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On Carrots and Curiosity: Eating Fruit and Vegetables is associated with Greater Flourishing in Daily Life

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Abstract

Objectives

Our aim was to determine whether eating fruit and vegetables (FV) is associated with other markers of well-being beyond happiness and life satisfaction. Towards this aim, we tested whether FV consumption is associated with greater eudaemonic well-being- a state of flourishing characterised by feelings of engagement, meaning, and purpose in life. We also tested associations with two eudaemonic behaviours- curiosity and creativity.

Design

Daily diary study across 13 days (micro-longitudinal, correlational design).

Methods

A sample of 405 young adults (67% women; mean age 19.9 (SD 1.6) years) completed an Internet daily diary for 13 consecutive days. Each day, participants reported on their consumption of fruit, vegetables, sweets, and chips, as well as their eudaemonic well-being, curiosity, creativity, positive affect, and negative affect. Between-person associations were analysed on aggregated data. Within-person associations were analysed using multilevel models controlling for weekday and weekend patterns.

Results

FV consumption predicted greater eudaemonic well-being, curiosity, and creativity at the between- and within-person levels. Young adults who ate more FV reported higher average eudaemonic well-being, more intense feelings of curiosity, and greater creativity compared to young adults who ate less FV. On days when young adults ate more FV, they reported greater eudaemonic well-being, curiosity, and creativity compared to days when they ate less FV. FV consumption also predicted higher positive affect, which mostly did not account for the

associations between FV and the other well-being variables. Few unhealthy foods (sweets, chips) were related to well-being except that consumption of sweets was associated with greater curiosity and positive affect at the within-person level. Lagged data analyses showed no carry-over effects of FV consumption onto next-day well-being (or vice versa).

Conclusions

Although these patterns are strictly correlational, this study provides the first evidence that FV consumption may be related to a broader range of well-being states that signal human flourishing in early adulthood.

Statement of Contribution

What is already known on this subject?

- There is growing evidence that a diet rich in fruits and vegetables (FV) is related to greater happiness, life satisfaction, and positive affect. These associations are not entirely explained by demographic or health variables including socio-economic status, exercise, smoking, and body mass index (BMI).
- Recent experimental and daily diary research suggests that FV consumption may be a causal factor in promoting states of positive well-being.
- Research has examined the links between FV consumption and hedonic well-being – whether people feel good (vs. bad) and satisfied—but has not addressed links between FV consumption and eudaemonic well-being— whether people feel engaged and experience their lives as meaningful and purposeful.

What does this study add?

- It provides the first evidence that eating FV is related to greater eudaemonic well-being in a naturalistic setting.
- Eating FV was also related to greater self-reported curiosity and creativity.
- FV consumption may underlie a broad range of experiences that signal flourishing.
- Future randomised controlled trials of FV should include measures of eudaemonic well-being as outcome variables.

On Carrots and Curiosity:

Eating Fruit and Vegetables is associated with Greater Flourishing in Daily Life

Research shows that people who eat more fruits and vegetables (FV) are less depressed, happier, and more satisfied with their lives (Rooney, McKinley, & Woodside, 2013). But might the emotional benefits of FV extend beyond simply feeling happy and satisfied? The vitamins and minerals in FV are known to modulate pathways involved in motivation and vitality (Depeint, Bruce, Shangari, Mehta, & O'Brien, 2006; Rao, Asha, Ramesh, & Rao, 2008; Seitz, Gebhardt, Beck, Bohm, Lode, Niethammer, & Bruchelt, 1998). It is therefore possible that FV could promote a broader range of experiences that signal human flourishing. This article aims to answer the question: Does higher FV consumption in daily life predict greater eudaemonic well-being (engagement, meaning, and purpose) and eudaemonic behaviours (curiosity and creativity)?

