Published in final edited form as:
Psychol Aging. 2015 June ; 30(2): 432–448. doi:10.1037/a0039050.

The Effects of Constraints and Mastery on Mental and Physical Health: Conceptual and Methodological Considerations

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Abstract

Perceived control and health are closely interrelated in adulthood and old age. However, less is known regarding the differential implications of two facets of perceived control, constraints and mastery, for mental and physical health. Furthermore, a limitation of previous research testing the pathways linking perceived control to mental and physical health is that mediation was tested with cross-sectional designs and not in a longitudinal mediation design that accounts for temporal ordering and prior confounds. Using data from the Health and Retirement Study (HRS; n = 7,612, M *age* = 68, SD = 10.66; 59% women) we examined the effect of constraints and mastery on 4-year changes in mental and physical health and whether physical activity mediated such effects in a longitudinal mediation design. Using confirmatory factor analysis, we modeled the two-factor structure of perceived control that consisted of constraints and mastery. In our longitudinal mediation model, where we accounted for possible confounders (e.g., age, gender, education, neuroticism, conscientiousness, memory, and health conditions), constraints showed a stronger total effect on mental and physical health, than mastery, such that more constraints were associated with 4-year declines in mental and physical health. Physical activity did not mediate the effect of constraints and mastery on mental and physical health (indirect effect). In order to demonstrate the importance of a longitudinal mediation model that accounts for confounders, we also estimated the mediated effect using two models commonly used in the literature: cross-sectional mediation model and longitudinal mediation model without accounting for confounders. These mediation models indicated a spurious indirect effect that cannot be causally interpreted. Our results showcase that constraints and mastery have differential implications for mental and physical health, as well as how a longitudinal mediation design can illustrate (or not) pathways in developmental processes. Our discussion focuses on the conceptual and methodological implications of a two facet model of perceived control and the strengths of longitudinal mediation designs for testing conceptual models of human development.

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Keywords

Sense of Control; Confirmatory Factor Analysis; Mediation; Health and Retirement Study (HRS); Adulthood and Old Age; Developmental Health Processes

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Perceived control is an important psychological factor that is linked to better cognitive, mental, and physical health across adulthood and old age (Baltes & Baltes, 1986; Bandura, 1997; Lachman, 2006; Rodin, 1986; Skaff, 2007). For example, higher levels of and more positive rates of change in perceived control are associated with better cognitive functioning (Agrigoroaei & Lachman, 2011; Infurna & Gerstorf, 2013; Windsor & Anstey, 2008), mental health (Heckhausen & Lang, 2001; Windsor & Anstey, 2010), and overall physical health and longevity (Brown, Levy, Rosberger, & Edgar, 2003; Caplan & Schooler, 2003; Gale, Batty, & Deary, 2008; Infurna, Ram, & Gerstorf, 2013; Lachman & Agrigoroaei, 2010; Sargent-Cox et al., in press; Surtees et al., 2010; Turiano, Chapman, Agrigoroaei, Infurna, & Lachman, in press). The construct of perceived control consists of two facets, constraints and mastery, that are often times combined, but rarely analyzed separately, which could provide insights into whether each facet has a differential association with mental and physical health. Conceptual models of perceived control delineate that behavior, motivation, and biological health are pathways that link perceived control to aging-related outcomes (Lachman et al., 2011). However, empirical tests of these pathways are typically done with cross-sectional data. We use a longitudinal mediation design that will allow for determining temporal ordering and accounting for potential confounders (e.g., MacKinnon, Fairchild, & Fritz, 2007; Maxwell & Cole, 2003; Muthén, 2011) to examine whether physical activity (behavior) mediates the effects of constraints and mastery on mental and physical health. To test our research questions, we use longitudinal data from the Health and Retirement Study (HRS) to first examine whether constraints and mastery show differential effects on mental and physical health. In a second step, we determine whether physical activity mediates the effects of constraints and mastery on mental and physical health in a longitudinal mediation design.

Perceived Control: Definitions and Components

Perceived control is broadly defined as one's beliefs regarding their ability to exert influence over their life circumstances (Pearlin & Schooler, 1978; Skinner, 1996). Perceived control is also referred to as sense of control and control beliefs and has a long history in psychological research beginning with Rotter's (1966) concept of (internal and external) locus of control, Rodin and Langer's (1977) research on choice and enhanced responsibility to Pearlin and Schooler's (1978) construct of mastery and Bandura's (1977) self-efficacy. In her seminal review, Skinner (1996) found that there were over 100 terms related to the concept of control with two primary components, competence and contingency. Competence is broadly defined as the ability to interact effectively with one's environment (White, 1959). The concept of competence is similar to mastery, which refers to beliefs regarding one's ability to perform specific behaviors or actions to attain desired outcomes (Lachman & Weaver, 1998; Pearlin & Schooler, 1978). Contingency broadly relates to beliefs regarding the connection between performing a specific behavior and an outcome (Skinner, 1996). The concept of constraints maps onto contingency, such that constraints are viewed as one's perceived obstacles or deterrents for achieving desired outcomes (e.g., learned helplessness, Seligman, 1975). We view perceived control or control beliefs as a general overarching construct that encompasses various indices, such as constraints and mastery, as well as attributions and self-efficacy (for discussion, see Lachman et al., 2011). When we use the general phrase, perceived control, this refers to studies that have combined items of constraints and mastery. Our focus is on two specific aspects of perceived control, constraints and mastery, which are oftentimes combined into one factor and less so analyzed separately.

Although, constraints and mastery are related, we argue that they are conceptually distinct and should be analyzed separately in that they may have differential implications for mental and physical health in adulthood and old age (see Caplan & Schooler, 2003; Lachman & Weaver, 1998). First, in the studies that have indeed analyzed them separately by creating average composite scores, they show low to moderate correlations with one another (e.g., $r = -.21$ to $-.43$; Lachman & Weaver, 1998; Windsor, Ryan, & Smith, 2009), suggesting that although there is some overlap, the constructs tap into distinct sources of information. Mastery focuses on one's efficacious beliefs that likely have a greater impact on the ability to attain desired outcomes, such as health, whereas constraints refer to individuals' perceptions that external factors detrimentally influence the ability to control life circumstances (Skinner, 1995; Windsor et al., 2009). Second, constraints and mastery could have differential implications for aging-related outcomes. For example, Specht and colleagues (2011) found that reporting higher levels of external control was associated with a less steep decline in life satisfaction with spousal loss, whereas higher levels of internal control was associated with a stronger decline in life satisfaction. In earlier phases of the lifespan, children whose parents are divorcing and report higher levels of control are more likely to have poorer adjustment to the divorce (Skinner, 1995). In life situations that are beyond one's zone of control, lower levels of control (i.e., perceiving more constraints) may be adaptive. Conversely, in situations that are more within one's zone of control, such as maintaining positive health, mastery beliefs may show stronger effects (see White et al., 2012). Third, examining constraints and mastery separately can have implications for interventions through focusing on a combination of increasing one's mastery or decreasing constraints. For example, Reich and Zautra (1990) observed that interventions focusing on mastery decreased participants psychological distress and negative affect; this was especially pronounced for individuals who reported a disability. Christensen and Johnson (2002) observed that encouraging internal control for individuals who like to be in control and focusing on structuring and external factors for those individuals characterized as being more external controls and who did not desire to be in control of their medical care led to overall positive results for patient satisfaction and adherence to medical regiments. It is likely that these sorts of principles could be applied to constraints and mastery.

Associations between Perceived Control with Mental and Physical Health

Constraints and mastery have implications for mental and physical health across adulthood and old age. Cross-sectional findings show that higher levels of mastery and fewer constraints are associated with better mental health (DeNeve & Cooper, 1998; Lachman &

Weaver, 1998; Windsor et al., 2009). Similar findings have been observed longitudinally over differing lengths of time. In a sample of older adults, higher levels of mastery were associated with higher positive affect, lower negative affect, and higher life satisfaction over a 6-month follow-up (Lang & Heckhausen, 2001). Windsor & Anstey (2010) found that reporting stronger feelings of mastery were linked to more positive 4-year changes in mental health in young adulthood, midlife, and old age.

