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Purposeful Engagement, Healthy Aging, and the Brain

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Abstract
Purpose of Review Research on psychological well-being in later life has identified strengths and vulnerabilities that occur with aging. We review the conceptual and philosophical foundations of a eudaimonic model of well-being and its empirical translation into six key dimensions of positive functioning. We also consider its implications for health, broadly defined.
Recent Findings Numerous findings from national longitudinal samples of US adults are described. They show declining scores on purpose in life and personal growth with aging, but also underscore the notable variability among older persons in these patterns. Recently, health benefits have been identified among older adults who maintain high levels of a particular aspect of well-being, namely, purposeful life engagement. These benefits include extended longevity, reduced risk for various disease outcomes, reduced physiological dysregulation, and gene expression linked to better inflammatory profiles. The brain mechanisms that underlie such outcomes are also examined via a focus on affective style. Adults with higher levels of purpose in life show more rapid recovery from negative stimulus provocation, whereas those with higher well-being overall show sustained activation of reward circuitry in response to positive stimuli, and this pattern is associated with lower diurnal cortisol output. Volumetric findings (right insular gray matter volume) have also been linked with eudaimonic well-being.
Summary Eudaimonic well-being predicts better health and longer lives, and thus constitutes an important direction for future research and practice. Intervention studies designed to promote well-being, including among those suffering from psychological disorders, are briefly described.

Keywords Eudaimonic well-being · Purpose in life · Morbidity · Mortality · Biological risk factors · Neural mechanisms · Intervention studies

Introduction

This article reviews an emerging body of research that is pertinent to, though somewhat removed from, work in geropsychiatry and studies of later life cognitive disorders. A central objective is to investigate positive psychological functioning as a potentially key influence on the prevention and treatment of mental disorders, including age-related cognitive decline. The first section describes the eudaimonic approach to well-being, giving emphasis to its conceptual and philosophical foundations. Operational indicators of six key aspects of eudaimonic well-being are described. The second section summarizes select scientific findings that have grown up around this model of well-being over the last 25 years. Findings from multiple large longitudinal studies document that certain aspects of well-being—especially purpose in life and personal growth—decline with aging. Nonetheless, some older persons maintain high levels of these existential components of being well. Moreover, the capacity to stay purposefully engaged has significant protective influences on health.

This article is part of the Topical Collection on *Geropsychiatry & Cognitive Disorders of Late Life*

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Numerous findings show that purposeful engagement extends life and reduces risk for multiple disease outcomes, including cognitive impairment and Alzheimer's. Purpose in life also promotes preventive health behaviors. The third section summarizes emerging findings linking eudaimonic well-being to neuroscience. Such work shows that the neural mechanisms supporting the processing of positive and negative stimuli vary depending on reported levels of eudaimonia. Further, the interplay between neural processing and well-being is shown to matter for other physiological systems, such as diurnal patterns of salivary cortisol. Given the salubrious effects of well-being across multiple domains, a final section notes intervention efforts to promote eudaimonic well-being, both in younger and older age groups. Promoting greater interplay between these endeavors and understanding the neural and physiological processes that link eudaimonic well-being to health is important for future research.

Eudaimonic Well-Being: Conceptual Foundations and Operational Indicators

The fields of psychiatry, clinical psychology, and cognitive aging focus primarily on assessment and treatment of disorders, although a substantial literature on positive psychological functioning has emerged in recent decades. An integrative review of well-being research [1] distilled two broad traditions: one dealing with happiness, hedonic, or subjective well-being [2, 3] and the other dealing with human potential or eudaimonic well-being [4, 5••, 6••]. Both are relevant for later life mental disorders (e.g., deficits in well-being may be contributors to the emergence of emotional or cognitive disorders). The focus in this article will be on the eudaimonic model of well-being [5••], as considerable age-related research has been generated with it.

Figure 1 displays the six components of a theory-guided model of well-being and its conceptual underpinnings. A key point is that the model emerged from the integration of diverse theoretical formulations of positive functioning in clinical, development, existential, and humanistic psychology [7–15]. Despite diversity in these perspectives, common themes were evident among them. These points of convergence constitute the six core dimensions of well-being identified in the top part of the figure. Aristotle's writings about eudaimonia, conveyed in the *Nichomachean Ethics* [16, 17], provides a deeper philosophical foundation of this model. Aristotle construed eudaimonia as the highest of all human goods. For him, eudaimonia involved activity of the soul in accord with virtue. Further, he defined the highest of all virtues as achieving the best that is within us. The central task of life thus involves coming to know one's unique capacities and then striving to realize them. These core ideas are embedded within aspects of well-being in the Ryff model [5••].

