

# Longitudinal Relationships Between Resources, Motivation, and Functioning

Thomas M. Hess,<sup>1</sup> Lisa Emery,<sup>2</sup> and Shevaun D. Neupert<sup>1</sup>

<sup>1</sup>Department of Psychology, North Carolina State University, Raleigh.

<sup>2</sup>Department of Psychology, Appalachian State University, Boone, North Carolina.

**Objectives.** We investigated how fluctuations and linear changes in health and cognitive resources influence the motivation to engage in complex cognitive activity and the extent to which motivation mediated the relationship between changing resources and cognitively demanding activities.

**Method.** Longitudinal data from 332 adults aged 20–85 years were examined. Motivation was assessed using a composite of Need for Cognition and Personal Need for Structure and additional measures of health, sensory functioning, cognitive ability, and self-reported activity engagement.

**Results.** Multilevel modeling revealed that age-typical changes in health, sensory functions, and ability were associated with changes in motivation, with the impact of declining health on motivation being particularly strong in older adulthood. Changes in motivation, in turn, predicted involvement in cognitive and social activities as well as changes in cognitive ability. Finally, motivation was observed to partially mediate the relationship between changes in resources and cognitively demanding activities.

**Discussion.** Our results suggest that motivation may play an important role in determining the course of cognitive change and involvement in cognitively demanding everyday activities in adulthood.

**Key Words:** Aging—Cognition—Health—Longitudinal change—Motivation.

ENGAGEMENT in cognitively complex activities is frequently touted in the popular press as one way of warding off the more negative effects of aging on our memory and thinking. This belief is encouraged by a substantial body of evidence, suggesting that people who engage in complex cognitive and social activities perform better on cognitive ability tests than those who do not and show less longitudinal decline in cognitive ability across time (for review, see Hertzog, Kramer, Wilson, & Lindenberger, 2008). Although the “use it or lose it” hypothesis enjoys both popular and scientific support, the focus has primarily been on the consequences of cognitive engagement on performance. Little of this research, however, is aimed at examining the reasons that older adults may increase or decrease their engagement over time. In other words, faced with the prospects of declining cognitive functioning, why do some older adults engage while others withdraw?

One possibility is that declining physical and cognitive capabilities may cause changes in the motivation to engage. For example, the Selection, Optimization, and Compensation model (Baltes, Staudinger, & Lindenberger, 1999) argues for a shift from growth-based to loss-based goals in later life as older adults focus their resources on prevention of loss and maintenance of functioning. A somewhat different but not inconsistent perspective on age-based motivational forces has to do with changes in personal resources—broadly defined—which affect an individual’s willingness to engage the complex cognitive operations necessary to

support performance. For example, fatigue, stress, and time pressure could be characterized as limiting resources, and all have been observed to affect younger adults’ motivational levels, which subsequently influenced performance (e.g., LePine, LePine, & Jackson, 2004; Webster, Kruglanski, & Richter, 1996). The aging process may also negatively affect resources. Hess and colleagues (Hess, 2006; Hess & Emery, in press; Hess, Germain, Swaim, & Osowski, 2009) have hypothesized that age-related changes in health and ability result in greater selectivity in task engagement in later life due to changes in both the relative costs of, and the resources necessary to support, performance. This perspective implies that there should be a linkage between resources and motivation, with this linkage in part accounting for age differences in behavior. In support of this relationship, Hess, Germain, Rosenberg, Leclerc, and Hodges (2005) and Hess, Waters, and Bolstad (2000) found a stronger association between cognitive and health-related resources and motivation—Personal Need for Structure (PNS)—in older than in younger and middle-aged adults. They also observed that motivation was a stronger predictor of performance in later life. Similarly, a closer link has been observed between physical symptoms and depression in later life (e.g., Moldin et al., 1993; Murphy, 1982), providing further support for an increasing association between physical resources and affective outcomes. Finally, Hess (2001) found that age differences in ability and health were predictive of motivation, which in turn accounted for variability in

self-reported engagement in everyday cognitive and social activities.

Other research with older adults has also demonstrated relationships between intrinsic motivation and both cognitive performance and engagement in everyday activities. For example, [Parisi, Stine-Morrow, Noh, and Morrow \(2009\)](#) found that predispositional engagement—as indexed by a composite of measures relating to mindfulness, Need for Cognition (NFC), and openness to experience—was positively associated with several measures of cognitive ability and some facets of activity engagement. Similar results were obtained by [Salthouse, Berish, and Miles \(2002\)](#). These findings further support the potential importance of motivation in understanding age differences in cognitive performance and everyday activity.

