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The Dual-Mode Theory of affective responses to exercise in metatheoretical context: I. Initial impetus, basic postulates, and philosophical framework

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The exercise psychology literature is replete with assertions that 'exercise makes people feel better'. However, this appears to be inconsistent with the high prevalence of physical inactivity and drop-out rates. Recent empirical findings, based on a new methodological platform, have demonstrated that the exercise-affect relationship is complex, exhibiting both a dose-response pattern and substantial inter-individual variability. The Dual-Mode Theory was developed to (a) bridge mind-focused and body-focused approaches for explaining the exercise-affect relationship, (b) provide a fit to extant data by accounting for patterns of dose-response and inter-individual variability, and (c) be consistent with information from exercise physiology and emerging evidence on the neural basis of affect. Investigations based on the Dual-Mode Theory could inform the ongoing debate on the role of somatic influences in generating affective responses and guide interventions designed to improve the affective responses of exercisers. A selective review of phenomenological accounts that served as the philosophical basis of the theory supports the thesis that affect has a dual basis, being driven by cognition in many circumstances but by direct somatic cues when homeostasis is challenged.

Keywords: exercise; physical activity; affect; phenomenology; embodiment

The study of the affective responses to single bouts of exercise has been one of the focal and most prolific research areas within exercise psychology for the past four decades. Textbooks and major reviews of this literature agree that the main finding emanating from the hundreds of studies that have been conducted during this period can be summed up in the phrase 'exercise makes you feel better' (e.g., Fox, 1999, p. 413). The consistency and robustness of this finding, as reflected in the published literature, seems remarkable.

Given the possible implications of this 'feel-better' effect for public mental health and well-being, it is perhaps not surprising that, over time, this phenomenon became the only aspect of the exercise-affect relationship receiving systematic attention. As one indicator, the hypotheses that have been proposed to explain the mechanistic basis of the exercise-affect relationship (e.g., the endorphin hypothesis, the monoamine hypothesis, the cognitive-behavioral hypothesis) have all targeted only one phenomenon, namely 'affective beneficence' (Morgan, 1985), usually operationalized as

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'anxiolysis' (i.e., a reduction in state anxiety; Raglin & Morgan, 1987) or mood enhancement (e.g., Berger & Owen, 1983). This focus on the 'feel-better' effect might have also been fostered by the fact that, according to research, this phenomenon appears surprisingly resistant to the influence of most moderators. For example, although perhaps most people who have some experience with exercise would attest that the intensity of exercise can attenuate its 'feel-better' properties, or even make it feel unpleasant, the literature (at least until very recently) did not appear to reflect this. Expert reviewers have concluded that 'studies of both acute and chronic exercise indicate that intensity may not be an important factor for psychological *benefits*' (Dunn & Blair, 1997, p. 58, italics added).

Although the exercise psychology literature seems to strongly support the notion that 'exercise makes you feel better', there are some signs that this might not be in line with public perception. For example, in many advertising campaigns, which are presumably based on marketing surveys and focus group sessions, various contraptions or concoctions are offered as ways of obtaining health, fitness, or weight loss benefits without having to resort to exercise, which is often portrayed as 'painful', 'uncomfortable', 'exhausting', or 'boring'.

Likewise, a skeptic might argue that if the only effect of exercise were to make people 'feel better', perhaps not as many people would be physically inactive (also see Backhouse, Ekkekakis, Biddle, Foskett, & Williams, 2007). According to estimates published in the literature, 'roughly 80 to 90%' of participants report feeling better when they exercise (Morgan & O'Connor, 1988), whereas two-thirds of adults do not meet the current recommendation of at least 30 minutes of moderate activity on five to seven days per week (e.g., Jones *et al.*, 1998). Considerable evidence from social psychology (e.g., Emmons & Diener, 1986), behavioral economics (Kahneman, 1999; Loewenstein & Lerner, 2003; Mellers, 2000, 2004; Mellers & McGraw, 2001; Mellers, Schwartz, Ho, & Ritov, 1997; Slovic, Finucane, Peters, & MacGregor, 2002), physiology (Cabanac, 1992), and affective neuroscience (e.g., Bechara, Damasio, & Damasio, 2000, 2003; Naqvi, Shiv, & Bechara, 2006) suggests that affect plays an important role in the human decision-making process. Thus, as a general rule, people tend to gravitate toward pursuits that make them feel better. On the contrary, they tend to avoid pursuits that make them feel worse or perhaps those that, even if somewhat pleasant, cannot compete successfully with other, more pleasant alternatives for the limited free time that most people have available. If exercise produced only the touted almost-universal 'feel-better' effect, would two-thirds of people consistently avoid exercise? This is certainly not the case with other activities that most people find pleasant, such as eating a tasty meal when hungry, resting after a tiring day, or engaging in sexual relationships. Yet, when humans are offered a choice between physically active and sedentary behavioral options, most individuals choose the sedentary ones (Vara & Epstein, 1993).

The contrast between the portrayal of the affective impact of exercise in the scientific and the popular press is striking enough to make one wonder whether there is more to the exercise-affect relationship than just the 'feel-better' phenomenon. Is it possible that some of the people some of the time may indeed find exercise 'painful', 'uncomfortable', 'exhausting', or 'boring'? Although this seems like an intriguing possibility, worthy of research attention, it is not one that is often raised in the exercise psychology literature. One might say that this notion is considered controversial, even incendiary, by many researchers in the field. Perhaps this is

due to 40 years of being immersed in and having invested time and effort on the positive and uplifting notion that 'exercise makes you feel better'. Alternatively, this could be due to a fear that opening the door to the idea that exercise might induce affective changes other than the well-publicized 'feel-better' effect could jeopardize the noble and important cause of promoting healthful exercise to the public. Whatever the reasons, the mission of scientists is to seek the truth, even when it conflicts with personal hopes, preconceived notions, or good intentions.

