Associative / Dissociative Cognitive Strategies in Sustained Physical Activity: Literature Review and Proposal for a Mindfulness-Based Conceptual Model

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Associative / Dissociative Cognitive Strategies in Sustained Physical Activity: Literature Review and Proposal for a Mindfulness-Based Conceptual Model

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We reviewed and summarize the extant literature on associative/dissociative cognitive strategies used by athletes and others in circumstances necessitating periods of sustained attention. This review covers studies published since a prior publication by Masters and Ogles (1998), and, in keeping with their approach, offers a methodological critique of the literature. We conclude that the distinction between associative and dissociative strategies has outlived its usefulness since initially proposed in an earlier era of ground-breaking research by Morgan and Pollock (1977) that was influenced to some extent by psychodynamic thinking. In recent years there has been an evolutionary shift in concepts of sustained attention toward mindfulness—moment-by-moment attention—that has had a significant impact on conceptual models and clinical practice in diverse areas including stress management, psychotherapy, and athletic performance. We propose that future research on cognitive activity in sustained performance settings be embedded in a mindfulness-based conceptual model.

The dichotomous terms "association" and "dissociation" (A/D) have been used for years to describe alternative cognitive strategies or predispositions for attention allocation in long distance runners and other athletes engaged in time-extended sports, following a pioneering study of marathon runners by Morgan and Pollock (1977). Twenty years later, Masters and Ogles (1998) published a comprehensive review of the preceding twenty years of research in this area, posing the question, "What do we know?" These authors made several cogent recommendations to encourage further research, recommended against continuing use of this dichotomous terminology, and called for development of a new conceptual/theoretical model to guide work in this area.

The purpose of this paper is to revisit research on attention allocation ten years after the Masters and Ogles (1998) article, in effect posing the question, "What have we learned in the past 10 years, about cognitive strategies in exercise, and are we any closer to developing a unifying theory?" It is our purpose to: (a)

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briefly discuss the meaning of A/D in exercise contexts, (b) summarize Masters and Ogles (1998) findings and critique of research in this area, (c) provide a detailed literature review of research in this area, and (d) discuss an emerging conceptual model of attention allocation based on *mindfulness* that is increasingly cited and integrated in contemporary clinical practice. Such a model may provide a useful explanatory framework to incorporate prior terminology, and inform the course of subsequent research.

Morgan and Pollock (1977) investigated psychological characteristics of world-class marathon runners to determine what makes them uniquely suited to the arduous and highly stressful nature of long-distance running and training. One issue related to prolonged physical activity concerned mental activity, and in particular attention allocation during multiple hours of constant, unremitting, and repetitive fast-paced movement. They assessed this via the following query: "Describe what you think about during a long distance run or marathon. What sorts of thought processes take place as a run progresses?" (p. 384). Implicit in this question was an understanding that physical activity generates a constant flow of perceptible interoceptive (organ-based), kinesthetic (movement-based), and proprioceptive (spatially-based) cues that may be the object of focused attention, and which collectively contribute to an integrative, cognitively-based sense of perceived exertion or effort.

It was reasonably assumed that long distance running is inherently stressful, and that unremitting exposure to internal cues related to effort needed to sustain a satisfactory pace would logically contribute to that stress. Of course, depending on external environmental conditions, the flow and pattern of internal cues vary as a function of imposed demands, resulting in greater or lesser degrees of salience, and perhaps eventual habituation during prolonged steady-state exertion. This latter state might generate its own peculiar stress in the form of boredom due to a relatively invariant internal "landscape", seemingly devoid of attentional value or interest.

In any case, the potential availability of cues contributing to a sense of perceived effort was viewed by Morgan and Pollock (1977) as one source of running-related stress, which could be reduced by directing attention elsewhere, for instance to external stimuli. In fact, in another study reported by Morgan and Pollock (1977), nonelite runners reported actively engaging in cognitive activity predominantly unrelated to running, lending support to this interpretation. The authors termed this pattern "dissociative cognitive rehearsal" and provided numerous examples of stories, narratives, and cognitive activities used by these runners as an alternative to focusing attention on effort-related somatic cues. The authors presumed that this "tuning out" process was the result of discomfort associated with somatic cues.

Although this use of the word dissociative is not meant to imply a clinical psychopathological condition, the word dissociation has been used for many years in the context of contemporary clinical nosology. In the context of physical activity, the term is intended to refer to a time-limited separation between cognitive activity and somatic perception under voluntary control. However, these two uses of dissociative are at least implicitly linked by the psychodynamic origins of the term, which refers to disconnecting or diverting conscious awareness from painful psychic or physical stimuli. One problem with continued use of this term is that the psychological theory on which it was based has been supplanted by cognitive models that are more open to empirical investigation.

As initially reported by Morgan and Pollock (1977), and supported by subsequent research, cognitive strategies characterized as dissociative appeared to be widespread among nonelite runners and other athletes. In contrast, elite runners reported patterns of cognitive activity which Morgan and Pollock (1977) described as "associative", meaning they directed their attention to running-related somatic cues, and used this information to inform the perception of effort involved in training and racing. This is a highly efficient way to "fine-tune" the allocation of energy resources to meet physical demands. However, both association and dissociation were characterized as "coping strategies" in the context of the perception of effort (Figure 7, p. 400), which implies adaptation to an inherently stressful, perhaps even noxious state. Nonetheless, one significant factor differentiating elite from nonelite runners is that the former operate at comparatively high levels of mechanical and metabolic efficiency. This efficiency tends to reduce perceived effort, and presumably the noxious quality of certain somatic sensations, such as muscle strain, reducing the need for dissociative coping. Seen from this vantage point, the term associative is also somewhat unsatisfactory because of its characterization as a coping strategy, a term that implies a response to noxious circumstances.

Anecdotal evidence clearly supports the view that cognitive processes during periods of sustained exertion are much more varied and richer than would be implied by this dichotomous model. Heinrich's (2001) autobiographical description of ultra-marathon running, for example, amply attests to the active variability of cognitive processing that occur at such times in the mind of a highly accomplished runner. Both a biologist and runner, he hypothesized that humans are extremely well adapted for this purpose from an evolutionary standpoint. His description of running reveals a highly flexible pattern of cognitive processing in which attention is variously allocated to random thoughts, physiological cues, and motivational "self-talk", all of which can vary on a moment-by-moment basis. Despite ample anecdotal evidence that cognitive processing during prolonged exertion involves wide variability in attention allocation, numerous studies continued to employ A/D terminology, despite Masters and Ogles' (1998) compelling recommendation that it be discontinued. We agree with the need for a shift in emphasis for the following reasons. First, the term dissociation retains lingering connotations of clinical psychopathology. Second, the use of dichotomous terminology itself connotes a view of cognitive activity that is static and categorical, rather than variable and dimensional. Third, these terms were originally defined as coping strategies and thus limit associative connotations to "stress", "effort", and other such terms with negative affective valences. However, such terms as "peak" or "flow experiences" (Csikszentmihalyi, 1990) commonly described by runners and others engaged in prolonged exertion suggest that the range of detectable experiences is potentially quite broad. For example, Heinrich (2001, p. 20) describes becoming "…lost in streams of consciousness and in long periods when introspection reached back to near unconsciousness...", which he described as a "runner's trance".

