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ARTICLE

Aesthetic flourishing: Scientists' experiences of beauty, wonder, and awe as indicators of higher wellbeing

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Abstract: The majority of existing empirical literature examining both the mental and physical health of academic scientists has focused almost exclusively on the negative outcomes of adverse working conditions and occupational stressors, especially burnout and attrition. Comparatively less attention has been given to potentially protective aspects of wellbeing. This disparity is possibly due to the fact that 'wellbeing' itself is less clearly defined. The wellbeing conceptual space has typically been divided into areas of hedonia and eudaimonia, but there have been recent interdisciplinary calls for consideration of higher or 'self-transcendent' aspects of wellbeing, which draw on primarily positive psychology and industrial/organizational sociology but also philosophy, theology, and the arts (Belzak et al., 2017; Huta & Ryan, 2010; Thrash, 2021; Varga, 2021). In contrast to hedonic and eudaimonic aspects, self-transcendent wellbeing seems to be related to higher goods (e.g., unity, truth, goodness, and beauty), as well as higher states (e.g., inspiration, insight, and awe), that indicate a form of flourishing beyond simple happiness or even self-actualization (Maslow, 1971; Thrash, 2021; Varga, 2021). In an effort to empirically differentiate these aspects of wellbeing, the present study measured and compared particular constructs—needs satisfaction, meaningfulness, aesthetic experiences—respectively prototypical of hedonic, eudaimonic, and self-transcendent wellbeing in a sample of biologists and physicists. We find that when controlling for both hedonic (basic needs satisfaction) and eudaimonic (vocational identity) wellbeing indicators, frequency of aesthetic experience (indicating self-transcendent wellbeing) still had a significant unique effect positively predicting human flourishing, with an effect size of greater magnitude than that of the eudaimonic predictor. These results suggest an empirically differentiable underexplored higher aspect of wellbeing above and beyond traditional markers of hedonic and eudaimonic wellbeing.

Keywords: aesthetics; meaningfulness; self-transcendence; eudaimonia; burnout

1. Introduction

Much literature on work and wellbeing has focused on negative outcomes and the absence of wellbeing as indicated by the presence of such factors as stress, burnout, and attrition (e.g., de Meis et al., 2003; Fimian et al., 1988; Hatch et al., 2011; Jourdain & Chênevert, 2010; Maslach, 2003; Maslach et al., 2001; Watts & Robertson, 2011). Less research has been dedicated solely to the positive aspects of wellbeing at work—possibly because wellbeing is harder to define affirmatively. We propose this is partly due to the structure of the wellbeing conceptual space, which we view as populated by overlapping topics, each encompassing sets of constructs. These constructs are in turn indicated by sets of hallmark characteristics. Historically, researchers have divided the well-being space into hedonic and eudaimonic topic areas—borrowing terms from

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ancient Greek philosophy (Huta, 2017; Ryan & Deci, 2001). More recently, however, theorists have begun to introduce greater nuance into the study and measurement of wellbeing (e.g., Huta, 2022).

In response to the degree of overlap among measured wellbeing outcomes, recent discussions have questioned whether the hedonic-eudaimonic distinction is supported empirically or rather is simply semantic (Huta, 2022). Theorists have also noted 'higher' wellbeing experiences (e.g., elevating experiences, self-transcendence, ecstasy, insight, inspiration) that might not fit into the traditional topical categories (Huta & Ryan, 2010), prompting a call for more systematic study (Belzak et al., 2017). This call has gone largely unanswered. Given these developments and consistent with precedent (Belzak et al., 2017; Huta & Ryan, 2010; Thrash, 2021; Varga, 2021), in the following, we do not construe these different types of hedonic, eudaimonic, and higher forms of wellbeing as exclusive constructs per se but rather as overlapping topics. Our aim is to measure and compare particular constructs (needs satisfaction, meaningfulness, aesthetic experiences) that are prototypical of these topics (hedonic, eudaimonic, self-transcendent wellbeing, respectively) in an effort to empirically address the question of their differentiation.

1.1 Hedonic wellbeing

The hedonic wellbeing topical area centers on the satisfaction of basic needs via pleasure-seeking and pain-aversion (Ryan & Deci, 2001). While hedonia is typically associated with physical pleasure, the hedonic wellbeing topic also includes the satisfaction of basic and motive needs, such as for achievement, affiliation-intimacy, and power (McClelland et al., 1953; 1989; Ryan & Deci, 2001; Winter, 1994). Because of this focus, a popular modern conceptualization refers to subjective well-being (SWB) given individual differences in the experience of pain and pleasure (Belzak et al., 2017; Diener & Ryan, 2009; Fisher, 2014). SWB is characterized by the satisfaction of basic needs resulting in frequent positive affect, infrequent experiences of negative affect, and consistently high positive cognitive evaluation of life satisfaction (Diener, 1984). None of these factors alone entirely accounts for hedonic wellbeing, but they are all important indicators of SWB (e.g., satisfaction of needs is an essential prerequisite, as in Maslow's [1943] hierarchy). Moreover, within the SWB framework, the relative frequency with which an individual experiences these factors is critical to overall wellbeing, which aligns well with lay conceptualizations of happiness (Green & Salovey, 1999; Ryan & Deci, 2001; Tellegen et al., 1999).