Research has accumulated linking constraints and mastery to physical health. Empirical evidence from cross-sectional data suggests that higher mastery and fewer constraints are associated with better physical health (Fauth et al., 2007; Femia et al., 1997). Similar associations have been observed longitudinally where reporting higher levels of mastery were protective against declines in physical functioning and overall physical health (Femia et al., 2001; Infurna, Gerstorf, & Zarit, 2011; Sargent-Cox et al., in press). Over a longer period of 10 years, reporting higher levels of perceived control (combined mastery and constraints items) were protective against accruing functional limitations (Lachman & Agrigoroaei, 2010).

Mediation of the Effects of Constraints and Mastery on Mental and Physical Health

Conceptual models of perceived control have long discussed that one potential pathway for why perceived control has effects on mental and physical health is health behaviors, such as physical activity (Bandura, 1997; Lachman et al., 2011; Rodin, 1986; Skaff, 2007). Our second research question revolves around testing in a longitudinal mediation design, whether physical activity mediates the effects of constraints and mastery on mental and physical health. As described in the research of Bandura (1997), social and thought processes are important for engaging in desired behaviors, which eventually lead to developmental outcomes, such as positive health. Perceived control is often instrumental in facilitating and regulating physical activity and strenuous exercise, which in turn is associated with better mental and physical health (Netz, Wu, Becker, & Tenenbaum, 2005; Penedo & Dahn, 2005). For example, perceiving more control over life circumstances provides individuals with the motivations and means to engage in regular physical activity, as well as attitudes and beliefs of contingency that behaviors will lead to desired outcomes (Bandura, 2004; Lachman et al., 1997). Furthermore, if people believe that their health is dynamic and malleable as opposed to static and predetermined, they are more likely to have the motivational resources to engage in health-promoting behaviors, such as physical activity. There are various ways through which physical activity may have these subsequent effects. First, physical activity increases exercise capacity, endurance, skeletal muscle strength and cardiovascular adaptations that are subsequently beneficial for both mental and physical health (Thompson et al., 2003). Second, physical activity additionally decreases one’s cardio-metabolic risk (Brach et al., 2004; Infurna & Gerstorf, 2014), which has downstream effects on mental and physical health (Penedo & Dahn, 2005; Rantanen et al., 1999). Third, physical activity indirectly enhances mental and physical health through affect and physical self-worth (Elavsky et al., 2005; McAuley et al., 2008; Netz et al., 2005), as well as improving mood and decreasing symptoms of anxiety (Maher et al., 2013; Ross & Hayes, 1988; Stephens, 1988).

Challenges in testing mediation

Figure 1 shows three scenarios through which mediation is typically tested; these models will be the basis of the analyses for our paper. Part A depicts a cross-sectional mediation design where each of the variables of interest, predictors (*CO*, *MA*), mediator (M_1), and outcome (Y_1) are assessed at one point in time. Our research has previously tested mediation using this cross-sectional design; we found that physical activity mediated the effect of perceived control on functional health and cardio-metabolic risk (Infurna & Gerstorf, 2014). However, a major pitfall of cross-sectional mediation is that it is not a suitable research tool for inferring developmental trends (Hertzog, 1996; Hofer et al., 2006; Maxwell & Cole, 2007). Part B of Figure 1 shows a longitudinal mediation design where baseline measures of physical activity and physical health (M_1, and Y_1) are not accounted for. For example, Infurna and colleagues (2011) found that perceived control was protective against 2.5 year declines in physical health; in a subsequent model that included physical activity, the effect of perceived control on physical health was no longer reliably different from zero. From this result, we inferred that mediation had occurred. However, physical activity was measured at the same occasion as perceived control, meaning it was a potential confounder that has shared associations with perceived control and physical health with no temporal ordering to determine mediation; there is only temporal ordering of perceived control and physical health. Although this design provides for examining developmental trends in the outcome variable of interest, this does not allow for disentangling time-ordering of the mediator and outcome of interest (Lindenberger, von Oertzen, Ghisletta, & Hertzog, 2011). A pitfall of previous research examining “mediation” processes is that it has largely been done with designs similar to Parts A and B of Figure 1, which does not allow for temporal ordering and accounting for prior confounds. This is commonplace across literatures when testing mediation processes and has a long history stemming from Baron and Kenny (1986).

Part C in Figure 1 graphically illustrates a longitudinal mediation design that allows for determining temporal ordering of the predictors (*CO*, *MA*), mediator (M_2) and outcome (Y_3). We emphasize that longitudinal data is essential for effectively testing longitudinal mediation (for discussion, see MacKinnon et al., 2007; Cole & Maxwell 2003; Muthén, 2011) and there are several reasons for this.

First, the temporal order has to be clear; it has to be non-ambiguous that *X* precedes *M*, and *M* precedes *Y*. This can be evident in some cases from a theoretical point of view (e.g., gender will influence humans’ mood and not vice versa) but in most cases it is necessary to have a temporal precedence in the design. We therefore use a longitudinal mediation design (similar to part C in Figure 1) to examine direct and indirect effects of constraints and mastery on 4-year change in mental and physical health. Additionally, we incorporated latent change score models to test longitudinal mediation. We strongly argue for longitudinal designs to assess mediational research questions because a mediator cannot be concurrent with the predictor and must precede the outcome variable (Lindenberger et al., 2011; MacKinnon et al., 2007; Maxwell & Cole, 2007). Longitudinal data is needed because it allows for empirically testing the pathways that conceptual models discuss underlying the effect of perceived control on mental and physical health over time. Developmental processes are not static, but transpire over time and the pathways that link perceived control to mental and physical health (e.g., physical activity) take time to develop and unfold.

Second, the mediation model is a causal model, i.e., it requires causally unbiased total, direct and indirect effects. This is a difficult problem that has often be neglected in applications of mediational models, partly because it is not mentioned in Baron & Kenny's (1986) influential paper, even though the authors were aware of this problem (Judd & Kenny, 1981). Recently, Mayer and colleagues (in press) showed in a simulated example, that even in a randomized experiment in which the treatment variable X and all pre-treatment confounders Z are independent, conditional dependence of X and Z given M has to be expected, which can bias the estimates of direct and indirect effects. This problem is exacerbated in quasi-experimental designs such is the case with longitudinal panel surveys, where the total effect of X on Y and the total effect of X on M are likely to be biased in models ignoring important confounding variables (see also Cole & Maxwell, 2007). We therefore controlled for various possible confounders in our mediation models.

Confounders

We include socio-demographic variables (age, gender, and education), neuroticism, conscientiousness, memory, and health conditions as potential confounders because they share common associations with constraints, mastery and mental and physical health. Inclusion of confounders will additionally allow us to more stringently test the mediating effect of constraints and mastery on mental and physical health and enhance the robustness of our results. Longitudinal research suggests that constraints and mastery remain relatively stable in young adulthood and midlife, with accelerated changes in older ages, with constraints increasing and mastery declining (Gerstorf, Ram, Lindenberger, & Smith, 2013; Lachman et al., 2009; Mirowsky & Ross, 2007). Gender differences are typical in constructs centered on perceived control with women typically reporting lower levels (Feingold, 1994; Ross & Mirowsky, 2002). Attaining more years of education is typically associated with reporting higher levels of and less steep declines in perceived control across the lifespan (Mirowsky & Ross, 2007). Personality factors of neuroticism and conscientiousness are interrelated with perceived control and share commons health outcomes, such as disability and mortality (Chapman et al., 2011). Empirical evidence suggests that better memory is associated with higher levels of and more positive changes in mastery and constraints over time (Lachman et al., 2009), which may operate via one's capability to complete everyday activities of living, which limit one's ability to successfully carry out desired outcomes (Infurna, Gerstorf, Ryan, & Smith, 2011). Overall disease burden and specific disease incidences, such as cardiovascular disease, cancer, stroke, and diabetes hinder perceptions of and striving for control (Gerstorf et al., 2011; Penninx et al., 1996; Wurm et al., 2007).