Fruit, Vegetables, and Well-being

The physical benefits of FV are well established. Greater FV intake is associated with a range of positive health outcomes including greater longevity and decreased risk of chronic diseases such as cancer, heart disease, and stroke (Bazzano, 2006; Bellavia, Larsson, Bottai, Wolk, & Orsini, 2013; Trichopoulou et al., 2003; Van Duyn & Pivonka, 2000). The health benefits of FV may be due to their higher levels of antioxidants such as vitamin E, selenium, and manganese that help prevent, remove, and repair the damage caused by free radicals that underlie the development of cancer and cardiovascular disease (Dreher & Junod, 1996; Gordon, 1996; Lampe, 1999; Sugamura & Keaney, 2011).

The psychological benefits of FV are less established, but there is evidence that a higher intake is related to psychological well-being (Rooney et al., 2013). People who consume more

FV show a lower incidence of depression (Adams & Colner, 2008; Allgöwer, Wardle, & Steptoe, 2001; Carr, Bozonet, Pullar, & Vissers, 2013; Jacka et al., 2010; Kulkarni, Swinburn, & Utter, 2014; McMartin, Jacka, & Colman, 2013), greater happiness (Blanchflower, Oswald, & Stewart-Brown, 2012), and higher life satisfaction (Blanchflower et al., 2012; Grant, Wardle, & Steptoe, 2009; Lengyel, Tate & Obirek-Blatz, 2009). For example, in a large sample of over 80,000 British people, a dose-response relationship was found between daily servings of FV and both life satisfaction and happiness. People who consumed 7 or 8 portions of FV per day reported the highest life satisfaction and happiness (Blanchflower et al., 2012). These associations remained significant when controlling for demographic and health factors including employment status, income, social class, education, major illness, exercise, smoking, and body mass index (BMI). The findings of Blanchflower and colleagues (2012) are also consistent with other correlational studies showing associations between FV consumption and greater happiness in students (Piqueras, Kuhne, Vera-Villarroal, van Straten, & Cuijpers, 2011), optimism (Boehm, Williams, Rimm, Ryff, & Kubzansky, 2013; Giltay, Geleijnse, Zitman, Buijsse, & Kromhout, 2007; Kelloniemi, Ek, & Laitinen, 2005), peacefulness (Blank, Grimsley, Goyder, Ellis, & Peters, 2007), improved self-esteem and self-efficacy (Brug, Lechner, & De Vries, 1995; Elfhag, Tholin, & Rasmussen, 2008; Steptoe et al., 2003) and higher state positive affect (White, Horwath, & Conner, 2013).

Most of the current evidence is correlational, but experimental and micro-longitudinal research suggests a causal link between FV and well-being. Two recent intervention studies showed that daily fruit consumption reduced self-reported anxiety across a 10-day period (Smith, & Rogers, 2014), and that eating two kiwifruits per day resulted in significant improvements among emotionally vulnerable men in self-reported "vigor," which included reports of feeling

cheerful, energetic, lively, and full of pep (Carr et al., 2013). Similar experimental effects have been found for high doses of vitamin B and C, which are found abundantly in FV (Kennedy et al., 2010). A study from our research group found a significant lagged association indicating that higher FV consumption predicted improvements in next-day positive affect, including happiness (White et al., 2013).

A major limitation of the literature is that research has focused mainly on how FV consumption is related to hedonic well-being – whether people are happy and satisfied with their lives. But happiness and life satisfaction do not capture the full breadth of well-being (Ryan & Deci, 2001). Another key element is eudaemonic well-being – whether people feel engaged and experience their daily lives as meaningful and purposeful (Ryan & Deci, 2001; Ryff & Keyes, 1995).

Plausible Biological Mechanisms linking FV and Eudaemonic Well-Being

Several biological pathways could link FV consumption to greater eudaemonic well-being. Many FV contain higher levels of vitamin C, an important co-factor in the production of dopamine (Girbe, Ramassamy, Piton, & Costentin, 1994; Seitz et al., 1998). Dopamine is a neurotransmitter that underlies motivation and promotes engagement "by adding attraction or zest to life" (Kringelbach & Berridge, 2009 pp. 479). FV also contain B-vitamins and complex carbohydrates that promote the synthesis of neurotransmitters involved in mood, including dopamine and serotonin (Rao et al., 2008; Rooney et al., 2013; Stough et al., 2011; Wurtman et al., 2003). B-vitamins play a further role in mitochondrial energy function, which could stimulate feelings of vitality and engagement (Depeint et al., 2006). Lastly, antioxidants in FV, such as vitamin E, C, and serum carotenoids, are known to reduce bodily inflammation (McMartin et al., 2013). Lower inflammation is thought to protect against depression (Berk et

al., 2013) and has been linked to higher levels of eudaemonic well-being (Friedman, Hayney, Love, Singer, & Ryff, 2007).

