, happiness, horny feelings, joy, love and warmth. Participants' representation of physical pleasure was characterised by more energetic feelings and less accomplishment, less pride, and less happiness than that of general unitary pleasure. Social pleasure also was associated with more energetic feelings than general unitary pleasure, but less love and less peaceful feelings. Finally, emotional pleasure was marked by more relief, more sadness, more greed, and more guilt than the general unitary pleasure.

Further insights into the differentiation of pleasurable experiences can be gained from comparing the pattern of affective qualities of each differentiated pleasure. Such comparisons revealed that physical and intellectual pleasures emerged as the most clearly differentiated types as a set of unique affective qualities could be identified on which they differed from all other types. Specifically, physical pleasure distinguished itself by more heart-pounding and horny feelings, less accomplishment and less pride than all other types of pleasure. Physical pleasure also scored higher on caring, energetic, joy, love, and warmth than intellectual pleasures but also displayed less sadness, less self-confidence, and less self-esteem than intellectual and emotional pleasure. Intellectual pleasure was associated with less caring, less joy, and less warmth than other types but also with more pride, self-confidence, and accomplishment than physical pleasure. Although the profile of emotional pleasure reveals no affective qualities on which it differs from all other types, it is unique insofar that it contains more "cognitive" emotions (i.e., pride, self-confidence, self-esteem), more negative emotions like sadness and guilt, and less arousal states (e.g., heart-pounding). Social pleasure was associated with more altruism, caring, joy and happiness than intellectual pleasure, and less love, peacefulness, and accomplishment than emotional pleasure.

GENERAL DISCUSSION

The results of these flve studies offer a comprehensive map of layperson's concept of pleasure in terms of both its content and structure. Instances of the pleasure concept collected in Study 1 were not types of pleasure as might have been expected in taxonomic categories but instead consisted of objects, events or persons that had been sources of pleasure. This suggests that the pleasure category, like emotional response categories, are formed at an implicit level where various instances are grouped on the basis of common phenomenological qualities of the affective experience they induce. Studies 2 and 3a showed that within the pleasure category, antecedents varied widely in terms of typicality and category membership, reflecting graded structure and fuzzy boundaries in line with prototype theory. Results further revealed that participants, either upon presentation of explicit verbal labels in Study 3b, or implicitly in the sorting task performed in Study 4, exercised discriminative judgement when assigning a large proportion of hedonic antecedents to the four differentiated pleasures. Res ults of both Studies 3 and 4 revealed the hierarchical structure of the pleasure concept where unitary pleasure differentiated itself into intellectual, social, emotional, and physical subtypes. Those four subtypes emerged as the clearest types in participants' representations obtained in the follow-up to Study 4. Finally, Study 5 showed that laypeople's representations of unitary and differentiated pleasures shared a set of common positive affective qualities but also that they can be distinguished on the basis of unique affective qualities.

How does the differentiation in laypersons' conception of pleasure observed in these five studies compare to prior theories and conceptual frameworks? The four differentiated pleasures observed in these studies are consistent with the most recent typologies proposed by Kubovy (1999) and Tiger (1992). The various antecedents participants associated with intellectual and emotional pleasures are reminiscent of Duncker's (1941) accomplishment and aesthetic pleasures respectively, combined by Kubovy (1999) under the label of pleasures of the mind. Physical pleasures emerged here from intense sensations, whether from natural or artiflcial sources. Finally, social pleasures emerged, as proposed by Kubovy (1999) and Tiger (1992), from activities shared with friends. The intermediary two-cluster level that emerged between the four differentiated pleasures and the general unitary representation in Study 4 was partially reminiscent of the mind-vs.-body dichotomy. For instance, intellectual and emotional pleasures, both stemming from antecedents that involved some ' 'work of the mind", were combined into a common cluster. Social and physical pleasures combined into a second cluster that less faithfully corresponds to pleasures of the body. Antecedents like shopping, phone conversations, parties, or other activities with friends and family that were at the core of social pleasures do not exactly qualify as pleasures of the body. However, as we elaborate below, the common evolutionary root shared by physical and social pleasures may account for their membership in a single cluster.

TABLE 5

A posteriori comparison of affective qualities of seven pleasure types

	Pleasure type							
Emotion word	*General*	*Physical*	*Social*	*Intellectual*	*Emotional*	*Embarrassing*	*Stressful*	$F(6,171)$
Accomplishment	*4.68*$_{ad}$	*3.03*$_{b}$	3.86$_{d}$	5.17$_{a}$	5.13$_{a}$	*1.96*$_{c}$	4.35$_{ad}$	16.94***
Altruism	*3.57*$_{a}$	2.91$_{ac}$	3.52$_{a}$	*2.62*$_{bc}$	3.55$_{a}$	*2.00*$_{b}$	*2.43*$_{bc}$	3.96**
Anger	*1.26*$_{a}$	1.97$_{ab}$	*2.36*$_{bc}$	*2.21*$_{bc}$	*2.21*$_{bc}$	*2.20*$_{bc}$	2.05$_{ac}$	1.56
Anxiety	*1.30*$_{a}$	2.09$_{a}$	1.86$_{a}$	2.08$_{a}$	2.17$_{a}$	*3.44*$_{b}$	*3.24*$_{b}$	5.58***
Bliss	*4.17*$_{a}$	4.22$_{a}$	4.18$_{a}$	3.74$_{ab}$	4.46$_{a}$	*2.92*$_{b}$	*3.05*$_{b}$	3.23**
Caring	*4.17*$_{a}$	3.56$_{a}$	3.91$_{a}$	*2.67*$_{b}$	3.54$_{a}$	*2.00*$_{b}$	*2.43*$_{b}$	8.30***
Content	*3.87*$_{a}$	3.61$_{a}$	3.50$_{a}$	3.87$_{a}$	3.88$_{a}$	*2.48*$_{b}$	*2.52*$_{b}$	4.22**
Crazy	*2.61*$_{a}$	3.09$_{ab}$	3.05$_{ab}$	3.04$_{ab}$	2.67$_{a}$	*4.00*$_{c}$	*3.71*$_{bc}$	2.45*
Ecstatic	*4.30*$_{ad}$	4.21$_{ad}$	4.20$_{acd}$	3.63$_{ab}$	4.9$_{d}$	*3.29*$_{bc}$	*2.90*$_{b}$	3.67**
Energetic	*3.78*$_{a}$	*4.58*$_{b}$	*5.09*$_{b}$	3.38$_{a}$	3.46$_{a}$	*2.56*$_{c}$	3.67$_{a}$	8.28***
Excitement	*5.30*$_{a}$	5.00$_{a}$	5.05$_{a}$	4.71$_{ac}$	5.08$_{a}$	*3.80*$_{b}$	*4.07*$_{bc}$	4.37***
Fear	*1.43*$_{a}$	1.67$_{a}$	1.59$_{a}$	1.88$_{a}$	1.96$_{a}$	*2.80*$_{b}$	*2.86*$_{b}$	3.85**
Fulfilment	*5.09*$_{a}$	4.45$_{a}$	4.36$_{a}$	5.08$_{a}$	4.83$_{a}$	*2.60*$_{b}$	*3.45*$_{c}$	11.12***
Greed	*1.48*$_{a}$	1.74$_{ac}$	1.91$_{ac}$	1.75$_{ac}$	*2.21*$_{cb}$	*2.84*$_{b}$	2.10$_{ac}$	3.10**
Guilt	*1.48*$_{a}$	1.39$_{a}$	1.73$_{ac}$	1.29$_{a}$	*2.38*$_{bc}$	*3.72*$_{d}$	2.00$_{ac}$	10.60***
Happiness	*5.48*$_{a}$	*4.67*$_{bd}$	5.41$_{a}$	*4.45*$_{b}$	5.21$_{ad}$	*2.88*$_{c}$	*3.00*$_{c}$	17.60***
Heart-pounding	3.70$_{ab}$	4.16$_{bc}$	3.05$_{a}$	3.50$_{ac}$	3.57$_{ac}$	4.28$_{bc}$	4.62$_{b}$	2.67*
Horny	*4.17*$_{ac}$	4.84$_{a}$	3.36$_{c}$	*2.33*$_{b}$	3.71$_{c}$	4.16$_{ac}$	3.57$_{c}$	5.54***
Joy	*5.52*$_{a}$	5.00$_{a}$	5.05$_{a}$	*4.00*$_{b}$	5.17$_{a}$	*2.56*$_{c}$	*2.90*$_{c}$	20.58***
Lazy	2.18	2.09	2.27	1.67	2.42	2.36	2.05	0.87

Love	*5.48*$_{a}$	5.09$_{ac}$	*4.45*$_{bc}$	*3.83*$_{b}$	5.50$_{a}$	*2.88*$_{d}$	*4.19*$_{b}$	11.63***
Nervousness	*1.48*$_{a}$	2.22$_{ac}$	2.14$_{ac}$	1.96$_{ad}$	*2.50*$_{cd}$	*4.16*$_{b}$	*2.90*$_{c}$	9.12***
Pain	*1.14*$_{a}$	1.61$_{a}$	1.86$_{abc}$	1.71$_{ab}$	1.75$_{ab}$	*2.32*$_{bd}$	*2.57*$_{cd}$	2.99**
Peaceful	*4.35*$_{a}$	3.83$_{ab}$	*3.32*$_{bd}$	4.04$_{ad}$	4.57$_{a}$	*2.08*$_{c}$	*1.90*$_{c}$	12.50***
Pride	*4.48*$_{a}$	*3.47*$_{b}$	4.41$_{a}$	4.71$_{a}$	4.79$_{a}$	*2.16*$_{c}$	*3.48*$_{b}$	11.08***
Relaxed	*4.48*$_{a}$	4.42$_{a}$	4.55$_{a}$	4.08$_{a}$	4.63$_{a}$	*2.12*$_{b}$	*1.62*$_{b}$	17.78***
Relief	3.35$_{ac}$	3.87$_{ab}$	3.73$_{ab}$	3.13$_{bc}$	4.17$_{a}$	2.60$_{c}$	2.48$_{c}$	3.84**
Sadness	*1.09*$_{a}$	1.12$_{a}$	1.64$_{ab}$	*1.83*$_{bc}$	*2.04*$_{bc}$	*2.4*$_{c}$	1.71$_{ab}$	4.07**
Self-confidence	*4.52*$_{ac}$	4.06$_{a}$	4.67$_{ac}$	4.92$_{c}$	5.00$_{c}$	*2.12*$_{b}$	*3.24*$_{d}$	14.33***
Self-esteem	*4.48*$_{ab}$	3.88$_{ad}$	4.41$_{ab}$	4.71$_{b}$	4.75$_{b}$	*2.21*$_{c}$	*3.29*$_{d}$	11.22***
Sleepy	2.17$_{ab}$	2.56$_{a}$	1.59$_{b}$	1.88$_{ab}$	1.92$_{ab}$	1.84$_{b}$	2.29$_{ab}$	1.51
Stress-free	*4.09*$_{a}$	4.00$_{a}$	3.91$_{a}$	4.25$_{a}$	4.58$_{a}$	*2.12*$_{b}$	*1.52*$_{b}$	13.33***
Surprise	3.70	3.22	3.09	3.17	3.71	3.16	3.76	1.03
Vulnerability	*1.39*$_{a}$	1.94$_{ac}$	1.77$_{ac}$	1.50$_{a}$	1.79$_{ac}$	*3.00*$_{b}$	*2.52*$_{bc}$	4.30***
Warm	*4.04*$_{a}$	4.67$_{a}$	4.73$_{a}$	*2.83*$_{b}$	4.29$_{a}$	*2.04*$_{c}$	*1.95*$_{c}$	20.74***

The F-ratio is derived from a one-way analysis of variance across all seven pleasure types. Means with different subscripts were significantly different using Fisher's LSD ($p<.05$). Means in italics indicate significant differences with the general pleasure type. *$p<.05$; **p<.01; ***p<.001.

According to Damasio (1999), pleasures that arise from social and physical antecedents are possible embodiments of the evolutionary role of pleasure. Research in affective neuroscience (for a review, see Berridge, in press) has shown that the same brain structures and neural substrates are at play in many types of sensory pleasures (physical in the present terminology) as well as in pleasures derived from social antecedents (including maternal interaction with infants, and video games). Damasio further suggests that the generation and experience of such evolution-based pleasurable states entail anatomical structures and neural substrates that are not the same as those involved in pleasurable states that require more complex processes, like the ability to sense beauty or to strive from sophisticated personal achievement. A similar distinction between the low and the high road to affective experiences has been proposed by LeDoux (1996) in the context of fear.

The patterns of affective qualities of the differentiated pleasures that emerged in Study 5 reflect the distinction between physical and social pleasures as simpler, evolution-based pleasures and intellectual and emotional pleasures as more complex "pleasures of the mind". For instance, physical pleasure appeared as the least affectively complex pleasure with distinctive affective qualities primarily positive and related to physiological responses (e.g., more heart-pounding) and without the ambiguity of negative emotions. These results are also consistent with propositions by various scholars (e.g., Bentham, 1781/ 1988; Rozin, 1999) that physical pleasures are more primitive and less complex than other pleasures. After physical pleasure, social pleasure was the second less complex differentiated pleasure and likely to possess the strongest and most automatic approach-inducing power. By contrast, emotional pleasures encompassed negative emotions like sadness and guilt and positive emotions that entailed complex appraisal. Distinctive features of intellectual pleasure, when compared to general pleasure, included sadness and many positively valenced qualities like happiness, whereas joy and warmth were atypical of this category. It is therefore to be expected that one's approach trajectory toward antecedents of intellectual and emotional pleasures may be less simple and less straightforward than for antecedents of physical pleasure.

Meaningful distinctions as to the way pleasure arises and operates could also be made between physical and social pleasures, or between intellectual and emotional pleasures. For instance, the role of alliesthesia, that is, the influence of physiological states like hunger, thirst, or craving (Cabanac, 1971), is likely to be more central in physical pleasure than in social pleasure. As for intellectual and emotional pleasures, even though both seem tied to more ambivalent affective make-up and more complex appraisals, they are likely to differ in terms of the temporal unfolding of their experience. For emotional pleasure, the subjective experience may begin with an important period of joyful anticipation of the actual encounter with the hedonic stimulus, whereas for intellectual pleasure, this anticipation is likely to be more dreadful than joyful. Such subtle approach-avoidance nuances underscore the need to develop a more systematic mapping of

every level in the pleasure hierarchy, which could provide significant insights into the motivational power of pleasure and its various forms of expression.

Our results, in line with prior research by Higgins, Niedenthal, and their collaborators, suggest that taking into account only the overall goodness-badness of stimuli does not capture the full psychological reality of the hedonic experience and the ways in which this subjective experience influences decision making and behaviour. In all studies, lay participants did not conceive of pleasure as simply a unitary phenomenon, independent of its antecedents and its experiential qualities. Instead, their mental representations included differentiated pleasures as well as a higher level of general, unitary pleasure. If we are to move beyond the current assumption that differentiated pleasures of the same intensity have the same approach-inducing power, future work is needed to explore further the implications of the view of pleasure as a hierarchical concept for models of decision making and behaviour.

A first set of questions to be addressed pertains to the combinatory rules that might prevail when different sources of pleasure combine: To what extent are differentiated pleasures substitutable to each other in making decisions and motivating behaviour? How do differentiated types combine during a single pleasurable episode? Can one simultaneously experience intellectual and physical pleasure? Would they have synergistic effects or would they compete against each other? Although background music would be pleasant for a couple on a romantic date, some French gastronomes argue that one should not hear the buzz of a fly in a dining room, much less background music. How does the interaction of different types of pleasure and their temporal unfolding influence the actual experience and one's evaluation thereof? In the end, can the pleasure of playing with a cuddly pet replace or be substituted by other pleasures, such as a walk in the park, a favourite musical selection, a good book, or the company of friends, assuming that these are rated as equally pleasurable and costing approximately the same? As our results suggest, the empirical answer to such questions requires a better understanding of when and how distinctive experiential qualities of differentiated types of pleasure combine into a single, unitary summary that eventually guides judgement and behaviour.