Whereas past research relied on dichotomous A/D terminology, Tenenbaum views association and dissociation as poles of an attentional dimension (Tenenbaum, 2001; Tenenbaum & Hutchinson 2007), emphasizing the dynamic nature of cognitive processing during sustained physical activity. Based in Social Cognitive Theory (SCT), Tenenbaum's model emphasizes the influence of perceived self-efficacy

(*SE*; Bandura, 1997) on task performance. This perspective proposes that attention allocation during prolonged physical activity (distance running, for example) varies as a function of perceived *SE*, in conjunction with other variables including ratings of perceived exertion (RPE), goal orientation, perceived competence (mastery and control), commitment, determination, and effort. Perceived exertion in particular largely determines the extent to which attention allocation is associative (high RPE) or dissociative (low RPE).

Review of the Literature

Masters and Ogles (1998) summarized research on cognitive strategies used by long distance runners through 1996. Their review included a summary table of A/D studies, enumerating various methods of measuring A/D available at the time. They called for the development of increasingly sophisticated measurement techniques, use of more rigorous experimental designs, and establishing linkages to a broader range of performance outcome measures than were in use at the time. They also recommended that use of the term dissociation be discontinued, and perhaps (at least implicitly) as well the use of dichotomous terminology. Summarizing the results of published studies at the time, they concluded that whereas associative strategies were linked to comparatively fast performance, dissociative patterns favored reduced perceived exertion and endurance. They concluded their review by calling for development of a theory or at least conceptual model that would not only encompass A/D phenomena, but one that would also perhaps be more broadly based and less indelibly associated with clinical psychopathology.

In reviewing the A/D literature, we used Masters and Ogles (1998) paper as a foundation. We conducted a search of published studies including, but not limited to, those cited in their article to assess overall research trends. Our purpose in doing so was to provide a detailed summary of how research methodology has evolved, what new knowledge has been gained, and to discuss a theoretical perspective that could be used to guide subsequent research. We limited our research to published studies employing A/D terminology, identifying a total of fifty studies published between 1977 and 2008 on the basis of literature searches using OVID and PUBMED databases. These studies are summarized in Table 1, which is organized according to research design, beginning with randomized control trials (RCTs), the "gold standard" of clinical research and concluding with observational, noncontrolled studies. Entries for each study include author(s), participants, sample size, etc. An explanatory key was developed to help interpret table entries related to A/D strategies, necessitated by the fact that numerous tasks and definitions have been employed.

Critique of the Associative/Dissociative Literature

Overview

Beginning with Morgan and Pollock's (1977) research, more than half of the A/D studies summarized here focused on running, though not necessarily of a prolonged

Table 1 Outcome Summary of Association / Dissociation Studies

Author(s)	Participants & Sample Size	Experimental Groups	Experimental Task	Outcomes
		Randomized control study / between subject		
Coote & Tenenbaum, 1998	48 female undergraduates Mean age = 19.42, *SD* = 3.60	DI[3] (5) DI (7) CC [4] (1)	Endurance: Handgrip @ 50% max. gripping power	• DI (5) improved by 28% • DI (7) improved by 30.5% • CC declined by 3.7%
Johnson & Siegel, 1992	44 female undergraduates Mean age = 21.3, ± 4.9	A [1] (1; 2) DE [2] (2) DI (4) CC (1)	Endurance: Cycling @ 60% VO_{2max}. for 15 min	• RPE (A) > RPE (DI), $p < .05$
McCaul, Monson, & Maki, 1992	213 undergraduates (115 m, 98 f; 3 distraction levels + control)	DI (3) DE (6) CC (3)	Performance/Endurance: Cold hand compress	• SCL: highest during most distracting level • RT & Error Rate ↑ as distraction ↑, $p < .01$ • Distress: N.S. • HR & SCL: N.S.
Morgan, et al., 1983	27 male military personnel Mean age = 22.3, *SD* = .42	DE (1) DI (6) CC (1)	Endurance: treadmill walking, variable elevation @ 80% VO_{2max}.3 trials over 3 days	• Endurance (DE, DI) > Endurance (CC; no *p*-value reported)

Author(s)	Participants & Sample Size	Experimental Groups	Experimental Task	Outcomes
Okwumabua, et al., 1983	31 undergraduate runners. (11 m, 20 f) Mean age= 21.4 Age range: 17–29 years	A (1; 2) DI (1; 6) CC (2)	Performance: 5 week running class one trial/week 1 1/2 mi/session	• Running time ↑ sig. for all conditions, $F(1, 29) = 8.34$, $p < .01$ • Reduction in running time (DI) > (A; CC), N.S. • All subjects increased (A) usage throughout trials
Padgett & Hill, 1989, Exp. #1	20 Undergraduates	A (2) DE (completed a "body image" survey during task)	Performance: Cycling: 30 min (twice over 2 days)	• RPE (A) > RPE (DE; $F(1, 18) = 352.58$, $p = .004$) • Perceived Time (A) > Perceived Time (D/E), $p < .0001$
Rejeski & Kenney, 1987 Exp. #1	60 female undergraduates Age range: 18–21 years	DE (completed a "body image" survey during task) CC (1)	Endurance: hand grip @ 40% max. gripping power	• Fatigue Tolerance (DI, DI)> Fatigue Tolerance (CC)$F(2, 57) = 3.98$, $p = .02$ • Endurance: N. S. diff. between conditions
Saintsing, Richman & Bergey, 1988	50 undergraduates (31 m, 19 f)	A (2; 4) DI (1; 6) CC (1) Other [5] (1)	Performance: 1.5 mile run	• Improved running time (A) > Improved running time (DI, $p < .05$, CC, $p < .01$, Other, $p < .05$)
Spink, 1988	36 High school students (20 m,16 f) Age range: 15–17 years	DI (1) CC (1) Other (2; DI, analgesic)	Endurance: Sustained leg extension	• Extension time (Other) > Extension time (DI, CC), $F(2, 33) = 4.71$, $p < .05$ • Pain ratings: N. S.