Eudaemonic Behaviours

FV consumption could also be associated with eudaemonic behaviours including curiosity and creativity. Curiosity involves seeking out new skills, learning new things, and becoming actively absorbed in an experience (Kashdan, 2009; Silvia, 2008). Apart from its beneficial effects on learning and motivation, curiosity is linked to eudaemonic well-being because it tends to focus people on activities that cultivate self-determination, purpose, and meaning in life (Kashdan, 2009; Kashdan & Steger, 2007). Curiosity also requires optimal functioning of approach-motivational brain areas, particularly those involving dopamine (Harmon-Jones, Price, & Gable, 2012; Kringelbach, & Berridge, 2009; Silvia, 2008). Given that vitamins and minerals in FV are cofactors in dopamine processes (Girbe et al., 1994; Seitz et al., 1998), we hypothesised that greater FV consumption would be associated with greater curiosity.

We also tested the association between FV and creativity. Creativity includes the expression of artistic or musical skills and the ability to originate novel ideas of worth (Hennessey, & Amabile, 2010). Although the conditions under which people are more or less creative are a matter of debate, people tend to be more creative when they are in a positive state, when they are engaging their curiosity, and when they are intrinsically motivated by a task (Hennessey, & Amabile, 2010). A recent experience sampling study of 79 university students found that students reported doing something creative 22% of the time they were sampled, and they felt happier and more active during those moments of creativity; creativity was unrelated to negative mood states (Silvia, Beaty, Nusbaum, Eddington, Levin-Aspenson, & Kwapil, 2014). Contrary to cultural beliefs that creativity is linked to mental illness (see also Silvia & Kaufman,

2010), creativity often emerges from eudaemonic conditions. Therefore, we hypothesised that greater FV consumption would be associated with greater creativity.

Present Study

We tested whether FV consumption is related to eudaemonic well-being and eudaemonic behaviours using a daily diary study of over 400 young adults. Each evening for 13 days, participants reported on their FV consumption that day and their experiences of eudaemonic well-being, curiosity, and creativity that day. Measures of unhealthy food consumption (sweets and chips), and positive and negative affect were also measured for comparison purposes. We tested for between- and within-person associations between food consumption and well-being. Analysis of the within-person associations provided added benefit by testing how each individual's well-being changed on days characterised by low versus high FV consumption. Next-day lagged analyses were also run to determine the direction of influence between FV and well-being across days.

Method

Participants. A sample of 405 young adults (66.7% female), 17 to 25 years old (M=19.85, SD=1.62) were recruited. Participants identified as European (81.3%), Asian (9.9%), Māori or Pacific Islander (4.2%), or other (4.6%). Participants were students at the University of Otago, New Zealand who were taking part in the 2013 wave of the Daily Life Study, a large interdisciplinary study of the health and emotional experiences of young adults. Participants were reimbursed with partial course credit if recruited through the University of Otago Psychology Department's experimental participation programme (N = 242, 60%) or with a small cash payment if recruited through flyers/word of mouth (N = 123, 30%) or from Human Nutrition

classes (N = 40, 10%). An additional 13 participants were excluded from analysis (six participants dropped out; seven participants completed fewer than 7 diary records).

Procedure. In an initial laboratory session, participants completed informed consent and several computerised measures including demographics measures of gender, age, and ethnicity. Next, they received training for the daily diary procedure that began the following day. For 13 days, participants completed an online daily survey between 3pm and 8pm that included self-report measures of food consumption, daily eudaemonic well-being, creativity, curiosity, positive affect, and negative affect.

