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Construing action abstractly and experiencing autonomy: Implications for physical activity and diet

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Abstract Mentally representing action in terms of abstract goals rather than concrete procedures has been found to facilitate self-regulation, including meeting health goals. The present research examined whether autonomous motivation mediates the association between abstract thinking and health behavior engagement. We hypothesized that abstract (vs. concrete) thinking relates to viewing oneself as behaving autonomously, which, in turn, is positively associated with engaging in health behaviors. Two studies tested whether abstract thinking is associated with greater health behavior engagement and whether autonomous motivation statistically mediates this association. In Study 1, abstract thinking was associated positively with physical activity and fruit and vegetable intake. In Study 2, supporting pre-registered hypotheses, there was a significant indirect effect of abstract thinking on vigorous physical activity and fruit and vegetable intake through autonomous motivation. Whereas past research has emphasized that abstract thinking orients attention towards the value of broader goals, this research establishes that autonomous motivation helps explain associations between abstract thinking and health behavior engagement.

Keywords Construal level · Autonomous motivation · Self-regulation · Physical activity

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Introduction

Numerous experimental and longitudinal prospective studies have found that engaging in regular physical activity is associated with a myriad of health benefits, including a reduced risk for developing cardiovascular disease (Lee et al. 2014), type 2 diabetes (Hu et al. 1999), breast cancer (McTiernan et al. 2003; Rockhill et al. 1999), and cognitive decline (Sofi et al. 2011). Despite these associations with significant physical and cognitive benefits, the majority of adults worldwide do not engage in sufficient moderate to vigorous physical activity (CDC 2014; Dumith et al. 2011; Sisson and Katzmarzyk 2008). Fruit and vegetable consumption is another example of a critical preventative health behavior that is associated with a significantly reduced risk for numerous chronic diseases (Hung et al. 2004; He et al. 2007). However, in the United States it is estimated that the majority of adults fail to meet national guidelines for daily fruit and vegetable intake (Moore and Thompson 2015).

People with a greater capacity to self-regulate their attention, emotions, and behaviors, in the service of furthering their goals, tend to engage in healthier behaviors, including physical activity and maintaining a healthy diet, as evidenced by cross-sectional studies (de Ridder et al. 2012; Willis et al. 2007) and by longitudinal studies following people from birth through adulthood (Moffitt et al. 2011). Given the critical role that self-regulation plays in guiding achievement, health, and well-being, there has been longstanding interest in understanding individual differences in self-regulation (Ivcevic and Brackett 2014; Mischel et al. 1989; Tangney et al. 2004). Building on experimental evidence that abstract vs. concrete thinking promotes effective self-regulation, we (1) test whether dispositional differences in abstract vs. concrete thinking relate to physical activity and fruit and vegetable consumption, and (2) examine a motivation-based mechanism that we propose helps to account for this relationship.

People can think about their actions at varying levels of abstraction. Engaging in regular physical activity, for example, can be construed in terms of abstract reasons ("improving my health") or concrete procedures ("lifting weights"). Action identification theory (Vallacher and Wegner 1987) proposes that people's mental representations of actions are organized along a hierarchy from low-level identities specifying *how* an action is performed to high-level identities specifying *why* an action is performed.[1] Relatedly, construal level theory (Trope and Liberman 2010) postulates that as psychological distance from an event increases, people will use increasingly high-level, abstract mental representations, focusing more on global and superordinate features than on specific and subordinate features.

Although many studies have used experimental designs to examine effects of concrete vs. abstract thinking, there also is evidence that people have dispositional tendencies to think in more abstract or concrete manners (Vallacher and Wegner 1989). Such individual differences appear to have a high test–retest reliability over 2 weeks (Vallacher and Wegner 1985). Correlates of individual differences in construal level include attributing others' behaviors to goals (Belayachi and Van der Linden 2013), perceiving greater commonalities between oneself and others (Levy et al. 2002), and perceiving greater commonalities among one's potentially conflicting goals (Freitas et al. 2009).

Abstract action representation and goal salience

Experimental studies have found that adopting abstract mental representations (abstract thinking), relative to concrete mental representations (concrete thinking), is associated with more effective self-regulation (Fujita et al. 2006), including an enhanced preference for healthy vs. unhealthy foods (Fujita and Han 2009), reduced consumption of unhealthy foods when paired with a visual-reminder cue (Price et al. 2016), and greater self-reported physical activity (Sweeney and Freitas 2014). To explain why abstract thinking facilitates effective self-regulation, existing theory has emphasized changes in the salience of goals' objectives relative to the convenience of their procedures (Liberman and Trope 1998; Vallacher and Kaufman 1996). For example, when led to think in an abstract (relative to concrete) manner, people are more likely to base decisions on the desirability of an outcome, such as the quality of a lecture, than on the feasibility of its process, such as the degree of difficulty of reaching the lecture hall (Liberman and Trope 1998). Experimental studies have shown that, relative to concrete thinking, abstract thinking increases the salience of one's long-term aims over immediate emotional discomforts (Freitas et al. 2004). Furthermore, experimental studies have indicated that abstract thinking promotes greater future-oriented thinking, as evidenced by a tendency to estimate that events will occur further in the future (Liberman et al. 2007) and that more time will be needed to complete a task (Kanten 2011).

Abstract action representation and autonomous motivation

As alluded to above, existing theory and experimental research, including our own prior work, has emphasized that whereas concrete thinking increases the salience of the immediate features of one's environment, abstract thinking helps people connect their actions to their broader goals, facilitating enhanced self-regulation (Freitas et al. 2004; Fujita and Carnevale 2012; Vallacher and Kaufman 1996). The present research examines an independent explanation for the relationship between abstract thinking and enhanced self-regulation. Specifically, we propose that the tendency to think in an abstract (vs. concrete) manner is associated with viewing oneself as performing goal-directed behaviors in a more autonomous (vs. controlled) manner, which, in turn, is associated with enhanced self-regulation.

According to self-determination theory (SDT), people's motivation to act varies from controlled to autonomous (Deci and Ryan 1985; Ryan et al. 2009). Behaviors are assumed to be autonomous to the extent that people act of their own volition and view a behavior as important, enjoyable, and consistent with their values and identity. Alternatively, behaviors are assumed to be controlled to the extent that people feel compelled to act by *external* sources (e.g., pressure from family or friends) or by *introjected* sources (e.g., feelings of guilt). According to SDT, motivation exists on a continuum with amotivation (lack of motivation) at one extreme and *intrinsic* motivation (engaging in a behavior because of its inherent satisfactions) at the other extreme. As behavioral regulation shifts from being guided by controlled reasons (e.g., pressure from others) to more autonomous reasons (e.g., valuing a behavior or self-identifying with a behavior), self-determination is theorized to increase.

[1] This distinction between (high-level) action purposes and (low-level) action processes is different from distinctions between and specific and global standards (cf. Locke and Latham 2002), given that purposes can be either specific (e.g., "lose weight") or global (e.g., "live a long life") and that processes also can be either specific (e.g., "use the treadmill today") or global (e.g., "exercise more").