Author(s)	Participants & Sample Size	Experimental Groups	Experimental Task	Outcomes
Stevens, 1992	48 undergraduates Mean age = 19.76, *SD* = 3.88 Age range: 18–42 years 2 groups (sensitizers or repressors) based on Modified Repression-Sensitization Scale	A (2) DI (1; 4) CC (1)	Endurance: pressure pain on finger	• Pain tolerance (DI) > Pain tolerance (A, $p < .01$, CC, $p < .05$)
Weinberg, et al., 1984, Exp. #1	60 male college runners	A (1; 2) DI (5) Other (3)	Performance: Run maximum distance in 30 min.	• RHR: N. S. . • Running Speed: N. S. • Fatigue: N. S.
Weinberg, et al., 1984, Exp. # 2	230 undergraduates. (115 m, 115 f)	A (2) DI (5) Other (3) CC (1)	Endurance: leg extension	• Endurance: (DI, Other) > (A) or (CC), $F(3, 219) = 2.96$, $p < .05$ • RHR: N. S. • SRQ: N .S.
Weinberg, 1985	120 Undergraduates (60 m, 60 f) Age range: 18–25 High or low self efficacy condition	DI (5) Other (3) Within subjects	Endurance: leg extension confederate induced high or low self-efficacy	• Endurance (High Self-efficacy) > Endurance (Low Self-efficacy; no p-value reported) • Endurance: N. S. between D/I or Other (no p-value reported)

Author(s)	Participants & Sample Size	Experimental Groups	Experimental Task	Outcomes
Baden, Warwick-Evans, & Lakomy, 2004, Exp. # 1	22 subjects from running club (14 m, 8 f) Mean age = 48.0 years, *SD* = 8.9	Dissociation/Association Scale The Borg Scale	Performance: Treadmill 8 and 10 mile outdoor runs	• Speed: N. S. • RPE: Higher during 8 mile run, F (1, 20) = 4.36, $p < .05$ • (A; 8 mi. run condition) > (D; 8 mi. run condition), F (1, 21) = 6.85, $p < .02$
Baden, Warwick-Evans, & Lakomy, 2004, Exp. # 2	*Group 1:* 18 healthy subjects (10 m, 8 f) Mean age = 21.28 (*SD*= 1.74) Age Range = 18–30 *Group 2:* 22 subjects who were prescribed an intervention program (10 m, 12 f) Mean age: 65.0 (*SD*= 5.95)	Dissociation/Association Percentages questionnaire The Borg Scale	Performance: Treadmill: 2, 10-min trials (one with 20-min. expectancy manipulation)	• RPE: Sig. higher in short condition than in long condition F (1, 38) = 8.03, $p < .01$ • "A" increased over time in both conditions. F (3, 32) = 6.31, $p < .01$
Baden, et al., 2005	16 subjects from local running club (8 m, 8 f) Mean age= 30.4 (*SD* = 4.1) -Manipulated subject time expectation	Other (4)	Performance: Treadmill running 3, 20 min. trials 75% PTRS (Peak Treadmill Running Speed)	• Oxygen consumption: VO_2 lower during "not told" trial, p < .05 • RPE: higher at 10–11 min. mark during 10 min. trial than 20 min. trial, $p < .05$ • Affect Scale: decreased (more negative affect) over all trials, $p < .01$ • Associative Thought Scale: increased across conditions, $p < .01$

Author(s)	Participants & Sample Size	Experimental Groups	Experimental Task	Outcomes
Bourdeauhij, et al., 2002	30 adolescents from 10 month weight treatment program (all severely obese and sedentary; 10 m, 20, f) Age range: 9–17 years Mean age = 13.1 ± 2.0	DE (3) CC (1)	Performance/Endurance: Treadmill running	• Running Time (DE) > Running Time (CC), $p < .01$ • Monitoring body (CC) > Monitoring body (DE), $p < .10$
Brewer & Karoly, 1989, Exp. #1 & #2	132 male undergraduates High or low pressure intensity conditions	A (1)(2) DE (1)	Endurance: Pressure Pain on shin area	• Overall: Perceived pain (A) > Perceived pain (DE), $F(1, 71) = 5.65$, $p < .03$
Butryn & Furst, 2003	30 female, non-elite runners Mean age = 31.0, (*SD* = 10.45) Age Range = 18–55	Profile of Mood States (POMS); Exercise Feeling Inventory (EFI); Thoughts During Running Scale (TDRS)	Running 2, 4-mile runs One run (park setting) One run (urban setting)	• *Urban Run:* N.S., but (A) more prevalent overall (no *p*-value reported) • *Preference:* 93% preferred park setting, 7% preferred urban setting
Fillingim & Fine, 1986	14 college freshmen (8 m, 6 f), 1 middle-aged female. All active runners. Age range: 18–20, 38	A (1; 2) DI (4) CC (1)	Performance: 1 mile indoor track run, 3 trials	• Symptom/Emotion Checklist: symptom reduction (DI) > (A), (CC), $p < .01$
Gill & Strom, 1985	34 female intercollegiate athletes Age Range: 18–22	A (2) DE (1)	Performance/Endurance: Leg extensions	• Leg extensions (D/E) > Leg extensions (A; no *p*-value reported) • Subjects preferred (D/E) vs. (A); $X^2(1) = 11.77$, $p < .01$
Harte & Eifert, 1995	10 male amateur marathoners or triathletes Mean age = 27.1 Age range: 18–37	A (1; heard own breath) DE (1; 3; heard ‘outdoor’ sounds) CC (1; No activity)	Running: Outdoors Treadmill indoors	• Adrenaline, noradrenaline, cortisol, BP $\uparrow$ after (A), (DE; 2 conditions), $p < .0001$ • RPE (A, DE) > RPE (CC)

Author(s)	Participants & Sample Size	Experimental Groups	Experimental Task	Outcomes
Hatfield, et al., 1992	12 male college cross country runners Mean age = 22 ± 1.3 years Age range: 18–31	A (1; 2; biofeedback) DE (1) CC (1)	Performance: Treadmill running: 3, 12 min. trials. Just below ventilatory threshold.	• *Feedback:* VO_2, VE, RR, VE/VCO_2, and $\bar{P}ETO_2$ (A) < VO_2, $\bar{V}E$, RR, $VE/\bar{V}CO_2$, and $\bar{P}ETO_2$ (D/E, CC; $p < .01$) • RPE: (A, D/E) < RPE (CC; no p-value reported)
Hutchinson & Tenenbaum, 2007 Exp. #1	35 undergraduates (21 m, 14, f) Mean age: 23.65, (*SD* = 3.23)	Schomer Thought Classification System	Endurance: 25% maximal handgrip	• "A" ↑ as task continued, χ^2 (1, N = 35) = 68.76, $p < .001$ • "D" ↓ as task continued, χ^2 (1, N = 35) = 16.36, $p < .001$
Hutchinson & Tenenbaum, 2007 Exp. #2	13 students (7 m, 6 f) Mean age: 26.85, (*SD* = 4.91)	Schomer Thought Classification System	Endurance: Cycling Varying VO_2 levels	• "A" ↑ = Intensity ↑, χ^2 (1, N = 13) = 90.13, $p < .001$ • "D" more prevalent at lower intensity, χ^2 (1, N = 13) = 44.63, $p < .001$
Padgett & Hill, 1989, Exp. # 2	12 university track team members (all m)	DE (1) DI (5) CC (1)	Performance: Running: 1608 meters on university track	• Running Time: (DE) < Running Time (CC; t (22) = 2.19; $p < .05$) • Perceived Time (CC) > (D/I) > D/E (N. S., $p = .27$) • RPE (DE) > (DI) > (CC), F (2,20) = 4.25, $p = .02$