Measures. The daily survey included the following measures. Four food consumption questions were modified from standard questions in the New Zealand National Nutrition Survey 1997 (NNS'97: Russell et al., 1999). Using local terminology, participants were asked to report the number of servings eaten today of (1) fruit (fresh, frozen, canned, or stewed, but excluding fruit juice and dried fruit); (2) "hot chips" (potato fries, wedges, or kumara chips usually from take-away outlets); (3) vegetables (fresh, frozen, or canned, not including juice or chips); and (4) sweets ("lollies", chocolate, or other confectionary items). Examples were provided of what constituted one serving size as specified in the NNS'97 (Russell et al., 1999). Participants were asked to record how many servings of each food group they had consumed since waking up each morning (none, <1 serving, 1 serving, 2 servings, 3 servings, 4 or more servings), which were recoded as 0, 0.5, 1, 2, 3, and 4 for analysis.

Daily eudaemonic well-being was measured with a daily adaptation of the Flourishing Scale, an eight item measure that assesses feelings of engagement, purpose, and meaning in life (DFS: Diener et al., 2010). Items include "I am engaged and interested in my daily activities" and "I lead a purposeful and meaningful life." The items were adapted for a daily format by

phrasing the statement in past tense and adding the word "Today" ("Today, I was engaged and interested in my daily activities."). Participants responded to each item on a Likert scale from 1 (Strongly disagree) to 7 (Strongly agree). Responses were averaged across items each day for a measure of daily eudaemonic well-being ($\alpha = 0.86$; multilevel item reliabilities based on Nezlek, 2012).

Daily curiosity was measured by the Curiosity and Exploration Inventory, a seven item measure that assesses the positive emotional-motivational system (CEI: Kashdan, Rose, & Fincham, 2004). Items included "I look for new things or experiences" and "I actively seek out as much information as I can in new situations." The items were adapted for a daily format by changing to past tense and adding "Today". Participants responded to each item on a Likert scale from 1 (Strongly disagree) to 7 (Strongly agree), which were averaged across items each day for a measure of daily curiosity ($\alpha = 0.70$).

Daily creativity was measured with a single item that we developed: "Overall, how creative were you today? Creativity includes coming up with novel or original ideas; expressing oneself in an original and useful way; or spending time doing artistic activities (art, music, painting, writing, etc.)." We based this question on common definitions of creativity (Hennessey & Amabile, 2010; Silvia et al., 2014). Participants responded on a Likert scale from 0 (None) to 4 (A great deal).

Daily affect was measured through nine items assessing positive affect (PA) (calm, content, relaxed, happy, cheerful, pleasant, energetic, enthusiastic, and excited) and nine items assessing negative affect (NA) (sad, dejected, depressed, nervous, anxious tense, angry, irritable, and hostile). These items captured low, medium, and high intensity positive and negative states based on the circumplex model of emotion (Barrett & Russell, 1999). Participants rated each

adjective on how they "felt today" on a scale of 1 (Not at all) to 5 (Extremely). Responses were averaged across items each day for a measure of daily PA and daily NA (PA $\alpha = 0.83$; NA $\alpha = 0.70$).

Data analysis. Between-person (cross-sectional) relationships were tested using correlation coefficients in SPSS. The daily food and well-being variables were averaged across the 13 days for each participant and then correlated across participants. Within-person relationships were tested using multilevel modeling with the Hierarchical Linear Modelling software program (HLM 6.08; Raudenbush, Bryk, & Congdon, 2004). In HLM, each food consumption variable was entered as the level-1 predictor and each well-being variable was entered as the level-1 outcome. The level-1 predictor was group-centered to model changes around each person's typical food consumption. An additional "weekend" level-1 predictor was entered uncentered (coded 0 for Mondays – Fridays and 1 for Saturdays and Sundays) to control for weekend differences in food consumption and well-being. This model allowed us to determine how food consumption and well-being covaried within a given individual over time, controlling for weekday versus weekend effects. Separate within-person models were run for eudaemonic well-being, curiosity, creativity, PA, and NA (as outcomes) across the four food categories of fruit, vegetables, sweets, and chips (as predictors). We also tested whether gender and recruitment population (as level-2 predictors) moderated the within-person patterns in separate analyses.