The purpose of the present article is to substantiate the need for a fresh look at the exercise-affect relationship. Its five specific aims are to (a) summarize recent evidence illustrating that the exercise-affect relationship is more complex than implied by the 'exercise makes you feel better' cliché, (b) build a case for the necessity of a new hypothesis-generating theoretical framework that can help move this line of research forward, (c) identify the desired features of the new theory, (d) describe the postulates of the Dual-Mode Theory as an idea that satisfies the specified requirements, and (e) outline the philosophical framework in which this new theory is embedded. The subsequent articles in the series will examine the limitations of dualistic views of affect, of both the 'bodiless head' (in the second article) and the 'headless body' varieties (in the third article), culminating (in the fourth article) with a review of theoretical formulations based on the idea of dual-route mechanisms (bottom-up and top-down) for eliciting and controlling affective responses. The ultimate goal of this series is to situate the Dual-Mode Theory within a meta-theoretical framework, specifying its historical antecedents and highlighting its implications for questions of broad psychological interest.

The critical role of methodology

An obvious starting point for exploring whether exercise could, in fact, have other effects, beyond the 'feel-better' one, is to critically reexamine the standard methodological platform that formed the basis of the research conducted over the past 40 years. Four issues of potential importance are summarized here (for a more detailed analysis and references, see Backhouse *et al.*, 2007; Ekkekakis, Hall, & Petruzzello, 2008; Ekkekakis & Petruzzello, 1999, 2000).

First is the issue of the measurement of affect. In the vast majority of published studies, the impact of exercise on the affective domain has been examined in terms of changes in a small sample of distinct variables, such as certain mood states (e.g., tension, vigor) or state anxiety. However, these states cover only a small portion of the global domain of human affect and there is no reason to believe that they can fully encapsulate the affective states elicited by all different types and amounts of physical activity in all possible samples of participants or under all possible combinations of experimental conditions. It is reasonable to assume that, under certain conditions, exercise might induce significant changes in other, untapped regions of the affective domain (Ekkekakis & Petruzzello, 2000).

The second issue refers to the timing of the assessment protocol used to sample the affective response to exercise. Most studies have typically employed a simple pretest-posttest design. Although this would be adequate if the interim changes in the assessed variables were linear, it would misrepresent the shape of the affective response if the changes were non-linear (e.g., a curvilinear decline during exercise, followed by a rapid positive rebound post-exercise; see Bixby, Spalding, & Hatfield,

2001). Basic principles of response sampling dictate that sampling must be frequent enough to faithfully reproduce the shape of the response that is being studied. Otherwise, the assessment protocol will yield a distorted picture of what transpired.

The third issue pertains to the standardization of exercise intensity. Studies of the exercise-affect relationship have largely followed the convention established in other areas of experimental research within exercise science by defining exercise intensity in terms of percentages of measured or estimated maximal exercise capacity (i.e., maximal heart rate or oxygen uptake). As common as this practice has become, it is not considered an effective way of standardizing exercise intensity across participants. According to authorities in exercise physiology, it is 'no longer justifiable' (Whipp, 1996, p. 88) and 'fundamentally flawed' (Gaesser & Poole, 1996, p. 43). The reason is that two individuals, even of the same gender, age, and general physical condition, when exercising at the same percentage of maximal capacity (e.g., 70%), might operate within two substantially different metabolic 'domains', characterized by a multitude of physiological differences (e.g., autonomic, neuroendocrine, or related to the acid-base balance in the muscle environment).

The fourth methodological issue of interest deals with the models of data analysis. The approach typically employed in analyzing exercise-induced affective changes is based on the general linear model, in which the focus is on average change. Inter-individual variation is treated as error. However, it has become clear that not all individuals respond to the same exercise stimulus in the same way. There are substantial differences not only in the magnitude (Gauvin & Brawley, 1993) but also in the direction of change (Van Landuyt, Ekkekakis, Hall, & Petruzzello, 2000). Thus, if one sub-group of participants reports affective change in one direction over the course of an exercise bout (e.g., increased pleasure) while another sub-group reports change of the same magnitude but in the opposite direction (e.g., reduced pleasure or increased displeasure), the two divergent trends would effectively cancel each other out, leading to the erroneous conclusion that the exercise stimulus produced no change.

A new wave of exercise-affect research

Recent years have witnessed the advent of studies that examine the exercise-affect relationship from a new methodological platform that addresses the four aforementioned issues. In response to the first issue, affect is assessed not in terms of a small sample of distinct affective states but rather in terms of broad dimensions theorized to define the global affective space (for an overview, see Ekkekakis & Petruzzello, 2002a). In response to the second issue, assessment protocols sample affect at multiple time points, both during and after the exercise bout, to provide an accurate and comprehensive representation of the shape of the affective response over time (Bixby *et al.*, 2001; Hall, Ekkekakis, & Petruzzello, 2002). In response to the third issue, these newer studies have defined exercise intensity not in terms of percentages of maximal capacity but rather in terms of important physiological landmarks, such as the lactate or ventilatory threshold (Bixby *et al.*, 2001; Ekkekakis, Hall, & Petruzzello, 2004; Hall *et al.*, 2002; Kilpatrick, Kraemer, Bartholomew, Acevedo, & Jarreau, 2007; Rose & Parfitt, 2007; Welch, Hulley, Ferguson, & Beauchamp, 2007) or the onset of blood lactate accumulation (Acevedo, Kraemer, Haltom,& Tryniecki, 2003; Parfitt, Rose, & Burgess, 2006). In response to the fourth issue, studies have

begun to examine affective change not only at the level of the group aggregate (i.e., on average) but also at the level of individuals and sub-groups (Ekkekakis, Hall, & Petruzzello, 2005a, 2008; Parfitt *et al.*, 2006; Rose & Parfitt, 2007; Van Landuyt *et al.*, 2000).

Collectively, these changes constitute the first major reform of the methodological platform that has been employed in the study of the exercise-affect relationship since the beginning of this line of research in the late 1960s. The payoff has been a host of promising new insights. The picture that has emerged has been one of a richness, complexity, and psychological interest that extends well beyond the 'exercise makes you feel better' stereotype. Perhaps principal among the new discoveries has been the emergence of a reliable dose-response pattern, after decades of inconclusive data (Ekkekakis & Petruzzello, 1999). Several studies, conducted at multiple independent laboratories, have provided evidence that the exercise intensity corresponding to the ventilatory or lactate threshold represents a 'turning point', beyond which the positivity of affect begins to decline (Acevedo *et al.*, 2003; Bixby *et al.*, 2001; Ekkekakis *et al.*, 2004, 2008; Hall *et al.*, 2002; Kilpatrick *et al.*, 2007; Parfitt *et al.*, 2006; Rose & Parfitt, 2007).