The Present Study

Our goal is to examine whether a two-factor model of perceived control that consists of constraints and mastery has differential effects on mental and physical health and whether physical activity mediates such effects. To do so, we apply a longitudinal mediation design to data from the nation-wide HRS that has longitudinal data on our constructs of interest. First, we examine whether the two facets of perceived control, constraints and mastery, have differential effects on mental and physical health in adulthood and old age. We hypothesize that mastery will have a stronger effect on physical health, whereas constraints will have a stronger effect on mental health. Mastery reflects one's efficacious beliefs, which are instrumental in the initiation and facilitation of human behavior associated with health (Bandura, 1997). Along the lines suggested by learned helplessness theory, we expect that constraints would be more strongly associated with mental health because of global perceptions of external factors that may interfere with life circumstances and persistence in the face of challenging tasks (Peterson & Seligman, 1984; Seligman, 1975). Second, we examine whether physical activity mediates such effects over time using a longitudinal mediation design that has temporal ordering and accounts for prior confounds. Up to this point, the literature on constraints and mastery has largely tested mediation using cross-sectional or short-term longitudinal data (for exception, see Sargent-Cox et al., in press) and our approach has the possibility of determining whether this effect exists longitudinally.

Method

Participants and Procedure

The HRS is a nationally representative sample of households in the contiguous United States of non-institutionalized adults aged 50 and older (McArdle et al., 2007; Soldo et al., 1997). Participants are assessed on a wide range of measures including economic, sociological, psychological, mental, and physical health information. Since its inception in 1992, the HRS has assessed over 30,000 participants and in 2006 introduced an enhanced face-to-face interview component for half of the sample that included a leave behind psychosocial questionnaire and the opportunity to provide physical and biomarker measurements (for details, see Smith et al., 2013; Crimmins et al., 2008, 2009).

For the present study, we analyzed data from the 7,612 participants who (a) participated in the 2006 enhanced face-to-face interview and (b) provided data on all of our measures of interest in 2006. Participants were, on average, 68 years of age (*SD* = 10.66), attained, on average, 12.62 years of education (*SD* = 3.09), and 59% were women. 7,612, 7,073, and 6,344 participants provided data in 2006, 2008, and 2010, respectively.

Measures

Predictor: Perceived control—Our measure of perceived control consisted of two facets, *constraints* and *mastery*, which were each measured using five items (Lachman & Weaver, 1998; Smith et al., 2013) and are consistent with Skinner's (1996) conceptualization of control as being comprised of contingency and competence, respectively. Participants were asked to indicate the extent to which they agree with each of the items, using a 6-point scale (1 = *strongly disagree* to 6 = *strongly agree*; e.g., mastery: "*I can do just about anything I really set my mind to*"; constraints: "*There is really no way I can solve the problems I have*"). Perceived control was assessed in both 2006 and 2010. The specific wording for each item is shown in Table 1.

Mediator: Physical activity—*Physical activity* was measured using a single item assessing how often participants partake in vigorous activity (e.g., jogging, swimming, or gym workout) using a 5-point scale (1 = *every day*, 2 = *more than once a week*, 3 = *once a week*, 4 = *one to three times a month*, 5 = *hardly ever or never*). The item was reverse coded, so that higher scores indicate more physical activity. We used observations from 2006 (M = 1.94, SD = 1.33) and 2008 (M = 1.95, SD = 1.31).

Outcomes: Mental and Physical Health—The targeted physical health variable was *functional limitations*, which were measured using a composite sum index of the number of everyday activities participants reported having any difficulty completing, including walking several blocks, climbing one flight of stairs, pushing or pulling large objects, lifting or carrying 10 lb (4.53 kg) of weight, and picking up a dime. Higher scores represent greater functional limitations or poorer physical functioning (Rodgers & Miller, 1997). Although abbreviated versions of standard activities of daily living (ADL) and instrumental activities of daily living (IADL) questionnaires were used, the HRS's measures of functional limitations are comparable with the standard scales (see Fonda & Herzog, 2004; Rodgers & Miller, 1997). We used observations taken in 2006 and 2010.

Mental health was assessed using measures of *positive affect* and *negative affect* (Watson, Clark, & Tellegen, 1988). Participants were asked the degree to which they felt various emotions during the last 30 days. Positive affect consisted of two items, happy and calm. Negative affect consisted of three items, hopeless, restless, and nervous. Each were answered on a scale from 1= *very much* to 5 = *not at all*. The questionnaire largely changed from 2006 to 2010 (see Smith et al., 2013) and we used the items for positive and negative affect that were assessed in both 2006 and 2010.

Confounders—*Episodic memory* was measured using a unit-weight composite of performance on the immediate and delayed free-recall tests. We used the percent of words correctly remembered from both tests, ranging from 0 to 20, with higher scores representing more words remembered or better memory (M = 49.08, SD = 16.89). Personality factors of conscientiousness and neuroticism were included (see Smith et al., 2013). Individuals were asked the extent to which a list of adjectives describes them (conscientiousness: organized, responsible, hardworking, careless, and thorough; neuroticism: moody, worrying, nervous, and calm), on a scale from 1 = *a lot*, 2 = *some*, 3 = *a little*, 4 = *not at all.* All items, except for calm were reverse coded and separate mean scores were created for conscientiousness (M = 3.34, SD = 0.48) and neuroticism (M = 2.07, SD = 0.61), with higher scores indicating being more conscientious or neurotic. *Health conditions* were assessed with a sum index of the number of self-reported physician-diagnosed medical conditions, including high blood pressure, diabetes, cancer, lung disease, heart condition, stroke, psychiatric problems, and arthritis (M = 2.08, SD = 1.43). For each confounder, we used data from the 2006 assessment.

Statistical Procedures

Our statistical analyses consisted of several steps that are illustrated in Figure 1: (1) cross-sectional mediation model (Part A in Figure 1); (2) longitudinal mediation model without confounders (Part B in Figure 1); and (3) longitudinal mediation model with confounders (Part C in Figure 1). As illustrated in Figure 1, we tested several mediation models to determine whether accounting for (or not) temporal ordering and potential confounders influences the effect sizes of the total, direct, and indirect effects of constraints and mastery on our outcomes of interest, with physical activity as the mediator. In additional analyses, we incorporated latent change score models. We analyzed each model separately for each outcome variable: Functional limitations, positive affect and negative affect. Positive and negative affect were modeled as latent variables, and the corresponding models therefore also included a measurement model for these latent variables.

Measurement models—In our mediation models, the two facets of perceived control (i.e., constraints and mastery) are two latent variables, which are measured by five indicators each. We assume a congeneric measurement model for both latent factors and fix their scale by setting the first factor loading to one and the first intercept to zero for each factor, respectively. For positive affect, we used two items as indicators and assumed a tau-equivalent measurement model. For negative affect, we used three items as indicators and assumed a congeneric measurement model. In the longitudinal mediation models with confounders, we included measurement models for both baseline measures (latent variables at time 1) and outcome variables (latent variables at time 3). The scales of all latent variables were fixed by setting the first factor loading to one and the first intercept to zero; this allows for interpreting their change in the latent change score models in absolute numbers and effects on latent variables in terms of the original scale of the first indicator.

Cross-sectional mediation model—The first model considered is the cross-sectional mediation model (see Part A of Figure 1). While it suffers from serious limitations (see Section Challenges in testing mediation), we included it in order to highlight differences between this model and the longitudinal mediation models. The cross-sectional mediation model for functional limitations consists of the measurement model described in the previous section and two regressions that are estimated simultaneously in the structural part of the structural equation model, (1a) the regression of functional limitations at time 1 (FL_1) on mastery (MA), constraints (CO), and vigorous activity at time 1(VA_1), and (1b) the regression of vigorous activity at time 1(VA_1) on mastery (MA) and constraints (CO):

$$E\left(FL_1|MA,\,CO,\,VA_1\right)=\gamma_0+\gamma_1\,MA+\gamma_2\,CO+\gamma_3\,VA \quad \text{(1a)}$$

$$E\left(VA_1|MA,\,CO\right)=\alpha_0+\alpha_1\,MA+\alpha_2\,CO, \quad \text{(1b)}$$

where γ and α denote regression coefficients. We chose linear parameterizations for the regressions, because tests for higher order terms and interactions were not significant. We also estimated the cross-sectional mediation model using positive affect at time 1 (PA_1) and negative affect at time 1 (NA_1) as outcome variables (e.g., Y_1 in Part A of Figure 1). From Equation 1a, the direct effect of mastery MA on functional limitations FL_1 is γ_1, and the direct effect of constraints CO on functional limitations FL_1 is γ_2. From Equations 1a and 1b, the indirect and total effects can be computed. The indirect effect of mastery on functional limitations transmitted via vigorous activity is $\gamma_3\alpha_1$, the indirect effect of constraints on functional limitations is $\gamma_3\alpha_2$. Finally, the total effect of mastery *MA* on functional limitations FL_1 is $\gamma_1 + \gamma_3\alpha_1$, and the total effect of constraints *CO* on functional limitations FL_1 is $\gamma_2 + \gamma_3\alpha_2$. The computation of total, direct, and indirect effects for all models is summarized in Table 2. Standard errors for total, direct, and indirect effects in the cross-sectional mediation model and all subsequent models are based on bootstrapping (see MacKinnon, Lockwood, & Williams, 2004).