Next-day lagged analyses were conducted for all significant within-person associations between the food and well-being measures, where t refers to time (day of report). We tested whether eating that food on one day (level-1, t predictor) predicted changes in next-day well-being (level-1, t+1 outcome) while controlling for previous day well-being (level-1 t covariate)

and, conversely, whether well-being on one day (level-1, t predictor) predicted changes in next day food consumption (level-1, t+1 outcome) while controlling for previous day food consumption (level-1, t covariate). All level-1 predictors were group-mean centered. Weekend effects were controlled in all lagged analyses.

Results

Descriptive Statistics

Participants completed 12 out of 13 diaries on average (91% response rate; $M = 11.8$; $SD = 1.5$; range 7 – 13). Table 1 shows the descriptive statistics. The average daily servings of fruit and vegetables was approximately 1.2 and 1.3 servings, which ranged from 0 servings to 4 and 3.5 servings, respectively. Unhealthy foods were consumed at a lower level, with an average daily consumption of .6 servings of sweets and .3 servings of chips. Participants recruited from nutrition classes ate more fruit and vegetables (1.6 and 1.8 servings per day) and fewer servings of chips (.1 per day) but the same amount of sweets (.6 per day) compared to participants recruited from Psychology or through flyers. Descriptive statistics for the well-being variables showed that participants tended to feel more positive than negative in their daily lives, which is usual for this population. The intra-class correlation coefficients (ICC) were all below .5 which indicated more within-person variability than between-person variability in the daily variables.

[Table 1 here]

Table 1 also shows the correlations among the food and well-being variables, which were as expected. The two strongest correlations showed that people who ate more fruit also ate more vegetables, and people who ate more sweets also ate more servings of chips. Measures of eudaemonic states (eudaemonic well-being, curiosity, and creativity) correlated with each other and with PA, and to a lesser extent with NA.

Between-Person Associations

Table 2 shows the between-person associations for the food consumption and well-being measures. People who ate more fruit and vegetables reported higher average eudaemonic well-being, curiosity, creativity, and PA, compared to people who ate fewer fruits and vegetables. People who ate more servings of chips reported less eudaemonic well-being and more negative affect, but they also reported more curiosity and creativity. Consumption of sweets was not related to well-being at the between-person level.

The correlations between fruit and eudaemonia, curiosity, and creativity shown in Table 2 were substantially reduced and two were no longer significant when controlling for PA (r = 0.085, p = 0.089; r = 0.100, p = 0.040; r = 0.045, p = 0.371, respectively). However, the correlations between vegetables and eudaemonia, curiosity, and creativity all remained statistically significant when controlling for PA (r = 0.174, p <.001; r = 0.123, p = 0.013; r = 0.100, p = 0.044, respectively). Thus, at the between-person level, vegetable consumption – but not fruit consumption – was uniquely associated with eudaemonic states when holding PA constant.

[Table 2 here]

Within-Person Associations

Table 3 shows the within-person associations between daily food consumption and changes in well-being from multilevel modeling. On days when participants ate more FV, they reported greater eudaemonic well-being, curiosity, creativity, and PA. Consumption of vegetables, but not fruit, was associated with lower NA. Unhealthy foods were not associated with changes in eudaemonic well-being, creativity, or NA; however, on days when people ate

more sweets, they reported greater curiosity and positive affect. Unlike the between-person correlations, consumption of chips was not associated with any daily changes in well-being.

[Table 3 here]

These within-person associations between FV and eudaemonic states remained significant when controlling for daily changes in PA. When entering PA as a group-centered level-1 covariate, fruit consumption continued to predict increases in daily eudaemonic well-being ($B(SE) = 0.034(0.013)$, $p = 0.006$), curiosity ($B(SE) = 0.032(0.016)$, $p = 0.049$) and creativity ($B(SE) = 0.036(0.017)$, $p = 0.037$). Controlling for PA, vegetable consumption also continued to predict increases in daily eudaemonic well-being ($B(SE) = 0.040(0.011)$, $p < 0.001$), curiosity ($B(SE) = 0.039(0.014)$, $p = 0.004$), and creativity ($B(SE) = 0.029(0.014)$, $p = 0.043$). Thus, at the within-person level, both fruit and vegetable consumption uniquely predicted eudaemonic states when holding PA constant.