Although controlled sources of motivation may encourage behavioral initiation, they appear to have limited utility for sustaining long-term changes in health behaviors, as evidenced by prospective and experimental studies which have found that controlled motivation has a negative or non-significant association with future health behaviors, including studies of healthy adults (Kwan et al. 2011; Rodgers et al. 2010; Wilson et al. 2003), of cardiac rehabilitation patients (Russell and Bray 2009), and of people who are overweight/obese (Edmunds et al. 2007). Conversely, evidence from both prospective and experimental studies with follow-up assessments spanning from 4 weeks to 3 years (Hagger et al. 2006; Kwan et al. 2011; Silva et al. 2010, 2011) have shown that autonomous motivation promotes greater maintenance of health behaviors, including physical activity (Ng et al. 2012; Teixeira et al. 2012).

Abstract thinking may promote autonomous motivation by changing how any one action is viewed. Powers (1973; see also Carver and Scheier 2012) proposed that a hierarchy of feedback loops guides self-regulation. Specifically, actions are guided by *programs* (i.e., activities that require conscious attention, e.g., "cook dinner"), which then give rise to *principles* (i.e., qualities that are inferred from *programs*, e.g., "be healthy"). Finally, *principles* give rise to the highest level of abstraction, *a system concept*, or an idealized self or identity. Accordingly, beyond increasing the accessibility of "do" or "be" goals, abstract thinking may facilitate viewing sequences of behavior in a relatively autonomous manner (i.e., consistent with one's identity and values). This prediction is supported partially by experimental studies, which have found that abstract thinking facilitates seeing one's actions as indicative of one's character (Wakslak et al. 2008) and using one's ideal self-concept as a framework for decision-making (Freitas et al. 2008).

More direct support for the prediction that abstract thinking facilitates seeing one's actions in a more autonomous manner comes from experimental research indicating that people see their goals as more meaningful and intrinsically motivated when led to think abstractly rather than concretely (Davis et al. 2016). In that study, participants who listed successively abstract reasons for pursing an academic goal subsequently reported higher levels of autonomy in pursuing that goal than did participants who listed successively specific means of pursuing the goal. Accordingly, in that study's adaptation of the abstract/concrete mindset approach, the content of the manipulation and of the outcome variable were within the same domain of academics. Moreover, given its focus on the phenomenology of academic goals rather than on academic-goal achievement, there was no effort in that work to assess effects of abstract thinking on goal-related performance.

In contrast, the present research examines whether people's more general dispositional tendency to think in an abstract or concrete manner relates to experiences of autonomy in specific domains, such as diet and physical exercise, and we examine implications of these relations for self-reported performance in these domains. As reviewed above, existing theory has emphasized changes in the salience of goals' long-term aims relative to the convenience of their procedures (Liberman and Trope 1998; Vallacher and Kaufman 1996) as a framework for understanding why abstract thinking promotes enhanced self-regulation. Thus, another distinct quality in the present work is that we sought to evaluate the relation between abstract thinking and self-reported health behaviors independent of individual differences in temporal perspective and trait self-control.

The present research focuses primarily on the relationships between abstract thinking, autonomous motivation, physical activity, and fruit and vegetable consumption; however, other health behaviors, including smoking, sleep, and unhealthy eating were measured and are reported. In the present research, we viewed physical activity and fruit and vegetable consumption as a goal-directed actions. As discussed above, given that the majority of adults fail to meet national recommendations for both physical activity and fruit and vegetable consumption (CDC 2014; Moore and Thompson 2015), we reasoned that relatively high levels of physical activity and fruit and vegetable consumption reflect the tendency to have either developed goals around these behaviors, or at the very least, to view engaging in physical activity and eating fruits and vegetables as desirable outcomes.

In Study 1, we hypothesized that there would be a positive association between abstract thinking and physical activity as well as with fruit and vegetable consumption. Numerous studies suggest that thinking about or valuing future outcomes is associated with engaging in more health-promoting behaviors (Adams and Nettle 2009; Hall et al. 2015). Furthermore, past studies have documented a small and positive association between abstract thinking and temporal perspective (Agerström and Björklund 2013). Accordingly, to examine the unique predictive utility of abstract thinking, we also measured individual differences in temporal perspective. There are diverse approaches to measuring temporal perspective. One frequently used measure, the Consideration of Future Consequences Scale (CFC; Strathman et al. 1994), requires individuals to self-reflect on their tendency to be immediate-versus future-oriented in their thinking and decisions. In the present research, in addition to the CFC scale, we included two measures of temporal perspective that, rather than relying on self-report and introspection, examine temporal perspective by evaluating the temporal trajectories people use when thinking about life events (Wallace 1956) or ongoing personal projects (Little 1983).

In Study 1, the primary aims were to test (1) whether abstract thinking is positively associated with self-reported physical activity and fruit and vegetable consumption; and (2) whether abstract thinking is positively related to these behaviors when taking temporal perspective into account. In Study 2, we tested the pre-registered hypotheses that abstract thinking relates positively to autonomous motivation and that autonomous motivation mediates the relationship between abstract thinking and vigorous physical activity, moderate physical activity, and fruit and vegetable consumption. Again, to provide further evidence that the association between abstract thinking and self-reported health behaviors is independent of individual differences in temporal perspective, temporal perspective was assessed with the CFC scale. Additionally, a measure of trait self-control was included in Study 2 to rule out the alternative explanation that abstract thinking is associated with greater self-regulation due to associations with self-control.

Study 1

Participants

In exchange for course credit, 405 undergraduate students participated. Prior to any hypothesis-testing, data were excluded from 18 participants who experienced technical difficulties completing the study and from 14 participants who self-reported many distractions while completing of the study. The final sample consisted of 373 participants, (132 male), aged 17–49, ($M = 19.77$, $SD = 2.28$); 39.40% of participants described themselves as White, 26.50% as East Asian, 11.20% as other or a combination of races/ethnicities, 8.80% as Latino/a, 8.30% as South East Asian, 5.40% as Black or African American, and 0.30% as American Indian or Alaskan Native. To determine sample size, an a priori power analysis was conducted, which indicated that a sample size of $N = 400$ was required to achieve power $(1 - \beta)$ of 0.80, with $\alpha = 0.05$ and an estimated effect size (ρ) of 0.15.

Procedures

After providing informed consent, participants completed an online study administered through Qualtrics (Qualtrics, Provo, UT) via the subject-pool website at Stony Brook University. Participants completed questionnaires in the following order: (1) Time Line of Personal Projects; (2) Behavior Identification Form; (3) Life Events questionnaire; (4) Consideration of Future Consequences Scale; (5) a questionnaire about their health behaviors; and (6) demographics.[2]

Measures and materials

Primary predictor variable

Behavior Identification Form (BIF)

Participants viewed a series of 25 behaviors (e.g., "making a list") and indicated whether they thought a concrete ("writing things down") or an abstract description ("getting organized") best described the target behavior (Vallacher & Wegener, 1989). Higher scores reflect a greater preference for abstract responses (Cronbach's $\alpha = 0.77$).