1.2 Eudaimonic wellbeing

The eudaimonic conceptualization of wellbeing broadly takes into consideration meaningfulness and fulfillment, but researchers have offered a variety of potential indicators. For example, self-determination theory emphasizes autonomy, competence, and relatedness (Deci & Ryan, 1985, 2000; Sheldon & Hilpert, 2012), to which other researchers have proposed adding unconditional self-regard and acceptance—Rogers's (1959) elaboration of Maslow's (1943) hierarchy of needs. As in Maslow's model, an individual's basic needs must be met to pursue personal growth along dimensions of meaning in life, goal achievement, and virtue. Because of the emphasis on meaning in life and personal growth, eudaimonic wellbeing is closely linked with self-actualization (Maslow, 1962). Combining these different elements, Ryff and Keyes (1995) proposed a theory of psychological eudaimonic wellbeing that identifies autonomy, positive relations, personal growth, purpose in life, environmental mastery, and self-acceptance as the core aspects of healthy functioning where long-term essential goals contribute to the meaningfulness of an individual's life.

1.3 Self-transcendent wellbeing

In empirical practice, researchers often integrate core elements of both hedonic and eudaimonic wellbeing because they are frequently correlated (Huta, 2022). While such interdependence demonstrates that hedonia and eudaimonia are not mutually exclusive, they are also not mutually exhaustive (Belzak et al., 2017; Thrash, 2021). As Huta and Ryan (2010) observed, both hedonic and eudaimonic factors contribute to wellbeing, but researchers should be cautious as there is a yet under-considered third topical area within the wellbeing space that consists of higher aspects that have been termed 'self-transcendent'. These 'elevating experiences' include psychedelic (MacLean et al., 2011; Yaden et al., 2017) and bodily (Maruskin et al., 2012) states, self-transcendent traits (Cloninger et al., 1993), inspiration (Cui et al., 2020; Thrash et al., 2014; Thrash & Elliot, 2003, 2004), insight (Kounios & Beeman, 2014), flow and mindfulness (Csikszentmihalyi, 1990; Kabat-Zinn, 2009; Schutte & Malouff, 2023), peak experiences (Maslow, 1964), and aesthetic emotions and higher goods experiences (Darbor et al., 2016; Juslin, 2013; Keltner, 2023; Keltner & Haidt, 2003; Shiota et al., 2006, 2007; Varga, 2021). Theorists have called for further examination of these higher states within the context of self-transcendent wellbeing (Belzak et al., 2017; Thrash, 2021; Varga, 2021), especially recognizing its Western roots in ancient Greek poetry and philosophy (Hesiod & Homer, 1914; Homer, 1897; Leavitt, 1997; Plato, 1993; Wilford, 1965), Hebraic philosophy and prophecy (ha-Levi, 2004; Heschel, 1962; Leavitt, 1997), and Judeo-Christian theology (Aquinas, 2018; Buber, 1970; ha-Levi, 2004) as well as its (often implicit) presence and influence in an even wider range of domains, from literary theory (e.g., Burke, 1757; Clark, 1997) to theoretical and clinical psychology (e.g., James, 1902; Kris, 1964).

Aesthetic experiences can also indicate self-transcendent wellbeing when experienced via a transcendent modality (Thrash, 2021; Varga, 2021)—awe as affective encounter, wonder leading to cognitive insight, beauty motivating transmission, for example. Frequency of aesthetic experiences has been found to positively correlate with human flourishing (Jacobi et al., 2022). Advances in neuroscientific and psychological research, particularly in the burgeoning field of neuroaesthetics, have suggested an underlying neuroscientific link between aesthetic experiences and wellbeing (Anglada-Tort & Skov, 2022; Mastandrea et al., 2019; Skov & Nadal, 2020). When aesthetic contents are experienced in characteristically transcendent ways, the effect is qualitatively different from more mundane experiences of 'prettiness' or 'pleasantness' and closely parallels other higher states (Marković, 2012; Thrash & Elliot, 2004; Varga, 2021), suggesting an underexplored relationship between aesthetics and self-transcendent wellbeing.

1.4 Human flourishing

Some attempts have been made to better capture various aspects of the wellbeing space within a single, combined model (Weziak-Bialowolska et al., 2021). Examples include the PERMA model with domains covering positive emotion, engagement, relationships, meaning, and accomplishments (Seligman, 2011), the Comprehensive Inventory of Thriving covering 18 domains (Su et al., 2014), and the Well-Being Assessment (WBA) covering six domains proposed by the Harvard Human Flourishing Program (VanderWeele, 2017; Weziak-Bialowolska et al., 2021). These latter six domains, as measured in the Human Flourishing Index (VanderWeele, 2017), potentially offer an outcome measure encompassing the different kinds of wellbeing we set out to study: happiness and life satisfaction (hedonic), meaning and purpose (eudaimonic), character and virtue (self-transcendent) as well as mental and physical health, financial and material stability (basic needs), and close social relationships (social needs). In contrast to earlier models (e.g., Ryff & Keyes, 1995), these aspects are meant to broadly cover all domains of a person's life, not just areas relevant to psychological wellbeing (Lee et al., 2021; VanderWeele,

2017). The inclusion of aspects like virtue and character (and to a lesser extent, relationships) is consistent with current trends in positive psychology and wellbeing studies to account for facets of flourishing that are less commonly measured by traditional wellbeing constructs (VanderWeele, 2017; Weziak-Bialowolska et al., 2021). The human flourishing space thus broadly includes hallmark indicators of different kinds of wellbeing, including hedonic, eudaimonic, social, and self-transcendent.