Furthermore, the new studies have supported the notion that the dose-response relationship between the intensity of exercise and affective responses cannot be effectively modeled by a single, universal curve (such as the time-honored inverted-U). There are clearly not only substantial individual differences in the magnitude (Gauvin & Brawley, 1993) and direction of change (Van Landuyt *et al.*, 2000) but also systematic, intensity-dependent shifts in the patterns of inter-individual variability (Ekkekakis *et al.*, 2005a, 2008; Parfitt *et al.*, 2006; Rose & Parfitt, 2007; Welch *et al.*, 2007). These seem to hold psychological significance and, therefore, should not be overlooked. More broadly, this new research has established that the exercise-affect relationship is complex and multifaceted and, as suspected, is not limited to 'exercise makes you feel better'. This implies that the mechanistic basis of the exercise-affect relationship is also more complex than originally thought, since it is responsible for the elicitation of a much wider range of phenomena than just the 'feel-better' effect (Ekkekakis & Acevedo, 2006).

The need for a new theoretical framework: desiderata and challenges

The recent studies of the exercise-affect relationship are making it apparent that the relationship is not monolithic. This, then, creates the challenge of developing a new, broader theoretical framework that can help propel this line of research forward by providing a basis for deriving testable hypotheses. Besides the standard requirements of testability and falsifiability that all theoretical propositions should satisfy (Popper, 1962), what are some of the other specific desiderata for this new theory?

Firstly – and this is certainly a lofty goal – it should ideally help bridge the persistent gap between mind-focused and body-focused approaches to the study of the exercise-affect relationship (see reviews by Hatfield, 1991; Morgan, 1985). Currently, this gap manifests itself as two very distinct and insular sets of mechanistic hypotheses, one labelled cognitive or psychological (e.g., the cognitive-behavioral and distraction hypotheses) and the other labeled physiological or biological (e.g., the endorphin and monoamine hypotheses). The underlying epistemological principles and the language employed by the researchers examining each set of

hypotheses are clearly different and, until now, there has been no sign of convergence or cross-fertilization between the two camps. Even if the convergence under a common meta-theoretical or epistemological worldview remains an unattainable vision, the new theory should, at a minimum, allow both researchers with a social–cognitive perspective on affective responses and those in neuroscience or psychobiology to derive hypotheses from a common framework and contribute information to a common knowledge base. Although this will undoubtedly prove to be a challenging undertaking, it is not the chimera that it might have once seemed. The doctrine of multilevel analysis has proven both practical and fertile in such new integrative areas as social neuroscience (Berntson & Cacioppo, 2003; Cacioppo & Berntson, 1992; Cacioppo, Berntson, Sheridan, & McClintock, 2000) and affective neuroscience (Davidson, 2003; Davidson & Sutton, 1995). Furthermore, bold new ideas, such as Damasio's 'somatic marker hypothesis' (Damasio, 1996), are making the mind–body dichotomy seem increasingly obsolete (Damasio, 1995, 2000, 2003) and could serve as a useful roadmap.

Secondly, the new theoretical framework should acknowledge that affective responses to exercise constitute a multi-layered phenomenon. On one end of the spectrum, there are changes in 'basic' (Ekkekakis & Petruzzello, 2000) or 'core' affect (Russell, 2003; Russell & Feldman Barrett, 1999). These are exemplified by the fatigue emanating directly from the body after a tiring run on a hot and humid day or the 'pure' sense of physical energy and exhilaration (a 'high,' according to some) that a relatively fit individual might experience during a power walk or a vigorous 'spinning' class. An introspective exercise should reveal that these responses, both undeniably affective (unpleasant or pleasant, respectively), do not necessitate the causal influence of thought. We do not need to weigh pros and cons, contemplate implications for our well-being, or make any other projections into the future to feel them. On the other end of the spectrum, there are complex, culturally-framed, appraisal-dependent emotions. These are exemplified by the fear, anxiety, and insecurity experienced by a patient in a cardiac rehabilitation program during the first exercise session after having suffered a heart attack or the pride experienced by an elderly, formerly sedentary individual after being able to exercise continuously for 30 minutes for the first time since becoming physically active. In this case, an introspective exercise should reveal a specific antecedent cognitive appraisal behind each response (recognizing the presence of an immediate, life-threatening danger in one case and the accomplishment of an important personal goal in the other). The displeasure of fear and the pleasure of pride are still distinctly felt but are now accompanied by a multitude of other ingredients that collectively constitute the emotions of fear and pride (cognitive appraisals, causal attributions, etc.). Studies of the exercise-affect relationship have notoriously disregarded the differences between these levels of affective phenomena (Ekkekakis & Petruzzello, 2000), even as their importance was becoming increasingly apparent in the general psychology literature (Batson, Shaw, & Oleson, 1992; Russell & Feldman Barrett, 1999; Russell, 2003). Recognizing that certain variants of affective experiences do whereas others do not stem from cognitive appraisals has direct implications for a mechanistic theory since, presumably, not all variants of pleasant or unpleasant responses would originate from the same mechanism.

Thirdly, the new theory should account for the dose-response patterns that recent studies have uncovered (summarized in the previous section). An important

supplement to this requirement is that the new theory should account not only for the positive or pleasant affective responses that exercise might induce, but also for any negative or unpleasant responses. As noted earlier, besides the difficulty of delineating a system capable of eliciting both pleasant and unpleasant affective responses with all their nuances and gradations, this requirement is also likely to prove challenging due to the fact that it might be perceived as endangering the agenda of promoting exercise to the public as a panacea-like health behavior. Presently, the closest thing to a theoretical model of the dose-response relationship available in the literature dealing with the exercise-affect relationship is the inverted-U (e.g., Kirkcaldy & Shephard, 1990; Ojanen, 1994). This model predicts that an exercise intensity that is 'too low' would be ineffective, an intensity that is 'too high' would be ineffective or even aversive, whereas mid-range intensities generally optimize the conditions for affective beneficence. However, the inverted-U has certain limitations, primary among them being that it does not fit the extant empirical data well (Ekkekakis & Petruzzello, 1999). Furthermore, as a unitary stimulus-response model, it does not account for the phenomenon of inter-individual variability in affective responses and, as a purely descriptive model, it does not provide a mechanistic explanation for the postulated dose-response pattern.