A limitation of this prior work relates to the cross-sectional nature of the data. For example, models examining mediation using such data have been shown to result in biased estimates of longitudinal relationships (e.g., [Maxwell & Cole, 2007](#)). Stronger support for the linkage between resources, motivation, and behavior would come from longitudinal data that charted changes between these factors. This was the goal of the present study. Specifically, we examined how changes in resource-related factors, such as health and ability, were related to changes in motivation and whether these changes in motivation were subsequently associated with changes in participation in cognitively demanding activities. Our motivational factor involved a composite of two related constructs: PNS ([Neuberg & Newsom, 1993](#)) and NFC ([Cacioppo, Petty, Feinstein, & Jarvis, 1996](#)). Both are related to preferences for demanding versus less complex cognitive activity. PNS has been characterized as a dispositional motive reflecting the need to cognitively structure one's world ([Neuberg & Newsom, 1993](#)). Individuals who are high in PNS display a preference for simple, well-defined structures for understanding the world and engage in cognitive activities oriented toward reducing ambiguity and simplifying representations (e.g., [Moskowitz, 1993](#); [Neuberg & Newsom, 1993](#); [Vess, Routledge, Landau, & Arndt, 2009](#)). Relatedly, NFC is characterized as a relatively stable intrinsic motivational factor reflecting the degree of enjoyment associated with engaging in cognitively demanding activities and is associated with engagement in complex thought (for review, see [Cacioppo et al., 1996](#)). Both constructs are representative of more than just ability in that they predict engagement in cognitive activity (e.g., [Cacioppo et al., 1996](#)). As can be inferred, these variables are negatively correlated, and shared variance should reflect a general preference for engaging in complex versus simple thought. Importantly, these constructs have been previously studied from a differential perspective involving cross-sectional comparisons across individuals. We extend those findings by examining intra-individual changes in these processes as they unfold over time.

In our study, we predicted that changes in resources reflected in physical and sensory functioning, mental health, and ability would affect motivation, with, for example, normative age-related declines in physical health being associated with reduced motivation to engage in complex or effortful activities. We also predicted that changes in motivation would predict changes in engagement in cognitively demanding everyday activities (e.g., reading, social interactions). We further investigated whether changing motivation would be associated with changes in performance on tasks commonly used to assess cognitive ability (e.g., working memory). There are two ways that this relationship could be conceptualized. First, ability might be characterized as a resource factor (e.g., [Hess, 2001](#)), with, for example, reductions in working memory being associated with decreases in the motivation to engage in complex cognitive activity. It is also conceivable, however, that scores on these ability tests might reflect changing levels of motivation (i.e., performance as opposed to competence). This directional issue is somewhat analogous to that associated with investigations of the causal linkages between cognitive ability and engagement in cognitively stimulating activities (e.g., [Hertzog, 2009](#)). The present investigation has the potential not only to contribute to our understanding regarding the directionality of this relationship but also to highlight motivational mechanisms that may underlie this relationship (e.g., reductions in motivation to engage in cognitively complex activities ultimately lead to declines in performance on tests of ability). Thus, we examined whether the strength of effects involving these abilities and motivation were stronger when considered as resources or as outcomes.

Finally, we predicted that motivation would at least partially mediate the relationship observed between changes in our resource and outcome factors. Consistent with previous observations of stronger linkages between resources and motivation in later life (e.g., [Hess et al., 2000](#)), we also were able to examine the possibility of moderated mediation effects ([Muller, Judd, & Yzerbyt, 2005](#)), that is, that the just-described mediation relationships might be accentuated in later life. [Figure 1](#) presents a visual depiction of the relationships under investigation.

## METHOD

### Overview

This study uses archival data collected from individuals participating in ongoing research studies on cognitive and social-cognitive functioning in the Adult Development Laboratory at North Carolina State University (NCSSU). In each test session, a standard background questionnaire, health survey, attitude questionnaire, and set of ability assessments were administered to characterize the sample and address study-specific questions. This set of common measures for individuals who participated in two or more studies constitutes the data used in the present study.

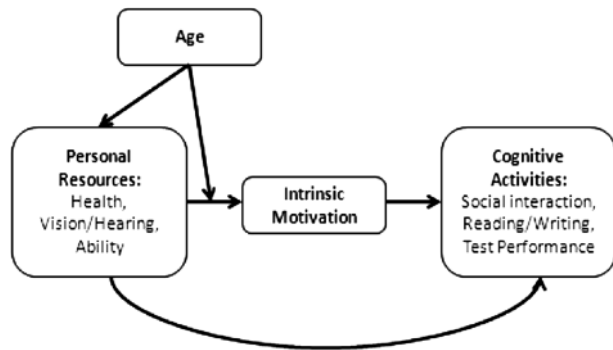


Figure 1. General model depicting relations between resources, motivation, and engagement in cognitively demanding activities. Age is depicted as being associated with some resource variables as well as potentially moderating their influence on motivation.

### Participants

The participants represented a convenience sample of community-residing adults who were initially recruited from the Raleigh, NC, metro area through newspaper advertisements to participate in specific research projects on cognitive functioning in the NCSU Adult Development Laboratory. Those participants who subsequently agreed to have their names listed in the laboratory participant pool were contacted by telephone in later years and invited to participate in additional testing sessions for independent projects. As opposed to a planned longitudinal study, selection for participation in subsequent projects (i.e., times of assessment) was based on participants (a) being the appropriate age for the study, (b) not having participated in another study during the previous 12 months, and (c) not having participated in a study with similar goals and methods. Participants were paid between \$20 and \$30 for each session. The final sample comprised 332 participants (165 women and 167 men). Age at initial participation ranged from 20 to 85 years ( $M = 58.7$ ,  $SD = 16.4$ ). The number of observations per participant ranged from 2 to 6 ( $M = 2.8$ ,  $SD = 1.0$ ), with an average length of 2.1 ( $SD = 1.4$ ) years between observations. Comparisons between younger ( $\leq 45$  years at baseline), middle-aged (46–65 years at baseline), and older ( $> 66$  years at baseline) revealed no differences in the mean number of times tested ( $p = .97$ ) but slightly higher mean test–retest intervals for middle-aged adults ( $M = 2.4$  years) versus younger ( $M = 1.9$  years) and older ( $M = 2.1$  years) adults,  $F(2,331) = 3.48$ ,  $p = .03$ . Participants were relatively high in education, with an average of 16.1 ( $SD = 2.3$ ) years of formal education at baseline. Age at baseline was not significantly correlated ( $r = .09$ ) with education.

