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Autonomic Specificity for Basic Emotions: A Review of the Implication of James–Lange theory of Emotion for the Autonomic Specificity Model of Emotion

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Abstract: ***''What is an emotion?'' William James's seminal paper in Mind (1884) proposed the idea that physiological and behavioral responses precede subjective experience in emotions that are marked by ''distinct bodily expression.'' This notion has broadly inspired the investigation of emotion-specific autonomic nervous system activity, a research topic which had great longevity. The route of this literature is traced through its major theoretical challenges from the Cannon–Bard, activation, and Schachter– Singer theories, through its rich empirical history in the field of psychophysiology. Although these studies are marked by various findings, the overall trend of the research supports the notion of autonomic specificity for basic emotions. The construct of autonomic specificity continues to influence a number of core theoretical issues in affective science, such as the existence of basic or 'natural kinds' of emotion, the structure of affective space, the cognition–emotion relationship, and the function of emotion. Moreover, James's classic paper, which stimulated the emergence of psychology from philosophy and physiology in the latter nineteenth century, remains a dynamic force in contemporary emotion research.***

Keywords: Autonomic Specificity, Basic Emotions, James–Lange theory, Emotion

1. Backgrounds of the Theories of Emotion

The issue of emotion-specific autonomic nervous system (ANS) activity is arguably one of the most enduring research topics in psychology. The seeds of this issue can be found in a paper by William James, published in the journal Mind in 1884, titled ''What is an emotion?'' Emotion, pleasure, and pain were perennial topics in Mind, and James's seminal paper articulated a theory of emotional feelings that generated a line of empirical research that continues in the twenty-first century. The fertility and contemporary value of this theory attests to James's brilliance and prescience as a theorist. In the present paper, the empirical history of James's venerable theory is traced from its original 1884 publication to current biopsychological research. Emphasis is on a particular tenet of the model, which holds that basic human emotions have distinct physiological patterns. James acknowledged major obstacles in testing his model experimentally, but the notion of physiologic discriminability among emotions has been proven to be empirically accessible. James's theory was a catalyst for many research programs in emotion, and has stimulated a lively debate that continues in contemporary affective science. This exposition begins with a brief synopsis of James's personal history, leading up to the publication of the Mind paper and its expanded version in The Principles of Psychology (James, 1890). Details of the James–Lange theory of emotion are then presented, with special reference to its implications for the autonomic specificity model of emotion. Subsequent major challenges to James's theory of emotion are reviewed: the Cannon–Bard model, activation theory, and the influential Schachter–Singer (1962) study. Empirical evidence for autonomic specificity is then examined, from early studies to contemporary psychophysiological[1] research (see Kreibig, this issue, for detailed examination of this evidence). The relevance of autonomic specificity for major theoretical issues in affective science, such as the existence of basic or 'natural kinds' of emotion and the depiction of affective space, is then considered. Finally, the impact of James's Mind paper and its associated theory of emotion are considered in retrospect.

2. Biography of William James

William James (1842–1910) came from a prominent 19th century intellectual New York family (see Pajares, 2002, for a chronology of James's life). His father, Henry James Sr., was an affluent philosopher and theologian who put strong emphasis on his children's education. William, the eldest child of five children, which included novelist Henry James, entered the Lawrence Scientific School of Harvard (1861), and spent the rest of his academic and professional career at Harvard. He received his doctor of medicine from Harvard Medical School (1869), was appointed Instructor of Anatomy and Physiology at Harvard (1873), and began teaching a psychology course there circa 1875 (James, 1895, cited in Green, 2001). This course in scientific psychology was the first of its kind in the United States of America (Benjamin, 2007). Associated with the course was arguably the first laboratory of experimental psychology in the U.S., although it was for the purposes of classroom demonstration rather than the conduct of original research.

James's career flourished at Harvard. He was appointed Assistant Professor of Physiology (1876), and shortly thereafter began work on his classic text, The Principles of Psychology (1890; henceforth referred to as Principles). In a chapter in this work titled The Emotions, James elaborated the emotion theory of the 1884 Mind paper, correcting some misleading aspects of it and comparing his ideas to those of Lange (Finger, 1994). His work on Principles accelerated his

transition from physiology to philosophy and the nascent field of psychology, which at the time was something of an amalgam of the former two. James switched from teaching physiology to philosophy (1879), was appointed Assistant Professor of Philosophy (1880), and ultimately Professor of Philosophy (1885). James's knowledge of physiology clearly influenced his theory of the relationship between the physical and psychological components of emotion. Five years later, Principles was published; it is widely acknowledged as watershed that was instrumental in establishing psychology as a field distinct from philosophy and physiology. This landmark text is widely considered to be beautifully written and perceptive, rich with ideas, insights, and observations that continue to inspire research and debate (‘‘‘Unforgettable’ classics,’’ 2003). Indeed, historians acknowledge that ‘‘The book has no rival for importance in the history of American psychology’’ (Benjamin, 2007, p. 58).

James was a progenitor of the functionalist school of thought in psychology, and Principles was a great influence on prominent functionalists such as John Dewey and James Rowland Angell (Tolman, 1999). This pragmatic, distinctly American approach to psychology, guided by Darwinian principles, emphasized the adaptive function of consciousness as expressed in the mind–bodymrelationship (Benjamin, 2007). James's theory of emotion was deeply influenced by Darwin's (1872) The expression of emotion in man and animals (Dunlap, 1922/1967). This perspective dominates Principles, which set the tone for twentieth-century psychology in America and has had an enduring influence on the field. These functional values are exemplified in James's theory of emotion, first expressed in Mind six years prior to Principles (Lang, 1994).

1 The term ‘‘biopsychology’’ is used in this paper in broad reference to biological approaches to the scientific study of human behavior, covering multiple subfields and paradigms; ‘‘psychophysiology’’ is used in reference to a distinct approach within biopsychology, traditionally characterized by studies of humans via noninvasive physiological measures (Pinel, 2009; Stern et al., 2001).

