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# Comment: Affective Chronometry Has Come of Age

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## Abstract

The articles in this special section attest to the vibrancy of research on affective dynamics. In this article, I raise a number of fundamental questions about affective chronometry that remain unanswered and largely unasked. These questions are: (a) What is the relation between the time course of positive and negative affect?; (b) What is the relation among measures that operate at different time scales?; (c) What underlies the duration of subjectively experienced emotion?; (d) Which parameters of affective chronometry matter most for psychological and physical health and well-being?; and (e) Which interventions might specifically relieve suffering and promote well-being via impact on affective chronometry? The article concludes with some recommendations for future research in this area.

## Introduction

In an article that was published 17 years ago, I (Davidson, 1998) introduced the concept of "affective chronometry" for what I believe is its first occurrence in the scientific literature. I defined affective chronometry as the temporal dynamics of emotional responding and specified particular chronometric parameters such as the rise time to peak and duration as examples of parameters of emotional responding that are subsumed under affective chronometry and that could be measured using objective methods. In that 1998 article, I also raised a number of questions about affective chronometry, the majority of which remain fundamentally unanswered today. I suggested in 1998 that affective chronometry was key to understanding individual differences in affective style and in vulnerability to psychopathology. Today in 2015, I am as, if not more convinced that affective chronometry is central to our understanding of affective style, psychopathology, and well-being.

The articles in this special section of *Emotion Review* clearly make the case for the continued relevance and importance of this concept and its applicability to a wide range of psychological phenomena. It is inspiring to witness the diverse ways in which this concept is being used, the subdisciplines which it impacts, the methodological approaches that are being deployed to measure it, and the breathtaking range of processes and mechanisms that are considered to potentially influence, and be influenced by, the time course of emotional responding. In this collection of articles, a diverse range of approaches is showcased that vary from ecological momentary assessment strategies (experience sampling) to measures of brain activity using functional imaging. The concept of affective chronometry is applied to normal emotion variation, to interpersonal relationships, and to psychopathology. A consistent theme is one related to individual differences. There appears to be widespread consensus that aspects of the time course of emotional responding vary greatly among individuals and play a role in psychopathology and well-being. As such, affective chronometry seems to matter for important constructs that are impacted by emotional processes.

In this brief commentary I focus on several questions that remain unanswered and in so doing, aspire to guide future research. Some of these questions raise critical conceptual issues about the fundamental nature of affective chronometry and its underlying biological bases. These questions also underscore important issues about the relations between the duration of the subjective experience of emotion and the duration of

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other correlates of emotion and how measures that operate on different time scales may relate to one another. It is clear that we have much to look forward to in unpacking the fundamental nature of the time course of emotional responding as research in this area proceeds.

## Some Key Unanswered Questions

Despite the incredible progress on this topic attested to by the content of these articles, many critical questions remain and few have been answered definitively. In this main section of this commentary, I list several of these key questions and indicate what is at stake in their resolution.