FV additively contributed to positive changes in eudaemonic states, although vegetables played a stronger role. In follow-up analyses, both fruit and vegetable consumption were entered together as group-centered level-1 predictors of the well-being variables. Results showed additive effects of FV on eudaemonic well-being (fruit $B(SE)=0.053(0.018)$, $p = 0.003$; veg $B(SE)=0.082(0.014)$, $p < 0.001$), curiosity (fruit $B(SE)=0.044(0.018)$, $p = 0.017$; veg $B(SE)=0.061(0.015)$, $p < 0.001$), and creativity (fruit $B(SE)=0.044(0.018)$, $p = 0.019$; veg $B(SE)=0.040(0.015)$, $p = 0.007$). However, only vegetables predicted PA (fruit $B(SE)=0.020(0.011)$, $p = 0.073$; veg $B(SE)=0.040\ (0.009)$, $p < 0.001$). Neither fruit nor vegetables predicted NA when entered as simultaneous predictors (fruit $B(SE)= -0.014(0.010)$, $p = 0.176$; veg $B(SE)= -0.015\ (0.008)$, $p = 0.069$).

Recruitment status did not moderate any of the within-person patterns shown in Table 3. Gender moderated the relationship between fruit and PA only ($B(SE)$ = -.046(.022), p = .040). Analysis of simple slopes showed that fruit consumption predicted increased PA among men ($B(SE)$ = .057(.017), p = .001), but not among women ($B(SE)$ = .011(.014), p = .446).

Next-day lagged analyses were conducted on the significant within-person associations from Table 3. There were no lagged relationships for FV. Consumption of FV did not predict changes in next-day well-being (Bs ranged from -0.012 to 0.015, ps from 0.147 to 0.986, ns) nor did well-being predict changes in next-day FV (Bs ranged from -0.033 to 0.018, ps from 0.257 to 0.775, ns). Lagged relationships were found for sweets. Specifically, greater curiosity and higher PA predicted increases in next-day consumption of sweets (curiosity $B(SE)$ = 0.030(0.031), p = 0.023; PA $B(SE)$ = 0.065(0.024), p = 0.007) but consumption of sweets did not predict increases in next day curiosity or PA (Bs = -0.001 and .001, ps > 0.951). This latter finding suggests that increases in curiosity and PA may be driving sweets consumption and not vice versa; however, the same cannot be said for the FV and well-being relationships because they were strictly within-day.

Discussion

Our research identified novel psychological correlates to healthy eating, over and above simply feeling good. Eating fruits and vegetables was associated with indicators of flourishing including greater eudaemonic well-being, creativity, and curiosity. These relationships were found between- and within-people, and most relationships were not accounted for by covariation with positive affect. Although our micro-longitudinal findings are strictly correlational, the within-person design alleviated some of the limitations inherent to the predominantly cross-sectional literature because it showed that well-being fluctuated as a function of FV consumption

within the same person over time. We also replicated our previous finding that FV consumption was tied more strongly to PA than NA (White et al., 2013). This finding highlights the unique association of FV to positive states of well-being. By contrast, unhealthy foods were not associated with eudaemonic well-being, although consumption of sweets was linked to greater curiosity and PA.

We cannot conclude that the link between FV consumption and eudaemonic well-being is causal or direct. Although our results showed within-person relationships between FV and eudaemonic well-being over time, this study was still correlational. We cannot determine whether FV caused the day-to-day changes to well-being, whether well-being caused changes in FV consumption, or whether a third variable might explain this relationship. The lack of lagged patterns for FV further limits interpretation of causality. We were surprised by this latter finding because we previously found that FV consumption predicted increases in next-day PA in young adults (White et al., 2013). One difference may be that the current study was 13 days long versus 21 days long for White et al. (2013). It is possible that lagged effects would have emerged with another week of surveying. In light of the ambiguous causal direction, we recommend intervention research to determine whether increased FV consumption can improve daily eudaemonic well-being.

