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Fragile and Enduring Positive Affect: Implications for Adaptive Aging

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Abstract
There is robust evidence linking interindividual differences in positive affect (PA) with adaptive psychological and physical health outcomes. However, recent research has suggested that intraindividual variability or fluctuations in PA states over time may also be an important predictor of individual health outcomes. Here, we report on research that focuses on PA level and various forms of PA dynamics (variability, instability, inertia, and reactivity) in relation to health. PA level refers to the average level of positive feelings. In contrast, PA dynamics refer to short-term changes in PA that unfold over time. We discuss how consideration of both PA level and PA dynamics can provide a framework for reconciling when high PA is conducive or detrimental to health. We conclude that more work on PA dynamics is needed, especially in combination with PA level, and suggest productive questions for future inquiry in this area.

Introduction

Encompassing both interindividual differences (e.g., affective traits) and intraindividual variability (e.g., dynamic states), positive affect (PA) refers to the extent to which a person experiences pleasurable emotional states, such as happiness, joy, excitement, enthusiasm, and contentment [1]. Theory and empirical research suggest that the experience of high PA conveys many desirable life outcomes, including marital satisfaction, workplace performance, and improved well-being [2, 3], the summative effects of which may be delaying the onset of disease and extending healthy functioning into later life [4]. Increasingly, however, it has become clear that high PA also has a costly side [5] that is associated with intense psychological distress [6], risky health behaviors [7], and even early mortality [8]. With high PA being linked to both favorable and poor health outcomes, it is imperative to determine when high PA relates to adaptive functioning and when it does not. One critical factor may be *time* – the extent to which PA is enduring or fragile. Whereas PA that is enduring (i.e., slowly changing) reflects feeling states that are relatively stable across time, PA that is fragile (i.e., quickly changing) reflects short-term fluctuations in PA that are variable and subject to external influence.

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In this article, we critically evaluate the existing body of empirical evidence and discuss how consideration of both enduring and fragile forms of PA can provide a framework for reconciling when interindividual differences in PA are conducive or detrimental to health. Specifically, we highlight the utility of analytic methods that allow for the assessment of affective dynamics (i.e., variability, instability, inertia, and reactivity) and suggest that examination of these dynamic patterns may help reveal both risk-protective and risk-augmenting effects associated with high PA. Finally, we discuss some implications of the enduring versus fragile PA distinction for models of emotional aging and theoretical perspectives on positive psychological well-being. We conclude with a discussion of several unresolved methodological challenges concerning PA, health, and aging that we believe deserve further attention.

Nature and Assessment of Affective Dynamics

The study of affective dynamics involves intensive longitudinal observations of individuals' emotional states. Perhaps nowhere more than in the field of affect research is repeated measurement and analysis so essential. In what follows, we discuss the importance of intraindividual affect variability. Specifically, we review the relevance of affective dynamic indices (i.e., variability, instability, inertia, and reactivity) in relation to mental and physical health. Extrapolating from Ram and Gerstorf [9], we highlight studies that distinguish measures and indices of affective dynamics that treat repeated observations as independent assessments (unstructured intraindividual variability) from those that assume time-related dependencies in the data (structured intraindividual variability). Throughout, we present a selective review of the literature, giving emphasis to recent works and historical treatments of affective dynamics.

Although most affect theorists share a common assumption that time is the essential medium through which affective-related phenomena are observed, there remain contradictory predictions in the literature about the direction of the association between affective dynamics and health. On the one hand, intraindividual or within-person variability in affect may reflect a tendency to respond flexibly to changing emotional circumstances [10]. If so, intraindividual variability in affective states may be adaptive. Waugh et al. [11], for example, contend that a hallmark of resilient individuals is their exquisite attunement and flexible emotional responsiveness to the nuances of their current circumstances. Similarly, Bonanno and colleagues [12] have argued for the importance of "regulatory flexibility" or the ability to flexibly choose among available regulatory strategies (e.g., reappraisal, distraction) that fit differing situational demands. On the other hand, some researchers have suggested that intraindividual variability in affect is significantly heritable [13] and may forecast higher rates of depressive symptoms and physical health problems [14, 15]. According to this view, intraindividual variability in PA and negative affect (NA) is a risk marker for poorer physical and mental health.