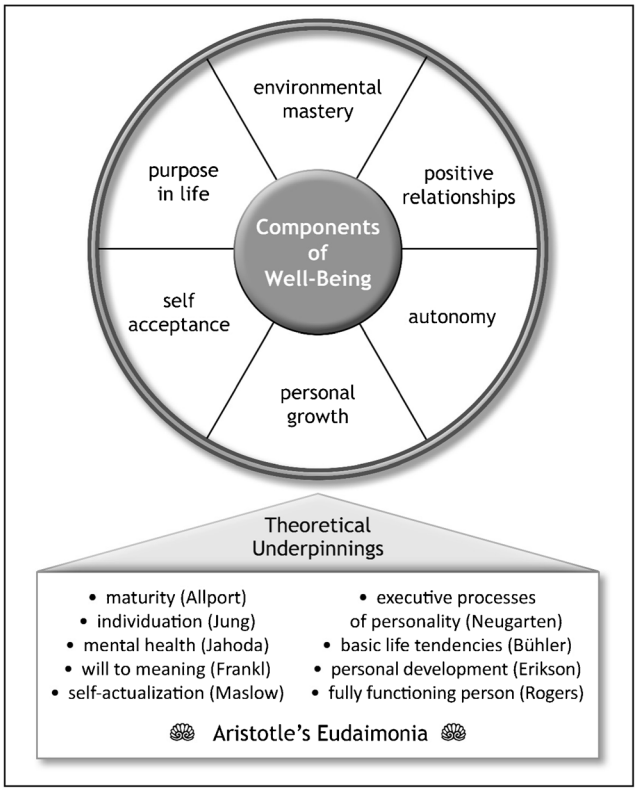

Fig. 1 Core dimensions of psychological well-being and their theoretical foundations

Table 1 provides definitions of each of the six dimensions. Based on these definitions, structured self-report scales were constructed to allow for quantitative assessment of well-being. These well-being instruments have been translated to more than 30 languages, from which more than 500 publications have been generated (see [6••] for a selective review of some of this prior work), including numerous psychometric analyses showing support for the theory-guided, six-factor model. Other prominent topics have examined, such as how well-being changes as individuals age, or as they deal with transitions and challenges in work and family life. Links between well-being and health have been extensively investigated. Select findings from this prior literature are summarized in the next section.

Empirical Research on Eudaimonic Well-Being and Aging: Why Purposeful Engagement Matters

Before eudiamonic well-being entered the scientific arena, it was impossible to know whether certain of the six dimensions would emerge as particularly important in later life. What has been learned is that the most existential aspects of well-being (i.e., purpose in life and personal growth) do, indeed, show vulnerability with aging. Cross-sectional findings with community volunteers [5••] first showed that older adults scored

Table 1 Definitions of theory-guided dimensions of well-being

Self-acceptance	
	High scorer: Possesses a positive attitude toward the self; acknowledges and accepts multiple aspects of self, including good and bad qualities; feels positive about past life.
	Low Scorer: Feels dissatisfied with self; is disappointed with what has occurred in past life; is troubled about certain personal qualities; wishes to be different than what he or she is.
Positive relations with others	
	High scorer: Has warm, satisfying, trusting relationships with others; is concerned about the welfare of others; capable of strong empathy, affection, and intimacy; understands give and take of human relationships.
	Low scorer: Has few close, trusting relationships with others; finds it difficult to be warm, open, and concerned about others; is isolated and frustrated in interpersonal relationships; not willing to make compromises to sustain important ties with others.
Personal growth	
	High scorer: Has a feeling of continued development; sees self as growing and expending; is open to new experiences; has sense of realizing his or her potential; sees improvement in self and behavior over time; is changing in ways that reflect more self-knowledge and effectiveness.
	Low scorer: Has a sense of personal stagnation; lacks sense of improvement or expansion over time; feels bored and uninterested with life; feels unable to develop new attitudes or behaviors.
Purpose in life	
	High scorer: Has goals in life and a sense of directedness; feels there is meaning to present and past life; holds beliefs that give life purpose; has aims and objectives for living.
	Low scorer: Lacks a sense of meaning in life; has few goals or aims; lacks sense of direction; does not see purpose of past life; has no outlook or beliefs that give life meaning.
Environmental mastery	
	High scorer: Has a sense of mastery and competence in managing the environment; controls complex array of external activities; makes effective use of surrounding opportunities; able to choose or create contexts suitable to personal needs and values.
	Low scorer: Has difficulty managing everyday affairs; feels unable to change or improve surrounding context; is unaware of surrounding opportunities; lacks sense of control over external world.
Autonomy	
	High scorer: Is self-determining and independent; able to resist social pressures to think and act in certain ways; regulates behavior from within; evaluates self by personal standards.
	Low scorer: Is concerned about the expectations and evaluations of others; relies on judgments of others to make important decisions; conforms to social pressures to think and act in certain ways.

