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Introduction to the Special Issue on Neurophysiological Markers for Emotion and Emotion Regulation

Tracy A. Dennis
Hunter College, The City University of New York, New York

In psychology, the latter half of the 20th century was characterized by a cognitive revolution. Now, we may be in the midst of an affective revolution, in which the roles of emotion and its regulation in the development of well-being and psychopathology are garnering academic attention, popular interest, and impassioned debate (Damasio, 1994; Davidson, 2000; Davidson & Sutton, 1995; Panksepp, 1998). This revolution has, in part, rested upon the study of the brain and grew in visibility during the "decade of the brain" in the 1990's. Indeed, neuroscientific tools have provided unparalleled opportunities to examine the nature of emotion and its neural bases, and to clarify the measurement of emotional processes in the absence of easily observable behavior. This zeitgeist, affective neuroscience, is often represented by research using neuroimaging techniques such as fMRI. The importance of such studies is substantial, and this Special Issue of *Developmental Neuropsychology* emerges in the context of this work.

The over-arching goal of this Special Issue, however, is to highlight how research using scalp-recorded event-related potentials (ERPs) can improve the measurement of emotional processes and can contribute to a deeper understanding of the clinical implications of emotion. This Special Issue was inspired by a symposium at the 47th Annual Conference of the Society for Psychophysiological Research (Dennis, 2007), in which our goal was to present innovative ERP findings from the burgeoning body of research on neurophysiological markers for emotion and emotion regulation. This symposium reflected the growing consensus that ERPs are particularly well suited for measuring emotion given their superior temporal resolution, relative ease of administration compared to other neuroimaging techniques, and ability to capture the dynamic interplay between emotion and cognition on the order of milliseconds (Banaschewsk & Brandeis, 2007). The five articles in this Special Issue attest to the fact that ERPs have the potential to change how we ask questions about emotional well-being and emotional disruptions. In particular, the articles focus on several key issues: identifying biomarkers for emotional processing and emotion regulation, clarifying how these processes vary with individual differences, describing the development of these processes, documenting interactions between emotion and cognition, and articulating how ERP biomarkers for emotion could be used to aid in the early detection of mood disruptions and affective disorders.

Central to all of these questions is whether ERPs are viable biomarkers for emotion. In the current empirical climate, the term biomarker has gained in popularity. But what can be considered a valid biomarker? One definition is that a biomarker is any biological measurement that has the potential to more closely reflect causal mechanisms in some process of interest or disorder with less measurement error than observation or subjective report. In a clinically relevant context, biomarkers should serve to improve diagnosis, prognosis, early detection, and treatment response. Biomarkers should also provide incrementally valid measures (explain

Correspondence should be addressed to Tracy A. Dennis, Hunter College, The City University of New York, 695 Park Avenue, New York, NY 10065. tracy.dennis@hunter.cuny.edu.

greater variance) in a construct of interest (Ritsner, 2009). Each author in this Special Issue must contend with the challenge of identifying ERP biomarkers for affective processes that meet these criteria and are relevant to emotional well-being and disorder. However, choosing the correct biomarker must be question-driven. Articles in this Special Issue primarily focus on three potential ERP biomarkers – the late positive potential (LPP) which indexes attention to and perceptual processing of emotional and motivationally significant stimuli, and two ERPs related to action monitoring and the activity of the anterior cingulate cortex, the N2 and ERN.

In the first article of the Special Issue, Hajcak and colleagues review research showing that the LPP is sensitive to the subjective affective and motivational intensity of emotional stimuli as well as to emotion regulation strategies like willful modulation of emotions, reappraisal, and manipulations of attention. Moreover, the time-course of the LPP, which begins as early as 250 ms and extends over several seconds, is particularly effective for measuring the affective chronometry of both emotional reactivity and regulation across the lifespan. However, research on the LPP as a biomarker for emotion and emotion regulation is in its nascent stages, and this review by Hajcak and colleagues fills an important gap by clearly articulating current findings, salient challenges, and critical future directions.

Following this review, the article by Lamm and Lewis applies a relatively novel ERP technique, source-space analysis, which brings together the benefits of spatial-anatomical sensitivity with that of the superior temporal resolution of ERPs. In this cross-sectional study of children and adolescents, Lamm and Lewis model the neural underpinnings of the N2, derived from a go/no-go task with an emotion induction component. The goal of this modeling is to strengthen inferences about cortical efficiency and maturation that are thought to correspond to changes in scalp-recorded N2 amplitudes across contexts and ages. Results show that, before applying source-space analysis, relatively few effects emerge for traditional scalp-recorded ERPs. Source-space analyses, however, reveal a much richer array of effects, including two unique regions of interest corresponding to the N2 that vary in distinct ways with age and emotional context. This article thus provides a compelling example of how source-space analysis complements traditional ERP analytic approaches and can reveal key information about cortical mechanisms of action monitoring. Source-space analysis is also is sensitive to individual differences such as age, as well as the interplay between emotional demands and cognitive performance.