Author(s)	Participants & Sample Size	Experimental Groups	Experimental Task	Outcomes
Pennebaker & Lightner, 1980, Exp. # 2	13 university undergraduates (8 m, 5 f)	DE (1) 2 conditions: I. Cross-country course II. Lap course	Performance: 1800 meters Cross-country course, ourdoor lap course	• Run Time: (Cross-country) < Run time (Lap), F (1, 12) = 10.33, $p < .01$ • HR, systolic and diastolic BP: N. S. between conditions (no *p*-value reported) • Boredom (Lap) > Boredom (Cross country), F (1, 12) = 16.77, $p < .01$
Russell & Weeks, 1994	7 male college-aged cyclists Age Range: 18–23	A (2; biofeedback) DE (4) CC (1)	Performance: Cycling 60 min. in each condition	• HR: N. S. (no *p*-value reported) • RPE: N. S., $p = .10$
Smith, et al., 1995	36 'experienced' distance runners (27 m, 9 f) Mean age: 23.6, (*SD* = 6.8) Age Range: 18–40	A (2; 4) CC (1) DE (1)	Performance: Treadmill 3, 10 min trials	• N. S. diff. across groups on physiological variables, F (6, 6) = 1.34, $p < .38$ • Least "economical" runners used "D" > Most "economical runners" • N. S. diff. in "A" used between "least" and "most" economical runners, F (4, 8) = .93, $p > .10$
Szabo, Small, & Leigh, 1999	24 students (12 m, 12 f) Mean age = 20.8, (*SD* = 0.64)	DE (3; 4 conditions) CC (1) Mixed between & within subject	Performance: Cycling Varying speeds of music.	• HR: N.S. (no *p*-value reported) • Slow-to-fast condition sig. diff. versus all other conditions on "efficiency" (work accomplished/HR above baseline), $p < .05$

Author(s)	Participants & Sample Size	Experimental Groups	Experimental Task	Outcomes
Annesi, et al., 2004	39 healthy, sedentary women Mean age: 65.3, *SD* = 7.9	A (1; 2) DE (2; 3) DI (5)	Performance: strength training 3 times/week for 10 weeks	• Reduced body fat: N. S. group differences, $t(37) = 0.72$, no *p*-value reported • Strength increase: N. S., $t(37) = 1.52$ • RPE (leg curl): N. S. group differences, $t(37) = 1.01$, no *p*-value reported
Blanchard, Rodgers, & Gauvin, 2004	69 physically active females Mean age = 24.37 Equipped with microcassette players to record thoughts	DE (2) CC (1)	Performance/Endurance: 25 or 40 min. run at 70% HRR. CC sat on bleachers	• Revitalization ↑ with presence of DE thoughts, $p < .002$ • Physical exhaustion ↓ with presence of DE thoughts, $p < .05$
Brewer, Van Raalte, & Linder, 1996	9 college cross country runners (4 m, 5 f) and 35 undergraduates (23 m, 12 f)	Attentional Focusing Questionnaire (AFQ)	Performance: Stair climbing machine: 12 min. trial	• Performance: "D" x Performance ($r = -.25$, $p < .05$; pretrial) • Performance: "A" x Performance ($r = -.37$, $p < .05$; posttrial) • (A; Cross country runners) > (A; Undergraduates) $F(1,43) = 4.33$, $p < .05$ (pretrial) • D (undergraduates) > D (cross country runners), $F(1,43) = 12.01$, $p < .05$ (pretrial)

Author(s)	Participants & Sample Size	Experimental Groups	Experimental Task	Outcomes
Clingman & Hilliard, 1990	16 experienced race-walkers (8 m, 8 f) Age Range: 33–76	A (2; 4; 2 conditions): I. Walk 'cadence' II. 'Stride Length' D/E (1) DI (1) Subjects experienced all conditions	Performance: Race Walking: 2 miles total, 4 separate 1/2 mile sessions	• Time (Cadence (A)) < Time (Stride Length (A), DE, DI), $p < .05$
Dyrlund & Wininger, 2008	200 undergraduates (74 m, 126 f) Mean age = 20.69 (*SD* = 4.41)	The Borg Scale (RPE) Attentional Focusing Questionnaire (AFQ)	Performance/endurance: Treadmill running. Assigned to 1/9 groups based on music preference and varying physical exertion (VO_2)	• High VO_2 (70%). RPE > Med/Low VO_2 Max (50%, 30%), $p < .001$ • "A" (High VO_2) > "A" (Med/Low), $p < .001$ • "Distress" (High VO_2) > "Distress" (Med/Low VO_2), $p < .001$
Morgan & Pollock, 1977	19 'world class' runners (11 middle-long distance runners, 8 marathoners) and 8 intercollegiate middle- distance runners.	State-Trait Anxiety Inventory (STAI), Physical Estimation and Attraction Scale, Running History and strategy structured interview.	Performance: Running middle, long, and marathon distances	• STAI: Subjects' scores sig. lower than college norm, $p < .05$ • Cognitive Strategies: Most runners reported using "A" strategies • RPE (Marathoners) < RPE (Middle-long distance) < RPE (Intercollegiate), $p < 0.002$ (at 11 min./ 12 mph) • VE (Middle-long distance) < VE (Marathoners) < VE (Intercollegiate), $p < .0001$