### Materials

The following measures were collected at each time of assessment.

**Motivation.**—Participants completed the 11-item PNS Scale (Neuberg & Newsom, 1993) and the 18-item NFC

Scale (Cacioppo, Petty, & Kao, 1984). Sample NFC items include “I really enjoy a task that involves coming up with new solutions to problems” and “Thinking is not my idea of fun (reverse-scored).” Sample PNS items include “I enjoy having a clear and structured way of life” and “I enjoy the exhilaration of being in unpredictable situations (reverse-scored).” To simplify analyses, PNS and NFC scores ( $r = -.38$ ) were combined into a composite motivational measure using regression-based factor scores from a principal components analysis. (The pattern of results and major outcomes reported in the *Results* did not vary appreciably when either PNS or NFS scores were substituted for the composite motivation measure.) The obtained component accounted for 69.6% of the variance, with higher scores indicating greater motivation to engage in complex effortful activities.

**Cognitive ability.**—At each session, participants completed tests assessing (a) working memory—the Letter–Number Sequencing subtest from the Wechsler Adult Intelligence Scale–Third Edition (WAIS-III; Psychological Corporation, 1997) or an Operation Span task (Turner & Engle, 1989), (b) processing speed—the WAIS-III Digit–Symbol substitution subtest or the letter/pattern comparison tests (Salthouse & Babcock, 1991), and (c) vocabulary—Vocabulary Test 2 from the Kit of Factor-Referenced Cognitive Tests (Ekstrom, French, Harman, & Derman, 1976) or the WAIS-III Vocabulary subtest. The specific test used to assess each of these abilities depended upon the methods employed in the specific study from which the data were taken. Although different instruments were used at different times, previous research has demonstrated strong correlations between the tasks included within each of these three domains (e.g., Salthouse, 1992; Shelton, Elliott, Hill, Calamia, & Gouvier, 2009), and controlling for task version in our analyses did not affect the results of interest.

To determine if there was systematic bias across age groups in terms of which type of test was taken, we examined the distribution of the two versions of each ability assessment across the previously described three age groups. No age differences were observed for the span tests ( $p = .30$ ), but significant biases were obtained for both speed,  $\chi^2(2) = 25.19$ ,  $p < .001$ , and vocabulary,  $\chi^2(2) = 24.26$ ,  $p < .001$ . These effects represented an increase in the proportional representation of the WAIS-III Digit–Symbol and Vocabulary subtests with increasing age. To correct for these biases, test type was examined as a potential influence on performance and was included as a covariate if such an effect existed. In addition, to create a common metric across different measures of the three ability constructs, each raw score was converted to a T-score based on the participant’s performance relative to other individuals who completed the same measure at the same time, using the predicted score at age 55—the approximate midpoint of our distribution—as the mean.

*Measures of engagement and health.*—Physical health and mental health scores were derived from the SF-36 health survey (Ware, 1993). Two questions on the background questionnaire assessed self-reported sensory functioning (i.e., vision and hearing) relative to other people the same age. Several additional items assessed self-reports of everyday behaviors that are similar to items included in instruments designed to assess activity levels (e.g., Jopp & Hertzog, 2010). Two of these items assessed engagement in activities thought to vary in cognitive demands by asking how many hours in an average day the participant spent (a) reading and writing, both presumed demanding activities, and (b) watching TV, a presumably more passive activity. The second set of four items was taken from the OARS Multidimensional Assessment Questionnaire (Duke University Center for the Study of Aging and Human Development, 1975) and assessed social activity: (a) number of people known well enough to visit in their homes, (b) the frequency of speaking with friends and/or relatives during the past week, (c) the frequency of visiting other people during the past week, and (d) frequency of participation in social and group activities over the past six months. Jopp and Hertzog (2010) found that scores on subscales of the Victoria Longitudinal Study activity scale that contained similar items were all correlated with cognitive ability: Reading/writing and social activity exhibited positive correlations, whereas TV watching was negatively correlated. To the extent that correlations with ability are reflective of task demands, we can infer that these items reflect involvement in everyday activities that place demands on cognitive resources. (Note that engagement in cognitively demanding activity from TV watching is inferred through lower levels of involvement.) The four social activity items were combined to create a composite index ( $\alpha = .54$ ). Unfortunately, the two cognitive activity measures were poorly correlated (.04). Given that the within-person variance on the reading/writing item was much greater than that on the TV item (45% vs 23%), we decided to include the former as a measure of cognitive activity while acknowledging the limitations associated with single-item indicators.

#### Analytic Plan

We used multilevel modeling (MLM) to test our hypotheses. MLM is a powerful analytic method for the present data set because it allows for variation across individuals in both the number of assessments as well as the time between assessments and also allows for missing data without excluding participants (Raudenbush & Bryk, 2002). The first step in the analyses was to conduct fully unconditional (null) models (i.e., models with no predictors included) for each of the constructs measured longitudinally to determine how much variance in each variable was attributed to within-person processes compared with between-person differences. Subsequent models were run with linear time (i.e., number

of years after initial test) as a Level 1 predictor and age at initial test as a Level 2 predictor (see example equations below). The cross-level interaction term ( $\gamma_{11}$ ) involving these two predictors allows us to examine the degree to which change (i.e.,  $\beta_1$  slope associated with linear time) varied as a function of baseline age.