1.5 A population of interest: wellbeing in scientific academia

The relationship between aesthetic experiences and higher forms of wellbeing can be put to especially rigorous test in scientific academia, where occupational stressors are high and aesthetic experiences, such as of wonder and awe, can be especially salient motivators and rewards of research, but where science and scientists have historically been averse to explicitly including or valuing aesthetics (Vaidyanathan & Varga, 2020). Rising levels of leaving intentions, particularly in response to the adverse effects of stress, burnout, and negative workplace environments (Blanco-Donoso et al., 2021; Fimian et al., 1988; Miller et al., 1990; Simon et al., 2010; Sull et al., 2022; Taris, 2022), have brought into sharp focus the extreme pressures placed on scientists in academia and the toll taken on academics' mental health at all levels (Bleasdale, 2019; de Meis et al., 2003; Duffy et al., 2011; Peterson et al., 2008). Research monitoring these trends have noted an increased prevalence of depression, anxiety, and suicidality even among university students, particularly postgraduates (Eisenberg et al., 2007; Evans et al., 2018; Garcia-Williams et al., 2014; Gewin, 2012). Both qualitative and quantitative studies have demonstrated that the adverse mental health effects of the pressures on academics have been compounded by the COVID-19 pandemic (e.g., Morin et al., 2022), including some large-scale and international studies specifically examining the impact on scientists (Bezak et al., 2022; Chan et al., 2020; Gao et al., 2021).

These trends and warning calls, especially urgent in the post-pandemic academic landscape, underscore the importance of understanding the numerous factors involved in scientists' professional lives. Stress manifests in a multiplicity of ways ranging from experiencing heightened arousal following a difficult day at work (Anderson, 2012) to struggling to meet basic survival needs (Maslow, 1962). The impact of stress on scientists varies with how much they identify themselves by the meaningfulness of their work (Wilson & Britt, 2021), which in turn has significant behavioral implications for how they respond to negative work environments and burnout with leaving intentions (Kelly et al., 2022; Kelly & Varga, 2022). This literature highlights the importance of considering the complex interactions of factors that affect scientists' wellbeing outcomes as traditional indicators of wellbeing might be less straightforward to interpret.

Recent examination of scientists' vocational identity also provides a helpful eudaimonic comparison for the more transcendent aesthetic experiences (Kelly & Varga, 2022). Vocational identity measures the degree to which an individual's work is meaningful in their life and thus is aligned closely with the central characteristics that define hedonic wellbeing. In previous research, scientists' vocational identity has been shown to significantly predict burnout and leaving intentions as well as moderate their relationship (Kelly et al., 2022). No research has yet examined vocational identity as a predictor of positive outcomes nor its relationship with other varieties of wellbeing.

In the present article, we examine how the aesthetic aspects of science might provide additional insights into human flourishing and offer some empirical evidence for the presence of a form of wellbeing beyond basic needs satisfaction and eudaimonic meaningfulness towards self-transcendence. Given recent findings demonstrating a strong positive association of aesthetic

experiences and human flourishing in scientists (Jacobi et al., 2022) and the significant effects of meaningfulness and vocational identity on scientists' endorsement of negative workplace wellbeing indicators (Kelly et al., 2022), we hypothesized that frequency of aesthetic experiences would uniquely predict flourishing in an international sample of scientists above and beyond the unique effects of basic needs satisfaction and vocational identity.

2. Method

2.1 Participants and procedure

Data for this research came from a larger empirical study of biologists and physicists at doctorate-granting institutions and research institutes in the United States, United Kingdom, Italy, and India who completed online questionnaires (starting $N = 3{,}442$; analytic $N = 3{,}082$).[1] These countries were chosen to provide a variety of social and cultural contexts as well as different scientific infrastructures. They were amongst the most responsive to a previous international survey of scientists (Ecklund et al., 2019), which allowed us to tap into existing networks of research collaborators. By percentage of gross domestic product spent on research and development, the United States has the most developed scientific infrastructure (3.46%), followed by the United Kingdom (2.91%), Italy (1.45%), and India (0.65%; UNESCO Institute for Statistics, 2023). Doctorate-granting universities and research institutes in these locations were identified by national databases of postsecondary education data and statistics, filtered for departments relevant to the research sample of biologists and physicists. Individual eligible participants were selected from the sampled research organizations to ensure the sample frame was nationally representative of the target population in each country. Additional information detailing sampling preparation can be found in the methodology report by Pacer and colleagues (2021) and the study materials are available in the public repository for the project (osf.io/jp86u). Based on the analytic sample, 1,209 participants identified as female, and 1,873 identified as male. The mean age was 42.2 years. Participants were excluded if they were not active in either biology or physics or not based in one of the four countries of interest.