Gender showed few moderating effects. The only gender difference we found was that fruit consumption was associated with increased positive affect among men but not women. We found this same gender difference in our previous study of young adults (White et al., 2013). Although we do not have an explanation, it is possible that young men and women metabolise fruit differently. Fruit consumption has been linked to lower inflammation in men but not women (C-reactive protein; Oliveira, Rodríguez-Artalejo, & Lopes, 2009). However, there are

no clear patterns of gender differences in the cross-sectional research linking FV consumption to other measures of well-being (Rooney et al., 2013).

Our finding that FV consumption was related to greater eudaemonia, curiosity, and creativity raises the question of what mechanism or mechanisms underlie these relationships. We can only speculate. The effect could be indirect and possibly mediated by improvements in daily health. However, previous studies have found associations between FV consumption and well-being adjusting for current physical health, suggesting that FV may have more direct influences (Blanchflower et al., 2012; Boehm et al., 2013). In fact, we measured self-reported physical health and daily exercise in this same study and neither variable accounted for the relationship between FV and well-being (data not shown).

The micronutrient content of food could provide an explanation for the current findings. Consumption of vitamin C, antioxidants, and B vitamins in FV may improve well-being by increasing the synthesis of neurotransmitters implicated in the neurochemistry of eudaemonia, such as dopamine, serotonin, and oxytocin (Rao et al., 2008). The carbohydrate content of FV could also play a role. The consumption of carbohydrates increases brain levels of tryptophan and tyrosine, which are key precursors to the synthesis of serotonin and dopamine (Rooney et al., 2013; Wurtman et al., 2003). Refined sugars characterised by simple carbohydrate content have been shown to promote temporary improvements in mood, whereas the complex nature of carbohydrates found in FV provides a moderate but significantly longer effect on brain chemistry (Rao et al., 2008). This may explain why FV consumption was associated with greater increases in eudaemonia and positive affect relative to unhealthy foods. The consumption of refined sugars found in sweets may operate to enhance positive affect on an immediate but transient basis, explaining why there was a small but significant association with PA. However, it could be

hypothesised that longer-lasting effects on brain chemistry are required to establish significant influences to eudaemonic states.

The link between FV and creativity is also biologically plausible. Vitamin C, B-vitamins, and carbohydrate consumption has each been shown to promote dopaminergic synthesis (Wurtman et al., 2003), which is implicated in the neurochemistry of the 'creative profile' (Blunt, 2010). Increased dopaminergic synthesis has been associated with increased positive emotion, goal directed behaviour, energy, incentive motivation, and exploration (Blunt, 2010; Peterson, 2011). Thus, these changes to brain functioning may also be responsible for the influence of FV consumption on levels of eudaemonic well-being, especially those characterised by creativity, exploration, and curiosity.

Other biological pathways could include vitamin and mineral-dependent increases in brain derived neurotrophic factor (Molteni, Barnard, Ying, Roberts, & Gómez-Pinilla, 2002) or changes in gut microbiota (Bested, Logan, & Selhub, 2013). Alternatively, the vitamins and minerals in FV could stimulate eudaemonic behaviours indirectly through increased energy and vitality (Depeint et al., 2006).

It is also possible that increases in eudaemonic well-being may lead individuals to choose healthier foods. Experimental evidence shows that inducing positive moods can shift people towards healthier food options (Gardner, Wansink, Kim, & Park, 2014). This interpretation would also be consistent with the Broaden and Build Theory of positive emotions in which positive emotions can foster improvements in other positive states leading to an "upward spiral" of well-being (Fredrickson, 2001).

Limitations

The daily diary surveys were completed between 3pm and 8pm; therefore, some of the surveys excluded evening meals. Future studies would be improved by administering the survey once all main meals had been eaten for the day. We also did not ask about the different types of fruits and vegetables, so we cannot say which fruits or vegetables more strongly predicted well-being. Another limitation was that all of our variables were self-reported. Although the survey items were administered in 'near to real-time', future research would benefit from behavioural measures of certain constructs, particularly creativity. Future research should also use the updated version of the Curiosity and Exploration Inventory (CEI-II; Kashdan et al., 2009) rather than the original CEI used in the current study.