1. **What is the relation between the time course of positive and negative affect? Are they positively correlated, inversely correlated, or orthogonal?** In other words, does the person who recovers quickly from a negative challenge, also recover quickly from a positive incentive? Or are they inversely correlated such that the person who recovers quickly from a negative challenge shows a long duration response to a positive incentive? Or are they relatively unrelated? This question is fundamental and it has not yet been resolved. The answer to this question may depend upon the specific methods used to address it, and/or the level of analysis or specific systems that are targeted. In recent research, we reported that marital stress produces short-lived responses to positive stimuli (Lapate et al., 2014). We have also found that depression is associated with shorter duration responding to positive stimuli (Heller et al., 2009), thus suggesting that certain forms of chronic stress and negative emotion impair the ability to sustain positive affect.
2. **What is the relation among measures that operate at different time scales?** For example, does a person who recovers quickly from a negative stimulus that is reflected in the millisecond domain using event-related potentials (ERPs) in the brain, also show faster recovery on autonomic measures that have a more sluggish time course such as heart rate and skin conductance? And what is the mechanism that binds these different time scales together? If our laboratory measures are to have ecological validity, it is imperative that we explicitly address this question and find positive associations between short-lived responses in the lab and longer lasting, more enduring processes in real-world contexts.
3. **What underlies the duration of subjectively experienced emotion? How does the duration of different biological processes relate to the duration of subjective experience?** Many of the articles in this special section make inferences about affective dynamics from self-report measures, experience-sampling, etcetera. The subjective experience of emotion after all is what makes affective processes so compelling. Are there specific underlying psychological and/or biological processes that are particularly related to the subjective duration of emotion? For example, is the duration of autonomic measures of emotion more systematically related to the subjective duration of emotion compared with measures of brain function? Or does it depend upon which specific parameters of brain function? Clearly this question, and Question 2 concerned with the relation among measures that operate at different time scales, are related, and are fundamental to our understanding of affective chronometry.
4. **Which parameters of affective chronometry matter most for psychological and physical health and well-being?** We have examined individual differences in the time course of ventral striatal activation in response to positive incentives in relation to both depression (Heller et al., 2009) and well-being (Heller et al., 2013). In Heller et al. (2013) we showed that participants with longer duration ventral striatal responding to positive stimuli reported higher levels of psychological well-being and also showed lower levels of cortisol. In Schaefer et al. (2013) we reported that participants with higher scores on the Purpose in Life subscale of well-being display faster recovery from negative stimuli. Are there other important metrics of affective chronometry that are associated with psychological and physical health? And related to the first question, is shorter duration responding to negative stimuli also related to well-being, or is well-being more specifically related to longer duration responding to positive stimuli? Our initial findings suggest that both parameters contribute to well-being, though additional work is needed where these factors are examined simultaneously to determine the unique and additive variance in well-being accounted for by these different metrics of affective chronometry.
5. **Which interventions might specifically impact affective chronometry? Should interventions be targeted to alter affective chronometry in order to relieve suffering and promote well-being?** This question is a critical one that has both theoretical and practical import. The neural circuits in which chronometric variation in affective responding have been found also exhibit considerable plasticity and are shaped by experience. As such, these circuits are also presumably amenable to training-induced change. If behavioral interventions can reduce suffering and promote well-being, it stands to reason that they may produce their effects through alterations in neural circuitry that govern affective chronometry. For example, we have reported that individual differences in the recovery of the amygdala signal following a negative stimulus predict neuroticism such that those with prolonged recovery report higher levels of neuroticism (Schuyler et al., 2014). In current work, we are examining the impact of mindfulness and related contemplative interventions on the alteration of this specific parameter of affective responding. We hypothesize that simple mindfulness practices will facilitate more adaptive recovery and will

specifically lead to less magnetic resonance signal in the amygdala during a recovery period following provocation with a negative stimulus.

## Conclusions and Recommendations

The collective corpus of research and theory contained in this special section provides a compelling case for the importance of affective dynamics and affective chronometry in the study of emotion. The time course of emotional responding clearly carries important significance and when examined as an individual difference, appears to account for unique variance in certain dimensions of affective responding. Additional research on affective chronometry is clearly warranted and the vibrancy of this new research area is conveyed in these articles.

As I noted in the previous lines, despite the extraordinary progress in this area, there are many fundamental questions that remain unanswered. Most of the extant literature in this area has used self-report measures to make inferences about affective dynamics. While the examination of emotional experience is clearly important, it is not sufficient and inferences made about affective dynamics exclusively from self-report should be regarded with some caution, particularly if participants are asked to report on experiences that occurred in the past (as in more than a few moments ago). We do not yet know how the time course of the subjective experience of emotion and of more objective measures relate to one another.

Going forward, it will be important to collect continuous objective measures that reflect different aspects of emotional responding to make inferences about affective chronometry. We can collect continuous central and autonomic measures. We can also obtain continuous skeletal-muscular measures including facial electromyography (fEMG); moreover the collection of such measures in the scanner will provide a real-time objective read-out of emotional behavior that can be parsed into different temporal domains and used to make inferences about reactivity and recovery (Heller, Greischar, Honor, Anderle, & Davidson, 2011; Heller, Lapate, Mayer, & Davidson, 2014).