Affective Variability

Affect fluctuates over time, with intraindividual *affective variability* indicating how and to what extent fluctuations in affect deviate from one's average affect level. Researchers interested in affect variability have used various indices to identify patterns of intraindividual variation (e.g., coefficient of variation, index of dispersion, intraindividual standard deviation [iSD], and signal-to-noise ratio). These indices all derive from the assumption that repeated observations of the same individual are independent and identically distributed. Among the various indices of affective variability, the within-person or iSD is perhaps the most widely used measure. The larger the within-person SD, the more extreme is an individual's fluctuation in affect. Recently, Wichers et al. [16] reviewed empirical data suggesting a link between increased affective variability – particularly variability in NA – and psychosis, borderline personality disorder, depression, and future psychopathology.

There is also growing interest in intraindividual variability in PA in relation to psychological and physical health. Gruber et al. [14] examined PA variability across 2 studies (using a combination of diary and day reconstruction methods) and found that greater variability in PA was associated with lower life satisfaction and higher depression and anxiety. Employing data from a longitudinal-burst design, Hardy and Segerstrom [15] recently reported a prospective association between greater PA variability and higher psychological distress and physical ill health 10 years later. Chan et al. [17] investigated the relationship between affective variability and physical health in a large-scale population-based survey in China. A total of 15,050 adults (aged 18–99 years) reported their affective experiences during the previous day and history of chronic health conditions (e.g., stroke, diabetes, hypertension, and depression). Findings revealed that PA variability (independent of mean-level affect) was associated

with greater risks of chronic health conditions like angina and depression. Finally, Human et al. [18] examined the association between within-day PA variability (i.e., iSD) and daily cortisol profiles in samples of middle-aged and older adults. Results revealed a curvilinear relation, such that relative to very low or very high PA intraindividual variability, a moderate degree of PA variability was associated with more favorable hypothalamic-pituitary-adrenal axis functioning (i.e., lower levels of cortisol and steeper daily slopes). Importantly, almost all of the reviewed studies herein adjust for mean PA level in estimating the association between PA variability and health outcomes, making it unlikely that the associations between variability and health are conflated with or driven exclusively by mean-level information.

Affective Instability

The term *affective instability* generally refers to the range/amplitude and tendency with which an individual's affective state is likely to change from one moment to the next. Whereas affective variability indices capture how much affect deviates around its mean, affective instability indices reflect the temporal dependency or consistency of affective states over time. Unlike measures of unstructured intraindividual variability that assume independent observations (e.g., the iSD), measures of affective instability are characterized by fluctuations and changes that are systemically patterned or organized in relation to time [9]. The various methods that have been used to quantify the degree of individuals' affective instability – including the probability of acute change and the mean square of successive differences (MSSD) – all assume that changes over time are part of the phenomenon to be modeled and explained. Using probability of acute change and MSSD indices, several studies have demonstrated that participants with borderline personality disorder symptoms exhibit greater NA instability than healthy controls [19] or than patients with major depressive disorders [20].

Evidence is mixed for an association between PA instability and health. For example, using an ecological momentary assessment (experience sampling) approach, Koval et al. [21] found that greater beat-to-beat variability in heart rate was inversely related to instability of PA (as measured by MSSD), even after controlling for mean level of PA, suggesting that lower parasympathetic tone may be protective against PA instability in daily life. By contrast, in a daily diary study of chronic pain patients, Rost et al. [22] found that the mean level of PA, but not PA instability, was associated with more daily disability and a higher level of cognitive complaints. Because these findings come from cross-sectional designs, it is difficult to assess the direction of influence.