2.2 Measures

We predicate coding decisions of all of the following wellbeing variables on the theoretical constructs they are meant to capture, thereby promoting greater specificity in the measurement of flourishing constructs. To illustrate, a low score on an 11-point positive state scale (e.g., "satisfaction" from 0 = *not satisfied at all* to 10 = *completely satisfied*) would indicate a low level of a positive: a rating of 2 does not state a net negative but a middling impact. This evaluation is substantively and theoretically different from an 11-point assessment scale where 0 = *poor* to 10 = *excellent*. In the latter case, the same low score (2) would indicate a negative state on the measured construct. The problem amplifies when assessing statistically; one cannot equate movement along different points of continuous scales that capture multiple dimensions (Long & Freese, 2014, pp. 385–386; Stevens, 1946).

Thus, the recoding of each variable below matches the valence of the given response. A measure that assesses the presence and level of a positive on an 11-point scale would retain all

[1] A subset of scientists ($n = 215$) who completed the online study were subsequently invited to participate in a more in-depth follow-up interview. An additional 394 scientists were interviewed prior to the online survey. The qualitative data from these interviews was used to inform the directionality of our hypotheses and is discussed separately in other papers. Examples of qualitative coding of hypothesis directionality are included in Appendix A in the supplementary materials.

responses as given (0 to 10), while a measure that assesses a construct from negative to positive state on an 11-point scale would have negative/neutral responses recoded as absence of the positive construct (0 to 5 = 0), with positive responses (6-10) coded as 1 to 5. Measures for all variables were then standardized to allow comparison while retaining the theoretical substance of all substantive quantitative responses.

2.2.1 Flourishing

Given the nature of indices (as opposed to scales; e.g., Krishnakumar & Nagar, 2008) and drawing on the factors found by Lee and colleagues (2021), we measured flourishing (outcome variable) as a composite of four items representing the happiness/life satisfaction, meaning/purpose, character/virtue, and close social relationships domains of the Human Flourishing Index (VanderWeele, 2017): "Overall, how satisfied are you with life as a whole these days?" (0 = *Not satisfied at all* to 10 = *Completely satisfied*), "Overall, to what extent do you feel the things you do in your life are worthwhile?" (0 = *Not at all worthwhile* to 10 = *Completely worthwhile*), "I always act to promote good in all circumstances, even in difficult and challenging situations." (0 = *Not true of me* to 10 = *Completely true of me*), "My relationships are as satisfying as I would want them to be." (0 = *Strongly disagree* to 10 = *Strongly agree*).[2] Our flourishing outcome variable had a good reliability (α = .77).

2.2.2 Basic needs satisfaction

In the present study, we are interested in the composite of basic needs as indicative of hedonic satisfaction and as a relevant control when looking at eudaimonic and transcendent areas of wellbeing. We have therefore elected to divide the Human Flourishing Index along the factors discussed by Lee and colleagues (2021) and in personal correspondence with the authors of the index (Lee, 2022). While hedonic wellbeing is not fully encompassed by the satisfaction of basic needs alone, this measure captures relevant normative basic needs underlying the core principles of pleasure and satisfaction, which are necessary dimensions within the hedonic wellbeing space (see Footnote 3). Because our flourishing outcome variable offers a holistic approach to human flourishing that contains SWB (the other hallmark measure of hedonic wellbeing), accounting for basic needs remained the missing component in our attempt to examine the effect of self-transcendent wellbeing on flourishing net of hedonic wellbeing. We thus operationalize the share of variance attributable to hedonic wellbeing via a composite control for meeting one's basic needs.

Following the factors found by Lee and colleagues (2021), we measured basic needs satisfaction with the mean of three items from the mental/physical health and financial/material stability domains of the Human Flourishing Index (VanderWeele, 2017): "In general, how would you rate your physical health?" (0 = *Poor* to 10 = *Excellent*), "How would you rate your overall mental health?" (0 = *Poor* to 10 = *Excellent*), and "How often do you worry about being able to meet normal monthly living expenses?" (0 = *Worry all of the time* to 10 = *Do not ever worry*). Together, these three measures assess mental health, physical health, and state of anxiety about material stability (as a proxy for lack of peace). Due to the wording of the questions (i.e., all

[2] The relationship satisfaction item is rated on an agreement Likert scale that appears to include the negative (absence) of flourishing in a way that the other items in the Flourishing outcome variable (concerning indication of the presence of a positive) do not. However, the wording of this question has a variable reference point ("as satisfying as I would want them to be"); "dissatisfaction" does not necessarily indicate that participants are dissatisfied with the relationships. It indicates that participants could see relationships improving (deepening, satisfying even more than they currently do) from their current status, which could be either positive or negative.

response values below the mean fail to meet subsistence), the mental and physical health items were recoded along six-point needs satisfaction scales capturing only the positive satisfaction of needs from *Not in good health* (0) to *Excellent* (1-5).[3] Our recoded basic needs satisfaction scale had acceptable reliability (α = .62).