On this issue, results from animal studies provide valuable insights. Shizgal and Conover (1996) have studied pleasure (more correctly, the computation of utility) with rats in a series of studies in behavioural neurobiology. Based on experiments on the relationship between the rewarding effects of electrical brain stimulation and gustatory stimuli, they proposed that brain stimulation reward arises from the electrical activation of neurons that convey a unidimensional representation of the utility of objects. It is the unidimensional character of this encoding that enables the electrical stimulation to produce a meaningful signal. However, they argue that survival and adaptive choices rely on multidimensional processing at earlier stages when physiological feedback exerts its specifIc influence on goal selection. For choice to be adaptive, the representation of the

stimulus must retain qualitative information reflecting level of need, biological benefits, etc.

The question remains, however, for animals as well as for human beings, as to what is the actual contribution of unitary and differentiated components of pleasure that makes approach-avoidance responses most adaptive. Studies looking at expectations of monetary gains and losses (Shizgal, 1999) suggest that rewards of different kinds involve overlapping patterns of neural activation. Shizgal proposed a three-channel model that recognises the common (unitary) nature of stimuli while allowing for differentiation at early stages of processing. Perceptual channels handle perceptual attributes and provide objective information. For choice to be adaptive, the distinct qualities of stimuli are preserved in an intermediate channel enabling the animal to account for type, amount, and even timing of reward. Finally, an action-oriented evaluative channel collapses multiple attributes of a stimulus into a single unidimensional signal. Moving from the intermediate to the action-evaluative channel is most probably when the specific information contained in the differentiated channel blends into a unitary signal of pleasure intensity. In humans, these issues have hardly begun to be addressed.

Although current research offers a reasonable map of the brain and how it processes sensory pleasures, there is little experimental evidence of as to how it processes other types of pleasures (see Berridge, in press). As for the integrative processes among various pleasure antecedents, based on clinical evidence, Damasio (1999) suggests that such second order, integrative processes entail interactions among various brain regions and that the cingulate cortex may play a central role. However, precise specification of these integrative processes and other unresolved aspects of hedonic information processing must await theoretical and empirical developments, especially in terms of new measures of subjective experience and improvements in brain imaging technology.

The contribution of the present results should be interpreted within the usual limitations of our methodology. A first limitation comes from the reliance on cognitive representations of pleasure. Simply asking people what they have in their mind when they experience pleasure cannot produce a clear and complete picture of what pleasure is and is not. For many people, emotions in general, and pleasure in particular, are hard to verbalise. As LeDoux (1996) suggested, nonverbal and unconscious systems underlying hedonic experiences may render some dynamics inaccessible to techniques such as the one used here. Recent research has provided empirical evidence for the behavioural impact of such unconscious pleasurable experiences (Berridge & Winkielman, this issue). In addition, memories are imperfect reconstructions (Bartlett, 1932). Thus, extension of our work using different subject pools and methodologies is needed. Recent developments in brain imaging could help trace neurological processes and link these to the subjective experience, thereby allowing more in-depth analyses of the contributions and operation of unitary and differentiated pleasures. A second limitation stems from the fact that we explored the

hierarchical structure of the pleasure category without testing whether the differentiated pleasures that emerged at the intermediate level correspond to the basic level as defined by Rosch (1975). Despite their limitations, the present studies expand the theoretical understanding of pleasure by showing that, in laypersons' conception, pleasure is at the same time of one and of many kinds. Taking into account this multilevel representation of pleasure in future research may well lead to more complete interpretations and conclusions with regards to the approach-inducing power of pleasure and its various behavioural manifestations.

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Approaching awe, a moral, spiritual, and aesthetic emotion

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In this paper we present a prototype approach to awe. We suggest that two appraisals are central and are present in all clear cases of awe: perceived vastness, and a need for accommodation, defined as an inability to assimilate an experience into current mental structures. Five additional appraisals account for variation in the hedonic tone of awe experiences: threat, beauty, exceptional ability, virtue, and the supernatural. We derive this perspective from a review of what has been written about awe in religion, philosophy, sociology, and psychology, and then we apply this perspective to an analysis of awe and related states such as admiration, elevation, and the epiphanic experience.

In the upper reaches of pleasure and on the boundary of fear is a little studied emotion—awe. Awe is felt about diverse events and objects, from waterfalls to childbirth to scenes of devastation. Awe is central to the experience of religion, politics, nature, and art. Fleeting and rare, experiences of awe can change the course of a life in profound and permanent ways. Yet the field of emotion research is almost silent with respect to awe. Few emotion theorists consider awe in their taxonomies and those who do have done little to differentiate it from other states.In this paper we offer a conceptual approach to awe. To do so we first review what has been written about awe outside of psychology, which turns out to be significant and illuminating. This literature review identifies two themes that are central to awe—that the stimulus is vast and that it requires accommodation—as well as five other themes that account for variation in awe-related states.Drawing upon this review, we propose a prototype-based approach thatexplicates how varieties of awe are felt towards powerful individuals, nature,and art, and how awe differs from admiration, elevation, and epiphanicexperience.

EARLY TREATMENTS OF AWE

Awe in Religion

Awe figures prominently in religious discussions of the relationship between humans and their gods. One of the earliest and most powerful examples of awe is found in the dramatic climax of the *Bhagavadgita,* which is an episode in the Hindu epic the *Mahabarata,* about a struggle between two branches of a royal family for control of a kingdom. As the hero of the story, Arjuna, is about to lead his forces into a cataclysmic battle, he loses his nerve and refuses to fight. The *Bhagavadgita* is the story of how Krishna (a form of the god Vishnu) persuades Arjuna that he must dutifully lead his troops, even though many of his kinsmen will die. Krishna lectures to Arjuna about duty and the workings of the universe. Arjuna is unmoved. Arjuna asks Krishna if he can see this universe for himself, and Krishna grants him his wish. Krishna gives Arjuna a "cosmic eye" that allows him to see God and the universe as they really are.

Arjuna then experiences something that sounds to a modern reader like a psychotic break or psychedelic experience. He sees gods, suns, and infinite time and space. He is filled with amazement *(vismitas)*. His hair stands on end. Disoriented, he struggles to describe the wonders he is beholding. Arjuna is clearly in a state of awe when he says "Things never seen before have I seen, and ecstatic is my joy; yet fear-and-trembling perturb by mind" (II. 45). He prostrates himself before Krishna, begs for forbearance, and hears Krishna's command: "Do works for Me, make Me your highest goal, be loyal-in-love to Me, cut off all [other] attachments…" (11.55). For the rest of the *Bhagavadgita* Arjuna wholeheartedly honours Krishna's commands.

A similar case of awe-inspired transformation can be found in the well-known story of Paul's conversion on the road to Damascus. Paul (as Saul) had been a rabid persecutor of early Christians (as heretic Jews). One day while journeying to Damascus to identify and persecute more Christians, Paul experiences the following:

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> suddenly a light from heaven flashed about him. And he fell to the ground and heard a voice saying to him, "Saul, Saul, why do you persecute me?" And he said, "Who are you, Lord?" And he said, "I am Jesus, whom you are persecuting; but rise and enter the city, and you will be told what you are to do." The men who were traveling with him stood speechless, hearing the voice but seeing no one (Acts 9.3–7).

Saul is blinded by the brightness of the light for three days. When he regains his sight he becomes the most devoted and prolific disciple of Jesus.

In both of these narratives, the individual experiences contact with a higher power. This contact triggers an overpowering and novel sensory experience that causes confusion and amazement. When the confusion lifts, the person is transformed and embraces new values, commands, and missions.

Awe in sociology

Sociological treatments locate awe within power dynamics and the maintenance of the social order. Max Weber offered one of the most nuanced and insightful treatments of awe in his analysis of charisma and charismatic leaders. Weber noted that, throughout history, social groups tend to settle into patriarchal or bureaucratic modes of organisation, which are fairly stable. Bureaucratic movements can transform society through changes "from the outside": first the material and social orders are changed, and in response, over time, people change too. But in times of crisis people sometimes overthrow these stable forms of power, transferring their allegiance to a charismatic leader who awes the masses by performing miracles or acts of heroism. Charismatic leaders bring about revolution "from the inside", by changing people, who then go on to change society:

> [Charisma] manifests its revolutionary power from within, from *a central metanoia [change] of the followers' attitudes*. The bureaucratic order merely replaces the belief in the sanctity of traditional norms by compliance with rationally determined rules and by the knowledge that these rules can be superseded by others…and hence are not sacred. But charisma, in its most potent forms, disrupts rational rule as well as tradition altogether and overturns all notions of sanctity. Instead of reverence for customs that are ancient and hence sacred, *it enforces the inner subjection to the unprecedented and absolutely unique and therefore divine*. In this purely empirical and value-free sense charisma is indeed the specifically creative revolutionary force of history. (Weber, 1978, p. 1117, emphasis added).

Weber's analysis illuminates how one charismatic person (Buddha, Jesus, Joan of Arc, Gandhi, Hitler, King, Mandela) can stir the souls of thousands, inspiring awe and reprogramming them to take on heroic and self-sacrificing missions.

Emile Durkheim likewise brought into focus the importance of powerful emotions in creating political, social, and religious movements. Durkheim (1887/1972) theorised about two kinds of social affects. A first class, including love, fear, and respect, binds one individual to other individuals. The objects of these emotions are individual concerns, such as an individual's safety, or position relative to others. A second class of affects binds the individual to social entities, such as communities and nations. Here, the object of the emotion is collective concerns. Within this second class of emotions, Durkheim considered feelings that closely resemble awe. Like Weber, Durkheim posited that certain collective emotions have transformative powers; they change people's attitudes and inspire them to follow something larger than themselves:

> A man who experiences such sentiments feels that he is dominated by forces which he does not recognize as his own, and which he is not the master of, but is led by…Following the collectivity, the individual forgets himself for the common end and his conduct is directed by reference to a standard outside himself (p. 228).

Through religious rites and other processes, Durkheim observed, these collective sentiments shape religious thought and organisation.

Perhaps what is most novel about Durkheim's analysis, and most informative for our approach to awe, is his contention that the elicitors of these social sentiments have to do with collective interests. Collective sentiments are triggered by stimuli that are associated with collective values (e.g., statements of ideological principles at a political rally), goals (e.g., rooting for the same sports team), and outcomes (e.g., suffering together through a natural disaster). Even the many natural elicitors of awe-like states, such as thunder, Durkheim suggested, are awe-inspiring because they have the potential of influencing the well-being and outcomes of whole groups. The elicitors of awe are vast in their meaning and effect.

More recent sociologists have extended these ideas about awe and social order. Awe can motivate alienated individuals to become impassioned members of fringe groups and cults. Clark (1990) has theorised that emotions serve as "place markers" designating individuals' roles and positions within social hierarchies. In this framework, awe designates the subject's subordinate status *vis-à-vis* others.

Awe in philosophy

One of the main puzzles of awe is that it is so easily felt in nonsocial situations, for example, while hiking in the mountains or experiencing art. This emotional

response has long been an interest of philosophers studying aesthetics (for a review, see Beardsley, 1966).

The most systematic early treatment of an awe-like aesthetic emotion can be found in the Irish philosopher Edmund Burke's (1757/1990) treatise on the sublime. Burke defined the sublime as the feeling of expanded thought and greatness of mind that is produced by literature, poetry, painting, and viewing landscapes). Burke's treatment of the sublime advances our discussion of awe in two ways.

First, Burke theorised that two properties endow stimuli with the capacity to produce the sublime experience. The first is power. Burke writes: "In short, wherever we find strength, and in what light soever we look upon power, we shall all along observe the sublime the concomitant of terror…(p. 61)". Power, and in particular the power to destroy and control the perceiver's will, accounts for why certain entities are more evocative of the sublime experience than others (e.g., the bull as opposed to the ox). Power also accounts for differences between the sublime and another aesthetic pleasure, the experience of beauty: "There is a wide difference between admiration and love. The sublime, which is the cause of the former, always dwells on great objects, and terrible; the latter on small ones and pleasing; we submit to what we admire, but we love what submits to us" (p. 103).

The other stimulus property that produces the sublime experience is obscurity. Objects that are clear, anticipated, and certain in their origin, form, and design, Burke reasoned, do not produce the sublime experience. Rather, objects that the mind has difficulty grasping are more likely to produce the sublime experience. Burke relied on this notion to develop several interesting ideas. Obscure images in painting are more likely to produce sublime feelings than are clearly rendered images. A despotic government keeps its leader obscure from the populace, to enhance the leader's power. And many of the stimulus features that produce the sublime experience, such as vastness, magnificence, succession, infinity, and certain properties of light, colour, and sound, do so because they suggest power while at times obscuring it as well.

Burke advances our discussion of awe in a second important way by directing attention to a number of states that are close relatives of sublime experience. These include milder feelings of beauty, admiration, astonishment, reverence, and respect. Considering these states in a discussion of the sublime raises questions about how they resemble awe, and how they differ—an issue to which we will return.

Awe in psychology

Psychology has had surprisingly little to say about awe. Even where one would expect extensive treatments of awe, it is absent. In the literature on aesthetics and emotion, researchers have primarily been concerned with how specific emotions, such as sadness or anger, are registered in different artistic media, and whether

artistically conveyed emotions can be reliably judged by observers (e.g., Gabrielson & Juslin, 2001).

One reason psychologists have devoted so little attention to awe may be that it has not yet been shown to have a distinctive facial expression (i.e., distinct from surprise). In *The Expression of the Emotions in Man and Animals* (1872), Darwin analysed admiration, a close relative of awe. Darwin defined admiration as a mixture of surprise, pleasure, and approval, as well as astonishment. His characterisation of the expression of astonishment was derived from fascinating observations, including descriptions of manic patients, whose hair would stand on end prior to manic episodes, and accounts of Australian aborigines' expressions upon seeing Europeans for the first time. The expression of astonishment includes raised eyebrows, bright eyes, gaping mouth, and in extreme cases, hair standing on end, or goosebumps.

Only two major psychologists have offered detailed accounts of awe: McDougall (1910) and Maslow (1964). McDougall focused on admiration, which he described as a binary compound of "wonder" and "power". Describing people's feelings towards an object of admiration he observed:

> we approach it slowly, with a certain hesitation; we are humbled by its presence, and, in the case of a person whom we intensely admire, we become shy, like a child in the presence of an adult stranger; we have the impulse to shrink together, to be still, and to avoid attracting his attention; that is to say, the instinct of submission, of self-abasement, is excited, with its corresponding emotion of negative self-feeling, by the perception that we are in the presence of a superior power, something greater than ourselves.

Perhaps the meaning of "admiration" has changed in the last 100 years; McDougall's emphasis on submissiveness and negative self-feeling sounds more like awe than what current English speakers mean by "admiration". Our own approach to awe will make McDougall's two components (power and wonder) central. McDougall goes on to discuss awe as a trinary compound that adds fear to the two components of admiration (power and wonder). We will suggest below that McDougall's awe is one kind of awe, but that some states of awe do not involve fear.

Abraham Maslow is well known for his descriptions of "peak experiences", which clearly involve awe. Based on his interviews with hundreds of people, Maslow (1964) listed 25 features of peak experiences. These include: disorientation in space and time, ego transcendence and self-forgetfulness; a perception that the world is good, beautiful, and desirable; feeling passive, receptive, and humble; a sense that polarities and dichotomies have been transcended or resolved; and feelings of being lucky, fortunate, or graced. We will return to many of these themes in our analysis of awe, in particular the emphasis on the transformative effects of peak experiences.

More recent emotion theorists have offered general definitions of awe, but have done little research. Lazarus (1991) treated awe as an ambiguous negative state that varies in valence depending on context and appraisal. Ekman (1992) posited that awe may be a distinct emotion but said little about its elicitors, meanings, or expressive behaviours. Izard (1977) suggested that awe is an intense variant of interest, and that it motivates curiosity and exploration. Frijda (1986) discussed wonder rather than awe, which he linked to surprise and amazement, and interpreted as a passive, receptive mode of attention in the presence of something unexpected.