3. The James–Lange theory of emotion

A model of emotion similar to, albeit more limited than James's was independently proposed by Danish physiologist Carl Lange in the same era (1885/1912); the two are often collectively labeled the 'James–Lange theory of emotion.' In contrast to James, Lange emphasized physiology and dismissed the importance of consciousness in shaping emotions (Lang, 1994). Lange's model was also restricted to vasomotor function, whereas James took a broader view of the role of somatic activity in emotion (Mandler, 1979). However, both theories share the premise that physiological responses are causal in emotional experience (i.e., 'feelings'), and James (1894) acknowledged the close similarities of the two models. Hence, the origins of the identification of James's theory with Lange's can be traced to James himself. Other writers of that era, such as Australian philosopher Alexander Sutherland, proposed emotion theories that bore similarities to those of James and Lange (Dunlap, 1922/1967). However, none attained the notoriety of that of James's or Lange's, and so were destined to become historical footnotes in the chronicles of the James–Lange theory (Mandler, 1979).

The counterintuitive sequence proposed by James and Lange is that emotional stimuli evoke physiological reactions, both visceral (i.e., autonomic, a term that was not yet in use when James wrote the Mind paper or Principles; see Finger, 1994, p. 2822) and somatic, and it is the perception of those changes that evokes the feeling state of an emotion. James wrote in the oft-cited passage, ‘‘. . .the bodily changes follow directly the PERCEPTION of the exciting fact, and that our feeling of the same changes as they occur IS the emotion’’ (1884; pp. 189–190 [italics in original]). In contrast to James's thesis, the common sense view is that affective stimuli generate feelings, which in turn produce bodily changes. To draw an example from James (1884, 1890) that was destined to become enshrined in textbooks, intuition says that if a person encounters a bear in the woods, that person becomes afraid and bodily changes ensue (i.e., he or she runs). James suggested the sequence was opposite; the emotional stimulus of the bear immediately produces motor reaction of fleeing, the sensory feedback of which generates emotional feelings. This passage and its accompanying bear example became the myopic focus of critics of James's multifaceted views on emotion. Unfortunately, this single-mindedness has led to pervasive oversimplification and misrepresentation of James's ideas (Ellsworth, 1994). This stereotyping of the theory obscured its nuances, with unfortunate scientific consequences. For example, James's acknowledgment of the importance of cognition in emotion is generally neglected, resulting in a one-dimensional depiction of the temporal relations among the various elements of affective processes.

James provided a variety of lines of anecdotal evidence for his theory. The crux of his argument was that if an emotion was stripped of its bodily manifestation, it is no longer an emotion, but rather is rendered ‘‘. . .a cold and neutral state of intellectual perception. . .’’ (1884, p. 193). Imagine, he contended, feeling sad without tears or sighing; anger without muscle tension or heat in the face; fear without a racing heart or an unsettled stomach. Hence, since the bodily responses are necessary for the experiential feelings, they must play a causal role in those feelings. James (1884; p. 189, 1890; p. 449, 468) was careful to disclaim that the theory applied solely to the ‘‘coarser’’ or ‘‘standard’’ (i.e., relatively pure) emotions such as grief, fear, anger, and surprise, rather than complex, blended, ‘‘subtler’’ affective states. Lange held a similar view, consistent with the functionalist notion that basic emotions serve adaptation (Lang, 1994). For example, the ability to flee a threat is supported by physiological changes such as increased heart rate (Finger, 1994). It is of interest to note that James also considered curiosity, rapture, love, lust, and greed to be among the standard emotions, but they have received relatively less attention in contemporary research.

James (1890) admitted that he was unable to provide a practical means to test his theory empirically. Like many of his other ideas articulated in Principles, he left that task for future experimentalists. The temporal aspect of the theory has remained, by and large, refractory to direct

experimentation. James stated that one would need to be numb inside to gauge the effect of blocking sensory feedback on emotional feelings, and this obviously could not be achieved by experimental means. He later related three actual cases that apparently met this condition and seemed to support his thesis, although alternative explanations could not be discounted (James, 1894). Subsequent reports on the emotional feelings of patients who had varying degrees of afferent (sensory) impulse blockage have yielded mixed results, with some cases showing blunting of affect and others not (Dana, 1921; Hohman, 1966; cf. Lowe and Carroll, 1993). Numerous flaws in these case studies have been noted, most salient of which is that afferent feedback is not completely eliminated by the spinal cord transactions described in these patients (Damasio, 2004).

The James–Lange theory generated considerable debate in his time. Notable supporters included Dewey (1894) and Baldwin (1894), but the theory also had numerous prominent critics, including Wundt (1891). James (1894) defended his theory in print against its detractors, but he also acknowledged that some of the misunderstanding of his ideas stemmed from the ''slapdash brevity'' (p. 519) of the language, in the Mind paper in particular. The temporal aspects of James's theory have been difficult to test experimentally, and the results have been mixed. Consistent with James, some studies have shown that somatic muscle activity can modulate emotional feelings (Adelmann and Zajonc, 1989; Laird, 1974; Rutledge and Hupka, 1985; Strack et al., 1988). In contrast, others have not replicated this effect (Tourangeau and Ellsworth, 1979), and low levels of shared variance between physiological and self-report measures have been reported (e.g., Lang, 1994; Rachman and Hodgson, 1974). Hence, no reliable trend has emerged from the patchwork findings in this area. However, recent neuroscientific data confirms that peripheral psychophysiological changes can precede the subjective experience of emotion self-generated via recall of a personal episode (Damasio et al., 2000).

A corollary of the theory has proven to be fertile ground for experimentation. In order for the posited causal relationship among elements of James's theory to hold, it is necessary that emotions have discrete somatic bodily response patterns. James (1884) in fact explicitly stated that his theory applied only to ''. . .emotions. . .that have a distinct bodily expression'' (p. 189). This constraint limits application of the theory to strongly characterized ''standard emotions'' such as fear, anger, and surprise. Otherwise, afferent sensory feedback would not provide sufficient information to differentiate among these emotions. Accordingly, James devoted considerable attention to depicting the specific physiological expressions of various emotions in the Mind paper and in Principles. This tenet evolved into the 'autonomic specificity' hypothesis of emotions, which holds that basic emotions can be distinguished by their ANS response patterns (Levenson, 1992). This notion remains controversial, and has produced debate that some 60-odd years of psychophysiological research has yet to resolve. The first major challenge to the idea of ANS specificity emerged from another sphere at Harvard, several years after James's death, from the work of renowned physiologist Walter Cannon.