$$\text{Level 1 (within-person)} : DV_{it} = \beta_0 + \beta_1 (\text{linear time}) + r_{it}$$

$$\text{Level 2 (between-person)} : \beta_0 = \gamma_{00} + \gamma_{01} (\text{Age}) + u_0$$

$$\beta_1 = \gamma_{10} + \gamma_{11} (\text{Age}).$$

We next tested the hypothesis that changes in resources would influence motivation using a series of MLM analyses in which the Level 1 model incorporated a single time-varying covariate (Raudenbush & Bryk, 2002) relating to health, sensory functioning, or ability in order to determine whether changes in resources were reflected in changes in motivation. This was accomplished by replacing the linear time term in the example equation above with the resource variables. A linear time variable was added to subsequent models involving measures that had a significant time trend in these initial analyses in order to control for time-specific variation. This allowed us to more specifically focus on time-based covariation between variables of interest (e.g., physical health and motivation). The pattern of results in these subsequent analyses was not altered by inclusion of this time trend, however, and thus, we report the results of the simplified models that exclude this trend.

The Level 2 model incorporated baseline age as a predictor in order to determine whether the relationship between resources and motivation varied as a function of age. We next examined whether changes in motivation predicted changes in activity and ability. Finally, we tested a series of mediation models to examine whether changes in motivation might mediate resource-related changes in outcomes. For all models, the measures of motivation, health, ability, sensory functioning, and activity as well as age were standardized to both center the variables and facilitate interpretation and comparisons of effects.

## RESULTS

### *Relationships Involving Age and Change Over Time*

Preliminary examination of intercorrelations between all variables at the initial time of test (Table 1) indicates typical age-based relationships: Age is negatively associated with physical health, speed, and working memory but positively associated with mental health and vocabulary. Age was also negatively associated with self-reported engagement in cognitively demanding activities (i.e., reading/writing). Age was not significantly correlated with our composite motivation measure nor was it related to sensory functioning or social activity. Age was also unrelated to education.

Table 1. Intercorrelations Between Variables at First Time of Measurement and Percentage of Within-Subject Variance Across Participants and Measurement Occasions

Measure	2	3	4	5	6	7	8	9	10	11	% Within-subject variance
1. Age	-.09	-.20***	.19***	-.04	.26***	-.64***	-.27***	-.09	.08	-.06	—
2. Years of education	—	-.02	.09	-.02	.33***	.19***	.17**	.14**	.03	.29***	—
3. SF-36 physical health		—	-.03	-.04	.03	.16**	.07	.05	.02	.07	81.5
4. SF-36 mental health			—	.01	.07	-.12*	-.17**	.01	.00	.08	66.1
5. Sensory functioning				—	-.05	.02	.02	.17**	.09	.14*	38.8
6. Vocabulary					—	-.01	.21***	.13*	.04	.29***	27.2
7. Speed						—	.33***	.05	-.03	.16**	22.7
8. Working memory							—	.06	.06	.20***	54.1
9. Reading/writing								—	.09	.21***	45.0
10. Social activity									—	.11*	46.6
11. Motivation										—	25.5

\* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ .

Initial tests involving null models revealed significant ( $ps < .0001$ ) within- and between-person variance in each of our study measures. The amount of within-person variance ranged from 25.5% for the summary motivation variable to 81.5% for physical health (Table 1, last column). Thus, all variables of interest exhibited fluctuations within individuals over time, allowing us to examine potential linkages across times of assessments.

Although our null models indicated significant within-person variability, there was no systematic variance in our motivation measure related to either linear time or age at baseline (see Table 2). That is, motivation fluctuated over time, but the fluctuation was not systematically related to the passage of time or to age. Note that this would not be unexpected because some of the factors hypothesized to influence motivation are positively related to age (e.g., mental health), whereas others are negatively related (e.g., physical health). In contrast, physical health, mental health, and sensory functioning exhibited significant linear change over time. Physical health declined with time, with change being primarily evident in later life. Specifically, when change was assessed at representative points 1 SD above or below the sample mean age, the impact of time was significant for older adults (slope =  $-.11$ ,  $p < .0001$ ) but not for younger adults (slope =  $-.03$ ,  $p = .15$ ). Note that this age moderation did not just reflect greater variability in older adults' physical

health. Tests for homogeneity of variance across young, middle-aged, and older groups on this measure were non-significant ( $p = .89$ ). Sensory functioning also exhibited significant decline over time, and greater baseline age was associated with poorer functioning. In contrast, mental health scores increased with both time and baseline age.

We next examined ability. In these and all subsequent analyses involving ability, we controlled for practice effects to get a cleaner picture of change over time. Practice was incorporated as a Level 1 variable reflecting number of previous administrations of the test. We found that working memory was negatively associated with baseline age, but no systematic change was observed over time. In contrast, speed was also negatively associated with baseline age, but age moderated the degree of change: Speed exhibited a marginal increase over time in young adulthood (slope =  $.04$ ,  $p = .07$ ) but declined over time in older adulthood (slope =  $-.05$ ,  $p = .01$ ). Baseline age was positively associated with vocabulary scores but also moderated change over time, with slight improvement with time in young adulthood (slope =  $.03$ ,  $p = .20$ ) and slight decline in later life (slope =  $-.01$ ,  $p = .51$ ). (The increase in young adulthood was significant if practice effects were not considered.) These results are generally consistent with observed findings in the literature. We also investigated whether the specific type of test within each of these ability domains influenced