Longitudinal mediation model without confounders—Our second model is the longitudinal mediation model without possible confounders (Part B in Figure 1). In contrast to the cross-sectional mediation model, it accounts for the temporal structure, which is one requirement to test mediation. The longitudinal mediation model consists of the measurement model described previously and the structural model given by:

$$E\,(FL_3|MA,\,CO,\,VA_2)=\gamma_0+\gamma_1\,MA+\gamma_2\,CO+\gamma_3\,VA_2 \quad \text{(2a)}$$

$$E\,(VA_2|MA,\,CO)=\alpha_0+\alpha_1\,MA+\alpha_2\,CO, \quad \text{(2b)}$$

Note that Equations 2a and 2b look similar to Equations 1a and 1b, except for the time indices of the mediator and outcome variables. However, the model is conceptually different as can be seen by the different path diagrams (compare Parts A and B in Figure 1). In the longitudinal mediation model, we use functional limitations at time 3 (2010) (FL_3) as outcome variable and vigorous activity at time 2 (2008) (VA_2) as the mediator variable. The computations for the total, direct, and indirect effects follow the computations outlined for the cross-sectional model (see Table 2). In subsequent steps, we also applied the longitudinal mediation model without confounders using positive and negative affect at time 3 (2010) (PA_3 and NA_3) as outcome variables.

Longitudinal mediation model with confounders—Our third model is the longitudinal mediation model with potential confounders. This model is given by the following two regressions that are estimated simultaneously in the structural part:

$$E\,(FL_3|MA,\,CO,\,VA_2,\,Z_1,\ldots,\,Z_q)=\gamma_0+\gamma_1\,MA+\gamma_2\,CO+\gamma_3\,VA_2+\gamma_4\,Z_1+\ldots+\gamma_{q+3}\,Z_q \quad \text{(3a)}$$

$$E\,(VA_2|MA,\,CO,\,Z_1,\ldots,\,Z_q)=\alpha_0+\alpha_1\,MA+\alpha_2\,CO+\alpha_3\,Z_1+\ldots+\alpha_{q+2}\,Z_q, \quad \text{(3b)}$$

The longitudinal mediation model with confounders differs from the previous model by conditioning on a multivariate covariate $Z=(Z_1,\ldots,Z_q)$. Previous assessments of the mediator and the outcome variable (VA_1 and FL_1) are almost always important confounders (Cole & Maxwell, 2007; Mayer et al., in press; Steiner, Cook & Shadish, 2010) and are included in our multivariate confounder *Z*. However, these might not be the only confounders, so we attempted to include as many relevant confounders as necessary to obtain unbiased effects. We also included socio-demographic variables (age, gender, education), conscientiousness, neuroticism, episodic memory, and health conditions in our multivariate confounder. The computations for total, direct, and indirect effects are shown in Table 2 and, as the previous models, we applied the longitudinal mediation model with confounders also to positive and negative affect as outcome variables.

Latent change score mediation model with confounders—In additional analyses, we estimated latent change score mediation models with potential confounders. We wanted to examine whether the size of the total, direct, and indirect effects differed between the longitudinal mediation model presented in the previous section and the approach using latent change variables (e.g., McArdle & Hamagami, 2001; Steyer, Eid, & Schwenkmezger, 1997). The latent change score mediation model is given by

$$E(FL_3 - FL_1 | MA, CO, VA_2, Z_1, \ldots, Z_q) = \gamma_0 + \gamma_1 MA + \gamma_2 CO + \gamma_3 VA_2 + \gamma_4 Z_1 + \ldots + \gamma_{q+3} Z_q \quad (4a)$$

$$E(VA_2 | MA, CO, Z_1, \ldots, Z_q) = \alpha_0 + \alpha_1 MA + \alpha_2 CO + \alpha_3 Z_1 + \ldots + \alpha_{q+2} Z_q, \quad (4b)$$

This model is very similar to the previous model, except for the outcome variable, which now is a change variable (compare Equations 4a and 4b with Equations 3a and 3b). In each model, the outcome variable is modeled as a latent change variable. Finally, to examine bidirectional associations between perceived control and each outcome, we estimated a bidirectional latent change model, where we additionally included latent change variables for constraints and mastery as outcome variables in the model. The values of these latent change variables are the latent differences for each person between their mastery and constraints values in 2010 (wave 3) and 2006 (wave 1). As in the longitudinal mediation model with confounds, previous assessments of the mediator and the outcome variable are almost always important confounders and are included in our multivariate confounder *Z* for all latent change score models (e.g., FL_1). We incorporated covariances between independent variables at time point 1 and allowed for residual covariances between the latent change scores in the bi-directional change model.

Results

Our results are structured as follows: First, we present the results for the measurement of the two facets of perceived control; Second, we present the results from three different mediation models; and, Third, we present results from our latent change score mediation models.

Measurement model of perceived control

Table 1 shows results from our CFA that examined whether the 10 items fit the hypothesized two factor model of perceived control, constraints and mastery. Items 1–5 load onto the conceptual factor of constraints and items 6–10 load onto the conceptual factor of mastery. The two factors, constraints and mastery, are moderately correlated, $r = -.44$, suggesting that higher levels of mastery are associated with reporting fewer constraints and vice versa.

Mediation models

We next examined whether the latent constructs, constraints and mastery, had a total effect on functional limitations, positive affect, and negative affect, and whether vigorous activity mediated this effect. First, we estimated a cross-sectional model where the assessments of constraints, mastery, physical activity, and each outcome were taken in 2006 (see Part A in Figure 1). The top section of Table 3 shows results from this model, which shows constraints and mastery have total effects on functional limitations, positive affect, and negative affect. On average, reporting more constraints and fewer mastery beliefs were associated with more functional limitations, less positive affect, and more negative affect. The effect size for the direct effect across each predictor and outcome variable was in the small to medium range (constraints: 0.22 to 0.47; mastery: 0.14 to 0.20). We also observed that vigorous activity mediated the effect of constraints and mastery on each outcome (indirect effect), but that the effect size was very small (constraints: 0.003 to 0.01; mastery: 0.001 to 0.01), suggesting that although vigorous activity mediated the effect of constraints and mastery on each outcome, the strength or evidence of the link is very small. The effect of constraints and mastery on vigorous activity was −0.23, $SE = 0.02$, $p < .05$ and 0.15, $SE = 0.02$, $p < .05$, respectively.

The second model that we estimated is similar to Part B in Figure 1 in that we examined the effect of constraints and mastery on each outcome and mediation longitudinally, without accounting for confounders. Results are shown in middle section of Table 3. Similar to the previous model, we found that constraints and mastery each had a total effect on functional limitations, positive affect, and negative affect and that the effect size was in the small to medium range (constraints: 0.20 to 0.38; mastery: 0.07 to 0.16). Higher levels of constraints and fewer mastery beliefs were associated with exhibiting more functional limitations, and reporting lower positive affect and more negative affect over 4-years of time. The effect size of vigorous activity as a mediator (indirect effect) was very small (constraints: 0.01 to 0.02; mastery: 0.003 to 0.01). The effect of constraints and mastery on physical activity was −0.21, $SE = 0.02$, $p < .05$ and 0.13, $SE = 0.02$, $p < .05$, respectively. Results focusing on the indirect effect of physical activity in our first two models suggest that although vigorous activity significantly mediated the effect of constraints and mastery on each outcome (p value was < .05), the size and practical relevance of the effect is in fact very small.