2 The term ''autonomic'' is used in this paper loosely in reference to what James generally termed 'visceral'.

4. Challenge: the Cannon–Bard theory of emotion

Walter Cannon is probably best known for his classic treatise on homeostasis (1939). However, he is also noted for his model of emotion, developed with his student Philip Bard, which came to be known as the 'Cannon–Bard' theory of emotion. Ironically, Cannon had been an undergraduate student of James at Harvard (Benison et al., 1987), and, like James, he ultimately established his professional career there. Unlike James, Cannon was an ardent experimenter, and he relied largely on his studies of animal physiology to test aspects of James's theory. Cannon's animal model was the cat, in which he severed afferent nerves of the sympathetic branch of the ANS. When provoked, these cats still displayed species-typical emotional behaviors such as hissing and piloerection. Hence, Cannon concluded that autonomic feedback is not necessary for emotional feelings. Rather, feelings and physiological responses are independent components of emotion. Emotional stimuli are processed in the brain, which then separately generates both bodily responses and feelings. These results were first compiled by Cannon in (1915), revised and elaborated in (1929), and then presented as a direct challenge and alternative model to the James–Lange theory of emotion (Bard, 1929; Cannon, 1927, 1931).

In their writings, Cannon and Bard argued against emotion specific visceral patterns, contrary to James–Lange, and instead held that emotions have highly similar autonomic responses. As an example Cannon culled the 'fight-flight' response that he had described in essays on homeostasis. This response to environmental threat can potentially serve two behavioral options: attack, with presumed attendant aggressive feelings of anger, or fleeing, which is assumed to be accompanied by fear. In either case there is increased metabolic demand that involves a unified increase in sympathetic nervous system activity—indistinguishable in fight or flight. Moreover, Cannon claimed that these autonomic changes occur too slowly to account for emotional feelings, which rapidly erupt in response to emotional stimuli. Finally, Cannon argued that visceral organs have insufficient afferent nerves to account for conscious differences in emotional experience.

James was no longer alive and was unable to respond to Cannon and Bard's assault on his theory of emotion. However, there were critics of the Cannon–Bard model in that era (e.g., Newman et al., 1930), and many of Cannon's assertions were ultimately called into question (Carlson, 2007; Damasio, 2004; Fehr and Stern, 1970). However, as emotion theorist George Mandler (1979) noted: ''. . ..[the] historical importance [of Cannon's criticisms] is not so much that they destroyed the James–Lange theory, but rather that they were influential in producing an extensive research tradition in the psychophysiology of emotion'' (p. 290 [italics added]). In particular, Cannon's argument that emotions are not discriminable based on their visceral responses generated a durable research paradigm that spans seven decades. Seminal work in this area can be traced to the

1940s, in conjunction with the emergence of the cognate fields of psychosomatic medicine and psychophysiology.

5. Autonomic specificity and the early era of psychophysiology

James–Lange theory and the topic of emotion in general faded from the psychological scene in the 1930s due to the rise of behaviorism, a perspective that eschewed consideration of subjective internal states (Skinner, 1938; Watson, 1913). Another force that tended to diminish interest in James–Lange theory was the emergence of activation theory, which prevailed in roughly the same era as behaviorism. From this perspective, emotions are viewed simply as variations in activation or ''arousal'' level under goal-directed behavior (Duffy, 1934, 1941). Activation is portrayed on a continuum from sleep through intense affect, with little physiologic differentiation among intense affective states (consistent with Cannon's notion of undifferentiated visceral activity in emotion). Discrete emotions were not considered, per se; in fact, activation theorists and radical behaviorists were of like mind in considering emotion to be a useless construct in behavioral science. Also similar to Cannon, activation theorists focused on central rather than peripheral nervous system activity, with the reticular formation viewed as the central mediator of global cortical activation (Lindsley, 1951; Malmo, 1959).

In contrast to the zeitgeist of that era, the issue of somatic response patterning was identified as a fundamental research topic in the nascent age of psychophysiology and psychosomatic medicine. Several early case studies supported emotion specificity of ANS activity, using measures such as skin temperature, blood pressure, and electrodermal activity (Lacey, 1950; Mittelmann and Wolff, 1943). These reports foreshadowed experimental research conducted over the next two decades, the most noteworthy of which was a landmark study by pioneering psychophysiologist Albert Ax (1953), a paper framed as an empirical challenge to Cannon's notion of unitary autonomic arousal in emotion. Utilizing an innovative staged anger- and fear-producing experimental manipulation in conjunction with the recording of a montage of autonomic variables, Ax demonstrated that these two emotions yielded distinct autonomic response patterns. In reference to Cannon's model, Ax concluded that the findings did ''. . .not refute Cannon's hypothesis of unitary visceral excitement. . .but merely revealed a further differentiation in physiological reaction pattern'' (p. 441). Perhaps Ax was merely being deferential to Cannon's legacy, because the results of the study seemed to clearly distinguish the ANS patterns of anger (i.e., ''fight'') and fear (i.e., ''flight'').

Although Ax's methodology has been criticized on various grounds (Cacioppo et al., 1993; Mandler, 1979), the study is notable for its establishment of a new paradigm in the psychophysiology of emotion. Ax is generally recognized for his inventive use of electrophysiological recordings in the study of human behavior, which was facilitated by methodological advancements in the 1940s and 1950s (Davis, 1957; Stern et al., 2001). Whereas the few previous studies in this area were based on clinical diagnoses, Ax was the first to manipulate emotional states in the lab with multiple physiological recordings serving as dependent measures. James's writings show no evidence that he anticipated the laboratory induction of emotion or physiologic recording as means to evaluate his theory. Of course, this is not surprising in view of James's lack of enthusiasm for laboratory research (Benjamin, 2007), and the fact that non-invasive electrophysiological recording of ANS activity in humans had not yet appeared on the scientific scene in James's era.