Indeed, two key themes in this Special Issue are how ERPs can be used to measure the interplay between emotion and cognition, and the role of individual differences in this interplay. For example, in the final article in this Special Issue, I argue that emotion and cognition have historically been considered to be in opposition, but more recent research suggests that they are also integrated, coordinated, and complementary. I draw on both behavioral and ERP research to propose a model in which ERP measures of emotion-cognition integration rather than opposition should receive research priority in our search for biomarkers for emotion regulation. Consistent with this goal, the two articles preceding mine, by Henderson and Ladouceur and colleagues, provide an outstanding example of research that uses action monitoring ERPs (ERN and N2) to explore the interplay between emotion and cognition in relation to individual differences and risk for psychopathology. Focusing on social-emotional outcomes in shy children, Henderson finds that greater shyness is associated with poor social-emotional outcomes primarily among children with relatively enhanced N2 responses to a flanker task. In a similar vein, Ladouceur and colleagues, examining typically developing adolescents performing a flanker task, find that youths high in negative affect and high in attentional control show increased N2 amplitude and a trend toward increased ERN amplitudes. These increased ERP magnitudes are interpreted as reflecting excessive or less efficient action monitoring. Thus, these studies suggest that larger-amplitude ERPs related to action monitoring may reflect risk for maladaptive outcomes, but primarily among those with greater anxiety-

related characteristics like shyness and negative affectivity. These early findings provide an important foundation for future clinical research on biomarkers for affective psychopathology, and highlight the need to take an individual differences approach to understanding risk and resilience.

In addition to presenting important new research, the five articles in this Special Issue articulate a range of empirical challenges. One core challenge is the need to rethink the interplay between emotion and cognition to include integration, which does not privilege one process over the other, but rather delineates how they interact and together underlie adaptive and maladaptive behavior. The study of this intricate interplay between emotion and cognition, and their neural bases, is still in its infancy. Another challenge is to delineate the functional significance of voltage changes in ERPs – larger or smaller ERPs do not necessarily indicate “adaptive” or “maladaptive” neural functioning. Instead, the significance of ERP fluctuations may largely depend on individual differences (Dennis & Chen, 2007), as illustrated in both Henderson's and Ladouceur and colleague's articles in this Special Issue. In both these studies, the N2 and its implications for adjustment were sensitive to cognitive factors, affective individual differences, and context of measurement.

Although this Special Issue demonstrates the importance of using ERPs as a tool for understanding the neural underpinnings of emotion and emotion regulation, an important future direction is that examination of ERPs must be integrated with that of other EEG measures, such as EEG asymmetry or gamma band activity. For example, Hajcak and colleagues in their article note that gamma activity in response to emotional stimuli may relate to psychopathology, and could be examined in relation to LPP measures of reactivity and regulation. There is also a great need for longitudinal research examining the development of these ERPs using standardized assessment protocols. Here, it will be important to consider more specific developmental factors in addition to age, such as level of pubertal maturation, which might have an impact on neural processes underlying emotion.

In conclusion, we hope that this Special Issue will inspire greater understanding of the potential for ERPs to serve as biomarkers for emotion and emotion regulation across the life span, and in relation to well being and psychopathology. This field of inquiry is rapidly growing and many exciting possibilities exist for future research.

References

Banaschewsk T, Brandeis D. Annotation: What electrical brain activity tells us about brain function that other techniques cannot tell us--A child psychiatric perspective. Journal of Child Psychology and Psychiatry 2007;48:415–435. [PubMed: 17501723]

Damasio, AR. Descartes' Errot: Emotion, Reason, and the Human Brain. New York: G.P. Putnam's Sons; 1994.

Davidson RJ. Cognitive neuroscience needs affective neuroscience (and vice versa). Brain & Cognition 2000;42:89–92. [PubMed: 10739607]

Davidson RJ, Sutton SK. Affective neuroscience: The emergence of a discipline. Current Opinion in Neurobiology 1995;5:217–224. [PubMed: 7620310]

Dennis, TA. Neurophysiological correlates of emotion regulation in adults and children. Symposium presented at the Forty-seventh Annual Conference of the Society for Psychophysiological Research; Savannah, GA. 2007.

Dennis TA, Chen C. Neurophysiological mechanisms in the emotional modulation of attention: The balance between threat sensitivity and attentional control. Biological Psychology 2007;76:1–10. [PubMed: 17582673]

Panksepp, J. Affective neuroscience: The foundations of human and animal emotions. New York, NY: Oxford University Press; 1998.

Ritsner, MS. The Handbook of Neuropsychiatric Biomarkers, Endophenotypes and Genes. New York: Springer; 2009.