notably lower on these two aspects of well-being compared to midlife and younger adults; such results were subsequently replicated with a national sample of US adults [18]. Because such cross-sectional age differences may reflect cohort differences rather than maturational change, longitudinal research was critically needed. Findings from three large longitudinal studies (two based on the US population) have now shown that purpose in life and personal growth do, indeed, decline with aging [19]. These findings may reflect the structural lag problem [20], which argues that contemporary social institutions (in work, education, and community life) lag behind the added years of life that many older adults now experience. Thus, declining levels of purpose and growth with age possibly implicate diminished opportunities for meaningful life engagement and continued self-realization during the added years of life many now experience.

However, there is much variability *within age groups*—some aging individuals are thus able to maintain high levels of purposeful life engagement and personal growth (i.e., they are above the average for their age group). Importantly, this variability among older adults, particularly for purpose in life, has become a flourishing arena of science. The take-home message from this collective body of work, as sketched below, is that high purposeful engagement is notably beneficial for reducing risk of disease and extending length of life.

A first study, conducted with the Rush Memory and Aging Project (MAP, a 6-year community-based longitudinal study) showed that those with higher levels of purpose in life at baseline were more likely to be alive 6 years later compared to those with lower levels of purpose [21•]. These findings were evident after adjusting for numerous covariates (depressive symptoms, disability status, neuroticism, number of medical conditions, income) that were correlated with purpose in life. A subsequent study from the Midlife in the US (MIDUS) study, based on a national sample of adults, aged 25 to 74 at baseline, showed that purpose in life predicts mortality across the adult life course [22]. Most recently, a meta-analysis involving 10 prospective studies and over 135,000 respondents showed that high purpose in life (assessed with multiple indicators, not just the above-described scale) was associated with reduced risk for all-cause mortality and reduced risk of cardiovascular events [23].

Another set of recent findings have documented the protective benefits of purpose in life (measured with the Ryff scale) vis-à-vis multiple disease outcomes. The Rush MAP study showed that those with higher purpose in life at baseline showed reduced risk for Alzheimer's disease and mild cognitive impairment 6 years later [24•], after adjusting for depressive symptoms, neuroticism, social network size, and number of chronic conditions. In the MAP study, post-mortem analyses have also been conducted to evaluate the degree of organic pathology in the brain. Using a global pathologic score and a measure of neurofibrillary tangles, links to global cognitive function while respondents were still alive were examined [25••]. Purpose in life was found to significantly modify the association between Alzheimer's disease pathology in the brain and cognitive function (net of age, gender, and educational level). At high levels of brain pathology, participants with higher levels of purpose in life showed higher levels of cognitive function while still alive relative to those with lower levels of purpose in life. Finally, the MAP study has also

shown that greater purpose in life is associated with with ~50 % reduced risk of cerebral infarcts, specifically macroscopic infarcts primarily caused by lacunar infarcts, even when controlling for negative affect, physical activity, clinical stroke, and vascular risk factors such as body mass index, smoking behavior, diabetes mellitus, and blood pressure [26].

The health effects of purpose in life have been investigated in the Health and Retirement Study (HRS), another national longitudinal study of aging. One key finding is that among those with coronary heart disease, respondents with higher levels of purpose in life showed reduced risk of myocardial infarction (net of confounds) 2 years later [27]. A related study showed that those with higher purpose in life showed reduced risk of stroke 4 years later, net of confounds [28]. Another study from HRS showed that higher purpose in life predicted (longitudinally) more preventive health behaviors, such as doctor check-ups, cholesterol tests, and cancer screenings [29••]. Finally, other supportive results have been reported in The Australian Longitudinal Study of Ageing (ALSA) where higher purpose in life was associated with lower levels of functional disability, better performance on cognitive tests including episodic memory and speed of processing, and better self-rated health and lower depressive symptomatology [30].