2.2.3 Vocational identity

We measured the meaningfulness of scientist identity as a predicted factor score of two Likert-scale items based on Wrzesniewski and colleagues (1997). These items asked participants to rate agreement (on five-point Likert scales) with the statements "My work as a scientist feels like a calling or vocation; it is one of the most meaningful aspects of my life" and "My work as a scientist is just a job; I may enjoy it but it is not among the most meaningful aspects of my life" (reverse coded). Vocational identity captures an aspect of occupation-based eudaimonic meaning. Our measure had an acceptable reliability (α = .64).

2.2.4 Aesthetic experiences

We measured frequency of aesthetic experiences using the 12-item summative scale of frequency anchored Likert items (0 = *never*, 1 = *rarely*, 2 = *a few times a year*, 3 = *a few times a month*, to 4 = *weekly or more*) capturing the domains of beauty, wonder, and awe used by Jacobi and colleagues (2022). The items are 'I felt pleased by encountering symmetry in scientific equations, models, or data', 'I felt pleased by the elegance of a scientific object', 'I felt surprised by discovering a hidden order or deeper systems underlying the phenomenon I was researching', 'I felt a sense of clarity as I saw how things fit together', 'I felt my sense of self become somehow smaller in the face of what I was researching', 'I felt that I was in the presence of something grand', 'I felt a sense of reverence or respect about the things I was discovering', 'I was thrilled by a new insight', 'Thinking about a scientific problem kept me awake at night', 'I felt my research opened up new mysteries for me to explore', 'I felt a sense of almost childlike delight or joy during my work', and 'I felt grateful for learning something new'. These items align closely with or were designed in consultation with the authors of other previously validated scales (Oleynick, 2015; Shiota et al., 2006; Varga, 2021; Yaden et al., 2019). As demonstrated by Jacobi and colleagues (2022), the items load onto a single underlying factor (in exploratory factor analysis, the first factor had an eigenvalue of 5.05, and a second factor would have an eigenvalue of only 0.49). The reliability of the scale is favorable (α = .89).

[3] On an 11-point scale ranging from 0 = *poor* to 10 = *excellent*, ratings of 0-4 connote some level of health declination (i.e., are below the available neutral rating of one's physical/mental health, indicating a negative assessment), a rating of 5 indicates a neutral rating (a subjective assessment neither negative nor positive), and ratings in the range of 6-10 indicate the presence of some level of a positive subjective assessment of one's physical/mental health. Because our basic needs measure is meant to indicate the meeting of one's basic needs, increasing positive numbers on these scales necessarily must indicate some level of a positive assessment. This would not be the case in the original coding: e.g., movement from 2→4 would indicate a decrease in a present negative state, movement from 4→6 would indicate the dissolution of a low-level negative state and movement to a new low-level positive state, while 7→9 would indicate an increase in a present positive state. We thus recoded original ratings of 0-5 as 0 (i.e., the basic need of physical/mental health is in a negative/neutral state: need unmet), and all values above this number (original ratings of 6-10, recoded as 1-5) as indicating the presence of (increasing levels of) physical/mental health in positive states. Thus, in our recoded measure, positive numbers of any value indicate the presence of a positive state (needs met, minimally to fully).

2.2.5 Demographics

We introduced control variables based on demographic measures. These controls included survey wave (given the then-ongoing COVID-19 pandemic); drop-down response questions for age, gender, position and status (i.e., academic rank), and country; and a binary stress experience question ('Other than the pandemic, in the past twelve months, have you experienced any stressful life events?'). Gender response options were *Male*, *Female*, and *Other* (dropped in the analysis due to very small *n*-size), and academic rank options ranged from *Masters/PhD student* to *Full, tenured professor*.

2.3 Analytic strategy

Cases with incomplete data were dropped listwise. We used ordinary least squares (OLS) regression analyses to model the relationships of basic needs satisfaction, vocational identity, and aesthetic experiences with flourishing. All continuous variables were standardized. Analyses controlled for gender, country, age, age squared, position/status, stress, and survey wave. All analyses were survey weighted. While causal inference must be limited due to our cross-sectional dataset (Taris et al., 2021), the directionality of the models is based on overwhelming literature precedent (including longitudinal studies of predictors of wellbeing and flourishing) and in-depth interviews conducted in tandem with the present online data collection.[4]

3. Results

Descriptive statistics are presented in Table 1. Before standardization, the mean positive flourishing score across all participants was 29.0 on its 40-point scale. The mean score for aesthetic experience frequency was 25.3 on its 48-point scale. When survey-weighted, standardized, and controlled for gender, country, age, age squared, position/status, stress, and survey wave, satisfaction of basic physical, mental, and financial needs significantly and strongly predicted flourishing, β = .56 [.51 - .62] as shown in Table 2, Model 1 (markers of hedonia – basic needs satisfaction alone). Consistent with past findings, when added to this model, vocational identity also significantly predicted flourishing, β = .13 [.08 - .17], reducing the effect of basic needs satisfaction by only 4% as seen in Table 2, Model 2 (traditional hedonia and eudaimonia – basic needs satisfaction and vocational identity).