Table 2. Standardized Results of Multilevel Analyses Examining Linear Change Over Time in the Primary Study Variables

Variable	Linear time		Baseline age		Baseline Age × Linear Time	
	Coefficient	$p$	Coefficient	$p$	Coefficient	$p$
Motivation	-.006	.42	-.063	.22	-.011	.20
Physical health	-.069	<.0001	-.194	<.0001	-.040	.004
Mental health	.029	.01	.204	<.0001	.010	.44
Sensory functioning	-.018	.03	.016	.70	.012	.82
Vocabulary	.007	.67	.254	<.0001	-.020	.04
Speed	-.004	.77	-.574	<.0001	-.040	<.0001
Working memory	-.023	.30	-.282	<.0001	.002	.88
Social activity	.019	.06	.109	.03	-.011	.35
Reading/writing	.017	.10	-.069	.18	.013	.28

Table 3. Standardized Results of Multilevel Analyses Predicting Linear Change in Motivation From Change in Other Study Variables, Age at Time 1, and Their Interaction

Predictor	Effect					
	Linear change		Age		Linear Change × Age	
	Coefficient	<i>p</i>	Coefficient	<i>p</i>	Coefficient	<i>p</i>
Physical health	.002	.91	-.098	.051	.087	.001
Mental health	.005	.051	.000	.98	.000	.48
Sensory functioning	.085	.02	-.088	.09	.009	.80
Vocabulary	.121	<.001	-.117	.02	-.028	.35
Speed	.065	.08	-.037	.51	-.011	.75
Working memory	.021	.42	-.079	.12	.013	.59

performance by including test type as a covariate. Test type was unrelated to performance for speed ( $ps > .24$ ). For span, test type interacted with time ( $p = .02$ ), but follow-up analyses revealed nonsignificant time effects for both forms of this test ( $ps > .16$ ), suggesting nonsystematic variation. A significant main effect of test was obtained for vocabulary ( $p < .01$ ), and thus, test type was included as a covariate in all analyses involving this measure. Finally, social activity and reading/writing did not change systematically over time, but age was positively associated with the former and negatively associated with the latter.

#### Predictors of Motivation

Table 3 summarizes the results for models predicting motivation. The impact of physical health was moderated by age, with physical health being positively associated with motivation (slope = .09,  $p = .005$ ) in old age but, somewhat surprisingly, negatively associated with motivation (slope =  $-.08$ ,  $p = .02$ ) in young adulthood. Sensory, speed, and vocabulary were all positively related to motivation, although the effect involving speed was only marginal. Thus, the results of these analyses provide support for the hypothesis that changes in resources—particularly those associated with health and physical functioning—will influence motivation.

#### Motivation Predicting Activity and Ability

Consistent with expectations, changes in motivation were positively associated with changes in both social activity and reading/writing (Table 4). We also examined the degree to which motivation was associated with change in our three indices of ability. Based on our idea that engagement in cognitively demanding activities is, in part, a reflection of motivation, it makes sense that performance on the ability tasks used in our research could be a reflection of both ability and motivation. Consistent with this reasoning, changes in vocabulary, speed, and working memory were predicted by change in motivation. In addition, a significant relationship was more likely to be observed—and the effects were generally larger—between these variables when motivation was used to predict performance than vice versa.

Table 4. Standardized Results of Multilevel Analyses of Change in Outcomes Based on Change in Motivation, Age at Baseline, and Their Interaction

Outcome	Effect					
	Motivation		Age		Motivation × Age	
	Coefficient	<i>p</i>	Coefficient	<i>p</i>	Coefficient	<i>p</i>
Social activity	.086	.03	.101	.03	-.061	.12
Reading/writing	.118	.002	-.038	.41	.007	.86
Vocabulary	.133	<.0001	.235	<.0001	-.031	.38
Speed	.066	.02	-.635	<.0001	-.009	.75
Working memory	.109	.003	-.275	<.0001	.006	.87

#### Mediation

Our final set of analyses examined whether changes in motivation might mediate resource-related changes in outcomes. Following procedures recommended by Kenny, Korchmaros, and Bolger (2003) and established elsewhere in the literature (e.g., Segrin & Rynes, 2009; Werner, Sansone, & Brown, 2008), lower level mediation analyses were conducted with outcomes (reading/writing, social activities, working memory, speed, and vocabulary) predicted by resources in the first step, motivation predicted by resources in the second step, and then outcomes predicted by both resources and motivation in the final step. (As noted earlier, we examined ability measures as both resources and outcomes.) Importantly, we examined whether these mediation processes differed by baseline age, so the models tested included interaction terms (Age × Resource and Age × Motivation) representing cross-level interactions (i.e., individual-level effect of age and time-varying effects of resource and motivation). Preacher, Zyphur, and Zhang (2010) note that this approach might produce biased estimates of indirect effects and suggest explicitly partitioning Level 1 and Level 2 effects as a potential way of combating this issue. In the present analyses, we standardized our Level 1 and Level 2 variables by subtracting the Level 2 mean and dividing the result by the Level 2 standard deviation. This procedure partially addresses the suggestions of Preacher and colleagues by allowing us to more clearly focus on the Level 1 effects.