The topic of autonomic specificity energized the burgeoning field of psychophysiology in the 1950s as further evidence emerged for distinct ANS responses to situations involving anger, anxiety, and pain (Funkenstein, 1956; Funkenstein et al., 1954; Schachter, 1957; Tjossem et al., 1959). In particular, anger and fear did not appear to share identical physiological response patterns, as Cannon had asserted. Even subtle within-emotion differences, such as the directionality of anger (inward vs. outward), were associated with distinct ANS patterns (Funkenstein, 1956; Funkenstein et al., 1954). Differences among these various affective states were interpreted in terms of the relative activity of epinephrine and norepinpherine, a distinction not made by Cannon.

Emotion-specific physiological responses can be viewed as a particular case of the general psychophysiological principle of stimulus-response specificity (Davis, 1957; Lacey, 1959, 1967). This principle holds that specific stimulus contexts tend to produce discrete, identifiable, and reproducible somatic response patterns. This notion must accommodate the possibility of individual variability in these patterns, consistent with James's (1890) acknowledgment of emotional differences among individuals. An early expression of this phenomenon was termed 'symptom specificity' in regard to physiological response differences that differentiated idiopathic medical disorders (Malmo and Shagass, 1949; Malmo et al., 1950). It was subsequently recognized that individual patterns, later termed 'autonomic response specificity', occurred in non-clinical populations as well (Lacey et al., 1953). The term individual response stereotypy ultimately emerged as the common expression in psychophysiology for the tendency of an individual to respond similarly across diverse stimuli (see Engel, 1972, for review).

Hence, psychophysiological studies of emotion in the 1950s were important for not only establishing an empirical basis for ANS specificity, but also for instituting a laboratory methodology for studying the physiology of emotion. However, this promising paradigm lost visibility amidst the cognitive revolution of the 1960s (Levenson, 1992). Furthermore, the notion of ANS specificity was to receive another staggering blow equal to that of Cannon's with the appearance and popularity of Schachter and Singer's (1962) landmark study.

5.1. Cognitive, Social, and Physiological Determinants of Emotional State: The Impact of Schachter and Singer

A theory of affect emerged in the cognitive zeitgeist in psychology of the early 1960s that emphasized cognitive interpretation of external cues in determining emotional

feelings. Based on a storied experiment that involved both social and physiological manipulations, Stanley Schachter and Jerome Singer (1962) proposed an alternative model of the relations among the components of affect. This highly creative, if flawed, study captured the imagination of a field that was eager to progress beyond the rigid constraints of radical behaviorism. The results suggested, as James held, that physiological responses play a causal role in the generation of feelings. However, the evidence argued against distinct ANS patterns for emotions, consistent with Cannon's position. In the absence of such differences, Schachter and Singer proposed that individuals rely on environmental cues in determining subjective emotional states.

The design of the Schachter–Singer study was complex, if not byzantine; for brevity's sake, only the critical manipulations are summarized here. Two groups of subjects received an injection of epinephrine. One group was accurately informed of the expected effects of the injection; increased heart rate, sweating, agitation— in general, the pattern of global sympathetic activation described by Cannon as 'fight-or-flight'. The other groupwas not informed of these expected reactions. Individuals in both groups were subsequently placed in a room with a collaborator who, posing as another subject, acted either euphoric or angry. The intent was to stage a situation from which attributions for 'unexplained physiological arousal' in the 'epinephrine uninformed' group could be derived. Consistent with predictions, those in the uninformed group reported feelings similar to that of the confederate with whom they were paired. In contrast, the group that anticipated the effects of epinephrine did not show this tendency. Schachter and Singer concluded that subjects in the uninformed group misattributed their unexplained feelings of physiological arousal to environmental cues (i.e., their assigned experimental condition). Ostensibly, a common physiological state induced by epinephrine led to distinct feelings as a function of environment, conflicting with the notion of distinct ANS patterns. However, the physiological changes did produce feelings in this group, in contrast to the informed group, who attributed these changes to the injection.

These results led to an emotion theory that became enshrined in textbooks alongside those of James–Lange and Cannon–Bard, both of which were invoked in the 1962 paper. In the Schachter– Singer view, individuals experience physiological arousal that is labeled consistently with their cognitive circumstances, and that label determines the subjective emotional state. To return to the bear example, a person sees a bear, simultaneously runs away (and has an increased heart rate, etc.), cognitively appraises the situation, and labels the arousal as fear.

Numerous methodological and conceptual flaws in this study were subsequently articulated by psychophysiologists, who were particularly troubled by the naı¨ve physiological assumptions upon which it was based. In a carefully constructed critique, Plutchick and Ax (1967) systematically dismantled the study by cataloguing its errors: (a) the various conditions evoked different physiological arousal levels; (b) the placebo groups (not mentioned in the above summary of the study) were not consistently different from any of the other groups (i.e., informed or uninformed) on various affective indices; (c) the self-report measures were deficient; (d) the study was not conducted in a double-blind manner; and (e) there was gross overgeneralization (i.e., to a global model of affective processing) based on a limited number of conditions, emotions, and types of subjects. Further problems related to the validity of using an epinephrine injection to induce emotion have been noted (Fehr and Stern, 1970). In retrospect, the methodology of Schachter and Singer (1962) has been characterized as ''exquisitely bad'' (Levenson, 1986).

Moreover, there were several conspicuous failures to replicate Schachter and Singer's (1962) findings, leading to a heated debate in the literature (Marshall and Zimbardo, 1979; Maslach, 1979; cf. Schachter, 1979; see Reisenzein, 1983, for discussion). Nevertheless, the study gained wide acceptance in the aura of the cognitive transformation that enveloped psychology in the 1960s and 1970s, and the notion of ANS specificity fell into decline (Levenson, 1992). What's more, the Schachter–Singer model achieved broad, enduring coverage in psychology textbooks, which often leads to distortion and uncritical acceptance of theory and research (Samelson, 1980). Indeed, the concept of non-specific, diffuse autonomic arousal persists, in spite of abundant evidence to the contrary.