In line with the hypothesis, frequency of aesthetic experiences significantly predicted flourishing, β = .22 [.19 -.25] as demonstrated in Table 2, Model 3 (combined markers of hedonia, eudaimonia, and transcendence – basic needs satisfaction, vocational identity, and aesthetic frequency). Unexpectedly, we found that the unique effect of aesthetic experience frequency on flourishing was significantly greater than that of eudaimonic vocational identity, which was reduced to β = .05 [.00 - .10]. Each of the three models is also associated with a significant increase in the R-squared value (from .11 in the Baseline Model to .45 in Model 3), hence pointing to the independent contribution of aesthetic experiences to wellbeing.

The full results of the OLS regression models presented in Table 2 further show that biologists and physicists in Italy have higher average levels of flourishing than scientists in the US (β = .22 [.14 - .30]) or in the other countries. Whereas scientists in the UK and India are predicted to have lower flourishing levels than scientists in the US in the baseline model, those differences disappear once basic needs satisfaction is controlled for in Model 1. Higher age is robustly

[4] While we could not manipulate the presence of aesthetic experiences in scientists' lives, interviewees discussed relative fluctuations in wellbeing and job satisfaction following on the presence or lack of aesthetic experiences in various settings, suggesting a specific directional relationship.

associated with higher flourishing in all Models. Even though there is no gender difference in wellbeing in the baseline model, women are predicted to have slightly higher flourishing scores once eudaimonic and transcendent wellbeing are controlled for the final Models.

Robustness tests in terms of interaction models of country, gender, position and age with the three focal variables are presented in Supplementary Table 1. We find that the significant and large regression coefficients of aesthetic frequency on flourishing are stable in all models. Further interaction models in which the positive association of position with flourishing is weakened with increasing age (i.e., suggesting that the benefit of position is stronger in younger age groups) are shown in Supplementary Table 2. Overall, the coefficients for basic needs satisfaction and aesthetic frequency are remarkably stable irrespective of various differing model specifications.

Table 1. *Descriptive statistics*

	Survey Proportion	Survey Mean	SD	Min.	Max.	Range
Country						
USA	54%					
UK	27%					
India	10%					
Italy	9%					
Gender						
Men	68%					
Women	32%					
Position/status						
Postgraduate student	29%					
Postdoc	16%					
Research Scientist	5%					
Junior Faculty	12%					
Mid-level Faculty	12%					
Senior Faculty	26%					
Survey wave						
Wave 1	68%					
Wave 2	32%					
Stressor other than pandemic						
No stressor	67%					
Stressor	33%					
Age		42.2	12.7	18.0	86.0	68.0
Flourishing scale		29.0	5.9	.0	40.0	40.0
Basic Needs Satisfaction (standardized)		.1	1.0	-2.3	2.4	4.7
Vocational Identity		7.7	2.0	2.0	10.0	8.0
Aesthetic Experiences		25.3	8.0	1.0	48.0	47.0

Note. N = 3,082; Proportion and Mean are survey-weighted; SD = unweighted standard deviation, Min. = Minimum, Max. = Maximum

Table 2. *OLS models regressing flourishing on control and predictor variables*

	Flourishing			
Predictors	Baseline Model	Model 1	Model 2	Model 3
Gender: Women (ref. Men)	-0.04	0.06+	0.07*	0.06*
	(-0.14 - 0.06)	(-0.01 - 0.13)	(0.01 - 0.14)	(0.01 - 0.12)
Country (ref. USA)				
UK	-0.14**	-0.03	-0.01	0.05
	(-0.25 - -0.04)	(-0.12 - 0.06)	(-0.11 - 0.08)	(-0.03 - 0.14)
India	-0.14***	0.03	0.03	-0.02
	(-0.21 - -0.07)	(-0.03 - 0.09)	(-0.03 - 0.09)	(-0.08 - 0.04)
Italy	0.22***	0.17***	0.18***	0.18***
	(0.14 - 0.30)	(0.10 - 0.25)	(0.10 - 0.25)	(0.11 - 0.25)
Age	0.23*	0.17***	0.14**	0.19***
	(0.03 - 0.43)	(0.08 - 0.27)	(0.05 - 0.23)	(0.11 - 0.26)
Age squared	-0.04	-0.03	-0.03	-0.04
	(-0.10 - 0.03)	(-0.08 - 0.02)	(-0.08 - 0.02)	(-0.09 - 0.01)
Position (ref. Postgraduate student)				
Postdoc	0.09	0.04	0.04	0.07
	(-0.04 - 0.22)	(-0.16 - 0.25)	(-0.17 - 0.25)	(-0.16 - 0.30)
Research Scientist	-0.12	-0.25*	-0.23*	-0.15
	(-0.30 - 0.05)	(-0.47 - -0.03)	(-0.45 - -0.00)	(-0.40 - 0.09)
Junior Faculty	-0.01	-0.13	-0.14+	-0.04
	(-0.34 - 0.32)	(-0.28 - 0.03)	(-0.31 - 0.03)	(-0.19 - 0.12)
Mid-level Faculty	0.08	-0.16*	-0.15*	-0.08
	(-0.21 - 0.37)	(-0.30 - -0.02)	(-0.28 - -0.02)	(-0.21 - 0.06)
Senior Faculty	0.05	-0.19*	-0.22*	-0.15+
	(-0.25 - 0.35)	(-0.36 - -0.03)	(-0.38 - -0.05)	(-0.32 - 0.02)
Survey wave: Wave 2 (ref. Wave 1)	-0.06	-0.04	-0.04	-0.02
	(-0.22 - 0.11)	(-0.16 - 0.08)	(-0.16 - 0.08)	(-0.14 - 0.09)
Stressor other than Pandemic:	-0.29***	-0.05	-0.05	-0.06
Mentioned (ref. Not mentioned)	(-0.45 - -0.13)	(-0.18 - 0.08)	(-0.18 - 0.08)	(-0.18 - 0.06)
Basic Needs Satisfaction		0.56***	0.54***	0.54***
		(0.51 - 0.62)	(0.50 - 0.59)	(0.50 - 0.57)
Vocational Identity			0.13***	0.05*
			(0.08 - 0.17)	(0.00 - 0.10)
Aesthetic Frequency				0.22***
				(0.19 - 0.25)
Observations	3,082	3,082	3,082	3,082
R-squared	0.11	0.39	0.41	0.45