Mediation tests were limited to those situations where a significant relationship existed between fluctuations in resources and outcomes. Such relationships were evident between (a) mental health and working memory; (b) physical health and working memory, speed, and vocabulary; and (c) sensory functioning, speed, and working memory with reading/writing. Table 5 contains the results from the mediation models. Motivation partially mediated the within-person relationship between mental health and working memory (Model 1; Sobel, 1982 test:  $p = .046$ ). Mediation models examining physical health revealed different patterns by age (Model 2). Specifically, there were significant age differences in the relationship between physical health and

Table 5. Standardized Results of Multilevel Mediation Analyses Examining Changes in Motivation Mediating Resource-Related Changes in Outcomes

Mediation steps	Coefficient	SE	t
Step 1: IV to DV			
1. Mental health → working memory	-.063*	0.032	-1.98
2. Physical Health × Age → speed	.070**	0.024	2.92
3. Physical health → working memory	.061*	0.031	2.01
4. Physical health → vocabulary	.064**	0.023	2.77
5. Sensory abilities → reading/writing	.155***	0.043	3.60
6. Working memory → reading/writing	.062*	0.032	1.98
7. Vocabulary → reading/writing	.078*	0.038	2.06
Step 2: IV to mediator			
1. Mental health → motivation	.005*	0.024	1.96
2. Physical Health × Age → motivation	.087***	0.025	3.45
3. & 4. Physical health → motivation	.002	0.021	0.11
5. Sensory abilities → motivation	.085*	0.035	2.45
6. Working memory → motivation	.021	0.026	0.81
7. Vocabulary → motivation	.121***	0.032	3.72
Step 3: IV to DV controlling for motivation			
1. Mental health → working memory	-.071*	0.048	-2.24
2. Physical Health × Age → speed	.064**	0.024	2.65
3. Physical health → working memory	.061*	0.031	1.99
4. Physical health → vocabulary	.064**	0.023	2.78
5. Sensory abilities → reading/writing	.145***	0.043	3.36
6. Working memory → reading/writing	.055	0.032	1.74
7. Vocabulary → reading/writing	.058	0.038	1.53

Notes: Separate models (indicated by the numbered rows above) were conducted for the resource variables. Based on the Sobel test, significant partial mediation was observed for each model except for Model 6 (working memory predicting cognitive activities).

\* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ .

speed, with no relationship between physical health and speed in the young (<60) part of the age distribution (slope =  $-.05$ ,  $p = .27$ ), but a positive relationship between physical health and speed in older adulthood (slope =  $.09$ ,  $p = .004$ ). As indicated before, decomposition of the significant Age × Physical Health interaction with motivation indicated a negative relationship between physical health and motivation for younger adults but a positive relationship for older adults. Results from the Sobel test revealed partial mediation involving physical health, motivation, and speed ( $p = .05$ ). Physical health was positively associated with working memory (Model 3), and results from the Sobel test revealed partial mediation involving physical health, motivation, and working memory ( $p = .04$ ). Age differences in mediation were also found for changes in vocabulary. Although there was a main effect of physical health on vocabulary and this effect did not differ by age, there were age differences in the relationship between physical health and motivation as noted above (Model 4) The Sobel test revealed that this partial mediation was significant ( $p = .01$ ). Changes in motivation also partially mediated the within-person relationship between sensory abilities and cognitively demanding activities (Model 5; Sobel test:  $p = .03$ ) as well as the within-person relationship between vocabulary and reading/writing (Model 7; Sobel test:  $p = .04$ ). Finally, no mediation was observed involving the relationship between working

memory and reading/writing, given the failure of changes in working memory to predict motivation (Model 6).

## DISCUSSION

The goal of the present study was to examine the relationship between changes in resources, motivation, and cognitive outcomes as a means for facilitating our understanding of the factors underlying age-related change in functioning in adulthood. The results of our analyses offer several interesting insights into this relationship. First, changes in physical and cognitive resources are linked to changes in motivation associated with complex information processing. Specifically, declines in physical and mental health as well as in self-reported sensory functioning were associated with reduced levels of motivation, as were changes in verbal ability. In addition, we also obtained evidence that the linkage between declining levels of physical health and motivation was strongest in later life, replicating previous findings based in cross-sectional data (Hess et al., 2000). Somewhat surprisingly, declining health in young adulthood was associated with increasing motivation. This may reflect age-specific responses to poor health, with young adults' responses perhaps being associated with the "off-time" nature of poor health. For example, young adults in poorer physical health might be more likely to pursue cognitive as opposed to physical activities.

From an aging perspective, these findings are important in demonstrating that typical patterns of age-related change in health and ability influence the motivation to engage in complex cognitive activity, which in turn has been shown to be associated with the maintenance of functioning in later life (Hertzog et al., 2008). In support of this potential relationship, our analyses also found linkages between changes in motivation and outcomes associated with social and cognitive activity. Thus, as motivational levels decreased, individuals were less likely to engage in complex cognitive and social activities. Although a significant association between age and motivation was not observed, fluctuations in resource factors that are related to age were linked to fluctuations in motivation. This covariation involving age-related resources thus has important implications regarding changes in motivation in later life.

Interestingly, when performance on our ability measures was examined as an outcome as opposed to a resource, we found that the changes on these measures were predicted by changes in motivation and further that this linkage appeared stronger than when cognitive ability was considered as resource variable influencing motivation; that is, changes in motivation were more reliable predictors of changes in ability than vice versa. This may suggest that some of the age-related change in performance on ability tests reflects changes in motivation in response to fluctuations in basic resources associated with health and physical functioning.