Across disciplines, theorists agree that awe involves being in the presence of something powerful, along with associated feelings of submission. Awe also involves a difficulty in comprehension, along with associated feelings of confusion, surprise, and wonder. We now propose a prototype approach to awe based on these two elements.

A PROTOTYPE OF AWE: PERCEIVED VASTNESS AND ACCOMMODATION

Our brief literature review highlights three requirements of a conceptual approach to awe. Such an approach must account for the range of objects and events that trigger awe, which include religious encounters, charismatic political leaders, natural objects, and even patterns of darkness and light. Such an approach must explain how the many awe-related states, including admiration, astonishment, and more mild feelings of beauty, relate to and differ from each other. Finally, an adequate account of awe must explain how awe can be both profoundly positive and terrifyingly negative.

To meet these requirements, we will approach awe from a prototype perspective (e.g., Fehr & Russell, 1984; Shaver, Schwartz, Kirson, & O'Connor, 1987). According to this view, a prototypical instance of an emotion has certain specifiable components, themes, or features. Variants of the prototype occur in which certain features are missing, or other features are added (e.g., Ortony & Turner, 1991; see also Lakoff, 1987, on radial categories). Some variants may be so similar to the prototype that they still share the same name (e.g., embarrassment after a *faux pas,* and embarrassment at being the centre of attention). Other variants are different enough that they warrant a different name (e.g., embarrassment vs. shame as members of the "self-conscious emotion" family). However it is important to note that linguistic markers do not necessarily trace out the most important psychological boundaries. Languages differ greatly in how they carve up a region of emotional space into specific emotion words (Heider, 1991; Russell, 1991), but those carvings do not necessarily imply differences in emotion-related experience or behaviour (Haidt & Keltner, 1999).

We propose that two features form the heart of prototypical cases of awe: *vastness,* and *accommodation*. Vastness refers to anything that is experienced as being much larger than the self, or the self s ordinary level of experience or

frame of reference. Vastness is often a matter of simple physical size, but it can also involve social size such as fame, authority, or prestige. Signs of vastness such as loud sounds or shaking ground, and symbolic markers of vast size such as a lavish office can also trigger the sense that one is in the presence of something vast. In most cases vastness and power are highly correlated, so we could have chosen to focus on power, but we have chosen the more perceptually oriented term "vastness" to capture the many aesthetic cases of awe in which power does not seem to be at work.

Accommodation refers to the Piagetian process of adjusting mental structures that cannot assimilate a new experience (Piaget & Inhelder, 1966/1969). The concept of accommodation brings together many insights about awe, such as that it involves confusion (St. Paul) and obscurity (Burke), and that it is heightened in times of crisis, when extant traditions and knowledge structures do not suffice (Weber). We propose that prototypical awe involves a challenge to or negation of mental structures when they fail to make sense of an experience of something vast. Such experiences can be disorienting and even frightening, as in the cases of Arjuna and St. Paul, since they make the self feel small, powerless, and confused. They also often involve feelings of enlightenment and even rebirth, when mental structures expand to accommodate truths never before known. We stress that awe involves a *need* for accommodation, which may or may not be satisfied. The success of one's attempts at accommodation may partially explain why awe can be both terrifying (when one fails to understand) and enlightening (when one succeeds).

We therefore propose that vastness and accommodation are the two central themes (e.g., Ekman, 1993; Smith & Ellsworth, 1985) of the awe family. Emotional experiences that involve perceived vastness and a need for accommodation, whether in response to a charismatic leader, a grand vista, or a symphony, are members of the awe family. Emotional experiences that lack one or both of these features are best called by some other name. For example, "surprise" involves accommodation without vastness. Feelings of deference involve vastness without accommodation. In Table 1 we represent 11 different awe-related situations, and we propose that the only ones that should properly be labelled as "awe" are the seven that include both vastness and accommodation.

How then do we account for differences among awe-related states, and how awe itself varies in its valence—our other two tasks in approaching awe? In Table 1 we propose that five additional themes alter or "flavour" an emotional experience, giving rise to the variety and diversity of awe experiences.

1. Threat. As discussed by Burke, threat and danger cause an experience of awe to be flavoured by feelings of fear. Variation in whether an entity is threatening or not might account for how charismatic leaders (e.g., Hitler vs. Ghandi) or natural scenes (e.g., an electrical storm vs. a sunset) evoke awerelated experiences of dramatically different valence.

2. Beauty. Beautiful people and scenes can produce awe-related experiences that are flavoured with aesthetic pleasure. We cannot give here an account of

TABLE 1

A prototype approach to awe and related states

	Central features		*Peripheral or "flavouring" features*				
Eliciting situations	*Vastness*	*Accom.*	*Threat*	*Beauty*	*Ability*	*Virtue*	*Supernatural*
Social elicitors							
1. Prototype: Powerful leader	X	X	?				
2. Encounter with God	X	X	?	?		X	X
3. Great skill (Admiration[a])		X			X		
4. Great virtue (Elevation[a])		X				X	
Physical elicitors							
5. Tornado	X	X	X	?			?
6. Grand vista	X	X		X			
7. Cathedral	X	X		X	X		?
8. Awe-inspiring music	X	X		X	X		
9. A beautiful painting (Aesthetic pleasure[a])				X	?		
Cognitive elicitors							
10. Grand theory	X	X		?			
11. Seeing an object levitate (Uncanny[a])		X	?				X

X Denotes that the appraisal is usually made in this case.
? Denotes that the appraisal is sometimes made in this case (and if it is made, it adds a flavour).
[a] Denotes states that are related to awe, but should not be labelled as awe.

what makes something beautiful, although we think it likely that there will be at least two sources of intuitions about beauty, one stemming from "biophilia" (Wilson, 1984), and the other from the evolution of sexual desire and attraction (Buss, 1994).

3. Ability. Perceptions of exceptional ability, talent, and skill will flavour an experience with admiration in which the perceiver feels respect for the other person that is not based on dominance and submission within a hierarchy. Exceptional ability may often trigger a need for accommodation, but if there is no perception of vastness, then the experience should simply be labelled "admiration", not awe, as in line 3 of Table 1.

4. Virtue. People who display virtues or strength of character often trigger in other people a state that has been called "elevation" (Haidt, 2000, in press). Elevation is an emotional response to "moral beauty" or human goodness; it usually includes a warm and pleasant feeling in the chest and a desire to become a better person, or to lead a better life. Elevation appears to be a member of the

family of awe-related states, but because experiences of elevation do not usually involve perceived vastness or power, they should be labelled as "elevation", not awe, as in line 4 of Table 1.

5. Supernatural causality. Finally, the perception that God or some other supernatural entity is manifesting itself (e.g., seeing an angel or a ghost, or seeing an object levitate) will flavour an experience with an element of the uncanny. The uncanny is usually terrifying (Angyal, 1941), but it can be glorious if the entity is perceived as benevolent.

These five flavouring themes will be further explicated below, as we work out specific examples.

PRIMORDIAL AWE AND ITS ELABORATIONS

How do the aforementioned appraisal themes combine to form a family of awerelated states? To answer this question, we draw on an approach that distinguishes between "primordial" and "elaborated" forms of emotions (Keltner & Haidt, 1999, 2001; Rozin, 1996). Primordial emotion refers to the relatively hard-wired pre-cultural sets of responses that were shaped by evolution and built into the central and peripheral nervous systems of the human species. Elaborated emotion refers to the full set of culture-specific norms, meanings, and practices that cultures build up around primordial emotions. Primordial disgust, for example, refers to the emotional rejection of foods that either smell like decay or that are known to have come into contact with excrement or other disgust elicitors. Elaborated disgust for modern Americans, however, is a much richer emotion involving the emotional rejection of things based more on ideation than on perceptual qualities (e.g., racists, cheap wine, and political corruption). Rozin, Haidt, and McCauley (2000) tell a story about how primordial disgust (or core disgust) got elaborated and extended to become a social emotion that is primarily a response to the impure deeds of other people.

Following this sort of reasoning we propose that primordial awe centers upon the emotional reaction of a subordinate to a powerful leader. Such reactions have an obvious evolutionary history and adaptive function, traceable to the submissive and fearful expressions of subordinate primates in the presence of a powerful dominant conspecific (Keltner & Potegal, 1997; de Waal, 1986, 1988). These responses to powerful social entities solidify social hierarchies, which are important to human survival (Fiske, 1991; Keltner & Haidt, 2001). Much as humans are biologically prepared to respond to certain fear inducing stimuli (e.g., fast approaching objects, darkness), we argue that humans are prepared to respond to awe-inducing stimuli (e.g., large stature and displays of strength and confidence). From this perspective, various components of the subordinate's response to the dominant individual, including passivity, heightened attention towards the powerful, and imitation (e.g., Keltner, Gruenfeld, & Anderson, in press), are biologically based action tendencies at the core of the experience of awe (see Frijda, 1986, on wonder).

The capacity to experience awe in response to cues of social dominance then generalises to other stimuli, such as buildings, operas, or tornadoes, to the extent that these new stimuli have attributes associated with power (see Keltner & Anderson, 2000). More specifically, stimuli that are vast and that require accommodation will elicit the primordial awe response. To the extent that these new stimuli bring in additional components of meaning, as we suggest in Table 1, the primordial awe experience will acquire new flavours, and a new phenomenology. Thus supernatural ideation added to primordial awe yields the religious conversion and submission of Arjuna and St. Paul (line 2). The removal of threat and the addition of beauty yields the transcendent feelings described by naturalists (line 6). In this way, cultures elaborate upon primordial awe, becoming experts in certain kinds of awe-related states.

We now turn to the family of awe-related states, starting with what we consider to be the primordial form of awe: Awe felt towards powerful others. This hierarchical form of awe may rarely be experienced by people in industrialised Western democracies, but this response is (we suggest) the foundation for other forms of awe that are more familiar to modern readers.

Primordial awe: Awe towards power

Humans are hierarchical animals. Status hierarchies are evident across cultures (Brown, 1991), they appear early in development, and, contrary to some stereotypes, are as salient to women as to men (Anderson, John, Keltner, & Kring, 2001). "Authority Ranking" appears to be one of four basic and universal models of social relationships (Fiske, 1991). Some cultures are more hierarchical than others, but even among egalitarian hunter-gatherers, constant vigilance is necessary to keep hierarchical relationships from forming (Boehm, 1999).

Emotions contribute to the formation, maintenance, and change of hierarchies in that they act as internal and external signals of the individual's social place (Clark, 1990; Keltner & Haidt, 1999; Ohman, 1986; Tiedens, 2001). Emotions, such as pride, signal the higher status individual's stance towards the self *vis-à-vis* lower status individuals. Emotions, such as contempt, signal the higher status individual's stance towards lower status individuals. Emotions, such as embarrassment and shame, signal the lower status individual's stance towards the self *vis-à-vis* higher status individuals (Keltner & Buswell, 1997; Keltner, Young, & Buswell, 1997; Miller & Leary, 1992). Finally, there are those emotions that the lower status individual feels towards higher status individuals.

We propose that awe, or at least its prototype, falls into this fourth category of status-related emotion. Following Weber and Durkheim, we propose that the primordial form of awe is the feeling a low status individual feels towards a powerful other. This feeling is likely to involve reverence, devotion, and the inclination to subordinate one's own interests and goals in deference to those of the powerful leader. Awe reinforces and justifies social hierarchies by motivating commitment to the leader, countervailing self-interested attempts to overturn the

social hierarchy (see Gonzaga, Keltner, Londahl, & Smith, 2001, for a similar commitment-based analysis of love).

This approach to primordial awe generates several testable hypotheses. Awe should be likely and intense in the presence of powerful individuals and in times when power is concentrated in the hands of one respected leader. Awe should be more frequent and intense during stages of development when individuals are especially concerned with entering into social hierarchies (e.g., adolescence, Ohman, 1986; or in the first year of college or military school). Awe should be more likely when there is a greater need for social hierarchy, for example when the allocation of abundant resources prompts the emergence of social hierarchy as a heuristic solution to the potential conflicts. This analysis also sheds light on certain social rituals that enhance the awe-inducing capacity of social leaders (e.g., architectural grandeur, the designed scarcity of access to leaders, and collective interactions such as public speeches).

The etymology of the English word "awe" is consistent with this focus on fearful submission to power. According to the *Oxford English Dictionary* "awe" is derived from related words in Old English and Old Norse that were used to express fear and dread, particularly towards a divine being. But as English developed, usage gradually began to connote "dread mingled with veneration, reverential or respectful fear; the attitude of a mind subdued to profound reverence in the presence of supreme authority, moral greatness or sublimity, or mysterious sacredness" (*OED,* "awe", entry 2).

The first line of Table 1 describes this original form of awe, for example for a commoner who is in the presence of the king for the first time. The experience would involve perceptions of vastness, for example in rank and prestige. The experience would also involve accommodation, because it would fall outside of the individual's everyday experience and knowledge. Any of the additional four appraisals could be in play as well: Powerful leaders can be perceived as more or less threatening, beautiful, supremely talented, and supernaturally (divinely) powerful, and any of these factors would alter the experience of awe systematically.

Yet, when modern Americans describe their own experiences of awe (Keltner et al., 2001), they rarely describe events defined by fear and dread. It is to the nonprototypical, nonprimordial cases of awe that we now turn.

Extensions to non-powerful people

Modern Westerners report or show signs of feeling awe-like emotions when in the presence of people who are famous (movie stars), exceptionally skilled (basketball stars, chess grandmasters), or morally admirable (heroes and altruists). All such cases involve accommodation, because these people are by definition out of the ordinary. None of these cases involves feelings of threat, fear, or dread; they seem, rather, to have a thoroughly positive affective tone. People seek out contact with such awe-inspiring figures, asking for autographs, trying to

touch (e.g., shake hands), and showing a variety of signs of positive contamination (Nemeroff & Rozin, 1994).

Are these examples of awe? We suggest that the determining factor is whether or not they involve perceptions of vastness. Celebrities often take on a "larger than life" presence which causes "awestruck" onlookers to gape, point, fawn, and act deferentially. In this case awe is elicited by the social size and importance of the individual—the extent to which they are known, and the extent to which their actions affect others. Celebrities who are exceptionally attractive may cause feelings of awe tinged with sexual desire as well.

But what about feelings elicited by people who are not famous, for example, a highly skilled craftsman, or a teenager who does good deeds for others? We suggest that these cases, shown as lines 3 and 4 in Table 1, should not be considered to be cases of awe. Instead, we treat these as cases of other states in the awe family. Admiration involves the accommodation required by witnessing extraordinary human talents, skills, or abilities. Admiration is often prompted by unexpected or unusual actions, but it differs from awe in that vastness in size or social power is not essential. Similarly, elevation is defined by the accommodation caused by witnessing extraordinary acts of virtue, but once again it does not involve perceived vastness or social power (see Haidt, in press).

Extensions to nature

Perhaps the most common experience of awe for contemporary Westerners in egalitarian societies is the response to natural and human-made objects. People feel awe in response to large natural objects, such as mountains, vistas, storms, and oceans. People also feel awe in response to objects with infinite repetition, as Burke suggested, including fractals, waves, and patterns in nature. In his essay "Nature" (1836/1982), the philosopher Emerson wrote:

> In the woods, we return to reason and faith. There I feel that nothing can befall me in life—no disgrace, no calamity (leaving me my eyes), which nature cannot repair. Standing on the bare ground,—my head bathed by the blithe air and uplifted into infinite space,—all mean egotism vanishes. I become a transparent eyeball; I am nothing; I see all; the currents of the Universal Being circulate through me; I am part or parcel of God. The name of the nearest friend sounds then foreign and accidental; to be brothers, to be acquaintances, master or servant, is then a trifle and a disturbance. I am the lover of uncontained and immortal beauty. In the wilderness, I find something more dear and cognate than in the streets or villages. In the tranquil landscape, and especially the distant line of the horizon, man beholds somewhat as beautiful as his own nature. The greatest delight which the fields and woods minister is the suggestion of an occult relation between man and vegetable (p. 39).