Author(s)	Participants & Sample Size	Experimental Groups	Experimental Task	Outcomes
Pennebaker & Lightner, 1980, Exp. # 1	56 university undergraduates	A (1; Heard own breath) DE (1; Heard 'outdoors' sounds) CC (1; Heard no sounds)	Endurance: Treadmill walking 3.4 mph for 10 min	• Physical symptoms (A) > Physical symptoms (D/E; p < .01), t (53) = 3.29, $p < .01$ • Perceived fatigue (A) > Perceived fatigue (D/E), t (53) = 2.33, $p < .05$ • Perceived fatigue (A) > Perceived fatigue (CC), t (53) = 1.99, $p = .05$
Tenenbaum & Connolly, 2008	30 'experienced' and 30 'novice' rowers (30 m, 30 f; divided evenly between groups) Age Range: 14–25	The Borg Scale (RPE) RG (assessed A/D)	Performance/Endurance: Rowing on ergometer. Varying intensities. Assessed RPE, A/D every 60 s	• Workload $\uparrow$ = RPE $\uparrow$, $p < .05$ • Workload $\uparrow$ = HR $\uparrow$, $p < .05$ • "A" $\uparrow$ as workload $\uparrow$ between 30% and 75% max. workload, $p < .05$
		Exploratory/Observational		
Goode & Roth, 1993	150 experienced runners (103 m, 47 f)	Profile of Mood States (POMS) Thoughts During Running Scale (TDRS) Observation based	Running	• Mood Changes: Engaging in "non-A" with vigor. Thoughts about relationships were correlated with reduction of tension and anxiety

Author(s)	Participants & Sample Size	Experimental Groups	Experimental Task	Outcomes
Acevedo, et al., 1992	112 ultra-marathon runners (86 m, 26 f) Mean age: 40.2	Sport Orientation Questionnaire forced A/D question open ended A/D question	Running: Ultra-marathon (100 miles)	• "A" and "D": N. S. diff. between finishers and non-finishers. • Forced A/D Question: equal number of "A" and "D" among runners • Open Ended Question: 75% runners' thoughts rated "external" by raters
Buman, et al., 2008	67 marathoners (40 m, 17 f) Mean age = 41.79 (*SD* = 10.05) Age Range = 24–66	Interview	Running: Retrospective analysis of past marathons	• 51% reported using 'cognitive strategies' after 'hitting the wall'. • "A" ($n = 1$) and "D" ($n = 7$) were reported after 'hitting the wall'
Masters & Lambert, 1989	48 marathon runners (30 m, 18 f) Mean age: 33.35 Age Range: 13–55	Marathon race diary Schomer Analysis	Performance: Running marathon (26.2 miles)	• Injury: N. S. relationship, D and injury t (46) = .54, $p = .59$ • Performance time x "A", r (46) = -.30, $p < .05$ • Preference: "A" most preferred during race • Pattern of Use: "D" used sig. more during miles 15–20 than in the final section between 20 and 26.2 (no p-value reported)

Author(s)	Participants & Sample Size	Experimental Groups	Experimental Task	Outcomes
Morgan, et al., 1988	14 male elite runners Mean age: 26.4, ± 2.1	State Trait Anxiety Inventory, structured Interviews	Running: Marathon (26.2 mi.)	• A (Race) > D (Race), $p < .05$ • Training: 21% (A), 43% (D), 36% (A) & (D) • Racing: 72% (A), 0% (D), 28% (A) & (D)
Ogles, et al., 1993	131 marathon runners (104 m, 27 f)	Thinking Style Questionnaire (TSQ) Bliss Scale (BS) Motivation of Marathoners Scales	Running: Marathon (26.2 mi.)	• TSQ: Training: "Internal focus" 28.8% (SD = 22.8), "External focus" 45.9% (SD = 23.0) • TSQ: Racing: "Internal focus" 52.9% (SD = 28.5), "External focus" 10.1% (SD = 13.7) • Runners that ran as a way of coping with negative emotions scored higher on BS, $r = .47$, $p < .01$

Author(s)	Participants & Sample Size	Experimental Groups	Experimental Task	Outcomes
Okwumbua, 1985	90 elite runners (82 males, 8 females) Mean age: 35.5, (SD = 9.0) Age Range: 16–64	RG	Running: Marathon (26.2 mi.)	• Longest training runs x “A”, $r = .27$, $p < .01$ • Faster goal times x “A”, r = -.31, $p < .01$ • Expectation of even pace during race x “A”, $r = -.30$, $p < .01$ • Overall during race: 60% (A), 40% (D)
Okwumabua, Meyers, & Santille, 1987	279 experienced runners over 40. (213 m, 66 f) Mean age: 47.43 Age Range: 40–71	RG	Running: (6.2 mi.)	• “A” higher before the race, • “D” higher during race • “A” higher after race • Opposite of young, elite runners during races
Schomer, 1986	12 novice runners in physical activity program (6 m, Mean age = 37.8, 6 f, Mean age = 30.8), 10 ‘average’ marathon runners (6 m, Mean age = 27.0, 4 f, Mean age = 29.8), and 9 competitive marathon runners (3 who were superior marathon runners; 6 males, Mean age = 29.3, 3 f, Mean age = 25.0)	Schomer Analysis (RG) Equipped with microcassettes to record thoughts	Running: (45–120 min at own pace)	• “A” used across groups • “A” $\uparrow$ = RPE $\uparrow$

Author(s)	Participants & Sample Size	Experimental Groups	Experimental Task	Outcomes
Silva & Appelbaum, 1989	32 volunteers from United States Olympic Marathon Trial.	Running Style Questionnaire (RSQ)	Running: Olympic Marathon Trials	• RSQ: Racers: Lower 50%ile ($n = 21$) reported using "D" strategies early and more often during race. • Top 50%ile ($n = 11$) reported shifting between "A" and "D"
Stevinson & Biddle, 1998	66 nonelite runners (56 m, 10 f) Mean age: 36.11 Age range: 21–59	RG (assessed attention, distraction, and 'hitting the wall')	Marathon (26.2 mi.)	• "Inward distraction" (D/I) higher for runners who "hit the wall", $p < .05$ • "Inward monitoring" (A) x "onset of hitting the wall", $r = -.039$, $p < .05$
Tammen, 1996	8 elite middle and long distance runners (4 m, 4 f)	The Mental Readiness Form The Borg Scale (RPE)	Performance: Running 2300 M at maximal pace on 'flat' track	• Pace ↑ = "A" ↑ • RPE ↑ = "D" ↓

Note. Each horizontal line in the "Experimental Groups" column typically indicates one experimental group/condition.