Fourthly, as alluded to in the previous paragraph, the new theory should incorporate a reasonable set of propositions for explaining both the phenomenon of inter-individual variability in affective responses to an identical exercise stimulus and the phenomenon of systematic, intensity-dependent changes in the patterns of inter-individual variability (Ekkekakis *et al.*, 2005a). In other words, what can explain the fact that, while performing a session of exercise with carefully standardized physiological demands, one individual might report increases whereas another might report decreases in pleasure? Moreover, how can we explain the fact that, at certain levels of intensity, most individuals report increased pleasure, at others most individuals report decreased pleasure, and at others affective changes might vary greatly from one individual to the next?

Fifthly, the new theory should incorporate a well-founded scheme for the physiological demands of exercise. This is essentially a prerequisite for attempting to establish a reliable and biologically defensible dose-response pattern. What complicates this effort is the fact that there is currently no universally agreed upon classification system for distinguishing different levels of exercise intensity.

Sixthly, the new theory should be informed by evidence emerging from neuroscience and should be accompanied by tenable neural underpinnings. It has been said that 'we need to temper behavioral and cognitive views of affect with what we know about the neurophysiology and neurochemical foundations of emotional behavior' because, otherwise, our theories could degenerate into an 'empty boxology' (Lang, 1994, p. 219), neurally untenable collections of boxes and arrows. The progress that has been made both in understanding the neural bases of affective responses (Damasio, 1995; Davidson & Sutton, 1995) and the relationship between interoceptive afferent signals and affective responses (Craig, 2002) is truly remarkable. Although, with few exceptions (e.g., Craig, 2006), this research rarely considers exercise as the stimulus for eliciting affective responses, there is an adequate basis for drawing at least some reasonable preliminary inferences. Perhaps a greater challenge lies in convincing researchers to transcend traditional disciplinary boundaries and learn to appreciate the value of neuroscientific evidence. Echoing the beliefs of many

at the time, Lazarus (1986) wrote several years ago that 'neurophysiological concepts are generally inadequate templates for psychological concepts' (p. 245). This point of view essentially places these two levels of analysis in an infertile antagonistic relationship. The key to moving forward lies in the realization that each level of analysis can contribute unique information, so, as long as the channels of interdisciplinary communication remain open, tackling problems from multiple levels of analysis probably holds more promise than relying upon any single level.

What could be the payoff?

Assuming that a new theoretical framework will be successful in providing at least some new insights into the patterns of affective responses to exercise and the mechanisms underlying these responses, the potential benefits are considerable. One could envision advances in at least two different but perhaps equally important arenas, one theoretical and the other applied. Firstly, from a theoretical standpoint, this area of research could become one of the few cases in which research on exercise could meaningfully inform the discourse in theoretical affective psychology. This is because delineating the role of cognition and peripheral physiology (i.e., the 'mind' and the 'body') in the genesis of affective responses has historically been one of the most hotly debated and controversial aspects of most major theories in this area, from James to Schachter to Damasio. Researchers in affective psychology have used exercise in efforts to manipulate the level of somatic activation and, thus, delineate the contribution of the 'body', as opposed to the 'mind', in shaping affective responses, within various theoretical frameworks (e.g., Cantor, Zillman, & Bryant, 1975; Erber & Erber, 2000; Sinclair, Hoffman, Mark, Martin, & Pickering, 1994; Zillman & Bryant, 1974; Zillman, Katcher, & Milavsky, 1972). Arguably, most such efforts have had substantial weaknesses. For example, there was no stated rationale for selecting the intensity or duration of the exercise stimuli that were used and no serious effort to standardize these stimuli across participants using physiological principles or methods. Likewise, some of the hypotheses have been somewhat unrefined, even puzzling. As a case in point, Erber and Erber (2000) hypothesized that exercise would 'attenuate' happy or sad moods previously elicited by watching videos, apparently ignoring the fact that exercise has been shown in hundreds of studies to elicit significant changes in 'mood' (Thayer, 2000). This situation illustrates that there is ample room for theoretically and methodologically sound exercise research in this area, a void which research in exercise psychology has so far left unfilled. Does exercise produce affectively 'vacuous' arousal, which can then be 'colored' by the 'mind' and transformed into different affective states? Or does the exercise-induced activation carry an 'inherent' affective charge, be it positive or negative? Such questions have direct implications for the extent of the cognitive influence on affect and the importance of input from the body.

Secondly, shedding light into the patterns of affective responses to exercise, as well as the mechanisms underlying such responses, is also interesting from a practical standpoint. Although definitive empirical evidence is still lacking, there is good reason to believe that affective responses to exercise bouts might be linked to long-term exercise adherence (for example, see the correlational studies of Kiviniemi, Voss-Humke, & Seifert, 2007; Williams *et al.*, 2008). Understanding what drives affective responses to exercise could lay the foundation for appropriate intervention

methods for regulating and optimizing these responses. For example, inasmuch as affective responses are controlled by cognitive processes, practitioners could recommend cognitive techniques, such as attentional dissociation, cognitive restructuring, or bolstering self-efficacy. Likewise, inasmuch as affective responses are determined by personality traits, such as those influencing somatosensory modulation (Ekkekakis, Hall, & Petruzzello, 2005b), practitioners could take this information into account in tailoring exercise prescriptions to individuals. Finally, inasmuch as affective responses stem directly from the body, in a cognitively unmediated fashion, techniques aimed at improving the self-monitoring and self-regulation of peripheral physiological activity, such as those based on principles of biofeedback, could be used (Ekkekakis & Petruzzello, 2002b). Sorting out the relative contribution of these factors seems crucial. For example, if cognition was shown to have a limited range of effectiveness and its contribution was rendered relatively minor beyond a certain range of exercise intensity, insistence on the part of the practitioner on cognitive techniques, particularly with obese, elderly, or otherwise physically vulnerable populations, could lead to frustration and consistently aversive exercise experiences among the participants.