We next estimated a longitudinal mediation model that accounted for temporal ordering and confounds and is similar to the one depicted in Part C of Figure 1. Results from this model are shown in the bottom section of Table 3. We found that perceiving fewer constraints was associated with reporting fewer functional limitations and higher positive affect, but was not associated with negative affect (direct effect). Vigorous activity did not mediate the effect of constraints on each outcome. Mastery was only directly associated with positive affect and vigorous activity mediated the effect of mastery on functional limitations. We observed that the effect sizes for the direct effects for both constraints and mastery on each outcome were drastically reduced (as compared to the previous two models) when we accounted for confounders (constraints: 0.03 to 0.14; mastery: 0.01 to 0.05). Different from our two previously tested models, when tested in a proper mediation model that included temporal ordering and accounted for confounders, we found that vigorous activity showed minimal mediation of the effects of constraints and mastery on each outcome (*p* values above .05). The effect of constraints and mastery on physical activity was −0.03, *SE* = 0.02, $p > .05$ and 0.04, *SE* = 0.02, $p < .05$, respectively.

Latent Change Score Models

In a final set of models, we used latent change score variables to more explicitly model change of physical and mental health and perceived control over the 4-year time period, whereas in the previous models change was implicitly built in. The difference between these models and the previously tested models was that the outcome variable is 4-year changes in the outcomes of interest, which is estimated with a latent change score model (McArdle, 2009), as compared to the latent/manifest outcome at Time 3. We found that there was significant 4-year changes and between-person differences in the amount of change for all three outcomes of interest (functional limitations: Δ = 0.04, *se* = 0.02, variance = 0.036, *se* = 0.001; positive affect: Δ = 0.63, *se* = 0.14, variance = 0.43, *se* = 0.02, ; negative affect: Δ = 1.017, *se* = 0.05, variance = 0.18, *se* = 0.01). The top section of Table 4 shows that more constraints were associated with reporting 4-year increases in functional limitations and declines in positive affect, but not associated with changes in negative affect. Furthermore, vigorous activity did not mediate the link between constraints and each outcome. Higher levels of mastery was associated with more positive 4-year changes in positive affect, but not associated with 4-year change in functional limitations and negative affect. Vigorous activity mediated the link between mastery and functional limitations, but the effect size was small. Most importantly, we see that the parameter estimates and effect sizes from Model 3 in Table 3 and Model 1 in Table 4 are *identical*, suggesting that although the outcome variables differ in face validity, each of the models are predicting the same outcome of interest.

The final model tested was a full bi-directional model that estimated 4-year change in both our outcomes of interest and in constraints and mastery. This model will help estimate whether the direct and indirect effects in this system are bi-directional. We found that the direct effects are bi-directional in that reporting more functional limitations was associated with 4-year increases in constraints (effect size = 0.35) and 4-year decreases in mastery (effect size = 0.60) and vigorous activity did not mediate these associations. Focusing on positive affect, higher levels of positive affect was associated with 4-year increases in mastery (effect size = 0.11), but not constraints and vigorous activity did not mediate these associations. Focusing on negative affect, higher levels of negative affect was associated with 4-year increases in constraints (effect size = 0.27), but not mastery and vigorous activity did not mediate these associations. Our findings from this model suggest that associations between constraints and mastery with mental and physical health are bi-directional. We elaborate on this in the discussion section.

Discussion

The objective was to examine the effects of constraints and mastery on mental and physical health in adulthood and old age and the mediating effect of physical activity. We used SEM to model the two facets of perceived control, constraints and mastery. Constraints showed stronger effects on mental and physical health as compared to mastery, suggesting that one's perceptions of external factors have a greater effect on mental and physical health than one's beliefs regarding their ability in attaining desired outcomes. Physical activity appeared to mediate the effect of constraints on functional limitations, positive affect, and negative affect, but showed *very small* indirect effects. When mediation was tested in the appropriate longitudinal model that accounted for prior confounds and temporal ordering, the indirect effect of physical activity was reduced to non-significance. These results show that the effect size of mediation is dependent on the type of design used, suggesting that temporal ordering and accounting for prior confounds need to be held for researchers to make statements regarding mediation. Additional analyses that utilized latent change score models showed that associations between constraints and mastery with mental and physical health operate in a bi-directional system. Our discussion focuses on the research and intervention implications of a two-facet model of perceived control and future research focusing on longitudinal mediation for informing conceptual models of perceived control and more broadly, human development.

Perceived Control: Definitions and Components

Our findings are consistent with previous research that has simultaneously examined the effects of constraints and mastery on mental and physical health. For example, Lachman and Weaver (1998) observed, using cross-sectional data, that constraints was associated with lower mental health and more functional limitations. This naturally leads to the question of why constraints exerted a stronger effect on mental health and physical health. It could be that constraints are actual things or barriers, whereas mastery is just a belief. When faced with difficulties or obstacles in their way, individuals who perceive more constraints may be less likely to persist in the face of challenging tasks and give up more frequently. Another explanation comes from learned helplessness/causal explanation theory (see Peterson & Seligman, 1984). Feelings of perceived barriers and external factors determining/shaping life circumstances is non-specific and permeates multiple domains of functioning, including one's cognition, emotions, and behaviors. Cognitively, constraints may relate to thought patterns that may hinder the ability to attain desired outcomes, as well as diminish motivation capacities and energies for exerting influence over one's environment (Bandura, 1989). For example, perceiving more constraints may cloud or mask one's forethought and ability to set personal goals that are precursors for better mental and physical health.

Why is it important to consider constraints and mastery as distinct and separate components? Studying constraints and mastery separately has intervention implications in hopes of improving/maintaining mental and physical health for those in adulthood and old age at risk for decrements. Based on our findings, interventions aiming to improve perceived control or control beliefs may be best suited to focus on constraints or perceived barriers and less so on mastery. Perceived barriers seem to be at the center of how one's perceptions of control determine the ability to shape life circumstances. Previous interventions have primarily focused on mastery. For example, Reich and Zautra (1990) in an intervention design found that a control enhancement intervention focusing on mastery beliefs was associated with modest increases in mental health and overall control beliefs. The mastery measure used in Reich and Zautra (1990) was the Pearlin Mastery scale (Pearlin & Schooler, 1978) where five of the seven items focus on perceived constraints or barriers. Lachman, Weaver, Bandura, Elliot, Lewkowicz (1992) tested a cognitive restructuring program to promote adaptive beliefs about memory and self-generated strategies and found that this was associated with improvements in perceptions of control and perceived ability to improve memory. More recently, Zautra and colleagues (2012) found that a daily intervention targeting mastery was linked to better emotional health and less so to self-reported physical health. Participants received a morning phone call for 25 consecutive days that focused on suggestions for identifying controllable and uncontrollable daily events by increasing the frequency of positive events in their lives (engagement), to avoid negative events, and to be aware that some events are common but neutral in impact on their feelings (Zautra et al., 2012). Our findings, coupled with those of interventions, supports arguments for an interactionist approach when it comes to interventions focusing on enhancing or decreasing facets of perceived control (for discussion, see Infurna & Okun, 2014). Interventions that focus on constraints may need to have individuals identify barriers or obstacles in life and focus on way to overcome or navigate them. For example, individuals who like to be in control (i.e., internals) may be more responsive to interventions that encourage actively engaging one's environment, whereas structuring may be more beneficial for people who do not desire to be in control, leading to more positive outcomes (see Baltes, 1996; Christensen & Johnson, 2002). In sum, existing intervention studies focusing on facets of perceived control provide empirical evidence to suggest in their ability to improve perceived control and transfer to mental and physical health, with future research needing to focus on the constraints facet of perceived control.