[1] Association (A): (1) breath; (2) bodily sensations; (3) nonspecific focus; (4) actively adjust body

[2] Disassociation (D), External (E): (1) focusing on external environment; (2) carrying on a conversation; (3) listening to music; (4) watch video/tv; (5) recall tasks; (6) physically manipulating environment

[3] Dissociation (D), Internal (I): (1) thinking about nonrelated task(s); (2) mental arithmetic; (3) non-arithmetic number operation (4) recall tasks; (5) pleasant imagery; (6) attention-diverting subvocalization (7); aggressive imagery

[4] Control Conditions (CC): (1) No cognitive strategy instructions; (2) relaxation instructions; (3) watch blank computer monitor

[5] Other: (1) "Psyching" up, e.g.,. emotional activation; (2) Internal dissociation plus positive suggestion; (3) positive self talk; (4) expectancy manipulation ; (5) monitor negative self-talk

Acronym key: A = Association; BP = Blood pressure; CC = Control condition; DE = Dissociation, external; DI = Dissociation, internal; HR= Heart Rate; HRR= Heart rate reserve; $PETO_2$ = Pressure of end-tidal 0_2; RG = Researcher generated; RHR = Resting heart rate; RPE = Rating of perceived exertion; RR = Respiratory rate; RT = Reaction time; SCL= Skin conductance; SRQ= Self-report questionnaire; VE = Ventrical efficiency; VO_{2max}= Maximal oxygen consumption nature. In order of decreasing frequency, activity modes reported by the 50 studies reviewed here include the following: running (29, 58%); strength/endurance (6, 12%); walking, stair climbing (5, 10%); and cycling (5, 10%). In addition, five studies (10%) employed pain-related stimuli (pressure, cold compress) to evaluate A/D tendencies. Collectively, these studies are notable for heterogeneous research methodology and wide variations in methodological rigor. Studies of A/D patterns employing randomized controlled designs are in the minority (12/50, 24%). Of the remainder, 18 (36%) are mixed within subject designs, 8 (16%) are mixed within/between designs and the remaining 12 (24%) are observational or exploratory in nature. It is interesting that, of the twelve RCTs, none involve long distance running, the focus of Morgan and Pollock's early investigations, which employed either observational (Morgan, et al., 1988) or mixed within/between-subject (Morgan & Pollock, 1977) designs. The experimental tasks used to study A/D vary considerably in standard exercise parameters (frequency, duration, intensity). In addition, the research literature is marked by variation in subject variables including age, gender, athletic experience, and background. Finally, a wide range of dependent measures have been employed to study exercise-related A/D patterns, including questionnaires, physiological (e.g., heart rate, VO_2) and psychophysiological (e.g., skin conductance) variables, and reaction time measures. As previously noted by Masters and Ogles (1998), such variability makes it difficult to discern clear trends in the data or to justify a meta-analysis. However, one fairly consistent finding beginning with Morgan and Pollock (1977) and recently reinforced by Hutchinson and Tenenbaum (2007) is a shift from dissociative to associative strategies in response to increasing task intensity. This finding suggests that A/D tendencies are fluid rather than fixed, showing more variance within than between individuals.

Validity

While Masters and Ogles (1998) analyzed many of the experimental shortcomings of past research in the area, there remain methodological issues that need to be examined more thoroughly before future research can progress. In particular, we believe the methodology of many past studies may have affected construct validity, and potentially the strength of results. For example, in terms of construct validity, past studies have included a range of measures to assess A/D, including various researcher-generated questionnaires (Brewer, Van Raalte, & Linder, 1996; Gill & Strom, 1985; Masters & Lambert, 1989; Ogles, et al., 1993–94; Okwumabua, 1985; Okwumabua, Meyers, & Santille, 1987; Stevinson & Biddle, 1998; Tenenbaum & Connolly, 2008) and interviews (Buman et al., 2008; Morgan & Pollock, 1977; Morgan, et al., 1998). Although these measures appear to have high face validity, few have been extensively validated, and the sheer variety of measures makes summarizing overall outcome trends difficult.

Overall, construct validation studies employing many of the instruments used in A/D studies are few in number and somewhat inconsistent. A study by Acevedo, Dzewaltowski, Gill, and Nobel (1992) illustrates this problem. Subjects in this study (ultra marathon runners) reported roughly equal percentages of external/dissociative thoughts (50.4% of overall running time) and internal/associative (49.6% of overall running time) thoughts during a marathon when queried using a forced-choice questionnaire. However, use of an open-ended question format resulted in 75% of the subjects' thoughts being rated as external/dissociative. This study suggests that data collection format influences results. However, several recent studies have shown more consistent results whether subjects are asked to report their thoughts aloud in-task (Hutchinson & Tenenbaum, 2007; Tenenbaum & Connolly, 2008) or to retrospectively classify their own thoughts (Tammen, 1996). Overall, however, we believe it is imperative to create core measures and/or data collection methods as a gold-standard to assess cognitive processing strategies during prolonged exertion.

Experimental Procedures and Design

The administration of A/D measures should shift toward more "real-time" analyses of attention allocation, rather than post-task/retrospective questionnaires, which are marred by procedural problems. For example, physically demanding tasks such as marathons carry risk of dehydration, which is linked to impaired fatigue estimates, perceptual discrimination, psycho-motor skills, and short-term memory loss (Cian, et al., 2000). Furthermore, posttask questionnaires are subject to primacy and recency effects (e.g., focusing on either the initial or final segment of an exercise session; Stevinson & Biddle, 1998). To circumvent this problem, several studies have equipped subjects with recording equipment during experimental tasks so they can verbalize their thoughts (Blanchard, Rodgers, & Gauvin, 2004; Schomer, 1986), a decided methodological improvement (Ericsson & Simon, 1993). However, even real-time verbal reporting introduces a time lag into the flow of experience, interrupting the flow of thought (Hayes, et al., 1999). Moreover, as noted by Masters and Ogles (1998) in reference to Schomer (1986), overt verbalizations may alter the flow of more natural cognitive processes. Realistically, any cognitive data collected during running or other endurance tasks in real time must minimally interfere with natural thought processes to obtain the most accurate data possible. Since Masters and Ogles' (1998) paper however, much research in the area of focused attention in sports and sustained physical activity continues to rely on retrospective measures and dichotomous A/D terminology, an exception being Tenenbaum's (2001) adaptation of Social Cognitive Theory. Several more current attention-focusing studies of sustained activity have included retrospective measures, such as questionnaires to assess cognitive strategies (Annesi, et al., 2004; Bourdeaudhuij, et al., 2002; LaCaille, Masters, & Heath, 2004).

While much research in the area continues to employ traditional retrospective questionnaires, several recent studies have used less invasive A/D measures *during* experimental tasks (Baden, Warwick-Evans, & Lakomy, 2004; Hutchinson & Tenenbaum, 2006; Hutchinson & Tenenbaum, 2007; Tenenbaum & Connolly, 2008; Tenenbaum & Hutchinson, 2007). These researchers informed subjects apriori about the questions they would ask, and emphasized the importance of brief responses. For example, Baden, Warwick-Evans, and Lakomy (2004) requested that subjects verbally report the percentage of thoughts that could be classified as 'associative' at ten predesignated intervals over a twenty minute period. But we question whether most subjects can accurately monitor, categorize, and quantifying their thoughts without training, a view consistent with Stevinson & Biddle (1998) who recommended psychoeducational training to improve self-report reliability and validity.