As in religious conversion (Spilka, Hood, & Gorsuch, 1985) and peak experiences (Maslow, 1964), nature-produced awe involves a diminished self, the giving way of previous conceptual distinctions (e.g., between master and servant) and the sensed presence of a higher power. Here again, our prototype of awe proves useful. Natural objects that are vast in relation to the self (e.g., vistas, waterfalls, redwoods) are more likely to produce awe, as are natural events that have effects upon many (e.g., tornadoes, earthquakes). Again accommodation plays a role: Natural objects that transcend one's previous knowledge are more likely to produce awe than are familiar objects.

Extensions to human art and artifact

Songs, symphonies, movies, plays, and paintings move people, and even change the way they look at the world. The same can be true of human creations, such as skyscrapers, cathedrals, stadiums, large dams, or even oddities, such as the world's largest ball of string. When do art and human creation elicit awe? First, size matters. Awe is more likely to occur in response to viewing art or artifact when the object is larger than the viewer is accustomed to seeing. The object itself may be large (e.g., Michaelangelo's David), or it may exemplify powerful or heroic forces and figures (as in Greek myths). In more subtle ways, art can produce awe by rendering exceptional moments in time that are signs of vast, powerful forces, as when seemingly trivial events foreshadow larger developments in the narrative. When art has these properties it should be more likely to produce awe, as opposed to, for example, aesthetic pleasure.

Accommodation also matters, and to the extent that an object or scene is not easily assimilated awe becomes more likely. Art and literature often present highly unusual or even magical and impossible events. Art can engage the spectator in a novel way of viewing things (e.g,. Monet's water lilies; Virginia Woolf's prose). When the form and meaning of a work of art are familiar and easily graspable, the work may be entertaining, but it is unlikely to be considered great art. Works that challenge and that involve obscurity are more likely to induce awe.

Extensions to the epiphanic experience

In Table 1 we consider a final source of awe, cognitive elicitors. It is remarkable that people can feel awe as they realise the breadth and scope of a grand theory (e.g., psychoanalysis, feminism, evolutionary theory). Not coincidentally, the progenitors and apostles of these theories are often revered as charismatic leaders.

The experience of grand theory is captured in discussions of epiphany, which involve the revelation of something profound in something ordinary or seemingly routine. In his book *Stephen Hero* James Joyce defines epiphany as "the significance of trivial things" and as "a sudden spiritual manifestation,

whether in the vulgarity of speech or gesture or in a memorable phrase of the mind itself'. In preliminary work we have found that the epiphanic experience stems from the connection between comprehensive causal variables (e.g., social class, biological evolution) and seemingly remote, isolated events (a manner of speech, pregnancy sickness) (Wallit, Langner, & Keltner, 2001). We suggest that these kinds of epiphanies (line 10 in Table 1) are part of the awe family. They clearly involve accommodation and the alteration of knowledge structures. They also involve vastness in that comprehensive, powerful forces are realised to be the cause of some distal, ordinary object or event.

In Table 1 we also refer to the uncanny experience (line 11), which we think is not a case of awe but is nonetheless related to awe. Spooky or uncanny events, such as seeing an object levitate for no reason, cause a massive need for accommodation, combined with the appraisal that supernatural forces are at work.

A RESEARCH AGENDA

Thus far we have argued that awe, whether felt towards powerful individuals, nature, or art, involves vastness and accommodation. The variety of awe-related experiences reflects the operation of five additional appraisals, or flavouring elements: threat, beauty, ability, virtue, and the supernatural. We have developed this approach, with some trepidation, in the absence of empirical evidence. We therefore conclude with some recommendations for the empirical study of awe.

First, our analysis suggests that the frequency of appraisals of vastness and accommodation will help explain why some people are more likely to experience awe than others. One would expect people in the upper echelons of social hierarchies to experience less awe than those in the lower strata of the same hierarchies (and thereby lose one source of meaning and motivation). Awe should also be more likely in individuals whose knowledge structures are less fixed, for example, early in development or in times of tremendous social change.

Our analysis generates clear predictions regarding the valence of the experience of awe. The appraisal of threat or beauty should lead to more negative or positive experiences respectively. The content of the stimulus, for example, whether it is a virtuous action or an exceptional ability, will determine whether admiration or elevation is experienced. These are all propositions that could be tested in narrative recall studies or in laboratory experiments.

There is a clear need to map the markers of awe, as has been done with other emotions. Research needs to concentrate on the similarities and differences between awe and gratitude, admiration, elevation, surprise, fear, and perhaps even love. Darwin cited certain facial actions that may be associated with awerelated states. Perhaps more interesting are the autonomic responses that people mention when describing awe, and in particular goosebumps. Goosebumps, or piloerection, are associated with sympathetic activity, suggesting that this may be a distinct autonomic nervous system marker of awe.

Finally, the consequences of awe should be of interest to emotion researchers, and to society in general. As the examples of Arjuna and St. Paul suggest, awe can transform people and reorient their lives, goals, and values. Given the stability of personality and values (e.g., John & Srivastava, 1999), awe-inducing events may be one of the fastest and most powerful methods of personal change and growth. The potential power of awe, combined with the mystery of its mechanisms, may itself be a source of awe, giving pleasure both to those who study it and to those who cultivate it in their lives.

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Spontaneous facial expressions of happy bowlers and soccer fans

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Kraut and Johnston (1979) found surprisingly few smiles in large samples of bowlers and hockey fans during happy events—unless they were simultaneously engaged in social interaction. A limitation of their studies is that there was no direct test of subjects' actual emotional experience at the moments in which they were observed. This article reports two field studies in which emotions were reported by bowlers and by soccer fans. Analysing facial behaviour of those who reported happiness, we found a low probability of smiling in the absence of social interaction (.09 for bowlers and .07 for soccer fans) and a high probability of smiling during social interaction (.78 and . 70). These findings question the common assumption that smiles are an indicator of happiness *per se,* and support the alternative hypothesis of a more complex and indirect relationship between smiling and happiness.

Many theorists assume that, except in cases of deliberate deception, smiles are a good indicator of happiness (pleasure or positive affect in general) (e.g., Ekman, Davidson & Friesen, 1990; Izard et al., 1995). Experimental studies of the empirical correspondence between smiles and happiness are scarce. Field studies are even scarcer. To the best of our knowledge, one of the most interesting field studies (see also Ekman, 1972) was carried out by Kraut and Johnston (1979). They observed the facial behaviour of 350 bowlers who had just made a good roll, 220 ice-hockey fans cheering their team's goals, and 663 pedestrians just having a stroll on a nice day. The three situations yielded similar results. People smiled frequently during these happy events when they were interacting withothers; the probability of smiling was: .42 for bowlers, .27 for hockey fans, and.61 for strollers. In contrast, when they were alone or were not interacting withothers, the probability of smiling during the happy event was lower: .04 forbowlers, .12 for hockey fans, and .12 for strollers. In Kraut and

Johnston'swords, "smiling had a weaker and more erratic association with happiness thanit had with social interaction" (p. 1551).

Kraut and Johnston's study was based on an ecological approach to emotion, in which subjects' emotion was inferred from the features of natural situations and their involvement in social interaction was monitored. Kraut and Johnston did not assess happiness directly; for example, they did not ask subjects to supply reports of the emotion elicited by the stimuli. We report data on the probability of a smile given an explicitly reported emotional experience of happiness freely provided by the participants.

Furthermore, Kraut and Johnston's study was limited to the members of one society; we enlarge the scope of Kraut and Johnston's study by reporting two studies, both with Spaniards. In Study 1, we recorded the facial behaviour of 10 bowlers with two synchronised cameras at two different times during the game (when the bowlers were facing the pins and when facing friends). Bowlers also provided reports about their emotional feelings after each roll. In Study 2, we recorded the facial behaviour of 20 soccer fans watching important soccer matches on TV; we again used two cameras and obtained self-reports about emotions every time the fans considered they were feeling emotion during the match.

The goal of our studies was an analysis of the facial expressions of people who are genuinely happy; from the three situations studied by Kraut and Johnston, we selected the two that most clearly involved relatively brief responses of happiness to specific events: bowling and watching soccer. A number of theories of happiness (see Salovey, Bedell, Detweiler, & Mayer, 2000) point out that happiness typically occurs when a goal is reached. Bowling and soccer are activities with clear goals, and laypersons assume that these games are powerful occasions for emotion. Soccer is an extremely popular sport in Spain, and a source of intense and explicit emotion. Bowling, meanwhile, is not as popular as watching one's favourite soccer team, but players still become actively involved in the game. The simple, formal rules provide unambiguous successes and failures for the players and fans.

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HAPPY BOWLERS

As had Kraut and Johnston, we chose to observe bowlers because we could distinguish two different phases of the game: In one, the bowlers are facing the pins to see the outcome of the roll. In the second, they turn away from the pins to face their friends or teammates; the presence of other people allowed social interaction. In this way, we could examine whether bowlers' smiles were more frequent when they were facing the bowling pins and reacting to the roll or when they turned to face their friends. Unlike Kraut and Johnston, however, we analysed facial behaviour only when the bowler chose to report feeling happiness.

Method

Ten bowlers (5 women and 5 men; mean age 24) volunteered to participate and play in a small, quiet bowling alley on the outskirts of Madrid. The players were all friends, and the game was played in pairs. In order to familiarise them with the cameras, two video cameras were set up, with the bowlers' permission, approximately 20 minutes before the beginning of the game. Participants were not informed about the goals of the study, and they expressed no suspicions about which particular behaviour we were interested in.

We provided the players with a short questionnaire, which they were asked to complete after each roll in which they felt any emotion about that roll. This questionnaire included an open-ended question about which emotion or emotions they felt. We defined a player as having felt happiness on a roll only when he/she explicitly mentioned happiness and no other emotion in this report. (In fact, happiness never was mentioned in combination with another emotion.)[1]

We recorded 92 rolls. Each roll was divided into two phases: a noninteractive phase (with the bowlers facing the pins while the ball reaches the pins and as they observe the result) and an interactive phase (after the roll, the bowlers turn toward the pit and observe the other players). Two independent cameras, pointing in roughly opposite directions, allowed us to make an objective distinction between the noninteractive phases and the interactive phases. Camera A recorded the noninteractive phases, that is, between the moment the ball reached the pins (while bowlers faced the pins to see the outcome of the roll) and the moment the bowlers turned their body toward the other players. Camera B, whose line of sight was approximately 135 degrees different from Camera A, recorded the interactive phases, that is, from the time the bowlers turned their body and their facial behavior began to be visible for this camera until they sat down for writing their report. For various technical reasons (e.g., subjects' unexpected movements off-camera, people passing between the camera and the subject, etc.), 20 of the 184 interactive and noninteractive phases were discarded. Thus, we obtained 164 scorable records.

We analysed the recorded facial behaviours with the Facial Action Coding System (FACS; Ekman & Friesen, 1978). This system describes facial move ments in terms of *action units* (AU) and allows an exhaustive codification of facial behaviour. The coder had specific training in FACS, and had not seen the players' emotion reports. Her reliability in coding the present data was checked by a standard statistic used by Ekman and Friesen.[2] A smile (the predicted expression of happiness) was defined as occurring if there was at least one occurrence of any of the configurations predicted by Ekman and Friesen (1978, table 11–1), namely, AU12, AU6+AU12, or any combination of AU12 with AU25 or AU26 with or without AU6.

Results

We analysed only those rolls: (a) for which bowlers reported happiness, and (b) their faces were discernable in both the interactive and noninteractive phases of the roll. Of the 92 rolls recorded, 25, which came from eight bowlers, fulfilled both criteria. For each bowler, we estimated the probability of smiling during each phase. The mean probability of a smile[3] was .09 (s=.18) for the non-interactive phases (95% confidence interval=.00 to .24), and .78 (s=.36) for the interactive phases (95% confidence interval=.48 to 1.00). The withinsubjects difference between the probabilities of smiling during each phase was highly significant, $t(7)$=5.74, p<.001.

The duration of the phases was variable, with bowlers spending less time on camera, on average, in the noninteractive phases. The mean duration (across fans and phases) of the noninteractive phases was 1.35 s; the mean duration of the interactive phases was 2.83. In order to take these differences in actual duration into account, we re-scored the data to obtain the mean probability of a smile for each bowler during the first 1.35 seconds of the interactive phases.[4] That probability was .65 (s=.37) (95% confidence interval=.35 to .96). In fact, during the interactive phases, 84% of the smiles appeared in the first 1.35 s. The within-subjects difference between the probabilities of smiling during the non-interactive phases and during the first 1.35 s of the interactive phases was also highly significant, $t(7)$=3.77, p<.007.

There were a few occurrences of AU12 (the key action unit in the production of smiles) combined with other action units (e.g., AU17); these combinations do not constitute a smile (i.e., a prototypical expression of happiness as defined by

[1]Bowlers reported basic emotions using the Spanish words (*alegria, miedo, tristeza, enfado, sorpresa, and* asco), or by words that were considered as a synonym of one of these by at least 7 out of 10 independent judges. The instructions for filling out the questionnaire were carefully read and explained at the beginning of the session.

[2]Inter-rater agreement, with respect to the coding of a subsample of the material of the reported studies, was .74, according to Ekman and Friesen's criterion: Agreements divided by the total number of agreements and disagreements (Ekman & Friesen, 1978).

Ekman and Friesen, 1978, table 11–1), but we performed a new analysis including these occurrences of AU12. In this reanalysis, AU12 was defined as occurring when there was at least one occurrence of AU12 alone or in combination with any other action unit (we found combinations of AU12 with AU6, AU17, AU25, and AU26) during the first 1.35 s. The mean probability of an AU12 given a report of happiness was .29 (s=.28) for the noninteractive phases (95% confidence interval =.06 to .53), and .81 (s=.37) for the interactive phases (95% confidence interval =.50 to 1.00). The within-subjects difference between the probabilities of showing AU12 during each phase was highly significant, t(7)=4.83, p<.002.

To provide a more direct comparison with results reported by Kraut and Johnston, we examined facial behaviour after a spare or strike. Seven bowlers made a total of 16 spares or strikes. For each bowler, we calculated the probability of smiling after a spare or a strike (number of smiles after a spare or strike divided by the number of spares or strikes).[5] The mean probability of a smile given a spare or a strike was .29 (s=.39) for the noninteractive phases (95% confidence interval=.00 to .65), and .94 (s=.15) for the interactive phases of these good rolls (95% confidence interval=.80 to 1.00). Once again, the within-subjects difference between the probabilities of smiling during each phase was highly significant, $t(6)$=4.65, p<.005.

In summary, our Spanish bowlers smiled more in general than had Kraut and Johnston's American bowlers, but the important finding is that Spanish and American bowlers showed the same pattern of smiling more during interactive than non-interactive phases.

HAPPY SOCCER FANS

In their study of hockey fans, Kraut and Johnston inferred the fans' happiness from the valence of the events during the game. In order to complement Kraut and Johnston's findings, we asked Spanish soccer fans to report their actual emotions while watching important matches on television.

We ran four pilot studies with fans who did not participate in the study to be reported here. In these studies we tested the questionnaire on felt emotions and designed suitable recording conditions such as suitable distances for the camera,

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[3]We observed that 18 smiles (16 in interactive phases and 2 in noninteractive phases) of the 22 with a report of happiness were Duchenne smiles (AU6+AU12).

[4]An alternative way of taking into account the differences in duration between the interactive and the noninteractive phases would be to calculate, for each participant, the mean probability of a smile in any given second. Mean probability was .07 (s=.17) for the noninteractive phases (95% confidence interval=.00 to .22), and .44 (s=.32) for the interactive phases (95% confidence interval = .17 to .71). The within-subjects difference between the probabilities of smiling during each phase was highly significant, $t(7)$=3.41, p<.01.

alternative settings for the records, and several controls on the degree to which fans were aware of the cameras (e.g., observational coding of fans' gazes at the cameras, debriefings about the fans' experience, and random controls of their attention to the screen; see Ruiz-Belda, 1995).