Consistent findings of emotion-specific autonomic response patterns continued to accrue in the 1960s (Averill, 1969; Ax et al., 1969; Lacey et al., 1963; Wenger, 1966). These findings further buttressed the body of evidence for ANS patterning of emotional states. In a review of the literature up to that point, Fehr and Stern (1970) concluded that the extant data were generally ''. . .in accord with James's hypothesis that different emotions are related to differential patterns of bodily change'' (p. 417). Nonetheless, these studies did not have wide impact on psychology in the 1960s, which was enamored with cognitive models of affect (e.g., Lazarus, 1968; Mandler, 1975). The apogee of such views was manifest in ''false-feedback'' studies, which implied that actual ANS feedback was incidental to and not essential for emotional feelings (e.g., Valins, 1966). It was argued that the mere impression that physiological changes had occurred was sufficient to influence feelings, even if that impression was not based on veridical ANS feedback: ''It is thus likely that the observed effects of bogus heartrate feedback [on affective ratings] are primarily a result of cognitive factors and not physiological ones'' (Valins, 1966; p. 407). It is of note that Valins's account is not entirely irreconcilable with the contemporary somatic marker hypothesis, which holds that the somatosensory cortex can simulate bodily feedback in the absence of actual afferent signals (Damasio, 1996; Bechara et al., 2000). Of course, the latter explanation is a decidedly physiological, rather than a cognitive one.

6. The Modern Era of ANS Specificity Research

The quest for evidence of emotion-specific ANS patterns rebounded when energized by publication of Autonomic nervous system activity distinguishes among emotions in the

prominent journal Science (Ekman et al., 1983). In this study, actors posed facial expressions (without direct knowledge of the intended emotion) while an array of autonomic variables were recorded. Consistent with ANS specificity and James's theory, results suggested autonomic differentiation of the basic emotions of anger, fear, happiness, disgust, sadness, and surprise. Moreover, it was inferred from the study's design that afferent feedback from facial muscles played a causal role in generating the distinct ANS patterns, which implied that peripheral input can evoke emotionlinked autonomic activity, independent of cognitive appraisal. This effect falls under the label of the ''facial feedback hypothesis,'' which posits that feedback from facial muscles intensifies emotion, a notion corroborated by some researchers (Adelmann and Zajonc, 1989; Laird, 1974; Rutledge and Hupka, 1985; Strack et al., 1988), and conflicted by others (Ellsworth and Tourangeau, 1981; Tourangeau and Ellsworth, 1979). The facial feedback hypothesis is drawn from Darwin's (1872) premise that the expression of an emotion amplifies its experience, and its suppression blunts feeling. This notion is clearly in accord with James's view that somatovisceral activity has a causal influence on feelings.

Ekman et al. (1983) symbolized renewed interest in the topic of ANS specificity of emotion, for which numerous studies in this era provided additional support (Levenson, 1988; Levenson et al., 1991, 1990, 1992; Roberts and Weerts, 1982; Schwartz et al., 1981; Sinha et al., 1992; Tourangeau and Ellsworth, 1979). The degree of ANS specificity may be context dependent, with greater specificity occurring with 'real life' affect inductions (Stemmler, 1989; Stemmler et al., 2001). Debate persists as to whether these results generally converge to support emotion-specific ANS activity (e.g., Barrett, 2006; Cacioppo et al., 1993; cf. Ekman, 1994; Levenson, 1992). Results of one meta-analysis suggest that negative and positive emotions, but not necessarily discrete emotions, per se, can be differentiated based on ANS responses (Cacioppo et al., 2000). In contrast, another meta-analysis showed considerable autonomic specificity of fear vs. anger (Stemmler, 2004).

Textbooks often take the middle ground in portraying this state of affairs, suggesting that the evidence for ANS specificity ''lies somewhere between the extremes of total specificity and total generality'' (e.g., Pinel, 2009, p. 436). This depiction is consistent with a theoretical perspective that proposes a continuum of physiologic specificity for emotions, marked by distinct somatic patterns at one end, and undifferentiated physiological arousal at the other (Cacioppo et al., 1993, 2000). Between these endpoints lie ambiguous response patterns that overlap for various emotions, requiring perceptual interpretation for emotion discrimination. The importance of considering unspecific but overlapping physiological response patterns of emotion was also noted by Stemmler (2004). In the model of Cacioppo and colleagues, 'somatovisceral afferents' play a causal role in emotion across the specificity continuum. In the case of distinct patterns, bodily feedback essentially determines the emotion; in the undifferentiated arousal case, cognitive appraisal is the governing factor. As such, this model reconciles the ANS specificity position with undifferentiated arousal/cognitive appraisal views, and allows for various points between these extremes.

An innovation in the study of ANS specificity involves the multivariate pattern classification approach. An empirical demonstration of this methodology appears elsewhere in this issue (Stephens et al., this issue); it is considered here briefly in the historical context of the ANS specificity literature. Utilization of multiple dependent variables (e.g., multiple physiological measures) in emotion research has been advocated as necessary to distinguish the coordination of multiple response systems (i.e., patterns) accompanying emotion (Cacioppo et al., 1993; Thayer and Friedman, 2000). Yet, virtually all of the ANS specificity studies described above are marked by univariate statistics, which fail to capture the gestalt of the psychophysiological patterns.