Secondary or control variables

Time line of personal project

Participants were provided with a description of personal projects, "All of us have a number of personal projects at any given time that we think about, plan for, carry out, and sometimes (though not always) complete. Some projects may be things you are working toward or things you are trying to avoid" (adapted from Little 1983). Participants generated two personal projects relating to their physical health, two relating to their job, education, or career, and two relating to their well-being/leisure time. Participants then indicated how long they had been working on each project, how long they thought they should continue working on that project, and how long they thought they would actually continue working on that project. For each judgment, participants entered a number and selected a unit of time (days, weeks, months, years). We converted these values into total days. Items were averaged to create composite Personal Projects Past, Should-Future, and Actual-Future scores.

[2] Study 1 originally included a response-time task in which participants judged whether values (e.g., artistic appreciation) were personally important to them. This task was administered through QRTEngine, an open-source javascript engine (Barnhoorn et al. 2015). We began collecting data on 9/14/15. On 9/23/15 QRTEngine's website reported a problem with their program and many participants began experiencing technical problems. This issue led to the exclusion of 18 participants (as indicated above). We stopped data collection between 10/5–10/19 to see if the issue would be resolved. When the issue persisted, we removed the response-time task from the study. Approximately 37% of the sample completed this task. Those who completed the response-time task reported greater Personal Projects Should-Future and Actual-Future scores; there were no other differences between participants who did and did not complete this task.

Life events

Participants were instructed to "list five events that refer to things that may happen to you during the rest of [their lives]" (adapted from Wallace 1956). After generating five events, they indicated how old they thought they would be when that life event occurred. These five reported ages were averaged together to create a composite Life Events score.

Consideration of future consequences scale (CFCs)

Participants completed items assessing their orientation toward immediate and distant outcomes (Strathman et al. 1994). Research supports a two-factor structure of this scale: an immediate-focused and a future-focused subscale (Joireman et al. 2008). Thus, separate scores were computed for CFC-Immediate and CFC-Future (Cronbach's $\alpha = 0.83$ and $\alpha = 0.72$, respectively).

Demographics Participants reported their sex, age, race/ethnicity, handedness, weight and height. Additionally, participants were asked if they experienced any technical difficulties with the study and about the environment in which they completed the survey in terms of level of noise ("quiet", "background noise", "noise") and degree of distractions ("no distractions", "some distractions", "many distractions").

Primary outcome variables

Health behaviors

Physical activity was measured with the short version of the International Physical Activity Questionnaire (IPAQ; Craig et al. 2003). Participants reported their physical activity over the last 7 days, including days of vigorous and moderate activity, and the average number of minutes spent daily on each of these types of activity. Average daily moderate and vigorous physical activity were examined as separate outcome variables.

Fruit and vegetable consumption was measured with the following two items: "In the last 7 days, how many servings of fruit (vegetables) did you eat on a typical day?" Participants were provided with examples of fruits and vegetables that constitute a single serving (e.g., 1 apple, 1 cup of broccoli) and were asked to exclude fruit drinks and fried potatoes from their total count. These two items were summed to create a single index of fruit and vegetables consumption.

Using a 16-point scale ranging from *0* to *15 or more drinks*, alcohol consumption was measured with a single item, "In the last 7 days, how much alcohol have you consumed in total? Please list the total number of alcoholic drinks you have consumed in the last week. Note that 1 drink equals 12 ounces of beer, 5 ounces of wine, or 1.5 ounces of hard liquor." Smoking behavior was measured with a single open-ended item, "In the last 7 days, how many cigarettes have you smoked in total?" Finally, using a 13-point scale ranging from *0* to *12* h *or more*, sleep was measured with a single item, "In the last 7 days, on average how many hours of sleep did you get each night?"

Analysis plan

Data analysis proceeded in four stages. First we checked participants' list of personal projects to confirm that they followed directions. Participants who listed a single word (e.g., "books") were removed ($n = 15$; however, their data on all other outcome variables was retained). Additionally, participants who listed Personal Projects Should-Future or Actual-Future values that exceeded 100 years were recoded to 100 years ($n = 9$). Participants who listed Personal Projects Past values that exceeded their age were recoded to the participant's age. Additionally, on the Life Events questionnaire, if participants listed events that had occurred in the past (e.g., high school graduation), those items were excluded from analysis ($n = 2$). Second, consistent with the guidelines for the IPAQ (Sjöström et al. 2005), participants who reported more than 180 min of activity on any given day were recoded to 180 ($n = 10$) and participants who reported less than 10 min were recoded to zero ($n = 16$). Third, we checked that participants completed the entire survey and that they did not experience numerous technical difficulties or many distractions. Fourth, bivariate correlations and linear step-wise regressions were used to test the hypotheses. Sex was controlled for in the linear regressions as there are well-documented differences in physical activity (Troiano et al. 2008) and fruit and vegetable consumption (Wardle et al. 2000) between men and women. Additionally, body mass index (BMI) was controlled for in the linear regressions as BMI is strongly associated with both physical activity (Schmitz et al. 2000) and diet (Newby et al. 2003). To correct for type-1 error, Holm's sequential Bonferonni procedure was used, which is considered to be a more powerful test than a single-step Bonferonni correction (Holm 1979). In accordance with Holm's (1979) procedure, after conducting the linear regression analyses, obtained *p*-values were ordered from smallest to largest and these values were compared against the following corrected alpha levels: (α/n), (α/n − 1), … (α/1). Thus, for the present research if the lowest p-value is less than ($\alpha = 0.05/3 = 0.016$), then we proceeded by testing whether the second lowest p-value is less than ($\alpha = 0.05/2 = 0.025$).

Table 1 Means, standard deviations, and bivariate correlations, Study 1.