Returning to the MIDUS study and assessments of biological risk factors, purpose in life at baseline was found to predict lower levels of allostatic load 10 years later [31•]. Allostatic load is a summary index of biological risk that has been implicated in multiple adverse outcomes including subsequent risk for decline in physical and cognitive functioning [32]. Also using the MIDUS biomarker sample, Friedman and Ryff [33•] showed that purpose in life and positive relations with others moderated the links between number of chronic conditions a person had (comorbidity is known to increase with aging) and markers of inflammation (interleukin-6 (IL-6) and C-reactive protein (CRP)). Among those with higher levels of comorbidity, having higher levels of purpose and quality ties to others buffered against elevated levels of IL-6 and CRP.

Another avenue of recent research involves linking psychological well-being to functional genomics via the conserved transcriptional response to adversity (CTRA), which is characterized by up-regulation of pro-inflammatory genes and down-regulation of type 1 interferon- and antibody-related genes. Findings from a sample of healthy adults showed that high levels of eudaimonic well-being were associated with CTRA down-regulation (the healthier profile), whereas high levels of hedonic well-being were associated with CTRA up-regulation (the less healthy profile) [34]. These findings were replicated and extended in a subsequent study, which demonstrated that the pattern of CTRA down-regulation was evident across five of the six components of eudaimonia, including purpose in life [35]. Another set of recent findings showed that eudaimonic well-being appeared to compensate for the adverse impact of loneliness on CTRA gene expression [36].

Taken together, the preceding findings underscore the protective benefits of purposeful life engagement in the following: extending length of life, reducing risk of dysregulation across diverse physiological systems, reducing risk of multiple disease outcomes (Alzheimer's, mild cognitive impairment, myocardial infarction, stroke), and promoting down-regulation of genes involved in a conserved transcriptional response to adversity. Higher purpose in life also predicts greater likelihood of practicing preventive health behaviors (doctor check-ups, cholesterol tests, cancer screening). Still needed in such inquiries is greater understanding of the role of brain mechanisms in understanding these salubrious effects.

Eudaimonic Well-Being and the Brain

The above evidence of substantial associations between psychological well-being and health implicate a mind-body connection must be mediated via the neural circuits in the brain. In the moment-to-moment timescale of daily life, various neurobiological circuits interpret salient incoming signals from the world, appraise them for personal relevancy, and orchestrate actions for navigating life. Importantly, the preceding findings underscore that individuals differ in how these processes work, including how they relate to self-reported levels of purposeful life engagement. Emerging neuroscience evidence suggests that acute and sustained neural responses—both in initial reactions to affective stimuli and how those responses are regulated over time—are essential for healthy psychological aging. Understanding the neural mechanisms through which affective stimuli are differentially processed among those with higher or lower levels of eudaimonic well-being is critical to explicating how healthy aging occurs. To that end, the MIDUS study has collected physiological and neural data on adults of widely differing ages so as to illuminate how individuals react in response to acute affective stimuli. These assessments are then be linked to psychological measures of emotional well-being and peripheral biomarkers of stress and inflammation.

As a point of departure, growing evidence has demonstrated that distinct brain structures differentially change in normative aging [37]. Paralleling the cognitive and executive function declines seen in aging, lateral areas of the PFC show the largest decrease in cortical thickness in senescence [38]. Dopaminergic signaling, implicated in both reward processing as well as executive functioning appears to be reduced in older adults [39]. In contrast, the amygdala—a region essential for processing of affective information—appears to remain relatively intact as individuals age [40]. In fact, some evidence suggests that the amygdala comes to preferentially process positive vs. negative information in aging [41, 42]. Furthermore, resting-state functional connectivity data

suggest that the strength of amygdala-cortical network connectivity increases with age [43]. This is in contrast with age-related functional connectivity density in other networks such as the default mode network [44].