The prototype for this approach can be found in an innovative study of facial expression in emotion (Fridlund et al., 1984). A multivariate tool known as pattern classification analysis (PCA; Huberty, 1994), which affords simultaneous consideration of multiple response variables, was used in this study. Results indicated that differing conditions of affective imagery were associated with emotion-specific patterns of covert facial muscle activity, as indexed by facial electromyography. Subsequently, this paradigm was extended to ANS specificity studies that employed a variety of affect induction techniques in conjunction with autonomic assessment. A seminal study of this type entailed the examination of cardiovascular and respiratory responses to music selected for its affective qualities (Nyklicek et al., 1997). A comprehensive montage of indices derived from heart rate variability analysis, impedance cardiography, blood pressure tonometry, and finger plethysmography yielded a rich portrait of ANS activity. The emotions of happiness, sadness, agitation, and serenity were found to be significantly and reliably discriminable based on these ANS responses. The finding that experimentally induced emotions can be distinguished by their autonomic patterns has been robustly replicated in other PCA studies using similar ANS variables, across a wide range of affect induction contexts, such as films (Christie and Friedman, 2004; Kreibig et al., 2007; Stephens et al., this issue), music (Stephens et al., this issue), and emotional recall (Rainville et al., 2006). Hence, the conclusion drawn from PCA studies of emotion-specific ANS activity is that ''distinct patterns of peripheral physiological activity are associated with different emotions'' (Rainville et al., 2006, p. 5).

In sum, the body of psychophysiological research over the past six decades has produced abundant empirical support for a substantial degree of ANS specificity across a range of emotions. Still, debate rages over the conclusions that can be drawn from the evidence on emotion-specific somatovisceral patterns. This controversy is a fruitful one for affective science because it stimulates basic research on the relationship between emotion and physiological responding, and consequently advances emotion theory. The issue of ANS patterning informs central conceptual issues such as the function of emotion, dimensional vs. discrete models of

emotion, and the question of whether ‘‘natural kinds’’ of emotion truly exist.

7. ANS specificity and emotion theory

The issue of emotion-specific ANS activity has fundamental implications for many aspects of emotion theory. In this section, James’s original position is integrated with the models of Cannon– Bard and Schachter–Singer, toward the end of advancing an integrated biopsycholgical view of emotion. This view is consistent with a functional perspective on emotion, which in turn compels the notion of basic or natural kinds of emotions subserved by distinct physiological signatures. These issues are examined vis-a` -vis the topography of affective space (i.e., dimensional vs. discrete models). The somatic marker hypothesis, referred to above in the context of Schachter–Singer theory, is in some senses Neo- Jamesian and is briefly considered below. In conclusion, James’s musings on emotion are discussed in terms of their remarkable generativity and endurance in psychological research. Perhaps for reasons of pedagogic simplicity, the James–Lange, Cannon–Bard, and Schachter–Singer models are often presented in textbooks as non-overlapping and mutually exclusive. However, some textbook authors recognize the value in each theory, and attempt to reconcile them, in the absence of unambiguous support for any of the three views. What emerges is a contemporary biopsychological perspective that acknowledges bidirectional interactions among the components of emotion: perception of emotion-inducing stimuli, bodily responses to those stimuli, and subjective feelings (e.g., Pinel, 2009, p. 434).

Careful reading of James’s writings reveals that he understood emotions to have multiple complex determinants, rather than being the mere automatic output of afferent peripheral activity (Ellsworth, 1994). Consistent with Schachter–Singer, James recognized the significance of the environmental context in which emotion occurs. He did not view emotions as reflexive responses to simple stimuli: ‘‘‘Objects’ are certainly the primitive arousers of instinctive reflex movements. But they take their place, as experience goes on, as elements in total situations. . .’’ (James, 1894, p. 518). Yet James keenly observed that peripheral feedback can modulate emotional feelings, a reflection that has received empirical support (Adelmann and Zajonc, 1989; Laird, 1974; Rutledge and Hupka, 1985; Strack et al., 1988). His assertion that certain emotions have specific bodily response patterns has been extensively, if not unequivocally validated. As James well understood, discrete somatic patterns are not likely found in all affective states, but rather in a small set of fundamental emotions that have evolved for adaptive reasons (Levenson, 1992).

James also appreciated that the concise language he used in presenting his model underrepresented the richness of somatic response patterns in emotion. In the legendary bear example, the act of running ‘‘. . .was meant to stand for. . .many other movements in us, of which invisible visceral ones seem by far the most essential’’ (James, 1894, p. 519) [italics added]. First, this statement shows that James considered autonomic activity to be the key element of bodily responses in emotion. Furthermore, this assertion implies that univariate designs are inadequate for testing the ANS specificity assumption. Even multivariate studies fall short of capturing all the somatic elements of a response pattern, constrained as they are by the limitations of physiological recording. In sum, James’s insights about the complexity of emotions and the parameters of his model have often been overlooked in the historical trajectory of the James–Lange theory (Ellsworth, 1994).

Cannon highlighted the role of brain in the generation of both physiological responses and feelings in emotion. Enormous advances have ensued in elaborating the specific central nervous system structures involved in emotion, and this has undeniably been a prolific area of research (and one that exceeds the scope of this paper). Although Cannon’s view of unitary autonomic arousal across emotions is at odds with contemporary views of ANS activity (e.g., Levenson, 1992; Wolf, 1995), varying degrees of overlap in autonomic response patterns do likely exist across emotions (Cacioppo et al., 1993, 2000).

Schachter and Singer’s notion of generalized physiological arousal is similarly challenged by the body of psychophysiological research. However, their model stimulated great interest in the role of cognition in affective processes, emblematic of which was a lively debate in the 1980s between two noted theorists, Richard Lazarus and Robert Zajonc. Lazarus (1982, 1984) held that there can be no emotion prior to some form of cognitive appraisal, a position that conflicts with James’s notion that perception of bodily changes is the emotion. In contrast, and consistent with James– Lange, Zajonc (1980, 1984, 2000) countered that ‘‘preferences need no inferences’’—emotional feelings unfold rapidly and can be triggered by mechanisms outside of conscious awareness. James (1884, p. 201) did acknowledge the existence of ‘‘. . .cerebral forms of pleasure and displeasure, apparently not agreeing in their mode of production with the so-called ‘standard’ emotions. . .’’ Yet, without accompanying bodily manifestations, these ‘‘pure cerebral emotion[s]’’ are more correctly labeled as ‘‘judgments’’ or ‘‘cognitive acts’’ (James, 1884, p. 201). The emotion-cognition debate generated voluminous research spanning a range of applications, from visual perception (Storbeck et al., 2006) to sexual behavior (Norton et al., 2005), yielding findings that support both perspectives.