The data analysed here were gathered in a private house, familiar to most of the fans, who watched the match together in groups of four to six. Video cameras were placed at each side of the group, with their permission, well in advance of the beginning of the match. We also kept a synchronised record of the match itself. Participants were not informed about the goals of our study, and they expressed no suspicions about which particular behaviour we were interested in. We obtained 30 complete records in all; these came from 20 different fans (11 men and 9 women; mean age 25) in six different important matches from the national league and the 1994 World Cup: Four fans were recorded during 3 matches (with another two fans during 2 of these 3 matches), and 14 fans during one match (six, four and four fans in 3 different matches). Methods of emotion and facial movement coding were as in Study 1. Participants were asked to report their emotions for any moment at which they felt them.

We provided the fans with the same short questionnaire used by bowlers. Fans were asked to complete the questionnaire whenever they felt any emotion while watching the match. This questionnaire included an open-ended question about which emotion or emotions they felt. We defined a fan as having felt happiness when he/she explicitly mentioned happiness and no other emotion in this report (in fact fans, as well as bowlers, never mentioned happiness in combination with another emotion).[6]

We analysed the facial expressions of all those fans who spontaneously reported happiness at any time during the match. Facial behaviour was coded for the period between a noticeable change with respect to the baseline facial appearance of the fan and the moment at which the participant took the questionnaire to report an emotion.[7] A coder distinguished interactive from non-interactive facial behaviour. A "noninteractive" phase was defined as occurring when the fan was facing the television screen and not speaking to other fans (i.e., when he/she was not speaking at all or when utterances were mere interjections). An "interactive" phase was defined as occurring when the fan talked to or looked at another fan. Placement of the two cameras allowed the coder to distinguish the fans' facial orientation (i.e., when their faces were facing the television screen or facing other people). In order to check reliability a second coder coded a random sample of 30% of all the recorded phases; intercoder agreement on this coding

[5] Participants reported happiness in 10 of the 16 spares or strikes. They also reported other feelings that were not categorised as happiness, such as hope, tranquility, and responsibility. Six out of seven participants that made spares or strikes reported happiness at least once. The participant who did not report happiness reported a word (*pleno,* full) that judges did not consider to be a synonym of happiness.

of whether a phase was interactive or noninteractive was .64 in terms of Cohen's kappa (z=7.96, $p<.01$).

Results

We obtained 52 spontaneous reports of happiness from a total of 16 different fans. Of these, 37 were accompanied by usable facial data from both a non-interactive and an interactive phases. For these 37 episodes, we estimated, for each participant, the probability of a smile[8] during each phase. Mean probability was .07 (*s*=.17) for the noninteractive phases (95% confidence interval=.00 to .16), and .70 (*s*=.36) for the interactive phases (95% confidence interval=.50 to .89). The within-subjects difference between the probabilities of smiling during each phase was highly significant, $t(15)=7.2$, $p<.001$.

Again, facial behaviour was observed during a predefined period, but in fact the mean durations (across fans and phases) of the noninteractive and interactive phases were different: 2.0 and 7.2 s, respectively. To take into account the differences in duration between the interactive and the noninteractive phases, we estimated the mean probability of a smile during the first 2 s of the interactive phases.[9] The mean probability was .60 (*s*=.38) (95% confidence interval=.40 to .81). In fact, during the interactive phases, 49% of the smiles appeared in the first two seconds. The within-subjects difference between the probabilities of smiling during the noninteractive phases and during the first 2 s of the interactive phases was also highly significant, $t(15)=6.15$, $p < .001$.

There were a few occurrences of AU12 combined with action units (e.g., AU10) in a way that did not define a prototypical expression of happiness by Ekman and Friesen's criteria. We performed a new analysis based on all occurrences of AU12 during the noninteractive phases and during the first 2 s of the interactive phases, that is, we took into account any possible occurrence of AU12 alone or in combination with any action unit; we found combinations of AU12 and AU1, AU2, AU4, AU6, AU8, AU10, AU25, and AU26). The mean probability of an AU12 given a report of happiness was .25 (*s*=.36) for the noninteractive phases (95% confidence interval=.05 to .44), and .79 (*s*=.24) for the interactive phases (95% confidence interval=.66 to .91). The within-subjects

[6]As bowlers did, fans reported basic emotions using the Spanish words (*alegria, miedo, tristeza, enfado, sorpresa, and* asco), or by words that were considered as a synonym of one of these by at least 5 out of 7 independent judges. The instructions for filling out the questionnaire were carefully read and explained at the beginning of each session.

[7]In a few cases, fans reported emotion but there was no noticeable change in the facial behaviour recorded before their report. In this case, we defined an observational period of 9 seconds (225 video frames) back from the moment in which the fan wrote his/her report. The length of the period corresponded to percentile 90 of the length of the periods between a noticeable change with respect to the baseline facial appearance of the fan and the moment at which the participant took the questionnaire to report an emotion.

difference between the probabilities of showing AU12 during each phase was highly significant, *t(15)*=5.66, *p*<.001.

To provide a more direct comparison with results reported by Kraut and Johnston, we examined facial behaviour after a goal was scored by the fan's team. There were 16 fans with discernable records in both interactive and noninteractive phases after a goal by their team. For these 16, the mean probability of a smile given a goal was .07 (*s*=.18) for the noninteractive phases (95% confidence interval=.00 to .18), and .90 (*s*=.29) for the interactive phases (95% confidence interval=.74 to 1.00). The within-subjects difference between the probabilities of smiling during each phase was highly significant, *t(15)*=10. 53, *p*<.005. Estimated probability of smiling during the non-interactive phases was similar to that found by Kraut and Johnston (.12); smiling during the interactive phases was even more frequent in Spain (.90) than in Kraut and Johnston's sample (.27).

In all, Spanish fans smiled more in general than Kraut and Johnston's American fans, but, once again, Spanish and American fans showed the same pattern of smiling more during interactive than noninteractive phases.

DISCUSSION

The two studies reported here were each based on a large number of observations from a small number of participants. Research based on small samples causes concern for two reasons. First, small sample sizes result in a lack of power, leading one to retain false null hypotheses, and thus making Type II errors (Howell, 1987). If a researcher is able to reject the null hypothesis, the statistical test obviously had sufficient power. When one had rejected the null hypothesis, it is impossible to make a Type II error; instead, one must be concerned about the probability of making a Type I error: the probability of a Type I error is controlled by setting appropriate stringent criteria for a, and sample size has no effect on Type I error rate. In this paper, we found uniformly significant results, and therefore Type II errors are not possible. We controlled Type I error rates by setting a=.05 for all significance tests.

The second reason small samples cause concern is that they may not be representative of the population. This is a serious concern, because if the sample

[8]We observed that 27 expressions (24 in interactive phases and 3 in noninteractive phases) of the 37 with a report of happiness were Duchenne smiles (AU6+12).

[9]An alternative way of taking into account the differences in duration between the interactive and the noninteractive phases would be to calculate, for each participant, the mean probability of a smile in any given second. Mean probability was .03 (*s*=.10) for the noninteractive phases (95% confidence interval=.00-.08), and .47 (*s*=.30) for the interactive phases (95% confidence interval=.30 to .63). The within-subjects difference between the probabilities of smiling during each phase was highly significant, *t(15)*=5.89, p<.001.

is not representative, we may not be able to generalise our results to the population (External Validity; Campbell, Stanley, & Gage, 1969). This concern is not restricted to small samples, however: Concerns about External Validity apply equally to all studies, regardless of sample size. The primary and most useful method of evaluating the external validity of a study is to replicate it in a different setting, using different subjects. One of the purposes of these two studies was to replicate the findings of Kraut and Johnston, to demonstrate the generalisability of their findings. The fact that their major conclusion—the probability of smiling given a happy event is low in noninteractive situations and higher in interactive situations—generalised across different countries and languages demonstrates that both their work and ours possess External Validity.

There is now a small body of field studies on the probability of smiling under different circumstances that found similar relationships between smiling and social interaction (Fernández-Dols & Ruiz-Belda,1995; Kraut & Johnston, 1979; [10] Schneider & Josephs, 1991). No one study is definitive, and all are open to criticism, but each is subject to different criticisms, and cumulatively they are coming to constitute a replicable pattern. Conversely, to our knowledge there are no field studies that provide evidence to the contrary.

The observed weak correspondence between participants' reports of happiness and smiling when not engaged in social interaction represents a warning about the assumption that smiles are natural expressions of the presence of happiness. This warning might be dismissed by arguing that bowlers and soccer fans controlled their facial behaviour by following display rules (Ekman, 1972). In our view, this argument can be countered on at least four points. The first point concerns the setting of these experiments: Participants were interacting with familiar people in familiar places; camcorders have also become a familiar appliance, and no participant manifested obvious control in their vocal utterances (e.g., swearing was heard), in their nonverbal behaviour (e.g., bodymanipulation was observed) or in their interaction with others (e.g., kissing or cuddling others was also frequently observed).

The second point concerns our procedure. The participants reported their emotions to the experimenter. This request undermines any need to control their "true" expression, and indeed might be seen as creating a demand to appear consistent that is contradicted by the lack of expressions in the non-interactive phases: People would try to show a coherent image of themselves, not hiding their emotions but trying to express whatever they would later report.

The third point concerns our design: Display rules should play a *smaller* role in noninteractive phases; lack of social concern should strengthen spontaneous expressions of happiness in those phases of the game in which participants' faces were out of sight, but our participants' smiles were almost nonexistent in the noninteractive phases.

The fourth and final point involves the concept of a display rule itself. As is the case with, for example, the psychoanalytic concept of repression, invocation of display rules is a *post-hoc* hypothesis with no empirical value: Any expression

that does not fit the predicted pattern can always be explained away in terms of hypothetical and unobserved display rules.

As an alternative to the display rule hypothesis, Fernández-Dols (1999) suggested that social context, emotion, and facial actions (including display rules) constitute a tension system that includes bidirectional relationships. On this view, facial actions index the causal interrelationships between emotional and contextual factors (see Ginsburg & Harrington, 1996; Messinger, Fogel, & Dickson, 1997). These relationships are neither linear nor direct: Research on behavioural development (Gottlieb, 1976) has found that experiences can induce, facilitate, or maintain a particular behaviour. On this view, emotion does not induce facial action, but it may facilitate whatever facial action (e.g., smiling) is induced by a particular social context. In the same vein, the psychological relevance of each factor might not be proportional to its consequences; some strong opposing emotional and contextual forces may be in unstable equilibrium before an apparently minor contextual factor channels the behaviour toward a particular expression (see also Fernandez-Dols & RuizBelda, 1997). For example, any interactive situation can "entrain" this tension system into smiling, while a nonsocial or uncertain situation keeps the tension system in its unstable balance.

Our findings also fit Owren and Bachorowski's (2001) evolutionary, "selfish-gene" account of smiling. They postulate that two different but related signal systems underlie smiling. An earlier system exists that is emotion-based and involuntary. The second system has evolved more recently and is controlled or volitional. The earlier and "true" smile emerged as an honest, reliable signal of positive feelings toward others that functioned to promote cooperative behaviour and thereby increased the chances of survival for our hominid ancestors who displayed and recognised this signal. These early-emerging smiles were reflex-like, elicited by the combination of an audience and positive feelings toward the audience. In the presence of an audience, a reliable signal of positive feelings served to hinder suspicion and to promote cooperation. Indeed, this system functioned only when the audience could rely on the smile as a good indicator of cooperative intent. On this account, you have to feel happy to display a true smile, but you do not produce smiles in the absence of others. The secondary, volitional smile is a deceptive version of the first. The secondary smile evolved to capitalise on the earlier system. So, on this account, smiles are never simply

[10]Kraut and Johnston (1979) concluded that smiles are not related to happiness even in interactive phases. Their study included observations in which people kept smiling in social interaction even in nonemotional situations. In our studies, we observed smiling during the interactive phases even when participants reported negative emotions (see Ruiz-Belda, 1995); we also observed smiles in interactive phases with no explicit reports of emotion. However, in order to increase the internal validity of our results, we have circumscribed our report to those pairs of noninteractive and interactive phase with an explicit report of happiness.

read-outs of happiness, but require an audience. Also, because of the existence of voluntary, deceptive smiles, even in the presence of an audience, smiles can no longer be taken as a reliable indicator of happiness.

Fridlund (1994) proposed a similar account, but dropped the link of smiles to happiness altogether. The smile simply and reliably conveyed to the audience cooperative intent, whatever the accompanying feelings. According to Fridlund, facial behaviour conveys involuntary expressions whose main function is to convey the sender's action tendency or social motive to the receiver. In Fridlund's terms, smiling is not a sign of happiness but a manifestation of affiliative motives. The accumulating data give credence to Fridlund's argument on two fronts. For the emotion of happiness, Fridlund predicted more smiling in interactive that noninteractive contexts, which was what was found here. Second, whereas other authors (e.g., Ekman, Davidson, & Friesen, 1990) seem to anticipate a strong correspondence between happiness and smiles even in nonsocial situations, this association was found to be weak in both bowlers and soccer fans.

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Antiphonal laughter between friends and strangers

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Drawing from an affect-induction model of laughter (Bachorowski & Owren, 2001; Owren & Bachorowski, 2002), we propose that "antiphonal" laughter—that is, laughter that occurs during or immediately after a social partner's laugh—is a behavioural manifestation of a conditioned positive emotional response to another individual's laugh acoustics. To test hypotheses concerning the occurrence of antiphonal laughter, participants *(n* = 148) were tested as part of either same-or mixed-sex friend or stranger dyads, and were audiorecorded while they played brief games intended to facilitate laugh production. An index of antiphonal laughter for each dyad was derived using Yule's Q. Significantly more antiphonal laughter was produced in friend than in stranger dyads, and females in mixed-sex dyads produced more antiphonal laughter than did their male partners. Antiphonal laughter may therefore reflect a mutually positive stance between social partners, and function to reinforce shared positive affective experiences.

Laughter is a highly common form of human vocal production that occurs in a wide variety of social circumstances. Given everyday experiences with laughter, it is not surprising to find that this signal is often theoretically linked to pleasurable states and circumstances. Specific hypotheses in this vein variously consider laughter to be an expression of positive internal emotional states (e.g., Darwin, 1872/1998; van Hooff, 1972), a signal of playful intent (e.g., Glenn, 1991/1992; Grammer & Eibl-Eibesfeldt, 1990), or a response to humour (e.g., Apte, 1985; Deacon, 1989; Weisfield, 1993). In addition to indicating internal state, laughter is also considered to induce arousal and affect in listeners (Bachorowski & Owren, 2001). The ensuing hedonic tone is thought to vary as afunction of the listener's sex, current affective state, and relationship to thelaugher (Owren & Bachorowski, 2002). In the light of evidence that

suchinduction effects do indeed occur (Bachorowski & Owren, 2001), we becameinterested in examining the temporal pattern of laughter between social partners.We more specifically wanted to determine whether the production of this affect-inducing signal is more closely time-locked between friends than betweenstrangers.

Although we are just beginning to understand the associations among laugh production, laugh perception, and affective experience, we have little reason to doubt that laughter enhances the perceived pleasure of social interactions. Regardless of whether laughs are soft and gentle, like those produced by young infants and their caregivers, or the more boisterous versions often produced among friends, we presume that a key aspect of the pleasure experienced in these interactions is due to the impact of laugh acoustics on listener response systems. A corollary hypothesis is that social interactions are on average less pleasurable when unaccompanied by laughter. We think of pleasure as being a mild to perhaps moderately intense positive affective state. Our use of the term "affect" draws from Russell and Feldman Barrett's conceptualisation (1999; see also Watson & Tellegen, 1985), in which affect refers to consciously accessible feeling states that vary in degrees of both pleasure and activation. Our reliance on an "arousal" construct is similar to their activation dimension, although we are more specifically referring to the impact of laugh acoustics on auditory response circuitry, including those brainstem nuclei that contribute to overall levels of brain activation (see also Owren & Rendall, 2001).