	M	*SD*	BIF	CFC-immediate	CFC-future	Life events	Personal projects Past	Personal projects Should-Future	Personal projects Actual-Future	Daily min. of vig. physical activity	Daily min. of mod. physical activity	Daily fruits and vegetables	Weekly alcohol consumption	Weekly smoking	Average hours of sleep
BIF	14.68	4.64	1.00	−0.20*	0.20*	−0.04	0.04	0.06	0.08	0.19*	0.12*	0.13*	0.02	0.03	−0.01
CFC-immediate	2.70	0.80	−0.20*	1.00	−.40*	−0.02	−0.06	−0.09	−0.12*	−0.04	0.03	−0.04	0.14*	−0.05	−0.01
CFC-future	3.79	0.70	0.20*	−0.40*	1.00	−0.01	0.09	0.22*	0.24*	0.07	0.02	0.05	−0.09	0.04	0.04
Life events	28.86	5.85	−0.04	−0.02	−0.01	1.00	0.18*	0.12*	0.10	0.03	0.10	−0.03	0.04	0.05	0.00
Personal projects past	11.47	10.34	0.04	−0.06	0.09	0.18*	1.00	0.29*	0.31*	0.07	0.04	0.07	0.02	0.02	−0.04
Personal projects should-future	40.93	47.31	0.06	−0.09	0.22*	0.12*	0.29*	1.00	0.83*	0.08	0.04	0.06	−0.08	0.09	−0.01
Personal projects actual-future	57.03	59.84	0.08	−0.12*	0.24*	0.10	0.31*	0.83*	1.00	0.130*	0.03	0.10	−0.09	0.10	−0.02
Daily min. of vig. physical activity	42.88	46.19	0.19*	−0.04	0.07	0.03	0.07	0.08	0.13*	1.00	0.33*	−0.01	0.06	0.02	−.11*
Daily min. of mod. physical activity	38.63	41.95	0.17*	0.03	0.02	0.10	0.04	0.04	0.03	0.33*	1.00	0.06	0.10	0.02	−0.01
Daily fruits and vegetables	5.19	3.22	0.13*	−0.04	0.05	−0.03	0.07	0.06	0.10	−0.01	0.06	1.00	0.01	0.02	0.12*
Weekly alcohol consumption	1.66	3.24	0.02	0.14*	−0.09	0.04	0.02	−0.08	−0.09	0.06	0.10	0.01	1.00	0.04	0.05
Weekly smoking	1.67	8.89	0.03	−0.05	0.04	0.05	0.02	0.09	0.10	0.02	0.02	0.02	0.04	1.00	−0.01
Average hours of sleep	6.61	1.47	−0.01	−0.01	0.04	0.00	−0.04	−0.01	−0.02	−0.11*	−0.01	0.12*	0.05	−0.01	1.00

CFC consideration of future consequences scale, *BIF* behavior identification form (measure of abstract thinking)

*Correlation is significant at the $p < 0.05$ level (2-tailed)

Results

Table 1 shows the means, standard deviations and bivariate correlations for the measures of temporal perspective, abstract thinking (BIF scores), and health-related behaviors. BIF scores (abstract thinking) correlated negatively with CFC-Immediate and positively with CFC-Future, but not with any of the other temporal measures. CFC-Future was associated positively with Personal Projects Actual-Future and Personal Projects Should-Future, and CFC-Immediate was negatively associated with Personal Projects Actual-Future. Average age of life events was positively associated with Personal Projects Should-Future and Personal Projects Past.

Furthermore, only abstract thinking had a significant and positive correlation with vigorous physical activity, moderate physical activity, and fruit and vegetable consumption. To examine further the predictive utility of abstract thinking, a series of three step-wise linear regressions were conducted on daily vigorous physical activity, daily moderate physical activity, and daily fruit and vegetable consumption, with sex and BMI entered in Step 1, CFC-Immediate and CFC-Future scores entered in Step 2, and BIF scores (abstract thinking) entered in Step 3. As shown in Table 2, in all three analyses the addition of CFC-Immediate and CFC-Future scores in Step 2 did not result in a significant increase in R^2. Conversely, the addition of abstract thinking scores in Step 3 resulted in a significant increase in R^2 when predicting vigorous physical activity, moderate physical activity, and fruit and vegetable consumption. Examining individual predictors, abstract thinking was associated positively with vigorous physical activity, moderate physical activity, and fruit and vegetable consumption, whereas CFC-Immediate and CFC-Future scores were not significantly associated with any of the health outcomes. Note that the main effect of abstract thinking on all three health-related outcome variables met the Holm-Bonferonni correction. These analyses confirm that although abstract thinking, CFC-Future, and CFC-Immediate scores related significantly with one another, abstract thinking related uniquely to vigorous physical activity, moderate physical activity, and fruit and vegetable consumption.

Discussion

Study 1 provides initial evidence that abstract thinking is associated positively with greater levels of physical activity and fruit and vegetable consumption. Abstract thinking did not relate to smoking, sleep, or alcohol consumption. A closer examination of these variables indicates that there was likely insufficient variability to afford sensitivity to detecting covariance with other constructs. Only 7.80% of the sample reported smoking 1 or more cigarettes, 35% of the sample reported consuming 1 or more drinks, and 5.40% of the sample reported receiving an average of 4 h of sleep or less. Thus, the findings for these variables should be interpreted with some caution.

Study 2

Study 2 was a confirmatory study in which we sought to replicate and extend findings from Study 1. To this end, the methods, directional hypotheses, and analysis plan for this study (including planned analyses, a data-stopping rule and criteria for excluding participants) were pre-registered prior to data collection; please see https://osf.io/kxq8p/?view_only=8144c4f02ac44a49950816317303a794. In Study 2, we aimed to replicate the finding that abstract thinking is associated positively with vigorous physical activity, moderate physical activity, and fruit and vegetable intake. Additionally, consistent with research indicating that abstract thinking relates to seeing one's goals as more meaningful and autonomously motivated (e.g., Davis et al. 2016), we aimed to test (1) whether abstract thinking is positively correlated with autonomous motivation; and (2) whether autonomous motivation mediates the association between abstract thinking and physical activity and fruit and vegetable consumption.

Participants

In exchange for course credit, 474 undergraduate students participated. Consistent with the pre-registered exclusion criteria, data from 10 participants were excluded prior to hypothesis-testing because they reported experiencing technical errors and/or many distractions during their completion of the study. The final sample consisted of 464 participants, (127 male), aged 17–46, ($M = 20.23$, $SD = 2.59$); 40.10% of participants described themselves as White, 23.30% as East Asian, 11.60% as other or a combination of races/ethnicities, 10.10% as South East Asian, 8.60% as Latino/a., and 6.00% as Black or African American.

An a priori power analysis indicated that 400 participants were required to achieve power $(1-\beta)$ of 0.85, with $\alpha = 0.05$ and an estimated effect size (ρ) of 0.15. We oversampled by approximately 15% to account for any participants lost due to technical issues or due to completing the study in an environment with many distractions.