The concept of ANS specificity ultimately derives from the evolutionary view of emotions as a pattern of situationally adaptive physiological and behavioral responses. This perspective is consistent with the original James–Lange formulation and complementary to the idea that there exists a finite set of discrete, universal emotions, as proposed by Darwin (1872). James (1884) restricted his model to these so-called ‘‘standard emotions,’’ the distinct bodily expression of which forms a ‘‘natural language’’ (p. 189). The concept of a limited set of basic emotions has been echoed in various prominent theories over the last five decades (e.g., Ekman, 1992; Izard, 1977; Plutchik, 1980; Tomkins, 1962, 1963). In this functionalist framework, emotion supplies a means by which behavior, facial expression, and ANS support can be effectively matched to environmental demands. That the ANS can support a

restricted number of basic emotion-behavior pairings forms the core of its evolutionary affective value (Levenson, 1988, 1994)3. Of course, these response patterns may no longer be adaptive in the contexts they are now evoked, and likewise the elicitation of these emotions can be mismatched to context: ‘‘Emotion is a functional provision, even if not all its occurrences are’’ (Frijda, 1994, p. 121). For example, persistent fear in the absence of actual threat may lead to chronic, maladaptive expression of autonomic activity such as sustained elevated heart rate and reduced parasympathetic heart rate control (Brosschot et al., 2006; Friedman, 2007; Knepp and Friedman, 2008). Physiological responses in emotion also reflect at least three different components: the nonemotional context, specific autonomic adaptations, and the effects of situational demands entailed by the pursuit of an emotion goal (Stemmler, 2004).

The question of basic emotions has been framed in a spirited debate over whether they exist as ‘‘natural kinds’’, i.e., as a category in nature that shares significant similarities and recognizable characteristics (Izard, 2007). Barrett (2005, 2006) and Barrett et al.(2007) have argued fervently against the ‘‘natural kinds’’ assumption that emotions exist as entities independent of human perception. This view contends that the natural kinds assumption takes for granted the existence of discrete somatic patterns for basic emotions, when such things may not exist outside of human subjective experience. This point was in fact addressed by Ellsworth (1994), who noted that oversimplification of James’s ideas has led to ‘‘. . .the reification of emotion as entities rather than processes. . .’’ (p. 222). Barrett (2006) does indeed correctly note that James acknowledged individual variation in the bodily expression of emotion, and that he discouraged conceptualization of discrete emotions as concrete entities (‘‘. . .there is no definite affection of ‘anger’ in an ‘entitative’ sense’’ (James, 1894, p. 520). At first blush, James’s quote may seem at odds with the existence of emotions as natural kinds. However, his remarks must be considered in full context. In the passage in question, James was addressing his critics on the issue of individual variation in emotion expression:

“The natural reply is that the bodily variations are within limits, and that the symptoms of the angers and of the fears of different men still preserve enough functional resemblance, to say the very least, in the midst of their diversity to lead us to call them by identical names. (p. 520; italics in the original)”

Hence, James clearly viewed emotions as functional processes that shared common physiological properties. His causal model is undeniably predicated on the assumption that there exists basic emotions ‘‘. . .that have a distinct bodily expression’’, James, 1884, p. 189). In the above passage, James displays his characteristic prescience and appreciation for complexity by articulating the complementarity of stimulus-response specificity and individualresponse stereotypy in application to emotion. As he recognized, there is some degree of stimulus-response specificity and individual response stereotype in all psychophysiological response patterns (Engel, 1972). However, James also appreciated that the response similarities within a basic emotion trump individual variability in these responses (to say the very least), a view that has received initial empirical support (Stephens et al., this issue). A common name for the emotion emerges from these shared features, a point consistent not only with the definition of natural kinds, but also with the universality in expression of basic emotions (Darwin, 1872; Ekman, 1984; Izard, 2007). Moreover, James’s italicization of ‘‘functional’’ indicates that he was of like mind with contemporary emotion theorists who infer an adaptive foundation for emotion-specific ANS activity (Ekman, 1994; Levenson, 1994). Hence, notwithstanding arguments to the contrary, the association of James with the concept of ANS specificity is both scientifically and historically accurate.

3 Emotion-behavior pairings are not context-invariant; e.g., there exist different forms of fear behavior (e.g., Lang et al., 1990). Thus, some theorists refer to action readiness or action tendencies rather than behaviors (e.g., Frijda, 1986).

A contemporary take on James’s functional view of emotion can be found in the somatic marker hypothesis, which holds that affective peripheral feedback can influence decision making in complex, uncertain situations (Damasio, 1996; Bechara et al., 2000). The model is based on evidence drawn from studies of patients with ventromedial prefrontal cortex damage (see Bechara et al., 2000; Dunn et al., 2006, for reviews). Such individuals do poorly on the Iowa Gambling Task, a paradigm designed to capture ecologically valid aspects of learning, uncertainty, reward, and punishment in the decision making process. Moreover, these patients do not display normative skin conductance responses prior to making poor choices, in spite of evidence that they have cognitive awareness of their mistakes. Damasio and co-workers interpret these findings as evidence that autonomic activity, manifested in skin conductance responses, provides a somatic marker signal that restrains poor decisions in complex situations (Bechara et al., 1996).