Note. N = 3,082; Standardized regression coefficients (β) computed separately for each model (columns); all continuous variables have been standardized; 95% confidence intervals in brackets; ***p < .001, **p < .01, *p < .05, +p < .1.

4. Discussion

We aimed to investigate how scientists' flourishing might be predicted by aesthetic experiences (a marker of self-transcendent wellbeing) as well as vocational identity (a marker of meaningfulness, a hallmark of eudaimonia), net of basic needs satisfaction (a marker of hedonia). We hypothesized that frequency of aesthetic experience would have a significant unique effect on flourishing, above and beyond the unique effect of vocational identity. The results of our analysis support this hypothesis. Moreover, we found that the predictive effect of aesthetic experience frequency was not only significant, but also greater in magnitude than the standardized effect of vocational identity on flourishing—an unexpected finding. This finding might imply that much of the downstream meaningful aspects of scientists' vocational lives are affected by aesthetic experiences in their work or that the identities scientists form around their work are significantly influenced by these higher experiences of beauty, wonder, and awe. This interpretation would be consistent with theory that proposes a motivating aspect of aesthetic experiences (analogous to inspiration; Thrash, 2021) that some scientists have previously suggested is a large part of why they embark on, and indeed remain in, scientific careers (Vaidyanathan & Varga, 2020). Taken together, these results indeed suggest a higher aspect of the wellbeing conceptual space (indicated here by our operationalization of aesthetic experience frequency) that is not fully accounted for by hedonic and eudaimonic constructs.

Especially relevant as conditions in academia increasingly predict negative outcomes, our findings build on previous work establishing that the frequency of scientists' aesthetic experiences is strongly correlated with measures of overall human flourishing (Jacobi et al., 2022). The present study builds on the simple correlation previously reported to empirically disentangle different types of wellbeing and how their hallmark indicators might uniquely predict flourishing in scientists. Our contribution thus helps confirm past findings and take steps towards unpacking the association between aesthetics and flourishing within the nuances of the wellbeing conceptual space. In so doing, we have attempted to respond to the call for increased attention to higher forms of wellbeing (Belzak et al., 2017; Huta & Ryan, 2010; Thrash, 2021) by suggesting that, consistent with precedent (e.g., Marković, 2012), aesthetic experiences might be especially relevant to transcendence and associated positive outcomes (Liu et al., 2023)—especially when experienced via characteristically self-transcendent modalities (Varga, 2021).

Future research should expand on these findings to examine whether aesthetic experiences can function as a protective buffer against adverse conditions with implications for interventions aimed at fostering a more holistic understanding of flourishing within the academy. Moreover, our findings also have implications for the future development of strategic interventions aimed at improving scientists' wellbeing at work by cultivating optimal environmental and organizational conditions for the promotion of aesthetic experiences. These applications might take the form of institutional initiatives to prioritize the provision of resources that promote the satisfaction of basic occupational needs or that take a job crafting approach (e.g., Laguía et al., 2024) to maximizing opportunities for scientists to pursue work that subjectively cultivates aesthetic experiences, which in turn might support productivity and retention (Kelly et al., 2022).

The premise of a higher domain within the wellbeing space, however, should be predicated on the understanding that the constructs involved are proper to overlapping topics that do not have neatly defined boundaries (Huta, 2022; Huta & Ryan, 2010). Aesthetic experiences are undoubtedly related to some hedonic experiences (e.g., liking, pleasure, delight) as well as higher experiences (e.g., self-transcendence). They might also contribute to flourishing via psychological richness, another neglected aspect of the wellbeing space that cuts across multiple wellbeing topics (Oishi et al., 2020). A substantial subset of scientists' aesthetic experiences tends to be

related to discovery, insight, and learning new things (Vaidyanathan & Varga, 2020). Rather than contributing solely to pleasure, happiness, or meaning, these 'reward' aspects of scientific work might also contribute to psychologically rich lives. All of these implications point to the need for future research to continue exploring the wellbeing space beyond traditional frameworks. Such future work should also investigate whether these under-considered topics within the wellbeing space can yield more effective interventions or contribute to protective factors already associated with well-studied wellbeing topics (particularly eudaimonia).