Our tests of mediation provided support for this last assertion. Specifically, motivation partially mediated the relationship between physical health and both vocabulary and cognitive ability. A similar relationship was observed between mental health and cognitive ability. Finally, motivation was also observed to partially mediate the relationship between sensory functioning and involvement in complex cognitive activities, such as reading. These relationships have interesting implications for understanding the nature of age-related change in functioning. Our analyses suggest that declining health and sensory functions affect both ability levels and self-reported engagement in effortful activities associated with the maintenance of ability through changes in levels of motivation. Consistent with our original conceptualization, we also found that motivation partially mediated the relationship between cognitive ability—when considered as a resource—and engagement in cognitively demanding activities. This may suggest a somewhat complex relationship between ability and motivation. For example, reductions in working memory and processing speed may reduce the motivation to engage in demanding activities due to the lack of resources but changes in physical health may also decrease level of cognitive engagement due to the perceived costs associated with such engagement. This, in turn, could negatively affect performance on tests of cognitive ability.

It is important to recognize that the observed mediating effects were only partial in all of our tests. One way to interpret these findings is that the effect of changing resources was accentuated by changes in motivation; that is, resources directly influence outcomes but also indirectly influence them through changes in motivation to engage in cognitive activities.

The primary importance of these results is the implication that motivation is also an important factor involved in determining changes in ability and functioning in adulthood. Rather than assuming a straightforward causal linkage between, for example, changes in physical health and functioning, our data suggest that the individual's subjective response to these changes is an important determinant of subsequent behavior. There is little other empirical work investigating such associations in the aging literature.

A recent study (Sharp, Reynolds, Pederson, & Gatz, 2010) examining the relationship between changes in openness to experience—a personality construct correlated with both PNS and NFC—and cognition found no linkages over time due to minimal changes in openness. Although our motivation measures may overlap with personality dimensions, the latter may represent fundamentally different and more stable dimensions. For example, Fleischhauer and colleagues (2010) demonstrated that NFC uniquely predicted goal-oriented behavior and allocation of attentional resources. Fluctuations in motivation—which in turn affect these types of behavior—may be more likely to fluctuate over time in response to both intrinsic and situational factors. This may

account for the presently observed relations between motivation and cognitive outcomes. The fact that we are only capturing intrinsic influences (e.g., health) on motivation may also account for the fact that we only observed partial mediation in our analyses.

The results may also provide some additional insight into the linkages between engagement in cognitively demanding activities and cognitive ability. Our findings suggest that changes in the motivation to engage in complex cognitive activity associated with changes in health and physical functions may affect both factors. To the extent that engagement in everyday activities does have a meaningful impact on cognitive change, our results imply that motivational factors may play an important role in driving this relationship. For example, declines in physical health may decrease one's motivation to participate in activities that put demands on cognitive resources, which in turn may have negative effects on ability. This results in some relatively novel suggestions regarding the focus of interventions. Indeed, evidence suggesting that physical exercise has beneficial effects on complex cognitive functions (Colcombe & Kramer, 2003) may be representative of a causal sequence involving physical functioning, motivation, activity engagement, and ability.

Several caveats should be considered in interpreting our results. First, the effects observed were small, but they are similar in strength to those found in other studies examining, for example, personality predictors of cognitive change (e.g., Schaie, Willis, & Caskie, 2004; Soubelet & Salthouse, 2011). Second, we relied on convenience sample data that were not part of a planned longitudinal analysis. Thus, there may be inherent biases associated with participant's initial recruitment and with their continued participation. For example, in contrast to a planned longitudinal study, there was no commitment to continued participation. One might assume, however, that this would actually work against our finding, the anticipated results in that continuing participation itself might be reflective of motivation for cognitive experience. Thus, the actual effects associated with motivation may have been attenuated in our analyses. Participants also varied in their frequency of participation and time between test sessions. Because MLM treated resources and motivation as time-varying covariates, however, balanced data are unnecessary and the processes of interest can be examined as they unfold for each participant. This also helps to address biases due to attrition. The sample size was also relatively small for the age range assessed, and future investigations would be enhanced by use of a narrow-age cohort design.

Another concern could be related to the limited assessment of both resource and outcome variables and concerns with the nature of the variables used. For example, although the items used to assess engagement in cognitively demanding activities were similar to items used in other studies (e.g., Hultsch, Hertzog, Small, & Dixon, 1999), the limited



breadth of assessment may have served to weaken observed relationships, particularly those involved in our mediation analyses.

In sum, our findings suggest that a more complete understanding of the cognitive change in adulthood would be achieved by considering the role of motivation. Our study shows that declines in basic resources may cause declines in the motivation to engage in cognitively demanding activities. These motivational changes could in turn account for both age differences in performance on cognitive tests as well as involvement in activities that support the maintenance of cognitive functioning in later life. Understanding the motives for older adults' engagement in cognitive activities may be as important for improving cognitive function as understanding the impact of engagement itself.

#### FUNDING

This work was supported by grants from the National Institute on Aging at the National Institutes of Health (grant numbers R01 AG005552, R01 AG020153, and R01 AG027633).

#### ACKNOWLEDGMENTS

The authors gratefully acknowledge Cliff Toney and Carla Strickland-Hughes for their assistance on this project.