The Dual-Mode Theory: a synopsis of basic tenets

The Dual-Mode Theory (DMT) of exercise-induced affective responses was developed in response to the aforementioned new requirements of the evolving landscape in the exercise-affect literature. The postulates of this theoretical formulation have been published in both abbreviated (Ekkekakis, 2003) and more detailed form (Ekkekakis, 2005). Likewise, the basis of the DMT in evolutionary theory (Ekkekakis *et al.*, 2005a) and its putative neural underpinnings (Ekkekakis & Acevedo, 2006) have been delineated elsewhere. What remains in order to complete the presentation is to specify the position of the DMT within the broader context of psychological theory and metatheory. This is a component of central importance in delineating what Cronbach and Meehl (1955) described as the 'nomological network' or the 'interlocking system of laws' (p. 290) that surrounds the DMT. It is essential to illustrate that, even though the DMT is focused on exercise, the theory is relevant to, and therefore has implications for, a wide range of issues in psychological theory. Thus, this presentation should aid researchers in discovering the theoretical basis of the DMT, understanding its relationship to previous or alternative theoretical formulations, and, perhaps most importantly, recognizing the implications of DMT-derived hypotheses to issues of broader theoretical interest.

The DMT is fundamentally based upon a set of core assumptions derived from evolutionary theory (see Ekkekakis *et al.*, 2005a, for a detailed discussion and references). First, it is assumed that physical activity has been an essential component of the conditions that shaped human evolution. Second, affective responses are manifestations of mechanisms that evolved, through the process of natural selection, due to their ability to promote health and well-being or to solve recurrent adaptational problems, with pleasure signifying utility and displeasure signifying danger. Third, affective responses, including those that originate in the body, depend on a hierarchically organized system involving multiple layers of control, from oligosynaptic, subcortical, and evolutionarily primitive pathways at the bottom and polysynaptic, evolutionarily recent, cortical pathways at the top.

Fourth, evolutionarily primitive functions exhibit less inter-individual variation, whereas functions that are evolutionarily recent show larger variation, since they are mainly determined by individual developmental histories.

Given this evolutionary framework, it follows that the intensity of exercise should also be examined in terms of its adaptational significance. In other words, one should consider the implications of each level of exercise intensity for adaptation, health, and survival. It is also important to avoid basing a categorization of exercise intensity upon ephemeral conventions and, instead, employ a scheme well-grounded in physiology. The DMT follows a three-domain typology of exercise intensity that has received considerable support within exercise physiology (Gaesser & Poole, 1996; Wasserman, Hansen, Sue, Casaburi, & Whipp, 1999). The domain of 'moderate' intensity covers the intensities up to the lactate threshold, the highest level that can be maintained without a buildup of lactate. Over time, lactate removal mechanisms can catch up to lactate production and, thus, lactate levels can again stabilize, albeit at a higher concentration. The highest level of intensity that permits this stabilization has been called the maximum lactate steady state, often also referred to as the level of critical power. The domain of intensity that extends from the lactate threshold to the level of critical power is called the domain of 'heavy' intensity. Finally, the range of intensity from the level of critical power to the point of maximal oxygen uptake has been characterized as the 'very heavy' or 'severe' domain. Within this range, the maintenance of a steady state is no longer possible, critical physiological parameters, such as oxygen uptake and lactate accumulation, rise continuously and exhaustion ensues within a finite and relatively short period of time.

Presumably, exercise performed within the moderate domain of intensity is consistently beneficial as it is essential for subsistence activities (hunting and gathering) and promotes the healthful effects of exercise without seriously challenging the maintenance of homeostasis or raising the risk of injury or exhaustion. On the other end of the spectrum, exercise performed within the very heavy or severe domain consistently raises the adaptational risk and should, therefore, be limited to short emergency periods in order to keep the chances of causing irreparable damage low. Between these two extremes, exercise performed within the domain of heavy intensity essentially represents a trade-off between potential benefits and potential risks. On the one hand, this level of intensity might help one cover more ground or perform more work more quickly and might, therefore, yield an adaptational benefit (i.e., provide increased opportunities for gaining access to food resources and potential mates). On the other hand, this intensity, if continued over an extended period of time, challenges several physiological systems, brings one closer to biological limits and, consequently, can pose a serious adaptational risk.

According to the DMT, the affective responses to exercise reflect the adaptational implications of the three domains of intensity. When exercise intensity is consistently adaptive (i.e., within the moderate domain), affective responses are expected to be predominantly positive. Conversely, when exercise intensity is consistently maladaptive, affective responses are expected to be mostly negative. Of the two trends, the latter is expected to be stronger (the affective decline being almost universal within the very heavy or severe domain). This is due to a 'negativity bias' in affective responses (Cacioppo, Gardner, & Berntson, 1997) resulting from the fact that, usually, negative affect and associated withdrawal behaviors have a higher adaptational value or a more immediate adaptational payoff (e.g., avoiding impending

death) than positive affect and associated approach behaviors. Finally, given the mixed adaptational significance of exercise performed within the heavy domain of intensity, affective responses are expected to be characterized by substantial inter-individual variability, with some individuals responding with positive and others responding with negative affective changes.

What are the mechanisms underlying these responses? As noted earlier, response variability is theorized to reflect the workings of evolutionarily recent mechanisms (such as those originating in the cerebral frontal cortex), which tend to be flexible, complex, and multivariate (i.e., taking into account multiple, diverse considerations). On the other hand, response homogeneity probably reflects the workings of evolutionarily older mechanisms (such as those in the brainstem or limbic system), which, by comparison, tend to be less flexible or more 'automatic' and 'obligatory'. The initial explorations of the sources of inter-individual variability in affective responses to exercise have pointed mainly to two broad clusters of variables. One consists of cognitive factors, the most extensively studied being self-efficacy (e.g., Bozoian, Rejeski, & McAuley, 1994; McAuley & Courneya, 1992; McAuley, Talbot, & Martinez, 1999; Mihalko, McAuley, & Bane, 1996). The other consists of physiological variables, such as heart rate, ventilation, respiratory rate, oxygen consumption, and blood lactate (e.g., Acevedo *et al.*, 2003; Acevedo, Rinehardt, & Kraemer, 1994; Hardy & Rejeski, 1989). Systematic research into a third cluster of variables, namely psychobiologic traits related to somatosensory modulation, is only now beginning to emerge (Ekkekakis *et al.*, 2005b). At this stage, the greatest challenge is to decipher how these variables function within an integrated system, how they interact and co-determine the affective responses to exercise.