The influence of the conceptualization and specifications of wellbeing scales on interpretations should also be considered more carefully. Likert scales frequently capture multiple dimensions (such as the distinct assessments of valence and vehemence included in *strongly disagree* to *strongly agree* measures), or (and) include measurement of both positive and negative aspects of relevant constructs (e.g., health measures that capture the presence and level of both positive and negative states). Operationalizations of ephemeral constructs such as multidimensional wellbeing, and attempts to disentangle the distinct overlapping elements it comprises, must be precise, and future research should accordingly always strive for greater clarity and precision of measurement.

While we hope the present study offers a solid step in a fruitful direction, our conclusions must be qualified by a number of limitations. First, methodologically, the dataset utilized for these analyses employed a cross-sectional design, which restricts our ability to infer causality between our proposed predictors and flourishing. While we have constructed our models based on the vast preponderance of literature supporting the directionality we have adopted (i.e., needs satisfaction, occupational meaning, and higher experiences predict flourishing rather than vice versa), future work utilizing longitudinal data should seek to confirm these findings.

We were also limited in selecting the most relevant variables available in the larger dataset. The dataset also did not include, for example, comparable data across countries that would have allowed us to meaningfully add race as a covariate without multicollinearity effects with country. Similarly, the dataset did not include all of the necessary indicators of socioeconomic status. We argue, however, that position (academic status) functions in a similar way within our sample of academic scientists.

The generalizability of our results is thus also limited to those populations of biologists and physicists in the United States, United Kingdom, Italy, and India from which our sample was drawn. We restricted participation to biologists and physicists to focus on two contrasting core disciplines with recognizably distinct approaches to aesthetics (MacArthur, 2021). Consistent with previous findings (e.g., Vaidyanathan & Varga, 2020), there were differences between disciplines in the type of experiences scientists reported as aesthetic: biologists, for example, were more likely to identify beauty in their work through instances of physical symmetry in their observations, while physicists were more likely to identify beauty in instances of theoretical symmetry in mathematics and equation. Differences in wellbeing outcomes by subfield (e.g., theoretical physics, astrophysics; cell biology, molecular biology) were more difficult to parse, however, as sub-disciplinary categories vary considerably by institution and research content; exploratory analyses yielded impractically large confidence intervals. Future research could take a more fine-tuned approach to investigate the implications of sub-disciplinary differences for downstream wellbeing effects.[5]

On the other hand, such a large international sample coupled with robust survey weighting goes a long way towards overcoming the limitations of previous research that has been restricted

[5] Qualitative research into these differences is ongoing utilizing the same dataset.

by small convenience samples and high nonresponse rates. Our findings are thus suggestive of likely trends in a broader population of scientists. Aesthetic experiences are also not unique to science; the frequency with which individuals in a general population experience beauty, wonder, and awe in their daily lives is also likely to play a large part in their human flourishing and should be studied as such. These findings are ripe for further investigation in tandem with ongoing research into creativity, inspiration, imagination, and their wellbeing implications as other indicators of self-transcendent wellbeing (Cui et al., 2020; Thrash, 2021).

Other limitations apply to our measures. The measures of aesthetics and vocational identity we used, while taken from previous studies (e.g., Jacobi et al., 2021; Jacobi et al., 2024; Kelly & Varga, 2022; Kelly et al., 2022) and closely related to similar measures in relevant parallel research (e.g., Oleynick, 2015; Shiota et al., 2006; Varga, 2021; Yaden et al., 2019), have not yet been validated. Moreover, whilst the Human Flourishing Index has been well-validated and widely used, our division to form a basic needs domain and a core wellbeing outcome domain is novel. Our approach, however, is both methodologically tenable given the nature of index measures and conceptually sound based on previous factor analyses (Lee et al., 2021) and consultation with the authors of the index (Lee, 2022).

Conceptually, we have demonstrated that aesthetic experiences contribute to wellbeing above and beyond measures of needs satisfaction and eudaimonia. The dataset we used, however, did not include information about the modality of scientists' experiences, only content data. It is therefore difficult to definitively attribute the unique effect of aesthetics purely to self-transcendence. To fully investigate aesthetic experiences in the context of self-transcendent wellbeing, future studies should examine both the contents and the modalities of such experiences (Varga, 2021).

4.1 Conclusion

Our results show that aesthetic experiences contribute to scientists' wellbeing above and beyond their basic needs satisfaction and the meaningfulness of their work. These findings suggest that aesthetics indicate an aspect of wellbeing empirically distinguishable from hedonia and eudaimonia. They also support the association between aesthetics and flourishing and grow the body of literature examining extant positive indicators of wellbeing in scientists. In addition to addressing the call for more systematic investigation of higher-order aspects of the wellbeing conceptual space, this research has implications for the potential protective effect of aesthetics against negative workplace environments, burnout, and distress.

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The authors report no conflicts of interest.

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Data availability statement

Data pertaining to the variables analysed in this article are available upon request.

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