In thinking about laughter's functional significance, one should bear in mind that laughter is decidedly a social signal, as it is far more likely to be produced in the presence of another individual than when alone. This basic effect has been

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observed in both naturalistic (Provine & Fischer, 1989) and laboratory settings (Bachorowski, Smoski, & Owren, 2002b; Brown, Dixon, & Hudson, 1982; Young & Frye, 1966). However, little is known about the ways in which social context influences the temporal sequence of laugh production. For example, whereas some investigators have indicated that the laughs produced by two social partners are associated (Grammer & Eibl-Eibesfeldt, 1990; Nwokah, Hsu, Dobrowolska, & Fogel, 1994), there have been few attempts to rigorously quantify such temporal associations. Provine (1992, 2000) likened these associations to a process of "contagion" and proposed that contagious laughter occurs due to the activation of a laugh-specific auditory feature detector and subsequent triggering of a "laugh-generator". Rather than relying on either the term "contagion", which suggests that some behaviour or agent has been unwittingly caught, or "reciprocal" (Nwokah et al., 1994), which can imply conscious intent, we prefer the term "antiphonal". Used in the animal literature to refer to co-occurring vocal signals (e.g., Biben, 1993; Snowdon & Cleveland, 1984), our application of the term to laughter refers to instances in which the laughter of one social partner co-occurs or is immediately followed by the laughter of another partner.

We conceptualise antiphonal laughter as being part of an affect-induction process that promotes affiliative, cooperative behaviour between social partners (Owren & Bachorowski, 2001, 2002; see also Dimberg & Öhman, 1996; Keltner & Kring, 1998; Owren & Rendall, 1997, 2001). From this perspective, laughter has a two-pronged impact on listener affect. First, the acoustic properties of laughter themselves can have a direct impact on listener arousal and affect. In support of direct-effect hypotheses, recent empirical evidence shows that particular kinds of laughs have acoustic properties that readily elicit positive affect in listeners (Bachorowski & Owren, 2001). The direct effects of laughter may in some ways be comparable to the effects of facial expressions, such as smiling and anger, which have been shown to elicit complementary responses in individuals viewing the expressions—even when perception is nonconscious (Dimberg, Thunberg, & Elmehed, 2000; see also Neumann & Strack, 2000).

The second way that laughter is hypothesised to impact listener response systems is through relatively indirect processes. We propose that antiphonal laughter can be understood as a conditioned positive affective response to the laughs produced by an individual with whom one shares an ongoing positive relationship. Individuals who routinely laugh together in positive circumstances, such as friends, have the opportunity to associate the idiosyncratic acoustic features of a given friend's laugh with a positive emotional state. As there is at least preliminary evidence that laugh acoustics are individually distinctive (Bachorowski, Smoski, & Owren, 2001), it is reasonable to suppose that individuals form conditioned positive affective responses to these acoustic features of a friend's laughter (see also Dimberg & Öhman, 1996).

The present study was designed to test several hypotheses concerning antiphonal laughter. The laughs we analysed were recorded during a

gameplaying paradigm that involved both affiliative and competitive tasks (Bachorowski, Hudenko, Blomquist, & Tomarken, 2002a). The high rates of laugh production that occurred during two of these tasks afforded us the opportunity to quantify the temporal pattern of laughter between two social partners, and then assess whether that pattern was differentially associated with social context. The dyads we tested were composed of either same-or mixed-sex friends or strangers. Using a quite different paradigm in which laughter was induced with film clips, we found that these two factors—sex and social-partner familiarity—influenced both the rate and acoustic features of laugh production (Bachorowski et al., 2002b). Specifically, individual male laughter was influenced by familiarity with one's social partner, whereas individual female laughter was more reliably associated with the sex of one's social partner.

Hypotheses concerning antiphonal laughter were driven both by these outcomes and the affect-induction framework. We specifically expected that more antiphonal laughter would occur between friends than between strangers. Laugher sex is a second factor that might moderate the occurrence of antiphonal laughter. As measured by self report (Doherty, Orimoto, Singelis, Hatfield, & Hebb, 1995; Eisenberg & Lennon, 1983), behavioural ratings (Doherty et al., 1995), and facial EMG (Dimberg & Lundquist, 1990), females have been shown to be more influenced than males by the emotional expressions of others. Females were therefore expected to produce more antiphonal laughter than males. Finally, we wanted to test whether the interaction between sex and social context found in our earlier study also occurred when antiphonal laughter was the behaviour of interest. The antiphonal laughter of mixed-sex pairs was thus of particular interest.

METHOD

Participants

A total of 204 Vanderbilt University undergraduates were recruited for participation. These individuals were tested as part of either a same-or mixed-sex friend or stranger dyad. Participants primarily came from sections of General Psychology and received research credit towards that course. Those tested as part of a stranger pair were matched with an unfamiliar student by the experimenter, and verification that the two were indeed unfamiliar to each other occurred when they were introduced in the laboratory. Those tested as part of a friend dyad were asked to bring a friend to the testing session. Friends participating at the request of another participant received $10, but had the option of receiving General Psychology credit if they were enrolled in that course.

Data from 42 of the 204 participants were excluded due to equipment problems (n=4), experimenter error (n=12), or because one or both members of the pair was an international student whose native language was not American

English (n=26). These last participants were excluded because they may have responded differently to the laugh-inducing stimuli we used than participant dyads in which both parties were native-born American English speakers. An additional exclusion criterion was based on the number of laughs available for analysis, with dyads excluded if either participant produced a total of three or fewer laughs during the two test items of interest. Seven pairs (i.e., 14 participants) failed to meet this criterion. Data from the remaining 148 participants were used in the present analysis, and included the laughs produced by 11 male-male friend, 8 male-male stranger, 12 female-female friend, 13 female-female stranger, 14 mixed-sex friend, and 16 mixed-sex stranger dyads. Participants had a mean age of 18.3 years (SD=0.94) and primarily identified themselves as White (n=128). The remaining participants identified themselves as Asian (n=10), Hispanic (n=3), Black (n=2), Middle Eastern (n=2), subcontinent Indian (n=1), and of mixed descent (n=1). One individual declined to provide ethnicity information. Informed consent was obtained prior to testing, and speciflc consent for the use of laughter data was obtained during debriefing.

Stimuli and apparatus

Instructions for the 17 items that comprised the "game-playing" paradigm were printed separately on laminated cards. Data from the two items that elicited the most laughter across individuals were included in these analyses. The first of these asked the pair to generate as many names as possible for an inflated plastic-doll version of Edvard Munch's "The Scream", and the second asked the pair to draw pictures of each other's faces using paper and crayons. Participants were instructed to work on each item for the full duration of a 90-s timer, although some dyads worked a bit longer than the designated interval. Details concerning the recording conditions can be found elsewhere (Bachorowski et al., 2001).

Design and procedure

Testing occurred in a comfortably furnished laboratory room. Participants first completed several personality inventories and were then audiotaped as they viewed and rated their emotional responses to each of three film clips (these data are not relevant here). Participants were then told that the remainder of the study concerned social problem-solving. For this game-like procedure, participants were seated in futon chairs positioned 0.9 m apart and separated by a low footstool; game materials were located in a cart next to the footstool. Participants were instructed to: "Take turns reading the card instructions out loud to your partner, and follow the cards' instructions". The experimenter then left the room and monitored participants through the headphone output of the digital audiotape recorder. The experimenter did not communicate with participants during the game, and did not re-enter the testing room until the game had ended.

Laugh selection and behavioural coding

Laughter was broadly defined as being any sound that would be considered a laugh if heard under everyday circumstances (Bachorowski et al., 2001, 2002b). Laugh sounds thus included comparatively stereotypical, song-like laughs, as well as noisier grunt-and snort-like laughs. An instance of antiphonal laughter was defined as the production of a laugh by one member of a dyad that began either during or within 1 s following the offset of laugh production by the other member of the dyad. Any 1-s or greater interval in which neither participant laughed was coded as "No Laughter". Three behavioural codes were thus used: Participant 1 Laugh (P1), Participant 2 Laugh (P2), and No Laughter (N). These three categories therefore comprised a mutually exclusive and exhaustive set in which codes could not repeat. Codes were then concatenated into a behavioural sequence for each dyad. For example, a "P2-P1-P2-N-P1" sequence meant that Participant 2 laughed first, Participant 1 began laughing prior to or within 1 s of the offset of Participant 2's laugh, Participant 2 began a second laugh prior to or within 1 s of the offset of Participant 1's laugh, neither person laughed for a 1 s or longer interval, and the sequence concluded with a laugh produced by Participant 1. Both the "P2-P1" sequence and the "P1-P2" sequence in this example are instances of antiphonal laughter, with the first reflecting antiphonal laughter on the part of P1, and the second reflecting antiphonal laughter on the part of P2. Coding was performed using ESPS/waves+5.3 digital signal processing software (Entropics, Washington, DC). Audio waveforms for both participants in a given dyad were viewed time-locked both to each other and to a labelling window. This procedure enabled visual representation of the timelocked vocal utterances to within 10−5 s accuracy.

An index of antiphonal laughter was determined for each dyad using sequential analysis techniques implemented in the General Sequencer (GSEQ) for Windows version 3.5.6 (Bakeman & Quera, 1999). Yule's Q was then used as an index statistic to quantify the sequential association (Bakeman & Gottman, 1997; Bakeman, McArthur, & Quera, 1996; Yoder & Feurer, 2000). Unlike transitional probabilities (i.e., the probability of one partner laughing given the occurrence of the other partner's laugh), Yule's Q is not confounded with base rates of behaviour. Yule's Q meets the assumptions underlying the general linear model, including an approximately normal distribution with a mean of zero (Bakeman et al., 1996). As such, it is appropriate for use in parametric inferential statistics. Possible values of Yule's Q range from −1.0 to +1.0, with a value of 0.0 reflecting no sequential association. In the present application, significant positive Yule's Q values indicate more antiphonal laughter than expected by chance, whereas significant negative values indicate less antiphonal laughter than expected by chance.

TABLE 1

Number of laughs produced and conditional probabilities of antiphonal laughter

	Dyad sex			
Social context	*Male-Male*	*Female-Female*	*Male-Female*	*Total*
Friends				
Number of laughs	26.91 (14.16)	24.00 (7.37)	30.57 (17.98)	27.35 (14.03)
Transitional probabilities	0.34	0.34	0.35	0.34
Strangers				
Number of laughs	15.00 (4.57)	26.85 (10.88)	18.06 (6.84)	20.49 (9.32)
Transitional probabilities	0.27	0.34	0.25	0.29
Total				
Number of laughs	21.89 (12.49)	25.48 (9.29)	23.90 (14.47)	23.92 (12.33)
Transitional probabilities	0.32	0.33	0.31	0.32

Note: Values for number of laughs are means, with standard deviations in parentheses. Values for transitional probabilities represent the cumulative probability of a laugh given the occurrence of a partner laugh across participants.

Results

Unless otherwise noted, analyses were conducted at the dyad level. Descriptive statistics for the number of laughs produced are shown in Table 1. For the purpose of comparison with Yule's Q outcomes, transitional probabilities are also provided. A univariate ANOVA was conducted with sex composition of the dyad (i.e., male-male, female-female, or male-female) and social context (i.e., friend or stranger) as between-subjects factors. The results showed that the number of laughs produced by each dyad did not depend on dyad sex, $F(2, 68) = .838$, n.s. However, the number of laughs did depend on both social context, $F(1, 68) = 6.836$, $p = .01$, and, importantly, its interaction with sex, $F(2, 68) = 3.532$, $p < .05$. Overall, friend dyads produced more laughs than did stranger dyads. *Post-hoc* tests showed that the average amount of laughter produced by stranger pairs involving males (i.e., male-male and male-female stranger pairs) was less than the average amount of laughter produced by all remaining pairs, $t(68) = 3.527$, $p = .001$.

Antiphonal laughter was examined by entering the same factors in a second univariate ANOVA, with the mean Yule's Q of each dyad used as the dependent measure. Although neither the main effect of sex nor its interaction with social context were significant, $F(2, 68) = 2.324$, n.s. and $F(2, 68) = .581$, n.s.,[1] the degree to which antiphonal laughter was produced did vary significantly with social context, $F(1, 68) = 9.171$, $p < .01$. Consistent with our earlier analysis, this social-context effect was due to the more frequent occurrence of antiphonal laughter in friend dyads than in stranger dyads (see Figure 1).

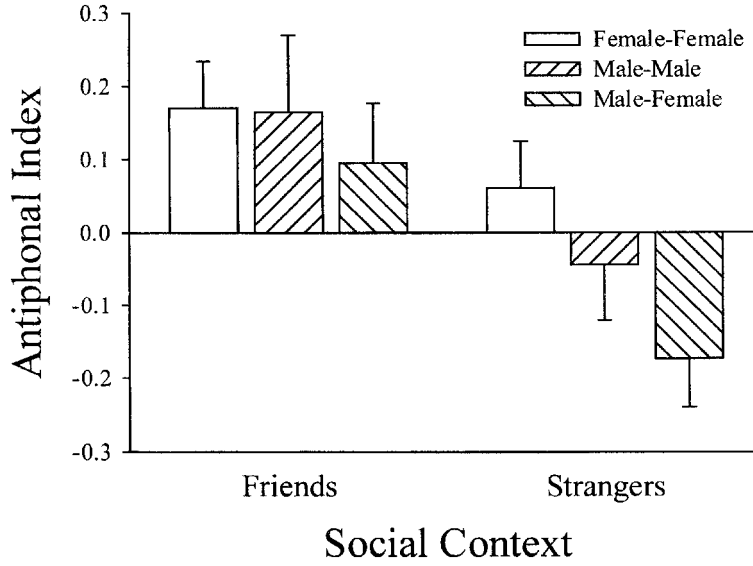

Figure 1. Mean Yule's Q and associated standard errors for all dyads as a function of sex and social context.

As the results of previous work (Bachorowski et al., 2001b; Grammer & EiblEibesfeldt, 1990; Provine, 1993) showed that sex-based differences in laugh production occurred within mixed-sex dyads, analyses at the individual level within mixed-sex dyads were conducted. Here, rather than the dyad mean, the Yule's Q for each participant was used as the antiphonal index. Specifically, the antiphonal index for each female reflected the degree to which she laughed within 1 s of her male partner, whereas the antiphonal index for each male reflected the degree to which he laughed within 1 s of his female partner. So that consideration was given to the variance shared between dyad members, a repeated-measures ANOVA was performed in which social context was the between-subjects factor, the sex of each dyad member served as a within-subjects factor, and the antiphonal index of each dyad member was the repeated-measures variable. The results of this test showed significant main effects of both sex, $F(1, 28)=9.009$, $p<.01$, and social context, $F(1, 28)=6.541$, $p<.05$. However, the interaction between sex and social context was not significant, $F(1, 28)=.043$, n.s. As can be seen in Figure 2, these outcomes indicate that in mixed-sex dyads, females were more likely to laugh antiphonally than were males, and friends produced more antiphonal laughter than did strangers.

[1]There was a significant correlation between the total number of laughs produced and the antiphonal index, $r=.48$, $p<.001$. However, an ANCOVA using the total number of laughs by each individual as a covariate led to equivalent statistical outcomes.

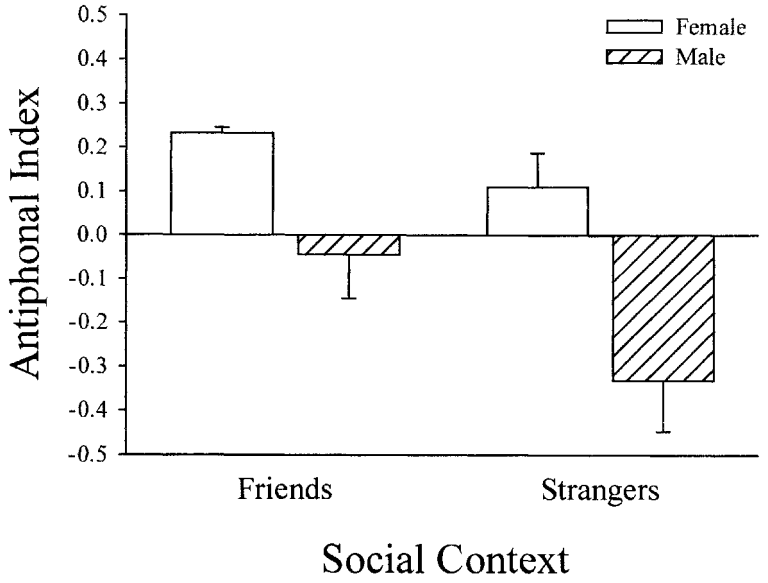

Figure 2. Mean Yule's Q and associated standard errors for mixed-sex pairs as a function of social context.