Affective Inertia

A third category of affective dynamics includes measures of persistence or inertia. Defined as resistance to affective change, *affective inertia* reflects the extent to which affective states persist over time [23]. Like instability, inertia involves temporal dependency; however, unlike affective instability, inertia does not yield information about the overall amplitude of affective changes. Typically estimated as the within-person autocorrelation, higher levels of inertia (i.e., greater resistance to change) in NA have been linked to low self-esteem, depression, and trait rumination [24]. Koval et al. [25] investigated the specific patterns of affective dynamics associated with depressive symptoms. After correcting for overlap between different measures (variability, instability, and inertia), only inertia and variability in NA remained associated with depressive symptoms.

To date, only a few studies have considered the relation between inertia indices of PA (i.e., autocorrelation) and psychological well-being. Evidence from 2 studies tentatively points to an association between higher levels of PA inertia and higher well-being. Notably, both studies focused on how inertia in PA was associated with the absence rather than the presence of well-being. For example, among adults with recurrent depression, greater momentary PA persistence was associated with better recovery [26]. In line with these data, findings from a functional magnetic resonance imaging study [27] support the hypothesis that anhedonia in depressed adults reflects an inability to sustain PA over time. However, despite scholarly interest [24], the majority of studies regarding affective inertia are cross-sectional, making it difficult to assess whether PA inertia influences mental and physical health or vice versa.

Affective Reactivity

Another form of affective dynamics is *affective reactivity*, generally conceptualized as the magnitude of emotional reactions that are elicited in response to external events [28]. Unlike other indices of affective dynamics, measures of affective reactivity directly capture within-person covariation, specifically the relation between external events and affect. Most research to date has focused on how individual differences in affective reactivity (particularly of NA) are associated with health and well-being. Evidence from a number of prospective investigations

suggests that NA reactivity to daily stressors increases the risk of mental disorders [28], diminishes eudaimonic well-being [29], and predicts chronic health conditions [30] up to a decade later.

Although much of the existing literature has focused on NA reactivity to daily stressors, research suggests that PA reactivity to everyday stressors may also account for important individual differences in health and well-being. For example, O'Neill et al. [31] demonstrated that heightened PA reactivity to daily interpersonal stressors was a unique vulnerability factor in the development of later depressive symptoms. Likewise, Finan et al. [32] observed that failure to maintain PA in the face of daily pain reflected vulnerability in fibromyalgia patients. Notably, recent work utilizing within-person measures of affective reactivity indicates that PA reactivity to daily stressors predicts poor sleep [33], elevated inflammation [34], and doubling of mortality risk [35] even after controlling for the effects of NA reactivity.

Toward an Integrative Conceptualization of PA

As the studies reviewed above demonstrate, the quantification and study of PA dynamics has proven useful and informative in predicting psychological and physical health outcomes. Beyond showing that within-person variation in PA is a dimension distinct from level of PA, along which individuals can be characterized, research on PA dynamics (i.e., variability, instability, inertia, and reactivity) may help to reveal important differences within global PA levels. Below, we discuss the interplay between PA level and PA dynamics and their potential role in psychological functioning and physical health outcomes.

Implications for High and Low PA

Understanding the relations between measures of PA level and markers of PA dynamics may provide a potential explanation for why, at very high levels, PA sometimes confers detrimental outcomes [5]. For instance, Diener et al. [6] reported that people who experienced intense PA were also more likely to experience intense NA. Likewise, Friedman and colleagues [7] found that extremely cheerful people were more likely to engage in risky health behaviors that increased their risk of early mortality [8]. Such findings suggest that high global levels of PA that are accompanied by variability, instability, reactivity, or low inertia may indicate a hidden vulnerability (i.e., fragile high PA). Although data are sparse, this hypothesis is congruent with findings from a recent study showing that elevated PA reactivity (i.e., defined as the magnitude of change in daily PA in response to daily events) confers vulnerability to poor sleep, especially among individuals high in trait PA [33].