The DMT posits that affective responses to exercise are the products of the continuous interplay between two general factors, namely (a) relevant cognitive processes originating primarily in the frontal 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 changes in peripheral physiology, which can reach the affective centers of the brain via multiple oligosynaptic, subcortical pathways (Ekkekakis & Acevedo, 2006). The relative salience of these two factors is hypothesized to shift systematically as a function of exercise intensity. Specifically, cognitive factors should be dominant at lower levels of intensity (in the moderate and, primarily, the heavy domain), whereas interoceptive cues should gain salience when the intensity does not permit the maintenance of a physiological steady state (primarily, in the very heavy or severe domain).

At this early stage, the DMT does appear to satisfy the key desiderata outlined above. It offers a system for integrating mind-based and body-based approaches to the study of the exercise-affect relationship. By fully endorsing the doctrine of multi-level analysis, it permits researchers in disciplines as diverse as social–cognitive psychology and affective neuroscience to contribute information to a common and mutually beneficial knowledge base. It recognizes that affective responses to exercise can take a wide range of forms, from variants that emerge in a cognitively unmediated fashion from the body (i.e., to signal critical homeostatic perturbations) to variants that rely upon cognitive appraisals (e.g., in response to perceived social conditions). It proposes a specific and testable dose-response model, incorporating the possibility of both pleasant and unpleasant responses. While maintaining that

affective responses to exercise can be meaningfully predicted, it does not assume that all individuals would respond in the same way to the same exercise stimulus. Instead, it addresses the issue of the inter-individual variability in affective responses and makes predictions about the intensity-dependent shifts in the patterns and underlying causes of this variability. In sum, arguably, the DMT could serve as a reasonable hypothesis-generating framework at the present stage of knowledge development in the study of the exercise-affect relationship.

The philosophical context

Before laying the groundwork for examining the links between the DMT and other theoretical formulations, it is useful to first draw a broad philosophical outline. This is meant as a window into the set of considerations that influenced the development of the DMT and by no means constitutes a systematic treatise on the enormously complex philosophical topic of the mind–body relationship. More specifically, the purpose of this overview is to highlight that, within the constant oscillation between ontological or metaphysical perspectives favoring either idealism or corporeal realism, philosophers on both sides have recognized that, in some cases, consciousness is defined by thoughts or affects resulting from thoughts, whereas in others, particularly those that are critical to survival (e.g., involve significant homeostatic perturbations), strong, unfiltered directives emerging directly from the body dominate. This theme, which transcends the philosophical accounts summarized here, formed the core of the philosophical basis of the DMT. The essential lesson derived from these accounts is that any attempt to understand consciousness in general, and affect in particular, as something that resides exclusively within either the mental or the corporeal sphere is bound to prove deficient.

Plato is often portrayed as one of the most ardent proponents of idealism (translated excerpts are from Cooper, 1997). It was Plato who asserted that 'desire is not a matter of the body' (Philebus 35c) and that emotions like 'wrath, fear, longing, lamentations, love, jealousy, malice, and other things like that' are only 'within the soul itself' (Philebus 47e; also see Laws X 896e-897b). Yet, upon closer examination, in Plato's thought the soul is not independent of the body. Instead, the body can, under certain circumstances, exert control over the soul, from which the soul seeks to escape: 'Indeed, the soul reasons best when none of these senses troubles it, neither hearing or sight, nor pain nor pleasure, but when it is most by itself, taking leave of the body and as far as possible having no contact or association with it in its search for reality' (Phaedo 65c). In many cases, however, the body's hold on the soul is so strong that independence is simply unattainable. In these cases, the soul is 'imprisoned in and clinging to the body' and it is forced to view things as if 'in a cage and not by itself' (Phaedo 82e). Affective responses ('pleasure' or 'pain') arising from the body are the instruments of its control on the soul:

> Every pleasure and every pain provides, as it were, another nail to rivet the soul to the body and to weld them together. It makes the soul corporeal, so that it believes the truth is what the body says it is. As it shares the beliefs and delights of the body, I think it inevitably comes to share its ways and manner of life and is unable ever to reach Hades in a pure state; it is always full of body (Phaedo 83d).

Aristotle's ideas are commonly seen as the antithesis to Plato's idealism (translated excerpts are from Barnes, 1984). His critique of Plato's beliefs on the relationship between body and soul could be applied directly to modern constructivism:

> The view we have just been examining, in company with most theories about the soul, involves the following absurdity: they all join a soul to a body, or place it in a body, without adding any specification for the reason of their union, or of the bodily conditions required for it. Yet such explanation can scarcely be omitted; for some community of nature is presupposed by the fact that the one acts and the other is acted upon, the one moves and the other is moved ... All however that these thinkers do is to describe the specific characteristics of the soul; they do not try to determine anything about the body which is to contain it (On the soul, Book I, 407b14–21).

According to Aristotle, 'there seems to be no case in which the soul can act or be acted upon without involving the body; e.g., anger, courage, appetite, and sensation generally' (On the soul, Book I, 403a7). Therefore, 'it seems that all the affections of soul involve a body' (On the soul, Book I, 403a16). Furthermore, 'sensation, memory, passion, appetite and desire in general, and, in addition, pleasure and pain' are 'attributes of body and soul in conjunction' (Sense and sensibilia, 436a8–9). In summary, 'it is obvious that the affections of soul are enmattered accounts' (On the soul, Book I, 403a25) and 'it is clear that the soul is inseparable from its body' (On the soul, Book II, 413a4).

Twenty-two centuries later, Descartes was responsible for swinging the pendulum back toward dualism and idealism. Yet, again upon closer inspection, it becomes clear that Descartes found it impossible to defend a complete separation between mind and body (Markie, 1992). This was due to the distinctive and often uncontrollable immediacy of the body that characterizes certain parts of the human experience. He tried persistently, yet unconvincingly, to find a defensible alternative to simple dualism that could account for what he called 'the close and intimate union of our mind with the body' (Descartes, 1644/1985, p. 209) while maintaining the distinction between the two (Rorty, 1992; Schmaltz, 1992). According to Descartes, this experiential 'union' manifests itself most clearly in three domains: 'appetites' like hunger and thirst, 'emotions or passions of the mind which do not consist of thought alone' such as anger, joy, sadness, and love, and 'all the sensations' such as pain, pleasure, smell, taste, etc. In his *Sixth Meditation*, Descartes (1641/1984) wrote:

> There is nothing that my own nature teaches me more vividly than that I have a body, and that when I feel pain there is something wrong with the body, and that when I am hungry or thirsty the body needs food or drink and so on ... Nature also teaches me, by these sensations of pain, hunger, thirst and so on, that I am not merely present in my body as a sailor is present in a ship, but that I am very closely joined and, as it were, intermingled with it, so that I and the body form a unit. If this were not so, I, who am nothing but a thinking thing, would not feel pain when the body was hurt, but would perceive the damage purely by the intellect, just as a sailor perceives by sight if anything in his ship is broken (p. 56).