Procedures

After providing informed consent, participants completed an online study administered through Qualtrics via the

Table 2 Linear regressions Study 1

Step	*B*	*SE*	*Beta*	*t*	*p*	95% confidence intervals		Model R^2	F change	*p*
Daily vigorous physical activity										
1										
Constant	55.97	13.14		4.26	<.001	30.14	81.80	0.11	23.57	< 0.001
Sex (female)	−31.33	4.67	−0.33	−6.71	<.001	−40.51	−22.15			
Body mass index	0.32	0.53	0.03	0.60	0.549	−0.72	1.35			
2										
Constant	50.08	22.71		2.21	0.028	5.43	94.72	0.12	1.27	0.281
Sex (female)	−31.77	4.68	−0.34	−6.78	<.001	−40.98	−22.56			
Body mass index	0.24	0.53	0.02	0.46	0.647	−0.79	1.28			
CFC-immediate	−2.17	3.10	−0.04	−0.70	0.485	−8.27	3.93			
CFC-future	3.63	3.51	0.06	1.04	0.301	−3.27	10.53			
3										
Constant	29.98	23.33		1.29	0.200	−15.90	75.85			
Sex (female)	−30.55	4.65	−0.32	−6.58	<.001	−39.68	−21.42			
Body mass index	0.15	0.52	0.01	0.28	0.777	−0.88	1.17			
CFC-immediate	−0.82	3.09	−0.01	−0.26	0.792	−6.90	5.27			
CFC-future	2.27	3.49	0.04	0.65	0.517	−4.60	9.14			
BIF	1.57	0.50	0.16	3.15	0.002	0.59	2.55	0.14	9.89	0.002
Daily moderate physical activity										
1										
Constant	36.37	12.42		2.93	0.004	11.95	60.80	0.04	7.4	0.001
Sex (female)	−15.59	4.41	−0.18	−3.53	<.001	−24.27	−6.91			
BMI	0.53	0.50	0.06	1.08	0.283	−0.44	1.51			
2										
Constant	24.41	21.53		1.13	0.258	−17.93	66.75	0.04	0.23	0.793
Sex (female)	−15.41	4.44	−0.18	−3.47	0.001	−24.15	−6.68			
Body mass index	0.54	0.50	0.06	1.08	0.283	−0.45	1.52			
CFC-immediate	1.60	2.94	0.03	0.55	0.586	−4.18	7.39			
CFC-future	1.97	3.33	0.03	0.59	0.555	−4.58	8.51			
3										
Constant	12.34	22.30		0.55	0.581	−31.52	56.19	0.05	3.91	0.049
Sex (female)	−14.68	4.44	−0.17	−3.31	0.001	−23.42	−5.95			
Body mass index	0.48	0.50	0.05	0.96	0.336	−0.50	1.46			
CFC-immediate	2.42	2.96	0.05	0.82	0.415	−3.40	8.23			
CFC-future	1.15	3.34	0.02	0.34	0.731	−5.42	7.71			
BIF	0.94	0.48	0.10	1.98	0.049	0.01	1.88			
Daily fruit and vegetable consumption										
1										
Constant	7.06	0.96		7.33	<0.001	5.16	8.95	0.02	3.85	0.022
Sex (female)	0.39	0.34	0.06	1.14	0.257	−0.29	1.06			
Body mass index	−0.09	0.04	−0.12	−2.37	0.018	−0.17	−0.02			
2										
Constant	6.65	1.67		3.99	< .001	3.38	9.93	0.02	0.76	0.469
Sex (female)	0.37	0.34	0.06	1.06	0.289	−0.31	1.04			
Body mass index	−0.10	0.04	−0.13	−2.47	0.014	−0.17	−0.02			
CFC-future	0.22	0.26	0.05	0.84	0.403	−0.29	0.72			
3										
Constant	5.37	1.72		3.13	0.002	1.99	8.75	0.04	7.41	0.007
Sex (female)	0.44	0.34	0.07	1.29	0.197	−0.23	1.12			

Table 2 (continued)

Step	*B*	*SE*	*Beta*	*t*	*p*	95% confidence intervals		Model R^2	F change	*p*
Body mass index	−0.10	0.04	−0.14	−2.64	0.009	−0.18	−0.03			
CFC-immediate	−0.03	0.23	−0.01	−0.12	0.908	−0.48	0.42			
CFC-future	0.13	0.26	0.03	0.50	0.618	−0.38	0.64			
BIF	0.10	0.04	0.14	2.72	0.007	0.03	0.17			

CFC consideration of future consequences scale, *BIF* behavior identification form (measure of abstract thinking)

subject-pool website at Stony Brook University. Participants completed questionnaires in the following order: (1) BIF; (2) CFC scale; (3) a questionnaire about health-related behaviors; (4) Brief Self-Control Scale; (5) Behavioral Regulation of Exercise Questionnaire; (6) the Regulation of Eating Behavior Scale; and (7) demographics. The order of the Regulation of Eating Behavior Scale and the Behavioral Regulation of Exercise Questionnaire was counterbalanced across participants.

Measures and materials

Primary predictor variable

Behavior identification form

As in Study 1, participants viewed 25 behaviors and selected a concrete or abstract re-description of each target behavior (Cronbach's $\alpha = 0.84$).

Secondary or control variables

Consideration of future consequences scale

Consistent with Study 1, separate scores were computed for CFC-Immediate and CFC-Future (Cronbach's $\alpha = 0.69$ and $\alpha = 0.81$, respectively).

Brief self-control scale

Participants answered questions about their tendency to practice self-control (Tangney et al. 2004; Cronbach's $\alpha = 0.80$).

Behavioral regulation of exercise questionnaire

Participants completed questions about their motivation to exercise (BREQ-3; Markland and Tobin 2004; Cronbach's $\alpha = 0.92$). The scale is comprised of six motivation subscales: intrinsic, integrated, identified, introjected, external, and amotivation. An example item from the intrinsic subscale is: "I get pleasure and satisfaction from participating in exercise." An example item from the external subscale is, "I exercise because other people say I should." Consistent with Wilson et al. (2006), a relative autonomy index score was computed to assess the degree to which participants feel self-determined about their exercise behavior by applying a weight to each subscale and then summing these weighted scores. Higher scores indicate greater autonomous motivation. Following Wilson et al.'s procedure, the following weighting equation was used: (Amotivation score* − 3) + (External* − 2) + (Introjected* − 1) + (Identified*1) + (Integrated*2) + (Intrinsic*3).

Regulation of eating behavior scale

Participants completed questions about their reasons for maintaining a healthy diet (Pelletier et al. 2004; Cronbach's $\alpha = 0.90$). Similar to the Behavior Regulation of Exercise Questionnaire, this scale is comprised of six motivation subscales: intrinsic, integrated, identified, introjected, external, and amotivation. A sample item from the intrinsic subscale includes, "I take pleasure in fixing healthy meals," and a sample item from the external subscale includes, "Other people close to me will be upset if I don't [maintain a healthy diet]." The same scoring procedure was used as the BREQ-3 to create a relative autonomy index score. With higher scores indicating greater autonomous motivation.

Demographics

Participants reported their sex, age, race/ethnicity, weight and height. Additionally, participants indicated if they experienced any technical difficulties and indicated the extent to which they completed the survey in a noisy and distracting environment.

Primary outcome variables

Physical activity and diet

Physical activity and fruit and vegetable consumption were assessed using the same items as Study 1. Study 2 included three new items to assess unhealthy eating: one item related to high-sugar foods ("How often do you eat sweets, such as chocolate, candy, cookies, ice cream, pastries, cake, or pie"?); one item related to high-sugar beverages ("How often do you drink at least 8 ounces of non-diet soda, juice, lemonade, coffee with sugar, or sweetened iced tea"?); and one item related to high-fat foods ("In the last 7 days, how often did you eat salty foods, such as chips, French fries, fried chicken, burgers, or pizza?"). Participants responded using an 8-point scale from *never* to *at least 4 times per day*. The two items about high-sugar foods and beverages ($r = 0.25$, $p < .001$) were summed to create a total sugar consumption score.