Conclusion

When people ate more fruits and vegetables, they reported greater eudaemonic well-being, greater curiosity, and more creativity in their daily lives. These findings suggest that FV intake is related to other aspects of human flourishing, beyond just feeling happy. These results are important because eudaemonic well-being is thought to play an important role in psychological resilience (Steger, Kashdan, & Oishi, 2008). Curiosity has also been linked to greater resilience (Kashdan, 2009). Although at this stage, we cannot say that eating carrots will make you more curious or that eating fruit will help you flourish, our results provide a first line of evidence by showing between- and within-person associations between these states. We await future studies to test these effects experimentally and to explore the possible mechanisms underlying such changes.

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Table 1. *Descriptive Statistics for the Aggregated Daily Food and Well-being Measures*

Daily Variables	*Min*	*Max*	*M*	*SD*	*ICC*	Fruit	Veg	Sweets	Chips	
Fruit	0.00	4.00	1.16	0.76	0.46	1	0.502**	0.115*	0.054	
Vegetables	0.00	3.50	1.27	0.75	0.36		1	0.155*	0.105*	
Sweets	0.00	2.83	0.63	0.49	0.27			1	0.183***	
Chips	0.00	2.54	0.27	0.33	0.25				1	
	Min	*Max*	*M*	*SD*	*ICC*	Eudaim	Curious	Create	PA	NA
Eudaemonia	1.33	6.85	4.70	0.83	0.49	1	0.487***	0.274**	0.717***	-0.431**
Curiosity	1.52	6.03	3.69	0.76	0.42		1	0.509***	0.427***	0.051
Creativity	1.71	4.93	3.51	0.57	0.42			1	0.371***	0.084
PA	1.24	4.20	3.01	0.50	0.44				1	-0.316***
NA	1.00	3.25	1.68	0.48	0.48					1

Note. *Min* = minimum, *Max* = maximum, *M* = Mean, *SD* = Standard Deviation, *ICC* = Intra-class correlation coefficient from HLM indicates the proportion of variance due to between person differences (1 – ICC = proportion of variance due to within-person differences), PA = positive affect, NA = negative affect. Numbers reflect the aggregated daily reports. Food variables are expressed in typical servings per day; a 0.00 minimum indicated no consumption of that food during the survey period.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 2. *Between-Person Associations between Average Food Consumption and Average Well-Being*

	Eudaemonia	Curiosity	Creativity	PA	NA
Fruit	0.185***	0.166**	0.107*	0.176***	0.009
Vegetables	0.200***	0.158**	0.134**	0.109*	0.002
Sweets	-0.007	0.037	0.041	-0.052	0.063
Chips	-0.113*	0.136**	0.233***	-0.028	0.134**

Note. PA = positive affect; NA = negative affect. Coefficients are Pearson *r* correlation coefficients with $N = 405$. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 3. *Within-Person Associations between Daily Food Consumption and Daily Well-being*

	Eudaemonia	Curiosity	Creativity	PA	NA
Fruit	0.063**	0.050**	0.049**	0.026*	-0.017
	(0.018)	(0.018)	(0.018)	(0.011)	(0.010)
Vegetables	0.078***	0.057***	0.038*	0.041***	-0.018*
	(0.015)	(0.015)	(0.015)	(0.009)	(0.008)
Sweets	0.027	0.040*	0.013	0.029*	-0.007
	(0.019)	(0.020)	(0.020)	(0.013)	(0.011)
Chips	0.042	0.004	0.004	0.016	0.006
	(0.024)	(0.025)	(0.024)	(0.015)	(0.014)

Note. PA = positive affect; NA = negative affect. Coefficients reflect final estimation of fixed effects computed (with robust standard errors) and with 404 degrees of freedom from multilevel modeling. Food variables were entered separately to predict each well-being outcome variable controlling for weekday vs. weekend effects. * $p < .05$; ** $p < .01$; *** $p < .001$.