DISCUSSION

The goal of this study was to test hypotheses concerning antiphonal laughter between two social partners. Both the total number of laughs produced and amount of antiphonal laughter were of interest. With respect to the latter, individuals tested with a friend were more likely than those tested with a stranger to laugh during or immediately following his or her partner's laugh. In addition, and despite the absence of overall sex differences in the occurrence of antiphonal laughter, females tested as part of a mixed-sex dyad were found to produce more antiphonal laughter than their male testing partners. Although the pattern of results was not fully identical to our previous work, important aspects of the results were the same and again show that both the familiarity and sex of a social partner play a significant role in laugh production.

As noted earlier, an affect-induction framework shaped our thinking about antiphonal laughter. In particular, we hypothesise that repeated associations between individually distinctive laugh acoustics and shared, positive experiences promote the occurrence of antiphonal laughter. More broadly, we think that laughter generally signals willingness to engage in cooperative behaviour (Owren & Bachorowski, 2001) and that antiphonal laughter, in particular, may support or reinforce mutually pleasurable affective experiences. In contrast, the absence of such interaction histories should make it less likely that antiphonal responding would occur between strangers. In line with this reasoning, dyads

composed of friends produced significantly more antiphonal laughter than those composed of strangers. These outcomes are consistent with the notion that conditioned positive emotional responses moderate the occurrence of antiphonal laughter between friends. Corollary support for this reasoning comes from the absence of or even inhibition of antiphonal laughter between strangers. It will be important in further work to specifically assess the associations between ongoing affective state and the use of antiphonal laughter.

Relative to their male partners, the high rate of female antiphonal laugh production in mixed-sex dyads is noteworthy. Contrary to our predictions, this pattern cannot be attributed to a general tendency on the part of females to produce more antiphonal laughter than males. However, it may be that females are specifically attuned to positive affective expressions by males. Others have noted that males are sociobiologically predisposed to be interested in females (Daly & Wilson, 1983; Geary, 1998), and producing affect-inducing sounds may thus help individual females to sway a male's affective stance towards her—independent of any actual interest she may have (Owren & Bachorowski, 2002). Although this kind of strategic behaviour may be entirely nonconscious, females have reported using related behaviours, such as flirting and playing on physical attractiveness and sexuality, to influence males (e.g., Dunn & Cowan, 1993; Johnson, 1976; Singer, 1964). In contrast to males' predilection to be interested in females, females may be more inclined to be wary or vigilant of males, especially male strangers. For individual male strangers, then, producing an acoustic signal that induces arousal in his female partner may serve to accentuate any negatively toned predispositions on her part. It may therefore be in a male's best interest to inhibit antiphonal responding when in the company of a female stranger (see also Owren & Bachorowski, 2002).

Although there have been few attempts to quantify antiphonal laughter, the present results can be reasonably compared to two earlier reports. In the first of these, Grammer and Eibl-Eibesfeldt (1990) had dyads wait for a 10 min interval while an experimenter returned a purported telephone call. These investigators subsequently examined the associations between several laugh-related measures and reported interest in one's social partner. Of particular relevance to the present study is the finding that co-occurring laughter was linked to individual's self-reported interest in going to the movies with their social partner. Thus, the degree of desire for further affiliation was statistically related to the amount of antiphonal laughter produced. The present findings extend this outcome by showing that the degree of actual affiliation (i.e., friend vs. stranger) is associated with antiphonal laughter. However, as the total number of laughs that dyads produced together was apparently used as the dependent measure in Grammer and Eibl-Eibesfeldt's study, overall laugh base rates were probably confounded with their index of co-occurring laughter. Using a much different paradigm, Nwokah and colleagues (1994) also found evidence of antiphonal laughter ("co-active" in their terminology). In this study, mother and infant laughter was shown to become increasingly co-active over the course of the infant's first year

of life. These results therefore indicate that antiphonal laughter occurs quite early in development, and suggest that its occurrence may be one marker of attachment.

With regard to total laugh production, we found that friends produced more laughter than did strangers, and that stranger pairs that include males (i.e., male-male and male-female stranger pairs) produced significantly less laughter than all other dyad compositions. As in our previous work, but in contrast to conclusions drawn by others (Adams & Kirkevold, 1978; Provine, 1993[2]), we found no overall evidence that females laugh more than males. Instead, the number of laughs produced by individuals of both sexes appears to be driven by the social context in which signal production occurs. Dyads in which males were paired with a stranger of either sex produced fewer laughs than the remaining pairs. These outcomes mirror findings from our previous study (Bachorowski et al., 2001b), in which males produced the least laughter with strangers of either sex. As males have been found to be more competitive than females in same-sex pairings (e.g., Aries, 1998; Keltner, Young, Heerey, Oemig, & Monarch, 1998; Maccoby, 1990; Miller, 1985; Sharkey, 1993), and are more likely to break cooperative coalitions (e.g., Bond & Vinacke, 1961; Garza & Borchert, 1990), they may be less likely to produce emotional cues—such as laughter—that encourage cooperation when paired with someone unknown to them. However, once cooperation has been established, the use of these cues may encourage the maintenance of the affiliative relationship.

Two statistical issues constrain our interpretations. First, not all dyads met the minimum number of behaviours recommended for calculation of Yule's Q (Bakeman & Gottman, 1997). As a potential consequence of insufficient codes is typically Type II error (Yoder & Feurer, 2000), the null findings of the present study should be interpreted with caution. Second, it is possible that excluding dyads based on insufficient laugh production biased the obtained outcomes. This seems unlikely, however, given that re-inclusion of the dyads in question did not change total-laugh outcomes. Ongoing work in our lab is explicitly addressing some of the theoretical and methodological shortcomings of the present study, such as the lack of self-reported affect and detailed information concerning the nature of the relationship between friend pairs. More broadly, further empirical work in this area will necessarily involve more exacting tests of conditioningbased explanations.

Experimental investigations of antiphonal laughter help clarify the "hows" and "whys" of laughter. In a general sense, we consider laughter to be both an index of positive affect and a signal that can induce affective states in social partners (see also Hess & Kirouac, 2000; Johnstone & Scherer, 2000). In this particular study, we show that antiphonal laughter is differentially associated with both sex and social context. These findings indicate that listener responsiveness to laughter is not solely attributable to signal acoustics, in which laughter is one behavioural outcome of comparatively direct links between signal perception and production systems. Instead, the occurrence of laughter in general—and

antiphonal laughter in particular—appears to be associated with a history of pleasurable interactions between social partners.

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[2] Although Provine (1993) concluded that females on average produce more laughter than males, he also noted that the amount of laughter produced by individuals of either sex is associated with both the sex composition of social groups and social role (i.e., speaker or audience) of the laughter.

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The pleasures of sex: An empirical investigation

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This study examined associations between the pleasurability of various sexual activities and behavioural experience with these activities. Participants were 145 female and 78 male undergraduates. Participants rated the pleasurability of various sexual activities (vaginal intercourse, anal intercourse, receiving oral sex, performing oral sex, masturbation by a partner, and self-masturbation) and answered questions about their experience with these sexual activities. Vaginal intercourse, receiving oral sex, and being masturbated by a partner received the highest pleasure ratings. For behaviours other than vaginal intercourse and receiving oral sex, pleasure ratings were significantly higher among respondents who had engaged in the activity. Pleasure ratings for several different sexual behaviours were intercorrelated. Participants who scored high on a pleasure index were more sexually experienced, engaged in more frequent sexual activity, and reported having more sex partners. Results are interpreted within the context of an evolutionary theory which suggests that pleasure motivates sexual behaviour.

The desire for pleasure is an important reason that people have sex. This does not mean that people desire sex *only* for the pleasure it affords. Clearly, there are many other reasons to have sex, including love, a desire for intimacy, stress reduction, and so forth (Browning, Hatfield, Kessler, & Levine, 2000; Levin,

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1994). Nor does this assertion imply that the pursuit of pleasure is entirelyconscious. Nevertheless, one of the main reasons that people have sex is becauseit feels good. Hence, it seems quite plausible to suppose that people who reportgreater enjoyment of sex would also report having sex more frequently, possiblywith a greater number of partners.

Several studies have sought to determine whether pleasure motivates sexual behaviour and whether pleasure is associated with sexual experience and frequency. However, most of these studies conceptualise pleasure as a nonspecific motive for engaging in sex, rather than examining the association between perceived pleasure and overt behaviour for specific sexual activities, such as vaginal intercourse or receiving oral sex. Past studies indicate that men typically endorse pleasure as a motive for sexual activity, whereas women report that love or affection is their primary motive for having sex (Browning et al., 2000; Carroll, Volk, & Hyde, 1985; Leigh, 1989). Moreover, men rate sex (usually understood as vaginal intercourse) as more pleasurable than do women (Hill & Preston, 1996; Whitley, 1988). The limited empirical evidence that is currently available also suggests that sexual pleasure ratings are correlated with having engaged in, and more frequently engaging in, sexual intercourse (Browning et al., 2000; Hill & Preston, 1996; Leigh, 1989).

A main limitation of most existing studies is that they used a global, nonbehaviour-specific measure of pleasure, rather than examining the pleasure associated with specific sexual behaviours. It seems clear that different people will have different preferences for various sexual pleasures—for example, some might find anal intercourse to be highly pleasurable, whereas others might find it to be painful and unpleasant. Typically, researchers have collapsed sexual behaviour into broad categories, such as "ever having engaged in vaginal intercourse, anal intercourse, or oral sex" or having engaged in "usual" versus "unusual" behaviours. This assumes that all sexual behaviours are evaluated similarly with respect to pleasure. A study by Wilson (1987) suggests that this is not true—that pleasure is activity-specific and that men and women assign different pleasure ratings to different activities. However, little is known about how pleasurable people find different sexual activities and whether their pleasure ratings influence their sexual behaviours.

The present study was designed to examine the relationship between sexual pleasure and sexual behaviour for specific sexual activities, such as vaginal intercourse, anal intercourse, giving and receiving oral sex, and masturbation (with and without a partner). College students were asked to rate how pleasurable various sexual activities are, and then were asked a series of

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questions about their experience with these same sexual activities. Several hypotheses were generated and tested.

First, if pleasure motivates people to engage in sex as many people posit (e.g., Abramson & Pinkerton, 1995; Diamond, 1997; Pinkerton & Abramson, 1992; Tiger, 1992), then one would expect that people who believe a particular activity is highly pleasurable would be highly motivated to engage in that behaviour, hence that higher pleasure ratings for specific sexual activities would be associated with prior experience with those activities. This hypothesis is consistent with the empirical results of Whitely (1988) and Hill and Preston (1996), who found a positive association between sexual experience and scores on a general pleasure (or "hedonism") scale. However, neither of these studies examined the relationship between pleasure and experience for specific sexual acts.

The second hypothesis was that the more pleasurable a sexual activity was deemed to be, the more often it would be repeated. This intuitively appealing hypothesis is consistent with prior research, which has demonstrated a positive correlation between nonspecific measures of sexual pleasure and frequency of (vaginal) intercourse (Hill & Preston, 1996, Leigh, 1989; Nelson, 1978).

Previous researchers have conceptualised the desire for sexual pleasure as a general trait of sexual hedonism (Hill & Preston, 1996; Whitely, 1988). If there is such a trait, then pleasure ratings for one sexual behaviour (such as vaginal intercourse) should be positively correlated with pleasure ratings for other behaviours (such as oral sex or masturbation). Moreover, in line with the studies reviewed above, it would be expected that respondents who find sex, in general, to be highly pleasurable would report engaging in various sex acts more frequently and would have more sex partners.

The final hypothesis was that men would report greater pleasure for all of the sexual activities included in the study. This hypothesis was based on conventional stereotypes of male and female sexuality (DeLamater, 1987; Griffitt, 1987; Simon & Gagnon, 1986), and on the general finding that men are more likely than women to cite sexual pleasure as a motive for engaging in sexual activity (Browning et al., 2000; Caroll et al., 1985; Hill & Preston, 1996; Leigh, 1989; Nelson, 1978; Whitley, 1988). There is very little empirical evidence available pertaining to this issue.

METHOD

Participants

Participants were 145 women and 78 men enrolled in an undergraduate human sexuality course at a large, urban university in California. The mean age was 22. 2 years (SD—2.2), with a range of 19 to 40 years. Almost all of the participants were college seniors (96%) and were single (97%). Just over half (51%) of the

single participants had a steady partner, whereas 38% were not presently dating and 11% were dating more than one person. Most participants were either Asian-American (37%) or White (34%).

Procedure

Participants completed an anonymous, self-report questionnaire during a regularly scheduled class period. The questionnaire took approximately 40 minutes to complete and assessed perceptions of the pleasurability of various sexual practices and respondents' own sexual behaviour. Participation was voluntary.

Measures

Demographics. Respondents were asked to indicate their age, gender, year in school, marital and dating status, and racial/ethnic background.

Pleasurability of sexual activities. Respondents were ask to rate, on a 5–point scale, the pleasurability of six sexual activities: vaginal intercourse, anal intercourse, receiving oral sex, performing oral sex, self-masturbation, and masturbation by a partner. Response choices ranged from "not at all pleasurable" to "very pleasurable". A "don't know" option also was provided.

Behavioral experience and frequency. For each sexual behaviour, participants indicated whether or not they had ever engaged in the behaviour, the number of times and the number of partners with whom they had engaged in the activity in the three previous months. Participants also were asked to indicate the number of male and female sexual partners for the past three months, past year, and during their lifetimes.

RESULTS

Pleasure ratings of sexual activities

As shown in Table 1, the highest mean pleasure ratings were associated with vaginal intercourse, receiving oral sex, and being masturbated by a partner. A large proportion of respondents indicated that they did not know how pleasurable anal intercourse is, but almost all respondents were able to assign pleasure ratings to the other sexual activities.

Most respondents reported having engaged in each of the behaviours, with the exception of anal intercourse (see Table 2). A greater proportion of men than women reported having engaged in self-masturbation, 98.0% vs. 63.6%, χ^2 (1)= 21.73, p<.001. Ethnic differences were obtained for performing oral sex, χ^2 (2) =7.42, p<.025, and masturbation by a partner, χ^2 (2)=8.33, p<.016. *Post-hoc* tests indicated that fewer Asian-Americans than Whites had performed oral sex, 72.

TABLE 1

Sexual activity pleasure ratings

	Range[a,b]	*Mean* (SD)[b]	*% Don't know*
Vaginal intercourse	2–5	4.61 (0.65)	3.6
Anal intercourse	1–5	2.34 (1.30)	44.4
Receiving oral sex	1–5	4.56 (0.72)	3.1
Performing oral sex	1–5	3.47 (1.03)	5.8
Self-masturbation	1–5	3.55 (1.09)	15.2
Masturbation by partner	1–5	4.03 (0.97)	9.0

[a]5-point scale: 1="not at all pleasurable" to 5="very pleasurable". [b] Includes all participants, regardless of whether they had ever engaged in target behaviour.

TABLE 2

Self-reported sexual behaviour

		Frequency	
	Experience[1]	*Range*	*Mean* (SD)
Sexual behaviour in past 3 months			
Vaginal intercourse	81.5	0–100	18.26 (22.00)
Anal intercourse	25.8	0–26	26.00 (4.73)
Receiving oral sex	87.5	0–80	10.09 (14.48)
Performing oral sex	82.3	0–90	10.63 (14.14)
Self-masturbation	74.5	0–200	23.57 (33.24)
Masturbation by partner	81.5	0–60	9.08 (11.79)
Number of sex partners			
Past 3 months		0–6	0.98 (0.97)
Past year		0–11	1.69 (1.86)
Lifetime		0–32	5.25 (6.42)

[1] Percentage of respondents who reported ever having engaged in behaviour.