Mediation of the Effects of Mastery and Constraints on Mental and Physical Health

It has long been theorized that individuals with more feelings of mastery and perceiving fewer constraints over life circumstances are more likely to partake in health-promoting behaviors that have subsequent beneficial effects on mental and physical health. Our findings that vigorous activity did not show a relevant effect in mediating the link between constraints and mastery with mental and physical health are inconsistent with conceptual models of perceived control (Lachman, 2006; Rodin, 1986; Skaff, 2007) and empirical evidence (Infurna et al., 2011; White et al., 2012). Perceiving fewer constraints and higher mastery were each associated with engaging in more vigorous activity, but the mediation effect was very small on our outcomes of interest and this differed depending on the mediation model tested. Physical activity has a role in effecting mental and physical health through decreasing one's cardio-metabolic risk, increasing endurance and cardiovascular adaptations, as well as improving self-worth that have downstream effects for mental and physical health (Infurna & Gerstorf, 2014; McAuley et al., 2008; Penedo & Dahn, 2005; Thompson et al., 2003). There could be several reasons why our findings are incongruent with previous research. First, the lag between assessments may have not been appropriate. The effect of constraints and mastery may transpire across a more fine-grained time scale, such as daily, as compared to several years of time. We discuss this proposition more in depth in the next section. Second, physical activity is one of many possible mediators at play, such as physical fitness (grip strength and forced expiratory volume) and biological health, which show similar associations with mental and physical health. These factors would be important to include in future multiple mediation models, in addition to physical activity to test and determine which are most pertinent for underlying the association between facets of perceived control and mental and physical health. One likely scenario is that physical fitness could be a stronger mediator because it is an immediate precursor for subsequent declines in physical health.

Challenges in testing mediation

The strength of the mediating effects of physical activity differed by the tested model. The effect size for mediation was relatively small across all three models, but was "strongest" when tested cross-sectionally and longitudinally without including confounders (part A and B in Figure 1). Our findings reveal that it *really matters* how the mediation model is specified. More specifically, we *demonstrated* the importance of temporal ordering and accounting for prior confounds in mediation and how cross-sectional "mediation" can inflate estimates of mediation and does not provide an accurate picture of mechanisms underlying developmental processes. One possible major reason why the cross-sectional approach (A and B in Figure 1) differed from the longitudinal approach is due to the inability of determining whether constraints and mastery influences physical activity or physical activity influences constraints and mastery or if the two are just correlated, because of other common causes. Longitudinal mediation that accounted for prior confound showed a significant direct effect of constraints on functional limitations and positive affect and mastery on positive affect, but minimal indirect effect of physical activity underlying such associations (physical activity mediated the effect of mastery on functional limitations). Additionally, we tested this similar model using latent change score models and found that the estimates were *identical* for the total, direct, and indirect effects. This is despite the outcomes differing in face validity. One explanation for this could be due baseline assessments (T1) for each outcome is accounted for in each model, resulting in identical parameter estimates and standard errors in the conventional (Part C in Figure 1) and latent change score models.

The differential strength of the mediation effect of physical activity could be due to the time interval of the study. The time-lag used in this study was a total of four years with biennial assessments. Even when the temporal order of the putative cause variable (constraints or mastery), the potential mediator (physical activity), and the outcome variable is established (mental health and physical health), the lag separating measurements of these variables in longitudinal mediation models may matter (for discussion, see Cole & Maxwell, 2007). Mediation is a stochastic process that evolves over time. Depending on the phenomenon under study, the distance between occasions of measurements has to be chosen in a way, that the time resolution can capture the process under study. The theory of causal lags has received little attention in psychology with papers by Maxwell and colleagues (e.g., Maxwell, Cole & Mitchell, 2011) and Gollob and Reichardt (1987) being among the few exceptions (see also, Hofer & Piccinin, 2010). The need for an adequate time lag between occasions of measurement is crucial in mediation models and in autoregressive models. In HRS, we did not have control over the 2-year time lag between adjacent measurement occasions. The two-year time interval may be too short because the accumulation of functional limitations takes time to develop over several years or even decades and mental health is typically relatively stable over adulthood and old age, only showing yearly fluctuations in the context of major life stressors (see Lucas, 2007).

One avenue to examine mechanisms involving mediation is through collecting data through a multi-modal approach of incorporating multiple time scales that may be best suited for testing such associations (e.g., measurement-burst designs; for discussion, see Nesselroade, 1991; Ram & Gerstorf, 2009; Sliwinski, 2008). Associations between perceived control and mediating mechanisms, such as physical activity may transpire at the daily level to later influence mental and physical health over years or decades. For example, perceiving more control over one's life circumstances may result in an increased likelihood of partaking in daily physical activity, with consistent physical activity accumulating to benefit mental and physical health over (several) years of time. Put differently, physical inactivity as a result of lower perceptions of control may make individuals more vulnerable to premature declines in mental and physical health. Research using daily-diary methodologies have already shown that perceiving more control is protective against emotional reactivity to daily stressors (Hay & Diehl, 2010; Neupert et al., 2007). Over the long-term, the stress-buffering effects of perceived control can be potentially protective against declines in mental and physical health (see Charles et al., 2013; Piazza et al., 2013)

Bi-directional associations between Perceived Control and Mental and Physical Health

We note that perceived control operates in a multi-directional system in that it is an antecedent of mental and physical health, but also is an outcome of functioning in these prominent domains (for discussion, see Infurna & Okun, 2014; Lachman et al., 2011). The primary objective in this study was to test the direct and indirect effect of constraints and mastery on mental and physical health. However, empirical evidence suggests that mental and physical health is associated with level and rates of change in perceived control. We found evidence to suggest for bi-directional associations in that functional limitations were associated with 4-year increases in constraints and 4-year declines in mastery. Furthermore, positive affect was associated with 4-year increases in mastery and negative affect was associated with 4-year increases in constraints. These findings are in line with previous research showing that reporting more functional limitations and specific diseases is associated with declines in perceived control (Gerstorf et al., 2011; Infurna & Okun, 2014; Wurm et al., 2007). Similarly, lower levels of life satisfaction and more depressive symptoms are associated with declines in perceived control over time (Infurna, Gerstorf, Ram, Schupp, & Wagner, 2011; Lang & Heckhausen, 2001; McAvay et al., 1996). Future research is warranted that assesses the bi-directional nature of these domains over a longer and more frequently assessed time-series. We were limited by only having two assessments of constraints and mastery, but given at least three assessments of each variable of interest, the bivariate dual change score model (see Ferrer & McArdle, 2010; McArdle & Hamagami, 2001) can be implemented to further examine the strength of bi-directional associations across time.

Limitations and Outlooks

We note several limitations of our study. First, we need to caution that our findings are based on a single sample and specific measures of the variables of interest (i.e., constraints and mastery, physical activity, and mental and physical health). Along the lines of recent calls for replication in psychological science (for discussion, see Cumming, 2008), more research is needed to determine the robustness of our finding that the direct and indirect effects of constraints and mastery on mental and physical health differ by the type of mediation model tested. This can be done by applying similar approaches (1) to samples that involve people across the adult lifespan (i.e., young adulthood, midlife, and old age) to examine possible age-differential effects, (2) across measures of perceived control, physical activity, and mental and physical health, and (3) including additional potential confounders. Second, our measure of physical activity was a single item self-report and broad and non-specific in the types of activities individuals partake in (Levine et al., 1999; McAuley, 1993). In follow-up analyses we included mild (e.g., vacuuming, laundry, home repairs) and moderate (e.g., gardening, cleaning the car, walking at a moderate pace, dancing, floor or stretching exercises) activity in place of vigorous activity and found substantially similar findings. Specificity in the items will allow for determining in future studies whether there are types of activities (e.g., jogging or running versus weightlifting) that are more beneficial for mental and physical health. Additional types of activities that can be targeted in future research includes social and cognitive activities and physical fitness, which have all been linked to common aging-related outcomes of constraints and mastery (Hultsch, Hertzog, Small, & Dixon, 1999). Third, we did not use psychometric techniques for all the variables included in our analysis. We note that this was not possible for each of the variables (e.g., single item for vigorous activity), or in the case of functional limitations, we used a sum measure because conceptually, we are interested in predicting the number of functional limitations. In follow-up analyses, we applied psychometric techniques for neuroticism and conscientiousness and found substantively similar findings. Fourth, mastery and constraints are only two of various components of perceived control. More specifically, a multi-dimensional approach needs to be taken that incorporates secondary control strategies (see Heckhausen et al., 2010). We consider facets of perceived control to encompass primary control strategies of engaging one's context or environment (striving for control) to attain desired outcomes, whereas secondary control strategies focus more on changing one's self in accordance with the surrounding context that can prove beneficial for health outcomes in old age (Wrosch, Schulz, & Heckhausen, 2004). For example, Hall and colleagues (2010) found that individuals with chronic health ailments who used more goal disengagement strategies reported better well-being and had a decreased likelihood for mortality, as compared to participants who used more goal engagement strategies. Additionally, health locus of control has consistently been associated with better mental and physical health (see Steptoe & Wardle, 2001; Wallston, 1992). It would be important to focus on the interplay amongst multiple measures of perceived control to examine whether under certain conditions (e.g., poor mental and physical health, younger vs. old age; see Infurna & Okun, 2014) that various facets of control are more pertinent for the outcome of interest. Fifth, each our outcomes of interest were assessed via self-reports. For example, we solely focused on self-reported functional limitations and it is an open question as to whether similar associations would be observed for objective measures of health, such as disease incidence, physical fitness and cardio-metabolic risk. Furthermore, our measures of mental health focused on affective components, whereas future research should also incorporate cognitive-evaluative components (e.g., life satisfaction). Lastly, even though we attempted to include all relevant confounders in our mediation models, we can never be sure to have included all of them. It might be the case, that an unmeasured relevant confounder would change parts of our substantive conclusions.