Finally, as noted by Stevinson and Biddle (1998), the inconsistent use of terminology makes it difficult to compare previous findings with more recent results. For example, Morgan and Pollock's 1977 study indicated that novices used more dissociative strategies to "push through" pain at high intensity levels. However, recent research suggests that at high intensity nonelite exercisers performing a handgrip task used association more because physiological demands appear to require direct internal attention focus (Hutchinson & Tenenbaum, 2007; Tenenbaum, 2001; Tenenbaum & Hutchinson, 2007).

Concerning experimental design, observational studies have predominated in the A/D research literature. While increased experimental design sophistication is desirable from a methodological standpoint, it does raise an important issue having to do with how best to elicit A/D strategies. Morgan and Pollock (1977) originally characterized them as coping strategies related to perception of effort. Coping strategies are commonly viewed as sustained behavior patterns acquired over time to help deal with stress, perhaps even reflecting personality characteristics. The fact that Morgan and Pollock's (1977) study was observational in nature contributes to this interpretation because no effort was made to either teach or instruct participants to use one or the other strategy; rather, as a group they uniformly reported associative tendencies. Likewise, nonelite athletes as a group tended toward dissociative patterns, the implication appearing to be that one or the other strategy was intrinsically linked to performance level, very likely as a result of long-term experience or perhaps an enduring predisposition. However, recent research has indicated that the difference in attention allocation between nonelite athletes and elite athletes is due to the mediating role of task intensity (Hutchinson & Tenenbaum, 2007; Tenenbaum, 2001).

Several studies have attempted to teach A/D strategies, but doing so raises the question of whether the strength of newly acquired A/D strategies is comparable to habitual patterns. The runners in Morgan and Pollock's (1977) study were highly experienced athletes, having trained for years to reach the pinnacle of their sport. Either as novices or over time, they employed patterns of attention allocation that favored the associative variant, which appears to be well adapted to prolonged physical activity. There may have been a self-selection process involved here, whereby increasingly high performance levels eliminated athletes whose physical and/or cognitive capabilities were less well adapted to the rigors of competition.

Perceived Effort and Intensity

The concept of "perception of effort" originally employed by Morgan and Pollock (1977) emphasized the significance of both intensity and duration as key contributory factors. We view "perceived effort" as involving a subjective sense of strain, which becomes increasingly pronounced as the demands of a given task increase. The initial choice of distance running reflected, at least in part, an interest in studying performance characteristics under highly challenging circumstances, with the intention of determining what cognitive strategies contribute to effective adaptation.

Intensity refers to the fact that elite athletes typically perform at or near peak capacities, which in the case of running means operating in the vicinity of the lactate threshold, associated with a marked increase in perceived effort. Prolonged, high intensity activity poses a particular challenge to physiological, perceptual, and cognitive domains that have a "steady state" quality. Of course, there are many variations in each of these domains over the course of a long-distance run, provided that one is attuned to them, as in the case of runners with associative tendencies. Perhaps most challenging is the cognitive domain, given the typical tendency of the mind to seek stimulation and change. The experience of highly repetitive activities may involve boredom, or other aversive mind states, particularly for those unaccustomed to prolonged mental or physical exertion. To a novice or an "outsider", the prospect of running at high intensity for a period of hours might appear unimaginable, but it is something to which one becomes habituated to over time and with practice (Heinrich, 2001).

Future Directions: A Mindfulness-Based Conceptual Model?

At present, A/D research is at a crossroads. Our review and summary of the extant literature suggests that, despite modest utility and conceptual explanatory power, this view of cognitive activity during sustained physical activity needs extensive modification to develop a broader conceptual model that incorporates, but is not limited to, A/D phenomena. Such a model could guide both observational and intervention-based studies of cognitive processes during sustained physical activity. So far, only Tenenbaum (2001) has accepted this challenge.

We believe that a new conceptual model based on *mindfulness* could provide an effective framework for further research. The foundation of this model rests in contemporary clinical research on regulation and control of attention, where it has attained prominence in stress management, psychotherapy, and, most recently, sport and athletic performance. Applying *mindfulness* to specific sports-related areas could not only help stimulate renewed interest in A/D research, but encourage new directions for future research as well (Gardner & Moore, 2007).

Mindfulness is embedded in Buddhist psychology, where it is one of several attributes of a pathway to health and harmony. Recently, it has become the focus of research and clinical practice in psychology, initially as a stress reduction program (Mindfulness-based Stress Reduction, or MBSR) developed by Kabat-Zinn (1990). MBSR has been effectively employed with a wide range of clinical populations and has influenced a form of psychotherapy known as Acceptance and Commitment Therapy, or ACT (Hayes, et al., 1999), and has more recently been applied to athletic performance (Gardner & Moore, 2007).

Mindfulness is but one of several "consciousness disciplines" (Walsh, 1980) based on self-reflective, contemplative practices to provide insight into the nature of mind and consciousness. The practice of mindfulness, as articulated by Kabat-Zinn (1990) and others, involves directing attention to present-moment experience in a nonjudgmental manner. This is deceptively simple, in that purposefully directing and sustaining attention is for most people a surprisingly challenging task, typically marked by incessant, wide-ranging, distracting, and ultimately disruptive mental activity.

Mindfulness encourages awareness of inner states, including cognitive and somatic phenomena (Brown & Ryan, 2003). It should therefore be a strong mediator of exercise-related variables such as perceived exertion, although at present there is little supportive data. However, a recent study by O'Loughlin & Zuckerman (2008) concerning mindfulness and sensitivity to physiological symptoms provides a starting point. University undergraduates (n = 265) completed a questionnaire assessing severity of recent physical symptoms, the Mindfulness Awareness and Attention Scale (or MAAS, Brown & Ryan, 2003) and provided salivary samples used to measure dehydroepiandrosterone (DHEA), a circulating steroid related to overall health and negatively correlated with aging. High mindfulness scores predicted a stronger negative relationship between DHEA and symptoms than did low mindfulness scores, suggesting that mindfulness influences concordance between perceived (questionnaire-based) and measured (DHEA) health.

Recently, Baron, Moullan, Deruelle, and Noakes (2009) proposed a model of pacing strategies for mid- and long-distance runners that is reminiscent of "mindful awareness". They describe an internalized process of "ongoing negotiation" involving factors that determine the necessary power required to complete events within a predetermined time frame. Specifically, they state that "...mental "acceptance" of the effort needed to be sustained for the duration of exercise that remains must also be managed and could be of great importance. . . " (p.3), which closely parallels use of the word 'acceptance' in the context of mindfulness, which as noted by Kabat-Zinn (1990, p. 38) connotes "...seeing things as they actually are in the present."