4% vs. 91.0%, χ^2 (1)=7.44, p<.006, or had been masturbated by a sex partner, 71.4% vs. 91.9%, χ^2 (1)=8.46, p<.004, and a trend in which fewer Asian-Americans than Whites reported receiving oral sex, 80.0% vs. 94.1%, χ^2 (2)=5.81, p<.055.

Men reported significantly more acts of masturbation in the past 3 months than did women, 36.02 ± 42.18 vs. 14.18 ± 20.21, t(60.58)=−3.24, p < .002, but there were no gender differences in the number of sex partners. There were ethnic differences for vaginal intercourse, F(2, 142)=3.05, p < .05, and for the number of lifetime partners, F(2, 165)=7.06, p < .001. Specifically, White respondents reported more acts of vaginal intercourse than did Asian-Americans (21.82 ± 27.21 vs. 11.48 ± 13.09), and both Whites (6.86 ± 8.39), and Others (5.92 ± 5.54) reported more lifetime sex partners than did Asians (2.65 ± 2.46)

A series of 2 x 2 (gender x experience) ANOVAs were conducted to determine whether the pleasure ratings for the sexual activities differed as a function of gender and/or having engaged in the activity (see Table 3). Because of the exploratory nature of this study, a conservative alpha of .01 was used to evaluate significance for each full model. The full model was significant for anal intercourse, performing oral sex, self-masturbation, and masturbation by a partner; for these four behaviours, higher pleasure ratings were given by those respondents who had engaged in the behaviour, as indicated in Table 4. Significant gender main effects were found for anal intercourse, performing oral sex, and masturbation by a partner. The men in the sample rated anal intercourse and performing oral sex as more pleasurable than did the women, whereas the opposite pattern was observed for masturbation by a partner (see Table 4).

The main effects for performing oral sex and for masturbation by a partner were qualified by significant interaction effects, as illustrated in Figure 1. Whether or not male respondents had previous experience performing oral sex did not significantly affect their pleasure ratings. In contrast, female respondents who had performed oral sex rated it as significantly less pleasurable than did females who had not. A similar interaction pattern was observed for masturbation by a partner.

A series of 3 × 2 ANOVAs were conducted to determine whether or not assigned pleasure ratings differed as a function of ethnic background (White, Asian, and Other) and having engaged in the activity. No significant main effects for ethnicity were obtained.

Bivariate relationships

For each of the six sexual behaviours, a Pearson product-moment correlation coefficient was calculated to assess the association between pleasure ratings and behavioural frequency. For men, a marginally significant association was obtained for performing oral sex (r=.30, p<.04, n=46). For women, significant correlations were obtained for vaginal intercourse (r=.36, p<.001,

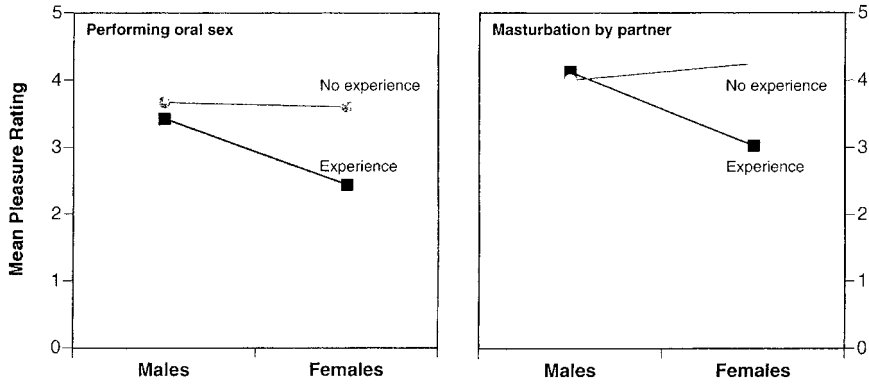

Figure 1. Mean pleasure ratings, by gender, for performing oral sex and masturbation by a partner.

TABLE 3

Results for ANOVA: Pleasure ratings as a function of experience and gender

	Overall model	*Experience main effect*	*Gender main effect*	*Interaction*
Vaginal intercourse	$F(3, 175) = 3.35$*	–	–	
Anal intercourse	$F(3, 100) = 19.72$***	$F(1, 100) = 15.62$***	$F(1, 100) = 30.33$***	n.s.
Receiving oral sex	$F(3, 172) = 3.50$*	–	–	–
Performing oral sex	$F(3, 165) = 7.04$***	$F(1, 165) = 8.66$**	$F(1, 165) = 4.79$*	$F(1, 165) = 3.70$*
Self-masturbation	$F(2, 135) = 18.43$***	$F(1, 135) = 36.81$***	n.s.	n.s.
Masturbation by partner	$F(3, 156) = 7.70$***	$F(1, 156) = 6.51$**	$F(1, 156) = 3.82$*	$F(1, 156) = 9.84$**

*$p<.05$; **$p<.01$; ***$p<.001$; n.s., not significant.

TABLE 4

Main effects: Pleasure ratings as a function of past experience and gender

	Engaged in behaviour?		*Gender*	
	Yes	*No*	*Male*	*Female*
	Mean (SD)	*Mean* (SD)	*Mean* (SD)	*Mean* (SD)
Anal intercourse	2.91 (1.16)	1.85 (1.17)	3.53 (1.07)	2.53 (1.07)
Performing oral sex	3.63 (0.98)	2.74 (0.98)	3.55 (0.89)	3.02 (1.03)
Self-masturbation	3.82 (0.99)	2.40 (1.14)	–	–
Masturbation by partner	4.17 (0.81)	3.43 (1.42)	4.00 (0.79)	4.25 (0.81)

n=96), performing oral sex (*r*=.35, *p*<.001, *n*=97), and masturbation by a partner (*r*=.33, *p*<.001, *n*=94). Marginally significant correlations were obtained for receiving oral sex (*r=.21, p*<.04, *n*=103) and self-masturbation *(r*=.26, *p*<.05, *n*=61). For all of these behaviours, higher pleasure ratings were associated with more frequent sexual activity.

A correlation matrix was created to investigate whether pleasure ratings for one activity (e.g., vaginal intercourse) were related to pleasure ratings for other activities (e.g., anal intercourse), as shown in Table 5. For this analysis, "Don't know" and missing values were replaced by the corresponding mean values, taking into account the respondent's gender and whether or not the respondent had engaged in the behaviour. Receiving oral sex, performing oral sex, masturbation by a partner, and self-masturbation were all significantly

TABLE 5

Correlations between pleasure ratings for pairs of sexual behaviours

	Anal intercourse	*Receiving oral sex*	*Performing oral sex*	*Self-masturbation*	*Masturbation by partner*
Vaginal intercourse	.05 (*N* = 118)	.12 (*N* = 206)	.25*** (*N* = 201)	−.05 (*N* = 179)	−.003 (*N* = 194)
Anal intercourse	–	.10 (*N* = 118)	.18 (*N* = 117)	.23* (*N* = 112)	.01 (*N* = 115)
Receiving oral sex	–	–	.33*** (*N* = 204)	.17* (*N* = 181)	.43*** (*N* = 197)
Performing oral sex		–	–	.17* (*N* = 178)	.26*** (*N* = 192)
Self-masturbation	–			–	.36*** (*N* = 175)

*p<.05; ***p<.001.

intercorrelated. Vaginal intercourse was correlated with performing oral sex, but with no other activity (this might reflect a ceiling effect caused by the large mean pleasure rating for this item). Because many participants did not know how pleasurable anal intercourse was, the power to detect associations involving this variable was low.

A"pleasure index" was created for each participant by summing his/her pleasure ratings for vaginal intercourse, receiving oral sex, giving oral sex, self-masturbation, and masturbation by a partner. (Anal intercourse was excluded because almost half of the sample did not assign a pleasure rating to this activity.) Pleasure index scores ranged from 9 to 25, with a mean of 19.99. There were no differences on this index due to gender, age, or race/ ethnicity.

As expected, for each of the main behaviours, respondents who reported having engaged in the behaviour had significantly higher pleasure index scores than did respondents who had not engaged in the behaviour (all *ps*<.01). Moreover, pleasure index scores were positively correlated with behavioural frequencies for the following sexual activities: vaginal intercourse (r=.29, p< .001, n=144), receiving oral sex (r=.26, p<.001, n=153), and performing oral sex (r=.27, p<.004, n=143). In addition, pleasure index scores were significantly correlated with the reported numbers of sex partners for the past three months (r=.18, p<.02, n=165), past year (r=.26, p<.001, n=165), and lifetime (r=.31, p<.001, n=164).

DISCUSSION

The results of the present investigation support the hypothesis that pleasure motivates sexual activity. Previous behavioural experience was associated with higher pleasure ratings for all activities other than vaginal intercourse and receiving oral sex (ceiling effects may have obscured significant findings for vaginal intercourse and receiving oral sex). An interesting interaction between experience and gender was noted for performing oral sex and masturbation by a partner. In both instances, past experience had no effect on men's pleasure ratings, but *reduced* women's ratings. This suggests that women believed these activities would be more pleasurable than they turned out to be.

Men's pleasure rating were higher than women's for anal intercourse and performing oral sex. The anal intercourse finding is not surprising given that anal intercourse can be painful for women. The oral sex results are consistent with Purnine, Carey, and Jorgensen (1994), who found that men enjoy giving and receiving oral sex more than women do. In the present study, the lack of gender differences with regard to receiving (as opposed to giving) oral sex and with regard to vaginal intercourse may reflect ceiling effects: men's and women's mean pleasure ratings for receiving oral sex were 4.72 and 4.64, respectively, and their ratings for vaginal intercourse were 4.72 and 4.52. Women reported greater pleasure for being masturbated by a partner than did men. This result supports Denny and colleagues' (1984) finding that foreplay is more important to women than men (foreplay may include more than just masturbation by a partner, of course).

For women, higher pleasure ratings were correlated with increased behavioural frequency for all of the behaviours examined except anal intercourse. For men, pleasure was only associated with increased frequency of selfmasturbation and performing oral sex. These gender differences are surprising in that previous research suggests that pleasure is a stronger motivation for men than for women (Browning et al., 2000; Caroll et al., 1985; Hill & Preston, 1996; Leigh, 1989; Nelson, 1978; Whitley, 1988). The relatively small number of men in this study may have limited the power to detect significant associations between pleasure and behavioural frequency.

Moreover, lack of sexual opportunity could have obscured significant relationships (Leigh, 1989). That is, someone might enjoy an activity and therefore be highly motivated to engage in it, but might have little opportunity to try or repeat it, either because he/she is unable to find a sexual partner, or because the available partners are unwilling to engage in that particular activity. With regard to the first of these possibilities, we examined whether respondents' pleasure ratings differed as a function of their current dating status (dichotomised as not dating or dating one or more persons). Only one significant finding was obtained: Respondents in dating relationships rated vaginal intercourse as more pleasurable than did those who were not dating anyone, $4.68 \pm .60$ vs. $4.46 \pm .69$, $t(144.20) = -2.37$, $p < .02$. However, dating relationships and sexual relationships,

as assessed in the present study, were not necessarily coextensive. Over a quarter of respondents who were not currently dating nevertheless reported having one or more sex partners in the past three months. In short, sexual behaviour is influenced by myriad factors, such as the availability of willing partners, that can limit sexual activity despite an individual's motivation. Conversely, sexual motivation might be counteracted by any of a number of personal, cultural, or societal influences, such as moral or religious objections to premarital or casual sex (Evans, 1989). In our sample, eight people reported having no sexual partners in the past three months despite being in one or more dating relationships.

The first two hypotheses addressed in this study presume that pleasure operates via two rather different motivational pathways. The first hypothesis posits that the *anticipation* of pleasure leads individuals to engage in particular sexual acts, hence pleasurability ratings for particular acts should be correlated with experience with these acts. In contrast, the second hypothesis applies only to individuals who have previous experience with a particular act. It presumes that the pleasure experienced during past sexual activities motivates people to repeat those activities, hence behavioural frequency should be positively correlated with pleasure ratings.

There is a fine distinction between anticipated pleasure and experienced pleasure. The anticipation of pleasure can arise from past pleasurable experiences as well as from other sources, such as socially normative expectations. Sex, after all, is *supposed* to be pleasurable. But sexual acts are not expected to be equally pleasurable. For example, it seems reasonable to assume that most women anticipate greater pleasure from their first experience with vaginal intercourse than their first experience with anal intercourse (the small number of women in this study who had never experienced vaginal intercourse precluded a direct test of this hypothesis). Past experiences with a particular activity obviously influence the anticipated pleasure associated with a particular behaviour, and it is this anticipation of pleasure that drives behaviour. Antici pated pleasure is a complex function of past experience, social/cultural norms, and individual expectancies that may relate to the particular partner or situation. The present research is unable to distinguish between these various sources of sexual motivation.

Significant correlations were found between pleasure ratings for several different sexual activities, suggesting that some people may find sex inherently more pleasurable than do other people (see also Browning et al., 2000; Leigh, 1989; Nelson, 1978). Moreover, the "pleasure index" (a summary pleasure score) results suggest that people who find sex inherently more pleasurable engage in more sexual activities, and do so more frequently, with greater numbers of partners. It is possible that people become more sexually discriminating as they become older and more sexually experienced, in which case one would expect the associations between pleasure ratings for different sexual activities to wane as (some) people develop into "sexual gourmets".

The results of the present study are generally supportive of an evolutionary role for sexual pleasure (Abramson & Pinkerton, 1995; Buss, 1994; Diamond, 1997; Symons, 1979; Tiger, 1992). They indicate that people who believe a particular sexual activity is pleasurable are more likely to engage in that activity, and that those who enjoy an activity engage in that activity more frequently. These findings are precisely what one would expect if sexual pleasure—or more accurately, the *anticipation* of pleasure—were a motivator for sexual activity, hence reproduction, as suggested by evolutionary accounts of pleasure. One also would expect that the capacity to experience sexual pleasure would be a fundamental trait, and therefore that pleasure ratings would be correlated across behaviours, as was observed in the present study.

These results are limited by several factors. First, a self-report survey instrument was used to collect information about participants' own sexual behaviours. Self-reported data can be subject to social desirability and recall biases (Berk, Abramson, & Okami, 1995; Catania, Gibson, Chitwood, & Coates, 1990). Also, respondents were drawn from a convenience sample of students taking a sexuality course at a major university. Students who elect to take such a course may hold more liberal attitudes toward sex and may engage in a wider variety of sexual behaviours than other students or members of the general population (Zuckerman, Tushup, & Finner, 1976).

Our sample consisted, in nearly equal thirds, of Asian-American and White students and students from other racial/ethnic groups. These groups differed in experience with various sexual behaviours, frequency with which behaviours were performed, and in the number of lifetime sex partners. However, there were no ethnic group differences in the pleasure ratings assigned to the various sexual behaviours. The lack of pleasure rating differences may be the result of the small ethnic group samples. A larger sample of persons from various demographic backgrounds is needed to test the generalisability of the present results.

Finally, this study was correlational in nature and therefore cannot establish direction of causation. Thus, although it appears that pleasure motivates sex, we can not eliminate the alternative explanation—namely, that sexual experience increases sexual pleasure. Moreover, most of the effect sizes were small. Possibly this was due to the masking effect of a lack of sexual opportunities, or to personal, cultural, or societal influences (as discussed above), or possibly to a weakness in the hypotheses themselves (i.e., perhaps pleasure and sexual behaviour are only weakly associated).

The "pleasure index" findings are suggestive of a general hedonistic tendency among some respondents. Future studies need to examine this construct and its relationship to related traits, such as erotophobia-erotophilia or sexual sensation seeking (Byrne & Schulte, 1990; Eysenck, 1976; Kalichman et al., 1994; Pinkerton & Abramson, 1995). Also, this study did not examine why respondents enjoy particular sexual activities. Reinholtz and Muehlenhard (1995) found that enjoyment of sex was positively correlated with positive genital perceptions and negatively correlated with negative genital perceptions.

Other possible factors that could influence whether someone finds a particular sex act pleasurable could include physical sensation, love/physical closeness, feelings of sharing, and psychosocial factors, such as gender-role socialisation, cultural norms, religiosity, depression, and erotophobia-erotophilia, among others. More research is needed to explore the multidimensional experience of sexual pleasure.

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