Taken together, our study examined the differential effects of constraints and mastery on mental and physical health and the mediating effect of physical activity. Our results underscore the importance of a two-facet model of perceived control and longitudinal mediation for testing conceptual models delineating associations amongst variables of interest. Our study contributes to extant reports showing that perceived control is associated with key outcomes of aging (Bandura, 1997; Lachman, 2006; Rodin, 1986) and that the pathways that underlie such effects differs by the type of mediation model that is tested (Cole & Maxwell, 2007; Lindenberger et al., 2011). We take our results to provide impetus to further examine mediators of control-health associations within a longitudinal mediation design that involves temporal ordering and accounting for potential confounders, in addition to utilizing multiple time scales to examine mechanisms underlying the effect of perceived control on aging-related outcomes, which will allow for thoroughly examining processes involved in health outcomes of facets of perceived control.

Acknowledgments

The Health and Retirement Study was supported by a cooperative agreement (Grant U01 AG09740) between NIA and the University of Michigan. Special thanks to John Reich for helpful comments and feedback on previous versions of this manuscript. The content is solely the responsibility of the authors and does not necessarily represent the official views of the funding agencies.

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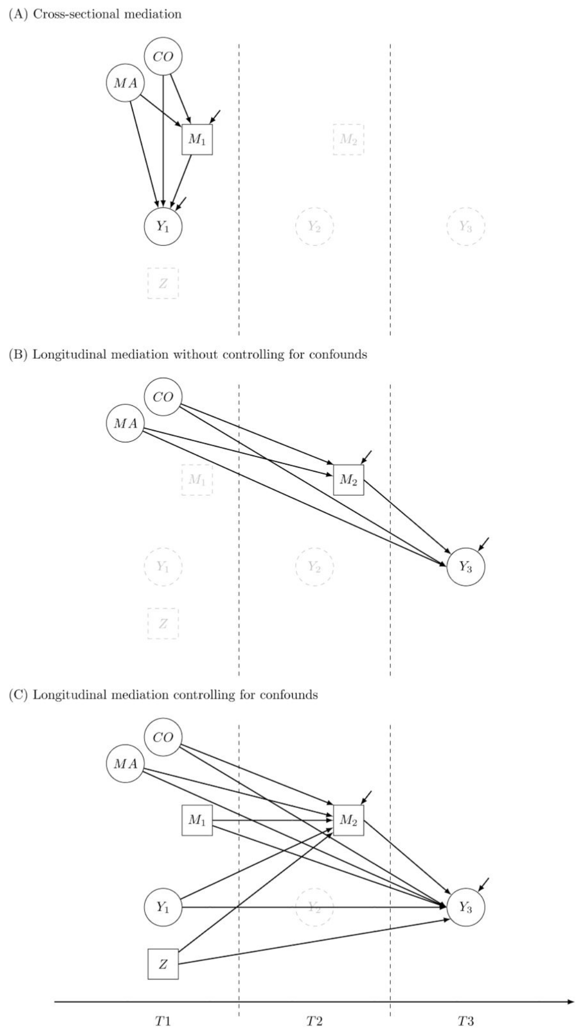

Figure 1.

Graphical representation of three mediation models. Part A shows cross-sectional mediation where the variables of interest are assessed at one point in time. Part B shows longitudinal mediation, where the effect of the predictor on the outcome is temporally dependent, but does not account for prior confounds. Part C illustrates longitudinal mediation that accounts for potential confounds. CO refers to constraints and MA refers to mastery. M refers to the mediation variable or physical activity in this study. Y refers to the outcome variable or mental and physical health in this study. Z refers to potential confounders. In our study, T1, T2, and T3 refer to assessments taken in 2006, 2008, and 2010, respectively.

Table 1

Unstandardized Estimates of Confirmatory Factor Analysis for Constraints and Mastery

	Constraints		Mastery			
	Factor Loading		Factor Loading		Residual Variance	
	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Manifest Item Wordings						
1. I often feel helpless in dealing with the problems of life	1.00				1.30*	0.03
2. Other people determine most of what I can and cannot do	0.94*	0.02			1.28*	0.03
3. What happens in my life is often beyond my control	1.27*	0.03			0.88*	0.03
4. I have little control over the things that happen to me	1.29*	0.03			0.69*	0.03
5. There is really no way I can solve the problems I have	1.13*	0.02			0.74*	0.02
6. I can do just about anything I really set my mind to			1.00		0.56*	0.03
7. When I really want to do something, I usually find a way to succeed at it			0.94*	0.01	0.42*	0.02
8. Whether or not I am able to get what I want is in my own hands			0.94*	0.02	0.78*	0.03
9. What happens to me in the future mostly depends on me			0.89*	0.02	0.88*	0.03
10. I can do the things that I want to do			0.98*	0.02	0.76*	0.03
Variance						
Constraints			0.97* (0.04)			
Mastery			1.22* (0.04)			
Covariance (Correlation)						
Constraints and mastery			−.44*			
Model Fit Statistics						
RMSEA			.095			
CFI			.942			

Note. N = 7,612. Items were scored on a 6-point scale: 1 (*Strongly disagree*), 2 (*Somewhat disagree*), 3 (*Slightly disagree*), 4 (*Slightly agree*), 5 (*Somewhat agree*), 6 (*Strongly agree*). RMSEA = Root Mean Square Error of Approximation. CFI = Comparative Fit Index.

* $p < .05$.

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Table 2

Computation of Total, Direct, and Indirect Effects For All Mediation Models.

Effect	Computation
Total Effect of *MA* on Outcome (FL_t, PA_t, or NA_t)	$\gamma_1 + \gamma_3\alpha_1$
Total Effect of *CO* on Outcome (FL_t, PA_t, or NA_t)	$\gamma_2 + \gamma_3\alpha_2$
Direct Effect of *MA* on Outcome (FL_t, PA_t, or NA_t)	γ_1
Direct Effect of *CO* on Outcome (FL_t, PA_t, or NA_t)	γ_2
Indirect Effect of *MA* on Outcome (FL_t, PA_t, or NA_t) transmitted via VA_t	$\gamma_3\alpha_1$
Indirect Effect of *CO* on Outcome (FL_t, PA_t, or NA_t) transmitted via VA_t	$\gamma_3\alpha_2$

Note. MA = Mastery, CO = Constraints, FL = Functional limitations, PA = Positive affect; NA = Negative affect; VA = Vigorous activity.