As with fragile high PA, the combination of low PA level and markers of PA dynamics (e.g., inertia) may represent a form of fragile low PA that constitutes vulnerability. This assertion is consistent with the previously mentioned finding that lower inertia or persistence of PA states is associated with worse recovery among individuals with chronically low levels of PA (i.e., anhedonia) [26]. Additionally, this view of fragile low PA fits with recent findings suggesting that variability in life satisfaction over time may be a meaningful predictor of health, especially in combination with mean levels. Specifically, Boehm et al. [36] found that individuals with low mean life satisfaction and high variability in life satisfaction had the greatest risk of mortality over a 9-year follow-up. Nevertheless, other studies suggest the opposite, namely that fragile low PA may indicate a "mood brightening" effect whereby individuals experiencing an overall deficit in PA level report improvements in affect (e.g., larger increases in PA) when responding to positive events [37]. In sum, it remains to be seen to what extent high or low PA level in combination with PA dynamics is a reliable indicator of vulnerability or resilience.

Implications for Adaptive Aging and Positive Psychological Well-Being

A large body of empirical research documents age differences in emotional well-being [38]. Cross-sectional and longitudinal studies reveal that negative emotions occur with less frequency with age, whereas positive emotions occur with greater frequency with age, though there is some evidence that these age associations may be moderated by functional health limitations [39] and the onset of terminal decline processes [40]. Additionally, in contrast to younger adults, older adults experience more stable positive emotionality [41, 42] and are more adept at maintaining and upregulating PA during unpleasant situations [43, 44]. Although most lifespan developmental theories of motivation and emotion recognize individual differences in PA as an important outcome of healthy aging, with few exceptions [e.g., 34, 35, see also 45], investigations that address the predictive utility of PA dynamics have been absent in contemporary aging research. This contrasts to inquiry into lifespan development in other domains where, for example, intraindividual variability in cognitive and sensorimotor functioning has been shown to be predictive of declines in fluid abilities, of

mild cognitive impairment, of the onset of dementia, and of early mortality [46]. To the extent that PA dynamics indicate an inability to adapt to the environment, fragility in PA may signal poor emotion regulation, particularly among older adults among whom the accrual of physiological deficits may accentuate vulnerability to disease and premature mortality [38].

On a broader level, the studies reviewed here suggest that labeling high PA as either unequivocally "good" or "bad" is not sufficient for a full understanding of PA-health associations. As such, interindividual differences in PA dynamics may be particularly important in distinguishing between various forms of fragile and enduring high PA. In one formulation of fragile high PA (i.e., variable high PA), a person may report typically experiencing high PA, yet their day-to-day PA may exhibit considerable short-term fluctuations. A second type of fragile high PA (i.e., unstable high PA) occurs when a person high in global PA experiences rapid, frequent, and extreme changes in PA. A third form of fragile high PA (i.e., inert high PA) involves the combination of high level and high temporal dependency in PA, such as among persons with bipolar disorder who experience persistent high PA across contexts [5]. Finally, a fourth category of fragile high PA (i.e., contingent high PA) occurs when a person with generally high levels of PA shows heightened and maladaptive PA reactivity to everyday events (i.e., severely diminished PA in response to daily stressors). Taken together, these various conceptualizations of fragile high PA point to the need for an alternative, more nuanced perspective on positive psychological well-being, one where high PA is viewed as a heterogeneous construct rather than as a unidimensional label.

Methodological Challenges and Conclusions

In closing, we discuss 5 methodological challenges that seem especially important for sharpening our understanding of the nature of fragile (vs. enduring) PA and its role in mental and physical health over the life course. Of primary concern is the limited number of longitudinal studies. Indeed, studies to date have largely been cross-sectional, making it difficult to infer the directional significance of associations. Overall, it is striking just how few studies have addressed the direction of an association between PA dynamics and health. In addition to providing a more rigorous assessment of mechanistic pathways, prospective, multiwave, longitudinal studies are critically important in advancing the science of PA dynamics and health because they (a) allow for tests of theoretical models of PA that assume stability in PA and in the relations between PA and health over time; (b) help address questions regarding the timescales (durations) on which sustained PA is associated with health outcomes; and (c) can provide evidence about the direction of causality.