In addition to age-related changes, findings from affective neuroscience strongly implicate individual differences in the overall patterns of results. For example, studies have suggested that low well-being is characterized by abnormalities in neural circuits that process and regulate emotion and are generally suggestive of a suboptimal affective style. In response to acute affective provocations, a maladaptive affective style typically takes the form of a slow recovery from negative emotional experiences and an inability to sustain positive emotional responses. One finding, from over 250 MIDUS participants aged between 36 and 84, found that individuals reporting a higher purpose in life showed evidence for better emotional recovery from acute negative emotional provocation 2 years later [45••]. Emotional recovery was indexed using the eye-blink startle reflex (EBR), a measure sensitive to emotional state [46], and dependent on the amygdala [47–49]. Specifically, individuals reporting a greater purpose in life 2 years earlier more rapidly recovered from negative stimuli, indexed by a smaller eye-blink in response to loud startle noise bursts after the negative picture disappeared. Importantly, this relationship was significant after statistically controlling for the initial eye-blink startle response to the negative picture, their general emotional state, as well as demographics such as age and gender. Such results suggest that purpose in life may promote resilience and protect against the harmful impact of negative events by enhancing emotion regulatory processes. This process may occur by higher levels of purpose motivating a more productive reframing and reappraisal of unpleasant and stressful situations and challenges.

In addition to more rapid physiological recovery from negative stimuli, higher levels of psychological well-being are associated with lower levels of depression [50]. Structurally, depressive symptomatology has been linked to decreased gray matter volume in the insula [51]. In contrast, eudaimonic well-being (particularly for dimensions of purpose in life, personal growth, and positive relations with others) has been positively associated with right insular gray matter volume [52]. The right insula is a region of the brain believed to be important for interoception of bodily signals, self-awareness, emotion, empathy, and control over bodily states [53, 54], and shows highly variable deterioration in aging [55]. As such, more gray matter in the insula supports better insula function and is suggestive of potentially better self-awareness of the mind and body to guide emotion regulation, decision-making, and behavioral choices.

In addition to structural studies of the brain, research using functional imaging has begun to explore the neural circuits linking psychological well-being and acute emotion elicited in the laboratory. A group of 64 individuals who participated in the MIDUS study viewed positive, neutral, and negative images during fMRI scanning. Those participants who evidenced more sustained activation in both the striatum (a brain region involved in reward processes) [56] and the DLPFC to the positive pictures over the time course of the 45-min task reported greater psychological well-being (composite score) and had lower daily cortisol output [57••]. Importantly, sustained striatal activity in response to the positive pictures significantly mediated the relationship between well-being and cortisol, suggesting that sustained engagement of striatal activity to pleasant events over time may act as a protective factor in reducing daily cortisol output and enhance adaptive stress regulation by the hypothalamic-pituitary-adrenal axis.

Further, in an fMRI study examining neural responses to negative and neutral emotional pictures in 29 individuals between 61 and 65 years of age, those reporting higher levels of purpose in life evidenced a lower response of the amygdala to negative pictures [58•]. Regulation of the amygdala was likely accomplished by a region of the PFC, specifically the ventral anterior cingulate cortex: higher engagement of the ventral part of the anterior cingulate in response to negative images was associated with higher purpose in life. Amygdala activity was reduced when there was greater ventral anterior cingulate cortex activation in response to negative relative to neutral pictures. This finding is paralleled by other imaging work suggesting that greater engagement of the PFC and PFC amygdala connectivity are related to healthy aging [59–61]. These findings suggest the salubrious impact of effectively engaging cortical-subcortical circuits as individual's age reflects intact emotional regulation capacity and heightened resilience to negative challenges.

An additional finding from the above study [58•] bears noting. Behaviorally, those participants reporting higher purpose in life were also slower to categorize the valence of negative relative to the neutral pictures. In other words, those reporting greater purpose in life appraised the negative pictures as less salient and potentially less threatening as those with lower levels of purpose in life. This behavioral finding may relate to the positivity effect in aging [62], in which older adults appear to spend more time looking [63] at positive and less at negative stimuli than middle-aged and younger adults [62]. Emerging research even suggests that older adults may appraise and respond to neutral stimuli more positively [64]. However, the degree to which a positivity effect in aging is associated with individual differences in whether one perceives purpose in their life, and the neural mechanisms mediating such an association has not yet been examined.