These studies suggest several important advantages of adopting a mindfulness-based approach to attention regulation. First, attention is viewed as a flexible cognitive capacity under voluntary control. Second, anchoring attention in the present moment is of fundamental importance. Third, attention focus can range from momentary physical sensations to cognitive and other events, depending on both intention and need. Concerning the latter, attitudinal factors are especially important, perhaps the most fundamental of which is adopting an open, accepting stance toward one's experience (Kabat-Zinn, 1990). Acceptance means being receptive to one's experience, whatever its nature, rather than avoiding things we label as unpleasant and seeking to prolong pleasant experiences. For example, "unpleasant thoughts" can be accepted and simply acknowledged, rather than suppressed or, as is often recommended, replaced by "positive thoughts" (Gardner & Moore, 2007). Proprioceptive cues provide potentially useful information if acknowledged and fully experienced, whether pleasant or not. Developing a capacity for sustained, neutral, and nonjudgmental openness to the broad domain of "conscious experience" is the hallmark of mindfulness, defined by Kabat-Zinn (1993, p. 145) as "... awareness that emerges through paying attention on purpose, in the present moment, and nonjudgmentally...".

The impact of mindfulness in stress management and psychotherapy is already widespread (Kristeller, 2007; Ludwig & Kabat-Zinn, 2008). It has been effectively applied in work with chronic pain, anxiety, and a range of medical conditions, documented in a meta-analysis by Baer (2003), reviewed by Salmon et al. (2004), and recently summarized by Brown, Ryan, and Cresswell (2007). An early athletic study by Solberg, Halvorsen, Sundgot-Borgen, Ingjer and Holen (1995) reported that attention-focused meditation may modulate immune responses to physical stress. The concept is now expanding its influence to exercise programming, sports, and athletics (Dutton, 2008; La Forge; 2005, 2007). Distance running in particular offers a fertile domain for mindfulness practice, owing to the striking parallel between sitting meditation and sustained physical activity. Both pose cognitive challenges arising from prolonged steady state conditions that foster the mind's tendency to wander, and for unregulated attention to constantly shift moment by moment. Seasoned runners and experienced meditation practitioners appear to cultivate a capacity for sustained, essentially nonjudgmental attention that can be directed at will toward a wide range of internal and external experiential cues.

Conceptual Model

The transactional model of stress first proposed by Lazarus and Folkman (1984) provides a useful first step in applying mindfulness to the stress of sustained physical activity. According to this model, stress is a function of perceived challenges (*primary appraisal*) in relation to coping resources (*secondary appraisal*). It occurs when resources are insufficient to meet apparent demands. Thus, stress is literally "in the eye of the beholder", rather than an objectively definable stimulus. Early research by Schwartz (1983) documented how chronic stress results in sustained activation of the sympathetic nervous system and hypothalamic-pituitary-adrenal axis, resulting in psychobiological dysregulation and adverse health effects. Limited awareness and avoidant tendencies (Baer, 2007) foster automated appraisal, resulting in chronic, unhealthy, and unnecessary physiological activation. Mindfulness is hypothesized to de-automate the appraisal process by bringing conscious awareness to moment-by-moment experience (Kabat-Zinn, 1990, 2003). The effect may be to foster more accurate appraisal processes (Garland, Gaylord, and Park, 2009) and either directly or indirectly reduce unwarranted physiological activation. Empirically documented mechanisms by which mindfulness and related meditation practice exert these effects have recently been summarized by Kocovski, Segal, and Battista (2009) and include neurobiological and physiological changes (reduced activation, increased sensory acuity and pain tolerance) and cognitive alterations (enhanced awareness, decreased rumination, improved attention control). Mindfulness fosters *meta-cognitive awareness,* an expansive capacity to nonjudgmentally observe thoughts and sensations that comprise the stream of ongoing consciousness (Shapiro, et al., 2006).

Applying this model to sustained physical activity is relatively straightforward. Mindful awareness is somewhat analogous to associative processing, and is hypothesized to enhance accurate appraisal and acceptance of challenges relative to coping resources, thus minimizing overall stress. For example, mindfulness could refine moment-by-moment perception of perceived exertion by increasing sensitivity to constituent interoceptive cues and limiting emotional reactivity via a nonjudgmental stance, a key attitudinal element. Mindfulness-based meta-awareness fosters awareness of potentially dysfunctional thoughts that, when unacknowledged, promote emotional distress and maladaptive physiological reactivity (Teasdale, et al., 2001). The capacity to flexibly allocate attention to any of several experiential domains (behavioral, physiological, cognitive) in a nonreactive, nonjudgment manner is perhaps the most valuable potential characteristic of mindfulness.

From a research perspective, the model invites empirical investigation using existing measures of appraisal and coping (Garland, Gaylord, & Park, 2009) and a range of recently developed questionnaire-based mindfulness assessment instruments (Baer, Walsh, & Lykins, 2009; Brown & Ryan, 2003). These can be incorporated with physiological, neurobiological, and immunological assessment procedures already used in medically-oriented mindfulness interventions (see, for example, Carlson, et al., 2003) and integrated with existing exercise research measures and procedures. One promising research avenue concerns the relationship between mindfulness and perceived exertion: sensitivity to inner states would almost sure impact ratings of effort or intensity.

Regarding practical applications, adapting existing mindfulness-based intervention protocols to athletic performance is an attractive option. The MBSR program described earlier is time-limited (8-session) and structured to provide intensive training in mindfulness practice (Salmon, et al., 2004). Aspects of the model have already been applied to enhance athletic performance (Gardner & Moore, 2007), though to date research-based outcome data are lacking. Key elements of the MBSR program (Kabat-Zinn, 1990; Salmon, et al., 2004) that are hypothesized to benefit stressful sustained physical activity include the body scan (nonjudgmental, inwardly focused progressive attention allocation throughout the body); sitting meditation (a means of cultivating nonjudgmental internal awareness); and mindfulness-based movement (Hatha Yoga) to heighten awareness of kinesthetic, interoceptive, and proprioceptive cues associated with movement patterns.

Strengths, Limitations, and Summary

We believe that a mindfulness-based attention allocation conceptual model is a viable evolutionary step in sustained exertion research. This model emphasizes the cognitive freedom to openly explore both inner cues/states and external stimuli without restricting thoughts to either associative or dissociative patterns. It acknowledges the fluidity of thought processes on a moment-by-moment basis. Based on recent mindfulness research (O'Loughin & Zuckerman, 2008), it is hypothesized that subjects employing this model may assess inner psychological and physiological states, such as fatigue, more accurately than their less mindful counterparts. However, currently there is a dearth of research involving mindfulness and attention allocation in the context of physical exertion. And the construct of mindfulness has yet to be satisfactorily operationalized, being limited at the present time largely to questionnaire-based assessment instruments (Grossman, 2008). However, we are confident that the near future will see increasing applications of mindfulness-based research in exercise science, as has been the case in clinical psychology and behavioral medicine.

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