Extensive consideration of this hypothesis, which has generated a great deal of research and controversy, exceeds the scope of this paper. However, a number of points bear mentioning, particularly in relation to James–Lange theory. First, the model is consistent with James–Lange theory in that somatic feedback associated with emotion precedes awareness and guides behavior (Dunn et al., 2006). Damasio (2004) holds that the Jamesian portrayal of the temporal sequence of events in emotion generation is largely correct, if restricted, a view that is supported by other noted contemporary neuroscientists (Iversen et al., 2000; LeDoux, 1996). In fact, brain imaging data from the Damasio lab indicate that peripheral changes precede self-generated emotional feelings, providing empirical support of a kind that James could not have envisioned in the 19th century (Damasio et al., 2000). The somatic marker hypothesis goes beyond James–Lange theory in positing a causal role for peripheral feedback in cognitive judgments, rather than in crude, high intensity emotional situations. However, autonomic evidence for the somatic marker hypothesis has thus far been limited to skin conductance responses, and so does not speak directly to the issue of emotion-specific autonomic patterns. It should also be noted that the hypothesis has been questioned on theoretical and empirical grounds, and has produced a lively debate in the literature

(Dunn et al., 2006; Maia and McClelland, 2004a,b, 2005; cf. Bechara et al., 2005). Hence, this Neo-Jamesian view bears historical similarity to the debates that have raged over the Cannon–Bard vs. James–Lange theories of emotion.

Another topic related to James–Lange theory concerns theoretical models of affective space. ANS specificity research is either implicitly or explicitly grounded in a particular structural model of affect, which guides the selection of emotions in such studies (Christie and Friedman, 2004). These models generally fall into one of two categories: discrete or dimensional. Discrete models emphasize a universal set of 'primary' emotions (e.g., fear, anger, or disgust), which are often viewed in terms of their evolutionary adaptive value (Plutchik, 1980). This functional view is in harmony with James's (1884) depiction of 'standard' emotions, and represents emotions in terms of their ability to organize multiple behavioral and physiological responses to match environmental demand (Levenson, 1988). On the other hand, James (1890) eschewed categorization of emotions as a scientifically trivial enterprise. He recognized that the number of possible different emotions is limitless, in view of the manifold elements of an emotion, the different circumstances in which they exist, and individual differences. Yet, in the case of ''coarser'' emotions, a core pattern of somatic responses must exist that drives the emotional feeling.

In contrast, dimensional models describe affective space with a limited number of underlying factors. It is notable that this perspective actually can be traced to Wundt (1896), not known primarily as an emotion theorist, who proposed that the three basic dimensions of emotion are pleasure, tension, and inhibition (see Lang, 1994, for a discussion of this topic). One currently established dimensional model is the circumplex, comprising a two-dimensional circular array of affect descriptors (Larsen and Diener, 1992; Russell, 1980). The two orthogonal factors of this circumplex are often labeled as valence or hedonic tone (positivity or negativity), and arousal or activation (energy level). The valence factor has also been conceived as approachwithdrawal in a manner consistent with motivational tendency (e.g., Davidson, 2003; Harmon-Jones and Allen, 1998); preliminary evidence suggests that the structure of this dimension depends on whether it is based on self-reported emotion or physiological measures (Christie and Friedman, 2004). An alternative dimensional model views activation and valence as inseparable, and instead posits orthogonal positive and negative affective axes (Watson and Tellegen, 1985). Both representations have empirical support, and their validity has been debated (e.g., Barrett and Russell, 1998; Faith and Thayer, 2001; Russell and Carroll, 1999; Watson et al., 1999). Autonomic and somatic responses may in fact differentially support circumplex and valence models of affect, further demonstrating that the depiction of affective space is a function of the measures used to represent it (Witvliet and Vrana, 1995). The discrete and dimensional views may also not be mutually exclusive, and a hybrid of the two has been advocated for ANS specificity research (Levenson, 1988). This approach, in which discrete emotions reflect unique points in dimensional space, has been applied in PCA studies of ANS activity in emotion (Christie and Friedman, 2004; Nyklicek et al., 1997).

James did not appear to consider laboratory manipulation of emotion in his writings, and instead based his hypothesis on logical inference drawn from anecdotal evidence. He speculated that verification of his theory would depend on analyses of rare individual cases in which a subject was internally and externally anesthetic, but otherwise physically and mentally unimpaired (James, 1884, 1890, 1894). Researchers would later appreciate that emotion induction under controlled laboratory conditions afforded empirical means for examining the somatic specificity tenet of the James–Lange theory. Diverse methodologies have been developed, including ''real-life'' inductions (e.g., Stemmler, 1989), reading affective scenarios (e.g., Witvliet and Vrana, 1995), directed facial expressions (e.g., Ekman et al., 1983), affective imagery and recall (e.g., Fridlund et al., 1984: Rainville et al., 2006), music (e.g., Nyklicek et al., 1997), slides (e.g., Lang et al., 1993), and films (e.g., Gross and Levenson, 1995). All of these manipulations have been used successfully; choice of induction method involves both theoretical and practical concerns.

8. Summary and Conclusion

Over 120 years following its publication in Mind, William James's seminal 1884 paper continues to inspire theory and research in emotion science. One would be hard pressed to identify another paper from this incipient age of psychology that has had such a lasting impact. James anticipated many of the core issues that subsequently drove the scientific study of emotion; to be sure, he was pivotal in setting that agenda. It is a striking tribute to James's intellect and eloquence that the Mind paper and its expanded version in Principles provided a wellspring of stimulation for emotion researchers, bridging to the twenty-first century. The wide reaches and rich legacy of James's theory have been chronicled here to convey its profound influence on well-known theoretical debates that in turn spawned abundant empirical work.

James's theory offered a research focus across various disciplines and perspectives, and facilitated the attainment of significant new knowledge and reformulation of important questions in affective science (Lang, 1994). Contemporary psychophysiological recording techniques coupled with statistical advances have, in many respects, addressed James's concerns about the impenetrability of the theory by experimental means. The endurance and generativity of James's Mind paper is arguably unmatched in psychology, and is consistent with the historical view of James as the progenitor of the field in America. Moreover, the paper is emblematic of the emergence of psychology from philosophy, and well represents the mission of the journal Mind in advancing a new conception of the human mind in the late nineteenth century.

As is the case with most complex psychological phenomena that James confronted in Principles, unequivocal support or refutation of his model of emotion is not likely to emerge. Rather, theories that accommodate the various factors and contexts that direct emotion are more likely to provide

accurate representation of emotion than extreme views. Nonetheless, the weight of evidence, particularly, but by no means exclusively, that which emerges from multivariate studies, indicates that basic emotions

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