Another methodological drawback concerns inadequate assessment of potential alternative explanations for why PA dynamics are related to health. Specifically, the inclusion of confounding variables, such as NA or psychological distress symptoms, differs considerably across studies. Given that NA may covary with PA [47], attention to potential confounding by negative arousal states is critical. Similarly, it is possible that self-report measures of both trait and state PA contain adjectives (i.e., vigor, energetic, alert) that are confounded with physical health [3]. This might be addressed in future work by eliminating an overlap between the putative measure of PA and the putative health outcome or by including objective measures of physical health and/or PA.

The measurement of affect also raises fundamental (but understudied) questions. For example, what is the role of affective arousal in the association between PA dynamics and health? There is reason to believe that social norms surrounding PA may vary across cultures, with activated feelings associated with high-arousal PA (e.g., excitement, fun) being more generally valued by European Americans compared to East Asians [48]. There is also conceptual overlap between constructs of affective dynamics, and it remains unclear which specific aspects of the dynamics matter most for psychological and physical health. Specifically, although measures of affective variability, instability, and inertia have been investigated as distinct constructs, they are not mathematically independent. Jahng et al. [49], for instance, highlight how measures of affective instability (i.e., δ^2) are a direct function of affective variability (i.e., σ^2) and affective inertia (i.e., $\rho(1)$):

$$\delta^2 = 2\sigma^2 (1 - \rho(1)).$$

The mathematical dependency between the various measures of affective dynamics suggests that examining each in isolation may obscure their true associations with health outcomes. Accordingly, additional research in this area is needed to both refine the construct definitions and evaluate the extent to which different mathematical and conceptual components of PA dynamics have distinct or overlapping contributions to psychological and physical health outcomes.

Beyond the measurement of PA, the measurement of health is also an issue for future work. Notably, most research to date has focused on how individual differences in PA dynamics are associated with vulnerability to ill-being and psychopathology. Less attention has been paid to whether interactions between PA level and PA dynamics account for unique variance in positive psychological functioning (e.g., eudaimonic well-being) and physical health (e.g., restorative health behaviors). Similarly, advancing the science of PA dynamics requires linking subjective experience to biology. What are the physiological substrates of fragile versus enduring forms of high PA? Considering the significant heterogeneity across studies in measures of PA and health, comparison and integration of findings across studies remains difficult. This suggests that the greatest clarity in future work would result from the inclusion of psychometrically valid, multichannel PA instruments and diverse measures of positive health and well-being (subjective and objective).

Finally, the relation between different facets of PA dynamics that act on different timescales – moment-to-moment and/or day-to-day and/or year-to-year – remains grossly unresolved [50]. As the processes underlying fluctuations and changes in individuals' PA states may be different, determining the timescale(s) on which PA actually operates may be crucial to resolving divergent findings in the literature [24]. Likewise, measures of health dynamics may reflect different processes when captured at different timescales (across seconds, minutes, hours, or even days/months). Given that the timescale that is appropriate for capturing affective and health processes of interest is basically unknown, a major challenge for future research on affect dynamics is to account for temporal complexity by examining affect dynamics and health at multiple timescales, simultaneously. Importantly, given that PA can change rather quickly, the cadence of assessment for moment-to-moment tracking of PA likely needs to be sped up considerably.

In sum, although there is growing support for an association between PA and mental and physical health, full understanding of the phenomenon is far from complete. Questions remain regarding the multiple forms of fragile versus enduring PA and their specific implications for well-being. More research is also needed to clarify the mechanisms underlying the association between PA dynamics and mental and physical health outcomes in different populations. For example, in addition to examining PA dynamics in healthy populations, studying clinical populations may enable a better understanding of how the normative function of PA can go awry [5], thus affording the discovery of the limiting conditions that determine the adaptive consequences of PA dynamics for health. Ultimately, a comprehensive understanding of PA and how it changes over the life course will require moving beyond the predictive value of PA level (whether it is high or low) to a systematic consideration of the interplay between PA level and various forms of PA dynamics (variability, instability, inertia, and reactivity) and their relation to health. The time for such inquiry is at hand.

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