Overall, the above research shows emerging findings that are linking eudaimonic well-being to neural markers of reactivity to, and recovery from affective stimuli. Such evidence indicates more effective emotion regulation—defined as more rapid recovery (eye-blink startle response) as well as more rapid offset of the amygdala from negative stimuli—is evident among those with higher levels of purpose in life. In addition,

sustained activation of reward circuitry vis-à-vis positive stimuli was evident among those with higher overall well-being. Multiple dimensions of well-being have also been linked with greater right insular gray matter volume. The causal directionality of these linkages cannot yet be discerned, but when combined with the health benefits of purpose in life, which have been examined prospectively (see prior section), a coherent tale involving subjective psychological experience, underlying neural mechanisms of emotion regulation, and salubrious health is emerging. In contrast to much of the prior research focused on age-related changes in brain structure and function that demonstrate cognitive and emotional impairment, these new integrative findings offer insight into the resilience of some older persons. These individuals, despite the structural lag problem described by sociologists, nonetheless remain purposefully engaged, and as a result reap protection from diverse forms of morbidity, including Alzheimer's disease, depression, and cardiovascular diseases. Such patterns bring into high relief the question of intervention—i.e., can these beneficial processes be promoted among wider segments of the population? The next section addresses this topic.

Interventions to Promote Well-Being

The lack of well-being is known to increase subsequent risk for mental illness [65]. Further, cross-time gains in well-being are known to predict cross-time declines in mental illness [66]. These findings, combined with the above evidence on the health benefits of well-being and growing findings on underlying neural processes, elevate the importance of identifying whether eudaimonic well-being is modifiable. Growing evidence, in clinical, educational, and community contexts, suggest that it is [6••, 67•]. Indeed, there is increased awareness that promoting positive mental health has notable public health significance. Further, in treating mental health problems, it has become clear that full recovery involves more than the reduction of symptoms, or even the absence of psychological distress. Importantly, full recovery must include the promotion of experiences of well-being [67•, 68].

"Well-being therapy" [69, 70], conceived as an addition to cognitive behavioral therapy in treating major depression, made explicit use of the Ryff model of eudaimonic well-being [5••]. The overarching goal was to promote positive psychological experiences for patients' as a way of preventing relapse. The intervention required patients to keep daily diaries of positive happenings. These then become the focus of therapy wherein patients learned about how to avoid premature curtailment of such experiences as well as how to enrich and extend them. First findings documented improved remission profiles among those who received well-being therapy. Subsequent longitudinal follow-up showed that relapse was prevented over a 6-year period [71]. Well-being therapy was also found to be effective in treating anxiety disorders [72–74], again with long-lasting effects.

Efforts to promote eudaimonia may also play an important role in preventing mental illness and psychological distress in the broader population. A promising context for such work in adolescence is the school. Ruini et al. [75] adapted well-being therapy for school settings with the goal of preventing the development of depression (especially among girls) during adolescence. Students who received the intervention were compared with an attention-placebo group, with findings showing significant improvements in personal growth, along with reductions in distress [74]. Another controlled investigation in the school context showed that well-being therapy produced significant improvements in autonomy and friendliness, whereas an anxiety management intervention ameliorated anxious and depressive symptoms [76].

At the other end of the life course, the promotion of eudaimonic well-being among older adults in the community is also underway [77]. Later life comes with many challenges, such as loss of roles, loss of significant others, and health events. These difficulties can increase vulnerability to depression. This intervention, known as "Lighten Up," was conducted over a period of 8 weeks. It involved group discussion of the importance of well-being in later life, the sharing of positive memories, and engagement in exercises designed to promote well-being as well as to deal with difficult life challenges. Pre-post comparisons showed gains in most aspects of eudaimonic well-being and life satisfaction as well as reductions in depressive and physical symptoms and sleep complaints. Such improvements were most strongly evident among individuals with lower levels of eudaimonic well-being prior to the intervention. This work has been expanded to include additional groups of older adults in multiple community contexts.

More interventions, in clinical and community contexts, are detailed in Ryff [6••]. In addition, Davidson and McEwen [78•] have documented the impact of a variety of interventions, including some based on meditative practices, on well-being and its neural correlates. Collectively, these endeavors support the idea that eudaimonic well-being can be promoted. Such initiatives constitute important new directions in research translation and public health education. It is notable that none of the conceptual formulations drawn on in the creation of the eudaimonic model of well-being [5••] were explicitly concerned with how to promote such positive functioning. Their aim rather was to articulate defining features of optimal human functioning. Similarly, Aristotle's writings were primarily about articulating varieties of virtue. Nonetheless, thanks to

contemporary science and practice, the possibility of promoting ever wider experiences of eudaimonia for ever larger segments of society is becoming a reality.