Analysis plan

We first checked the physical activity data for outliers. Consistent with the guidelines for the IPAQ (Sjöström et al. 2005), participants who reported more than 180 min of activity on any given day were recoded to equal 180 ($n = 16$). Values of 10 min or less were recoded to zero ($n = 16$). Additionally, if participants specified their weight as an implausible value (≤ 70 pounds and over 5 feet tall) their weight was recoded as a missing value ($n = 4$). Second, we checked for any technology-related errors. Specifically, we checked that participants completed the entire survey and that they did not experience numerous technical difficulties or many distractions. Third, we proceeded with hypothesis testing. Step-wise linear regressions examined whether abstract thinking scores related to moderate physical activity, vigorous physical activity, and fruit and vegetable consumption. Fourth, autonomous motivation was tested as a mediator of the association between abstract thinking and vigorous physical activity, moderate physical activity, and fruit and vegetable intake, respectively.[3]

Importantly, by pre-registering directional hypotheses, Study 2 allows for a confirmatory test of a positive relationship between abstract thinking and vigorous physical activity, moderate physical activity, and fruit and vegetable intake, respectively. Particularly when relatively many variables are measured, one of the most effective means of decreasing type-I errors is to formally pre-register one's hypotheses before data collection. In this way, the researcher makes clear beforehand which hypotheses will be tested and which analyses will be used, thereby dramatically decreasing what has been termed "researcher degrees of freedom," through which researchers otherwise could conduct many different analyses and report the ones that met some criterion, such as $p < .05$ (Simmons et al. 2011). Thus, in Study 2 we did not apply a Holm-Bonferonni procedure because type-1 error rates were already controlled for by using a pre-registered analysis plan with directional hypotheses.

Results

Table 3 shows the means, standard deviations, and bivariate correlations for abstract thinking (BIF), CFC-Immediate, CFC-Future, autonomous motivation, and health-related behaviors. Note that the bolded and italicized values in Table 3 indicate pre-registered predictions. Again, BIF scores (abstract thinking) were negatively correlated with CFC-Immediate and positively associated with CFC-Future scores. Additionally, BIF scores (abstract thinking) were positively associated with trait self-control, autonomous motivation for exercise, and autonomous motivation for diet, but not with sugar of fried food consumption. Three step-wise linear regressions were conducted with sex and BMI (Step 1), CFC-Immediate, CFC-Future, and trait self-control (Step 2), and abstract thinking (BIF scores) (Step 3) as predictors and vigorous physical activity, moderate physical activity, and fruit and vegetable consumption as outcomes.

As shown in Table 4, for vigorous and moderate physical activity, the addition of CFC-Immediate, CFC-Future, and trait self-control scores in Step 2 did not yield a significant increase in R^2. However, for fruit and vegetable consumption, the addition of the Step 2 variables was associated with a significant increase in R^2. The addition of abstract thinking (BIF scores) in Step 3 was associated with a significant increase in R^2 across all three outcomes. Abstract thinking was significantly related to greater daily vigorous physical activity, moderate physical activity, and fruit and vegetable consumption. CFC-Immediate and CFC-Future scores were not significantly related to any of the outcome variables. Trait self-control was significantly related to fruit and vegetable intake, but not to vigorous or moderate physical activity.

Having found confirmatory evidence that abstract thinking related to vigorous physical activity, we proceeded by testing the prediction that autonomous motivation mediates the association between abstract thinking and vigorous physical activity. To test for mediation, we used SPSS PROCESS (v 2.15), an ordinary least squares regression model that assesses the direct and indirect effects with a bootstrap set to

[3] We had planned to use Baron an Kenny's (1986) three-step meditation approach, but, instead used bootstrapping to be consistent with the most recent mediation recommendations (Hayes 2013). The results are the same with both approaches. Additionally, at the recommendation of our anonymous reviewers we made two additional changes from the pre-registration: 1) we controlled for body mass index in the linear regressions instead of weight to be consistent with previous research; and 2) we report the results of the linear regressions in a step-wise format to clarify the unique contribution of abstract thinking above and beyond covariates and temporal perspective/self-control.

Table 3 Means, standard deviations, and bivariate correlations, Study 2

	M	*SD*	BIF	CFC-immediate	CFC-future	Trait self-control	Autonomous motivation for exercise	Autonomous motivation for diet	Daily min. of vig. physical activity	Daily min. of mod. physical activity	Daily fruits and vegetables	Daily sugar consumption	Daily fried food consumption
BIF	19.35	2.70	1.00	−0.11*	0.18*	0.10*	***0.18****	***0.20****	***0.15****	***0.10****	***0.12****	−0.06	−0.07
CFC-immediate	2.70	0.71	−0.11*	1.00	−0.36*	−0.39*	−0.18*	−0.33*	−0.02	−0.01	−0.11*	0.13*	0.20
CFC-future	3.73	0.61	0.18*	−.36*	1.00	0.29*	0.17*	0.30*	0.03	0.01	0.08	−.15*	−0.13
Trait self-control	3.09	0.64	0.10*	−0.39*	0.29*	1.00	0.28*	0.38*	0.03	0.05	0.14*	−0.22*	−0.25
Autonomous motivation for exercise	3.81	4.61	0.18*	−0.18*	0.17*	0.28*	1.00	0.50*	0.37*	0.10*	0.16*	−0.17*	−0.21
Autonomous motivation for diet	6.88	7.21	0.20*	−0.33*	0.30*	0.38*	0.50*	1.00	0.18*	0.05	0.35*	−0.34*	−0.34
Daily min. of vig. physical activity	39.32	44.37	0.15*	−0.02	0.03	0.03	0.37*	0.18*	1.00	0.33*	0.13*	−0.04	−0.11
Daily min. of mod. physical activity	40.99	43.54	0.10*	−0.01	0.01	0.05	0.10*	0.05	0.33*	1.00	0.12*	−0.03	−0.05
Daily fruits and vegetables	7.12	3.17	0.12*	−.11*	0.08	0.14*	0.16*	0.35*	0.13*	0.12*	1.00	−0.16*	−0.23
Daily sugar consumption	4.92	1.27	−0.06	0.13*	−0.15*	−.22*	−0.17*	−0.34*	−0.04	−0.03	−0.16*	1.00	0.39
Daily fried food consumption	4.91	1.43	−0.07	0.20	−0.13	−0.25	−0.21	−0.34	−0.11	−0.05	−0.23	0.39	1.00

Bolded and italicized values indicate pre-registered predictions

CFC consideration of future consequences scale, *BIF* behavior identification form (measure of abstract thinking)

*Correlation is significant at the $p < 0.05$ level (2-tailed)