While this may not constitute a formal refutation of dualism, in this and other passages (see Schmaltz, 1992, for a review), Descartes expressed his frustration with the fact that he could not find a rational explanation for the experiential unity between mind and body. Following Descartes, the conceptual dominance of dualism continued in Western thought essentially uninterrupted (challenged only by Spinoza's *Ethics*) until the late nineteenth century. Although operating in an

essentially dualistic framework ('dualist interactionism'; see Natsoulas, 1998), William James, influenced by the writings of Darwin (1872/1965), can be credited with attempting to reestablish a symmetry between cognition and direct sensory perception in human experience. While acknowledging the 'omnipresence of cognition' (James, 1890/1980a, p. 186), James also emphasized the omnipresence of the body:

> Our own bodily position, attitude, condition, is one of the things of which *some* awareness, however inattentive, invariably accompanies the knowledge of whatever else we know. We think; and as we think we feel our bodily selves as the seat of the thinking. If the thinking be *our* thinking, it must be suffused through all its parts with the peculiar warmth and intimacy that make it come as ours (p. 242).

This 'warmth and intimacy' is derived directly from the body: 'we feel the whole cubic mass of our body all the while, it gives us an unceasing sense of personal existence' (James, 1890/1980a, p. 333). Discussing the bases of emotions, in particular, he noted that 'everyone of the bodily changes, whatsoever it be, is FELT, acutely or obscurely, the moment it occurs' (James, 1890/1980b, pp. 450–451). For James, this feeling of bodily changes is the core of emotional experience: 'If we fancy some strong emotion, and then try to abstract from our consciousness of it all the feelings of its bodily symptoms, we find we have nothing left behind, no "mind-stuff" out of which the emotion can be constituted, and that a cold and neutral state of intellectual perception is all that remains' (James, 1890/1980b, p. 451).

James' ideas had a significant impact on the way that the phenomenologists of the twentieth century came to view the body. According to Husserl, for instance, the 'I' is not just a 'thinking thing', as Descartes had maintained, but has a body as well as a 'soul' (or 'psyche') and the two form an 'indivisible totality' (Husserl, 1954/1970, p. 220), 'a concrete unity' (Husserl, 1952/1989, p. 168), or 'a genuine experiential unity' (Husserl, 1952/1989, p. 176). Thus, for Husserl, the 'empirical *I*' is an 'embodied, psychophysical, human *I*' (Woodruff Smith, 1995, p. 346). In Husserl's terms, sensations from the body were described as 'hyletic data' (from the Greek *hyle*, matter). Hyletic data are conceived as *pre-reflective* experiences (Gallagher, 1986) of the 'living body' (as opposed to a 'physical body'; Husserl, 1954/1970, p. 107). A dominant theme in Husserl's philosophy is that 'a human being's total consciousness is in a certain sense, by means of its hyletic substrate, bound to the Body' (Husserl, 1952/1989, p. 160). Using pain as an example to present his own interpretation of the notion of 'hyletic data', Gallagher (1986) wrote: 'It is not the body as objectified in consciousness that experiences the pain, it is the lived body that lives through the hyletic experience' (p. 143). Importantly, Husserl distinguished between 'Bodily' and 'extra-Bodily' experiences. The former, due to the unity of body and soul 'are apprehended as properly belonging to [the] human subject, i.e., are apprehended as "mine"'. The latter 'have indeed a "meaning", but they have no soul, no meaning which points to a psychic subject really connected to them, connected into a single founded reality' (Husserl, 1952/1989, p. 102).

The role of the body in human experience was further explored by Merleau-Ponty (1962). He argued that 'perception is ... already charged with a meaning' (p. 4). This is largely because the body possesses a tacit, 'latent knowledge' of the world, 'a knowledge anterior to cognitive experience' (Gallagher, 1995, p. 233) which gives it the capacity for 'prenoetic performances' (p. 233). According to Merleau-Ponty

(1962), 'there is a logic of the world to which my body in its entirety conforms' (p. 326). Furthermore, because we exist as bodies and our bodies are the subject of consciousness, our freedom is limited:

> A consciousness for which the world 'can be taken for granted', which finds it 'already constituted' and present even in consciousness itself, does not *absolutely* choose either its being or its manner of being. What then is freedom? ... The world is already constituted, but also never completely constituted; in the first case we are acted upon, in the second we are open to an infinite number of possibilities. But this analysis is still abstract, for we exist in both ways at once. There is, therefore, never determinism and never absolute choice' (Merleau-Ponty, 1962, p. 453).

Despite his efforts to overcome both the Cartesian and the Husserlian variants of dualism, Sartre has been criticized for espousing an essentially dualistic perspective in claiming that consciousness is immaterial (Barnes, 1992) and not subject to biological constraints. As an example, Sartre (1943/1956) discussed whether he was 'free' to continue a tiring hike with friends beyond the point where 'fatigue increases and finally becomes very painful' (p. 584). Sartre was convinced that 'the fatigue by itself could not provoke my decision [to stop or continue]' (p. 585). Instead, 'a reflective consciousness is directed upon my fatigue in order to live it and to confer on it a value and a practical relation to myself. It is only on this plane that the fatigue will appear to me as bearable or intolerable. It will never be anything in itself ...' (p. 586). Many people who have experienced the state where physical fatigue turns into exhaustion would probably find Sartre's account dubious. Responding to Sartre more than half a century later, Baumeister and Sommer (1997) wrote: 'We agree that he could probably have stopped elsewhere; but that does not mean that his stopping there was a conscious product of free will. Instead, it seems more likely that the automatic processing of inner cues pertaining to fatigue and other factors prompted him to stop when the cues reached a certain criterion, and so he automatically stopped there' (p. 80). In fact, elsewhere, Sartre himself asserted that '*my* body is a conscious structure of my consciousness' (Sartre, 1943/1956, p. 434) and that 'the body is *lived* and not *known*' (p. 427). Physiological signals are immediately experienced as pleasant or unpleasant (Sartre, 1939/1948). What about symbolic appraisal? 'We are first inclined to exaggerate the primacy of the representative, to feel that there must always be a representation to arouse the feeling. Nothing is further from the truth' (Sartre, 1940/1948, p. 100).