Conclusions and Future Directions

Although geropsychiatry and cognitive aging have traditionally focused on disorders, deficits, and decline, new research and practice is afoot that emphasizes positive psychological functioning. In this article, emphasis has been given to a eudaimonic model of well-being built on the theoretical integration of perspectives from clinical, developmental, existential, and humanistic psychology. Aristotle's depiction of eudaimonia as the realization of personal potential provided distant philosophical inspiration. Contemporary empirical research was then examined to discern how various aspects of eudaimonic aspects of well-being change with age. Drawing on national longitudinal studies of aging, later life decline was documented in purposeful life engagement and personal growth. These diminished profiles possibly reflect the structural lag problem (i.e., social institutions have not kept up with the added years of life many adults are now experiencing). Nonetheless, some older persons continue to show high levels of eudaimonic well-being—that is, they look better than their same-aged peers.

The scientific story became notably more interesting at this juncture. The reason is that numerous empirical studies have recently emerged documenting later life health benefits of high eudaimonic well-being. Older persons who maintain high levels of purposeful life engagement, for example, show numerous health benefits: they live longer, their physiological systems show less dysregulation, they succumb to fewer disease outcomes, they have healthier gene expression profiles, and they practice more preventive health behaviors. Importantly, this evidence has been assembled with prospective epidemiological studies that include extensive controls for confounding factors such as socioeconomic status (education, income) and baseline profiles of health. For the most part, these kinds of findings have not been linked to brain mechanisms, though it is clear the effects documented must be mediated by neurobiological circuits.

Select evidence on age-related change in brain structure and function was briefly noted, with emphasis given to individual differences in obtained patterns of results. Studies showing abnormalities in neural circuits that process and regulate emotion were considered. One maladaptive affective style takes the form of showing slow recovery from negative emotional stimuli, or the inability to sustain responses from positive stimuli. Drawing on new findings from our collaboration, we showed that adults with higher levels of purpose in life recover more rapidly from negative stimulus provocation. In addition, functional imaging results showed that those with higher eudaimonic well-being evidenced more sustained activation to repeated positive provocations in brain regions involving reward processes, with such effects mediating diurnal cortisol output. Volumetric findings were also been reported: although depressive symptomatology has been linked with decreased gray matter volume in the insula, eudaimonic well-being (especially purpose in life, personal growth, and positive relations with others) has been positively linked with right insular gray matter volume.

These findings offer promise that the neural mechanisms behind eudaimonic well-being are becoming empirically tractable, though much work remains to be done. More explicit linkage between these differing lines of evidence (longitudinal/epidemiological versus laboratory/experimental) is needed. Of particular importance is the need to track these mind/body/brain linkages in the same respondents over time so that more probing analyses of causal directionality can be carried out. Such work requires labor-intensive assessments, as are being obtained in the MIDUS national study, and must also incorporate samples of sufficient size so that aging related processes (i.e., comparing young-, middle-, and older-aged adults) can be more carefully investigated. Recognizing these future needs, a key message behind the research summarized herein is that this kind of wide-ranging integrative research, which in prior eras would likely have been dismissed as undoable, has begun.

Finally, because purposeful life engagement, along with the broader formulation of eudaimonia, seems to offer so many salubrious health benefits, we included a brief overview of interventions designed to promote well-being. This work is being done in multiple contexts—clinical interventions designed to treat people suffering from depression and anxiety, school contexts seeking to prevent the development of emotional disorders in adolescence, and community settings with older adults negotiating the challenges of aging. In the best of all possible worlds, these efforts to effect change in experienced levels of eudaimonic well-being, would be a wonderful place from which to study underlying mechanistic processes. The future vision grows.

Compliance with Ethical Standards

Conflict of Interest Dr. Carol D. Ryff declares grants from the National Institute on Aging, on which some findings in this article are based (Grant number 1U19AG051426-01A1). Dr. Stacey M. Schaefer and Dr. Richard J. Davidson declare a grant from the National Institute on Aging (P01 AG020166). Dr. Aaron S. Heller and Dr. Carien van Reekum declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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- • Of importance
- •• Of major importance

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