Table 4 Linear regressions Study 2

Step	*B*	*SE*	*Beta*	*t*	*p*	95% confidence intervals		Model R^2	F change	*p*
Daily vigorous physical activity										
1										
Constant	40.66	10.28		3.95	< 0.001	20.45	60.87	0.02	5.62	0.004
Sex (female)	− 14.71	4.51	− 0.15	− 3.26	0.001	− 23.57	− 5.85			
Body mass index	0.40	0.42	0.05	0.97	0.334	− 0.42	1.22			
2										
Constant	28.25	23.86		1.18	0.237	− 18.64	75.14	0.03	0.52	0.672
Sex (female)	− 15.27	4.54	− 0.16	− 3.36	0.001	− 24.20	− 6.35			
Body mass index	0.45	0.42	0.05	1.06	0.289	− 0.38	1.27			
CFC-immediate	− 0.97	3.24	− 0.02	− 0.30	0.765	− 7.35	5.40			
CFC-future	1.82	3.67	0.03	0.50	0.620	− 5.39	9.04			
Trait self-control	2.48	3.57	0.04	0.69	0.488	− 4.54	9.49			
3										
Constant	− 11.20	27.19		− 0.41	0.681	− 64.62	42.23	0.05	8.69	0.003
Sex (female)	− 14.41	4.51	− 0.15	− 3.19	0.002	− 23.28	− 5.54			
Body mass index	0.51	0.42	0.06	1.21	0.226	− 0.31	1.33			
CFC-immediate	− 0.65	3.22	− 0.01	− 0.20	0.839	− 6.98	5.67			
CFC-future	0.21	3.68	0.00	0.06	0.954	− 7.02	7.45			
Trait self-control	2.05	3.54	0.03	0.58	0.562	− 4.91	9.01			
BIF	***2.27***	***0.77***	***0.14***	***2.95***	***0.003***	***0.76***	***3.78***			
Daily moderate physical activity										
1										
Constant	20.58	10.20		2.02	0.044	0.53	40.62	0.02	3.59	0.028
Sex (female)	− 5.06	4.47	− 0.05	− 1.13	0.259	− 13.85	3.73			
Body mass index	1.03	0.41	0.12	2.50	0.013	0.22	1.85			
2										
Constant	7.57	23.75		0.32	0.75	− 39.11	54.24	0.02	0.606	0.611
Sex (female)	− 5.60	4.51	− 0.06	− 1.24	0.215	− 14.46	3.26			
Body mass index	1.10	0.42	0.12	2.62	0.009	0.28	1.92			
CFC-immediate	− 0.13	3.22	0.00	− 0.04	0.967	− 6.46	6.19			
CFC-future	− 0.28	3.64	0.00	− 0.08	0.938	− 7.44	6.87			
Trait self-control	4.34	3.54	0.06	1.23	0.221	− 2.61	11.29			
3										
Constant	− 20.60	27.07		− 0.76	0.447	− 73.79	32.59	0.03	4.58	0.033
Sex (female)	− 4.92	4.50	− 0.05	− 1.09	0.275	− 13.77	3.92			
Body mass index	1.14	0.42	0.13	2.73	0.007	0.32	1.95			
CFC-immediate	0.07	3.21	0.00	0.02	0.984	− 6.24	6.37			
CFC-future	− 1.46	3.67	− 0.02	− 0.40	0.69	− 8.67	5.75			
Trait self-control	4.00	3.53	0.06	1.13	0.257	− 2.93	10.93			
BIF	***1.63***	***0.76***	***0.10***	***2.14***	***0.033***	***0.13***	***3.13***			
Daily fruit and vegetable consumption										
1										
Constant	7.20	0.74		9.68	< 0.001	5.74	8.66	0.01	0.44	0.643
Sex (female)	0.28	0.33	0.04	0.87	0.383	− 0.36	0.93			
Body mass index	− 0.01	0.03	− 0.02	− 0.40	0.689	− 0.07	0.05			
2										
Constant	5.40	1.71		3.16	0.002	2.04	8.75	0.02	3.47	0.016
Sex (female)	0.18	0.33	0.03	0.55	0.586	− 0.46	0.82			
Body mass index	0.00	0.03	0.00	− 0.10	0.924	− 0.06	0.06			

Table 4 (continued)

Step	*B*	*SE*	*Beta*	*t*	*p*	95% confidence intervals		Model R^2	F change	*p*
CFC-immediate	−0.23	0.23	−0.05	−1.00	0.319	−0.69	0.23			
CFC-future	0.18	0.26	0.03	0.68	0.495	−0.34	0.70			
Trait self-control	0.52	0.26	0.11	2.05	0.041	0.02	1.03			
3										
Constant	3.34	1.96		1.71	0.089	−0.51	7.18	0.03	4.58	0.033
Sex (female)	0.22	0.33	0.03	0.69	0.494	−0.42	0.86			
Body mass index	0.00	0.03	0.00	0.01	0.993	−0.06	0.06			
CFC-immediate	−0.22	0.23	−0.05	−0.93	0.353	−0.67	0.24			
CFC-future	0.10	0.27	0.02	0.36	0.718	−0.43	0.62			
Trait self-control	0.50	0.26	0.10	1.97	0.049	0.00	1.00			
BIF	***0.12***	***0.06***	***0.10***	***2.14***	***0.033***	***0.01***	***0.23***			

Bolded and italicized values indicate pre-registered predictions

CFC consideration of future consequences scale, *BIF* behavior identification form (measure of abstract thinking)

1000 samples (Hayes 2013). Abstract thinking accounted for a significant proportion of variance in autonomous motivation to exercise ($B=0.30$, $SE=0.08$, $t(462)=3.60$, $p<.001$, 95% *CI* 0.14, 0.46) and autonomous motivation accounted for a significant proportion of variance in vigorous physical activity ($B=3.41$, $SE=0.42$, $t(462)=8.19$, $p<.001$, 95% *CI* 2.59, 4.23). There was a significant total direct effect of abstract thinking on vigorous physical activity ($B=2.41$, $SE=0.71$, $t(462)=3.40$, $p<.001$, 95% *CI* 1.02, 3.81). The mediation model revealed a significant indirect effect of abstract thinking on vigorous physical activity through autonomous motivation ($B=1.02$, $SE=0.31$, 95% *CI* 0.49, 1.70), with autonomous motivation accounting for a substantial amount of the total effect, $P_M=0.42$.

Next, using the same mediation model we tested whether autonomous motivation to exercise mediated the effect of abstract thinking on moderate physical activity. Again, abstract thinking accounted for a significant proportion of variance in autonomous motivation to exercise ($B=0.304$, $SE=0.084$, $t(462)=3.631$, $p<.001$, 95% *CI* 0.140, 0.469), but autonomous motivation did not account for a significant proportion of variance in moderate physical activity ($B=0.755$, $SE=0.519$, $t(462)=1.456$, $p=.146$, 95% *CI* −0.264, 1.774).