In modern philosophical explorations of the mind, embodiment is a strong emerging theme (Johnson, 1987; Lakoff & Johnson, 1999; Leder, 1990; Varela, Thompson, & Rosch, 1991). Of particular interest to this review is the analysis presented by Leder (1990). Leder noted that the inattention and occasional disdain toward the role of the body in some phenomenological accounts may be due to the tendency of the body to 'recede' from consciousness (and volitional control) when it functions within normal, healthy parameters. On the other hand, accounts that view the body as antagonistic to the mind may be explained by the tendency of the body to 'dys-appear' (to use Leder's illustrative term), that is to make its presence felt under conditions of dysfunction. In such cases, the body and the salient affective cues arising from it seem to dominate consciousness, severely limiting the mind's ability to disregard its directives. As Leder observed, 'the viscera seem most able and most articulate in relation to dysfunction' and, thus, the 'interoceptive vocabulary

is ... most developed in relation to pain' (p. 40). What Leder calls 'pain' is a generic term that describes the 'affective call' (p. 73) associated with 'sensory intensification' (p. 71).

Among many examples, Leder discussed the case of a tennis player experiencing a heart attack. As long as his physiological function was normal, interoceptive cues like 'sweat, breath, and effort' remained mostly outside awareness, allowing the tennis player to concentrate on the game. However, 'when the character of these [bodily sensations] changed from those of vigorous well-being to the unpleasant, it is as if a magnet had reversed poles, reorganizing the experiential field inward' (p. 73). The tennis player is then 'seized by a power holding sway over him' (p. 73). And Leder reminds us that this powerful hold is not limited to disease states, such as a heart attack, but applies to all cases in which 'normal physiology reaches certain functional limits' (p. 84), including 'enduring a long-distance run' (p. 79).

The theme that emerges from this overview is that phenomenologists who have dealt with the body to some extent, despite their differences and signs of adherence to dualistic or idealistic principles, seem to reject the notion of the body as a detached and distant source of peripheral information that merely communicates information to central cognitive processors. Instead, most have argued that we live our bodies, we do not simply know that they exist and that they function. The body forms the foundation and sets the boundaries of our cognition and our consciousness. In other words, human consciousness is embodied. This is particularly true when one approaches certain physiological limits of possible relevance to adaptation and survival. In such cases, philosophers from Plato to Leder agree that all ostensible rifts between *mind* and *body* vanish. The unity that emerges may not have a gentle or pleasant 'feel', but it is precisely through its harshness and unpleasantness that it succeeds in ensuring the establishment of an adaptationally sensible hierarchy of goals: survival comes first.

The implications for the mechanistic basis of affective responses to exercise start to become apparent. Over much of the range of exercise intensity, as long as homeostasis is not being critically jeopardized, the meaning of interoceptive cues remains cognitively malleable and cognition can potentially maintain a certain degree of independence or detachment from the body. Consequently, affective responses over this range may be determined by a multitude of cognitive appraisals (e.g., self-perceptions, situational evaluations, future projections). For example, one individual may experience pride by contemplating the achieved fitness gains, another may feel embarrassment after appraising a failure to meet perceived expectations, and yet a third individual may daydream about chores or issues altogether unrelated to exercise. On the other hand, when homeostasis is being challenged or is seriously disrupted, affect – and consciousness – become dominated by an inexorable and indomitable sense of unity with the body. It seems that affect (more specifically, displeasure) becomes the gripping force via which attention is focused on the exercise task and plans are instantly redrawn. The capacity of thought to modify the content of consciousness is diminished, to ensure that the adaptational need will not lose any of its urgency. The result is that the motivation or desire to continue exercising at the same level of intensity quickly evaporates and the homeostatic threat subsides.

The purpose of the present series

Despite its focus on physical activity and its fundamentally interdisciplinary subject matter, exercise psychology has not been impervious to dualistic influences (Acevedo & Ekkekakis, 2006). As a relatively new scientific field and one that has traditionally adopted an insular or isolationist approach, having limited interactions with related disciplines like psychology or philosophy, it also has not been immune to a tendency to adopt and reproduce assumptions in an uncritical manner. However, assumptions such as whether affective responses to exercise originate 'in the mind' or 'in the body' can have tremendous implications for both theory development and clinical practice. The simplicity of adhering to popular catchphrases such as 'exercise makes you feel better' or 'mind over muscle' might be comforting but it clearly underestimates both the theoretical interest and the complexity of the phenomenon under study. This approach also does not seem to be optimal for stimulating growth by generating new hypotheses and advancing knowledge.

The purpose of the present series is to elaborate on the theoretical basis of the DMT. However, in addition, by so doing, it aims to stimulate a more general intellectual discussion on the theoretical significance and the future of research on the exercise-affect relationship. Over a decade ago, Morgan (1997) wrote: 'There is no need for further research or reviews dealing with the question of whether or not physical activity results in improved mood. There are, however, many questions that remain unanswered, and these questions will hopefully be addressed in the decade ahead' (p. 230). The decade is now over but the progress that Morgan had envisioned has been slow. This is probably not a function of the number of studies being conducted, as there is no visible sign that the rates of publication and research have decelerated. Instead, perhaps a more likely explanation relates to an apparent unwillingness to recognize the profound theoretical implications of this line of research and, consequently, the continued absence of a broad theoretical dialogue. The accompanying papers will hopefully help initiate this dialogue by focusing on (a) a critical review of several dualistic assumptions relevant to the exercise-affect relationship that have been endorsed in the exercise psychology literature over the years and (b) a summary of theoretical formulations from general psychology that have been aimed at overcoming the dualistic barrier and have influenced the formulation of the DMT.

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