A number of the articles in this special section feature ecological momentary assessment or experience sampling measures. This method is particularly well-suited to capture the subjective component of affective chronometry. However, when this is the only method that is used, in the absence of any experimental emotion provocation, some of the variance across individuals will likely be due to variations in exposure to different forms and intensities of affective challenge. A new paradigm that involves a combination of ecological momentary assessment along with standardized affective challenges that can be deployed in the real world on smartphones (e.g., a simple probabilistic reward task) is worthy of consideration. Using such a strategy in our current work, we are densely probing affective experience following a standardized incentive (e.g., monetary reward) compared with a control condition (e.g., nonreward) and examining individual differences in the time course of emotional responding.

In addition, we advocate the importance of conducting studies in which participants can be assessed in both real-world settings (with ecological momentary assessments) and in the lab so that the time course measured objectively in the lab in different systems can be compared with the time course of emotional experience reported in the real world in units that are typically much longer than those examined in the laboratory.

In conclusion, the study of affective dynamics has come of age. It is now a vibrant research area and cuts across many areas of behavioral and neuroscience. Individual differences in these processes appear to play an important role in temperament and personality, and in vulnerability to psychopathology. It is important that investigators focus their efforts on addressing some of the key fundamental questions that motivate this area of research and that studies be conducted with participants who are assessed in different contexts so that the generalizability and applicability of these constructs can be discerned. The next decade should be an exciting one for this new field of research.

### Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: RJD is the Founder and President of the Center for Investigating Healthy Minds, Inc., a nonprofit entity which has an interest in the research reviewed here.

### References

Davidson, R. J. (1998). Affective style and affective disorders: Perspectives from affective neuroscience. *Cognition & Emotion*, *12*(3), 307–330. doi:10.1080/026999398379628

Heller, A. S., Greischar, L. L., Honor, A., Anderle, M. J., & Davidson, R. J. (2011). Simultaneous acquisition of corrugator electromyography and functional magnetic resonance imaging: A new method for objectively measuring affect and neural activity concurrently. *NeuroImage*, *58*(3), 930–934. doi:10.1016/j.neuroimage.2011.06.057

Heller, A. S., Johnstone, T., Shackman, A. J., Light, S. N., Peterson, M. J., Kolden, G. G., … Davidson, R. J. (2009). Reduced capacity to sustain positive emotion in major depression reflects diminished maintenance of fronto-striatal brain activation. *Proceedings of the National Academy of Sciences of the United States of America*, *106*(52), 22445–22450. doi:10.1073/pnas.0910651106

Heller, A. S., Lapate, R. C., Mayer, K. E., & Davidson, R. J. (2014). The face of negative affect: Trial-by-trial corrugator responses to negative pictures are positively associated with amygdala and negatively associated with ventromedial prefrontal cortex activity. *Journal of Cognitive Neuroscience*, *26*, 2102–2110. doi:10.1162/jocn_a_00622

Heller, A. S., van Reekum, C. M., Schaefer, S. M., Lapate, R. C., Radler, B. T., Ryff, C. D., & Davidson, R. J. (2013). Sustained ventral striatal activity predicts eudaimonic well-being and cortisol output. *Psychological Science*, *24*(11), 2191–2200.

Lapate, R. C., van Reekum, C. M., Schaefer, S. M., Greischar, L. L., Norris, C. J., Bachhuber, D. R. W., … Davidson, R. J. (2014). Prolonged marital stress is associated with short-lived responses to positive stimuli. *Psychophysiology*, *51*(6), 499–509. doi:10.1111/psyp.12203

Schaefer, S. M., Morozink Boylan, J., van Reekum, C. M., Lapate, R. C., Norris, C. J., Ryff, C. D., & Davidson, R. J. (2013). Purpose in life predicts better emotional recovery from negative stimuli. *PloS One*, *8*(11), e80329. doi:10.1371/journal.pone.0080329

Schuyler, B. S., Kral, T. R. A., Jacquart, J., Burghy, C. A., Weng, H. Y., Perlman, D. M., … Davidson, R. J. (2014). Temporal dynamics of emotional responding: Amygdala recovery predicts emotional traits. *Social Cognitive and Affective Neuroscience*, *9*, 176–181. doi:10.1093/scan/nss131