Finally, the same model was tested with abstract thinking as the predictor, fruit and vegetable consumption as the outcome variable, and autonomous motivation to eat a healthy diet as the mediator. Abstract thinking accounted for a significant proportion of variance in autonomous motivation to eat a healthy diet ($B=0.534$, $SE=0.126$, $t(462)=4.226$, $p<.001$, 95% *CI* 0.286, 0.782) and autonomous motivation accounted for a significant proportion of variance in fruit and vegetable consumption ($B=0.147$, $SE=0.021$, $t(462)=7.094$, $p<.001$, 95% *CI* 0.106, 0.188). There was a significant total direct effect of abstract thinking on fruit and vegetable consumption ($B=0.139$, $SE=0.051$, $t(462)=2.735$, $p=.007$, 95% *CI* 0.039, 0.239). The indirect effect of abstract thinking on fruit and vegetable consumption through autonomous motivation to maintain a healthy diet was significant ($B=0.079$, $SE=0.023$, 95% *CI* 0.036, 0.127), with autonomous motivation accounting for more than half of the total effect, $P_M=0.566$.

General discussion

We examined whether dispositional abstract thinking is associated with viewing oneself as engaging in physical activity for more autonomous reasons. In Studies 1 and 2, abstract thinking, even when taking trait self-control and temporal perspective into account, related to self-reported vigorous physical activity, moderate physical activity, and fruit and vegetable consumption. Furthermore, in Study 2 there were significant indirect effects of abstract thinking on daily vigorous physical activity and fruit and vegetable consumption through autonomous motivation. However, in Study 2 we found that abstract thinking was not significantly correlated with sugar or fast food consumption. Future research is needed, then, to clarify why abstract thinking relates more strongly to certain health behaviors than others.

Self-determination theory posits that integration and identification (that is, viewing a behavior as consistent with one's values and as part of one's identity) are critical processes through which a person comes to self-regulate and sustain behaviors (Deci and Ryan 1985). Supporting this view, several prospective studies have found that a positive self-concept for physical activity predicts future physical activity engagement (Marsh et al. 2006, 2007; Sweeney et al.

2017), with some studies finding effects spanning 13 years (Wichstrøm et al. 2013). In the present research, we found that vigorous, but not moderate physical activity, was mediated by autonomous motivation. More people reported engaging in at least some moderate physical activity (73.3%) than in vigorous physical activity (59.1%) in Study 2; thus, the present findings may reflect that the tendency to view one's physical activity in an autonomous manner is more robust among relatively advanced exercisers, perhaps due to differences in integration and identification. Relatedly, although several studies have examined the extent to which physical activity becomes integrated into one's self-concept, relatively little research has examined the extent to which dietary choices are integrated into a person's self-concept. Future research is needed to clarify when and why various types of health behaviors (e.g., healthy eating vs. unhealthy eating) become integrated into a person's self-concept.

Although there are several strengths to the current research, including using an a priori power analyses, using a relatively diverse sample of young adults, and pre-registering the hypotheses, methods, and analysis plan in Study 2 (which served to reduce type-1 errors), there are several limitations to acknowledge. First, the health behaviors were measured through self-reports. The IPAQ, which was used to assess physical activity, has satisfactory test–retest reliability (0.65–0.88) and past research has found moderate levels of agreement between physical activity scores collected with the IPAQ and with accelerometers (Craig et al. 2003). However future research should consider incorporating more objective measures of health behaviors. Second, although Study 2 yielded support for our pre-registered mediation hypotheses, we cannot draw a causal inference based on these analyses. The outcome variables (behavior in the last week) were measured in reference to a time that preceded the predictor and mediator, which limits our ability to establish temporal precedence. The present results provide correlational support for an indirect association between abstract thinking and vigorous physical activity and fruit and vegetable consumption through autonomous motivation. Future research in which concrete vs. abstract thinking is experimentally manipulated will be better suited for establishing a causal chain from abstract thinking to goal-directed behaviors through autonomous motivation (Spencer et al. 2005). Third, although the present research was able to account for two alternative variables of interest (temporal perspective and trait self-control), it remains possible that there are additional unmeasured variables that may help to explain the relationship between abstract thinking and health-related behaviors.

In the present research, we assumed that engaging in regular physical activity and eating fruits and vegetables were goal-directed behaviors. We expect the tendency for dispositional abstract thinking to relate to viewing one's actions in a more autonomous manner to be evident only when a behavior is seen as goal-relevant. That is, if engaging in regular physical activity is not seen as a goal-relevant behavior, we expect that the tendency to think in an abstract manner should not lead individuals to think of this action in a more autonomous manner; however, this prediction will need to be tested in future research. Future research also may examine whether experimentally manipulating abstract thinking impacts whether discrete actions come to be viewed in a more autonomous manner, and any implications this may have for behavior change.

The present research observed small associations between individual differences in abstract vs. concrete thinking and health behaviors (rs = 0.12–0.19). These effects are comparable in size to those representing relations between physical activity and other individual differences; for example, one meta-analysis observed that the correlations between extraversion ($r = 0.23$), neuroticism ($r = -0.11$), and conscientiousness ($r = 0.20$) and physical activity also were small-to-moderate in magnitude (Rhodes and Smith 2006). Furthermore, whereas other studies have found that individual differences in future-oriented thinking relate to health behaviors (e.g., Adams and Nettle 2009), the present research found that abstract thinking related to physical activity even when future temporal perspective was taken into account. Moreover, the tendency to think in an abstract or concrete manner is malleable for at least short periods of time (e.g., Liberman et al. 2002; Freitas et al. 2004). Building upon research which has sought to understand individual differences that promote effective self-regulation (Ivcevic and Brackett 2014; Mischel et al. 1989; Tangney et al. 2004), the present research suggests that mental construal, which can be altered through procedures that emphasize the procedures vs. the long-term aims of action, is a potentially useful construct for understanding when and why individuals succeed in engaging in healthy behaviors.

Past studies of mental construal and self-regulation have emphasized that abstract vs. concrete thinking differentially impacts the salience of different goal-relevant features in one's environment. As an example, Fujita and Carnevale (2012) propose that a dieter faced with a tempting food would likely benefit from abstract thinking because it would increase the salience of his or her long-term aims (e.g., "lose weight"), relative to the salience of immediate, incidental features (e.g., taste). The present research suggests that, apart from changing the salience of different types of goal-relevant features (e.g., feasibility vs. desirability), the tendency to adopt a more abstract style of thinking may lead people to view their goal-directed actions (e.g., engage in greater PA) in a more autonomous (rather than controlled) manner. By providing evidence for a novel mechanistic account for how abstract thinking relates to vigorous physical activity and fruit and vegetable consumption, the present research advances the growing body of literature linking social, cognitive, and motivational processes to health-related outcomes.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

Ethical approval All procedures were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. These studies were approved by the Institution Review Board at Stony Brook University.

Informed consent Informed consent was obtained from all individual participants included in these studies.

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