Table 3

Series of Models Testing Mediation at Cross-Sectional and Longitudinal Level of Analysis

Cross-sectional mediation without accounting for confounders (Similar to Part A in Figure 1)

	Y1: Functional Limitations		**Y2: Positive Affect**		**Y3: Negative Affect**	
Effect of	**Estimate**	**SE**	**Estimate**	**SE**	**Estimate**	**SE**
Constraints						
-- Total	0.037*	0.003	−0.249*	0.012	0.259*	
Effect size	0.23		0.37		0.48	0.012
-- Direct	0.035*	0.003	−0.247*	0.012	0.255*	0.012
Effect size	0.22		0.33		0.47	
-- Indirect	0.002*	0.000	−0.002	0.001	0.003*	0.001
Effect size	0.01		0.003		0.01	
Mastery						
-- Total	−0.024*	0.002	0.134*	0.011	−0.085*	0.009
Effect size	0.15		0.20		0.16	
-- Direct	−0.022*	0.002	0.133*	0.011	−0.084*	0.009
Effect size	0.14		0.20		0.16	
-- Indirect	−0.001*	0.000	0.001	0.001	−0.002*	0.001
Effect size	0.01		0.001		0.004	

Longitudinal mediation without accounting for prior confounds (Similar to Part B in Figure 1)

	Y1: Functional Limitations		**Y2: Positive Affect**		**Y3: Negative Affect**	
Effect of	**Estimate**	**SE**	**Estimate**	**SE**	**Estimate**	**SE**
Constraints						
-- Total	0.045*	0.004	−0.297*	0.017	0.101*	0.010
Effect size	0.21		0.39		0.32	
-- Direct	0.041*	0.004	−0.291*	0.017	0.099*	0.010
Effect size	0.20		0.38		0.31	
-- Indirect	0.004*	0.001	−0.007*	0.002	0.002*	
Effect size	0.02		0.01		0.01	0.001

Longitudinal mediation without accounting for prior confounds (Similar to Part B in Figure 1)

	Y1: Functional Limitations		Y2: Positive Affect		Y3: Negative Affect	
Effect of	**Estimate**	**SE**	**Estimate**	**SE**	**Estimate**	**SE**
Mastery						
-- Total	−0.017*	0.003	0.122*	0.015	−0.037*	0.007
Effect size	0.08		0.16		0.12	
-- Direct	−0.015*	0.003	0.119*	0.015	−0.036*	0.007
Effect size	0.07		0.16		0.11	
-- Indirect	−0.002*	0.000	0.003*	0.001	−0.001*	0.001
Effect size	0.01		0.004		0.003	

Longitudinal mediation accounting for confounders (Similar to Part C in Figure 1)

	Y1: Functional Limitations		Y2: Positive Affect		Y3: Negative Affect	
Effect of	**Estimate**	**SE**	**Estimate**	**SE**	**Estimate**	**SE**
Constraints						
-- Total	0.014*	0.003	−0.105*	0.018	0.010	0.008
Effect size	0.06		0.14		0.03	
-- Direct	0.013*	0.003	−0.105*	0.018	0.010	0.008
Effect size	0.06		0.14		0.03	
-- Indirect	0.000	0.000	−0.000	0.000	0.000	0.000
Effect size	0.00		0.00		0.00	
Mastery						
-- Total	−0.004	0.003	0.039*	0.013	−0.008	0.006
Effect size	0.02		0.05		0.02	
-- Direct	−0.003	0.003	0.038*	0.013	−0.008	0.006
Effect size	0.01		0.05		0.02	
-- Indirect	−0.000*	0.000	0.000	0.000	0.000	0.000
Effect size	0.00		0.00		0.00	

Note. N = 7,612. Direct refers to the effects of mastery or constraints on the outcome of interest, functional limitations, positive affect, or negative affect. Indirect refers to the role of vigorous activity in mediating the effect of mastery or constraints to the outcome of interest, functional limitations, positive affect, or negative affect. Confounders that were included in the third set of models were age, gender, education, neuroticism, conscientiousness, memory, and health conditions. The effect size was taken by dividing the effect estimate by the standard deviation of the outcome variable.

* $p < .05$.

Table 4

Series of Models Testing Mediation Using Latent Change Score Models

Longitudinal mediation accounting for confounders

	Y1: Functional Limitations		Y2: Positive Affect		Y3: Negative Affect	
Effect of	**Estimate**	**SE**	**Estimate**	**SE**	**Estimate**	**SE**
Constraints						
-- Total	0.014*	0.003	−0.105*	0.018	0.010	0.008
Effect size	0.06		0.14		0.03	
-- Direct	0.013*	0.003	−0.105*	0.018	0.010	0.008
Effect size	0.06		0.14		0.03	
-- Indirect	0.000	0.000	−0.000	0.000	0.000	0.000
Effect size	0.00		0.00		0.00	
Mastery						
-- Total	−0.004	0.003	0.039*	0.013	−0.008	0.006
Effect size	0.02		0.05		0.02	
-- Direct	−0.003	0.003	0.038*	0.013	−0.008	
Effect size	0.01		0.05		0.02	0.006
-- Indirect	−0.000*	0.000	0.000	0.000	0.000	0.000
Effect size	0.00		0.00		0.00	
Mean change	0.04*	0.02	0.63*	0.14	1.02*	0.05
Variance in change	0.036*	0.001	0.43*	0.02	0.18*	0.01

Bi-directional longitudinal mediation accounting for prior confounds

	Y1: Functional Limitations		Y2: Positive Affect		Y3: Negative Affect	
Effect of	**Estimate**	**SE**	**Estimate**	**SE**	**Estimate**	**SE**
Constraints						
-- Total	0.014*	0.003	−0.099*	0.018	0.011	0.009
Effect size	0.07		0.15		0.03	
-- Direct	0.014*	0.003	−0.099*	0.018	0.011	0.009
Effect size	0.07		0.15		0.03	

Bi-directional longitudinal mediation accounting for prior confounds

	Y1: Functional Limitations		Y2: Positive Affect		Y3: Negative Affect	
Effect of	Estimate	SE	Estimate	SE	Estimate	SE
-- Indirect	0.000*	0.000	0.000	0.000	0.000	0.000
Effect size	0.00		0.000		0.000	
Mastery						
-- Total	−0.002	0.003	0.035*	0.013	−0.009	0.006
Effect size	0.01		0.05		0.02	
-- Direct	−0.002	0.003	0.035*	0.013	−0.009	0.006
Effect size	0.01		0.05		0.02	
-- Indirect	0.000*	0.000	0.000	0.000	0.000	0.000
Effect size	0.00		0.000		0.000	
Outcome (T1) on Change in Constraints						
-- Total	0.352*	0.123	−0.055	0.034	0.261*	0.048
Effect size	0.36		0.06		0.27	
-- Direct	0.343*	0.123	−0.053	0.034	0.260*	0.048
Effect size	0.35		0.05		0.27	
-- Indirect	0.009*	0.005	−0.002	0.001	0.001	0.001
Effect size	0.01		0.002		0.001	
Outcome (T1) on Change in Mastery						
-- Total	−0.739*	0.148	0.131*	0.038	−0.072	0.053
Effect size	0.61		0.11		0.06	
-- Direct	−0.732*	0.148	0.129*	0.038	−0.071	0.053
Effect size	0.60		0.11		0.06	
-- Indirect	−0.007	0.006	0.001	0.001	−0.001	0.001
Effect size	0.01		0.001		0.001	
Mean change						
Outcome	0.04*	0.02	0.63*	0.14	1.02*	0.05
Constraints	0.071	0.12	0.047	0.12	0.048	0.12
Mastery	−0.15	0.15	−0.122	0.15	−0.123	0.15
Variance in change						

Bi-directional longitudinal mediation accounting for prior confounds

	Y1: Functional Limitations		Y2: Positive Affect		Y3: Negative Affect	
Effect of	**Estimate**	**SE**	**Estimate**	**SE**	**Estimate**	**SE**
Outcome	0.036*	0.001	0.43*	0.02	0.18*	0.01
Constraints	0.94	0.03	0.94	0.03	0.91	0.03
Mastery	1.46	0.04	1.45	0.04	1.45	0.04

Note. $N = 7{,}612$. Direct refers to the effect of mastery or constraints on the outcome of interest, functional limitations, positive affect, or negative affect. Indirect refers to the role of vigorous activity in mediating the effects of mastery or constraints to the outcome of interest, functional limitations, positive affect, or negative affect. Confounders that were included in the third set of models were age, gender, education, neuroticism, conscientiousness, memory, and health conditions. The effect size was taken by dividing the effect estimate by the standard deviation of the outcome variable.

* $p < .05$.