#### CORRESPONDENCE

Correspondence should be addressed to Thomas M. Hess, PhD, Department of Psychology, North Carolina State University, Raleigh, NC 27695-7801. E-mail: [thomas\\_hess@ncsu.edu](mailto:thomas_hess@ncsu.edu)

#### REFERENCES

- Baltes, P. B., Staudinger, U. M., & Lindenberger, U. (1999). Lifespan psychology: Theory and application to intellectual functioning. *Annual Review of Psychology, 50*, 471–507. doi:10.1146/annurev.psych.50.1.471.
- Cacioppo, J. T., Petty, R. E., Feinstein, J. A., & Jarvis, W. B. G. (1996). Dispositional differences in cognitive motivation: The life and times of individuals varying in need for cognition. *Psychological Bulletin, 119*, 197–253. doi:10.1037/0033-2909.119.2.197.
- Cacioppo, J. T., Petty, R. E., & Kao, C. F. (1984). The efficient assessment of need for cognition. *Journal of Personality Assessment, 48*, 306–307. doi:10.1207/s15327752jpa4803\_13.
- Colcombe, S. J., & Kramer, A. F. (2003). Fitness effects on the cognitive function of older adults: A meta-analytic study. *Psychological Science, 14*, 125–130. doi:10.1111/1467-9280.t01-1-01430.
- Duke University Center for the Study of Aging and Human Development. (1975). *OARS multidimensional functional assessment questionnaire*. Durham, NC: Author.
- Ekstrom, R. B., French, J. W., Harman, H., & Derman, D. (1976). *Kit of factor-referenced cognitive tests* (Rev. Ed.). Princeton, NJ: Educational Testing Service.
- Fleischhauer, M., Enge, S., Brocke, B., Ullrich, J., Strobel, A., & Strobel, A. (2010). Same or different? Clarifying the relationship of need for cognition to personality and intelligence. *Personality and Social Psychology Bulletin, 36*, 82–96. doi:10.1177/0146167209351886.
- Hertzog, C. (2009). Use it or lose it: An old hypothesis, new evidence, and an ongoing controversy. In H. B. Bosworth & C. Hertzog (Eds.), *Aging and cognition: Research methodologies and empirical advances* (pp. 161–180). Washington, DC: American Psychological Association.
- Hertzog, C., Kramer, A. F., Wilson, R. S., & Lindenberger, U. (2008). Enrichment effects on adult cognitive development: Can the functional capacity of older adults be preserved and enhanced? *Psychological Science in the Public Interest, 9*, 1–65. doi:10.1111/j.1539-6053.2009.01034.x.
- Hess, T. M. (2001). Aging-related influences on personal need for structure. *International Journal of Behavioral Development, 25*, 482–490. doi:10.1080/01650250042000429.
- Hess, T. M. (2006). Adaptive aspects of social cognitive functioning in adulthood: Age-related goal and knowledge influences. *Social Cognition, 24*, 279–309. doi:10.1521/soco.2006.24.3.279.
- Hess, T. M., & Emery, L. (in press). Memory in context: The impact of age-related goals on performance. In M. Naveh-Benjamin & N. Ohta (Eds.), *Perspectives on memory and aging*. London: Psychology Press.
- Hess, T. M., Germain, C. M., Rosenberg, D. C., Leclerc, C. M., & Hodges, E. A. (2005). Aging-related selectivity and susceptibility to irrelevant affective information in the construction of attitudes. *Aging, Neuropsychology, and Cognition, 12*, 149–174. doi:10.1080/13825580590925170.
- Hess, T. M., Germain, C. M., Swaim, E. L., & Osowski, N. L. (2009). Aging and selective engagement: The moderating impact of motivation on older adults' resource utilization. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 64*, 447–456. doi:10.1093/geronb/gbp020.
- Hess, T. M., Waters, S. J., & Bolstad, S. A. (2000). Motivational and cognitive influences on affective priming in adulthood. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 55*, 193–204. doi:10.1093/geronb/55.4.P193.
- Hultsch, D. F., Hertzog, C., Small, B. J., & Dixon, R. A. (1999). Use it or lose it: Engaged lifestyle as a buffer of cognitive decline in aging? *Psychology and Aging, 14*, 245–263. doi:10.1037/0882-7974.14.2.245.
- Jopp, D. S., & Hertzog, C. (2010). Assessing adult leisure activities: An extension of a self-report activity questionnaire. *Psychological Assessment, 22*, 108–120. doi:10.1037/a0017662.
- Kenny, D. A., Korchmaros, J. D., & Bolger, N. (2003). Lower level mediation in multilevel models. *Psychological Methods, 8*, 115–128. doi:10.1037/1082-989X.8.2.115.
- LePine, J. A., LePine, M., & Jackson, C. L. (2004). Challenge and hindrance stress: Relationships with exhaustion, motivation to learn, and learning performance. *Journal of Applied Psychology, 89*, 883–891. doi:10.1037/0021-9010.89.5.883.
- Maxwell, S. E., & Cole, D. A. (2007). Bias in cross-sectional analyses of longitudinal mediation. *Psychological Methods, 12*, 23–44. doi:10.1037/1082-989X.12.1.23.
- Moldin, S. O., Scheftner, W. A., Rice, J. P., Nelson, E., Knesevicha, M. A., & Akiska, H. (1993). Association between major depressive disorder and physical illness. *Psychological Medicine: A Journal of Research in Psychiatry and the Allied Sciences, 23*, 755–761. doi:10.1017/S0033291700025526.
- Moskowitz, G. B. (1993). Individual differences in social categorization: The influence of personal need for structure on spontaneous trait inferences. *Journal of Personality and Social Psychology, 65*, 132–142. doi:10.1037/0022-3514.65.1.132.
- Muller, D., Judd, C. M., & Yzerbyt, V. Y. (2005). When moderation is mediated and mediation is moderated. *Journal of Personality and Social Psychology, 89*, 852–863. doi:10.1037/0022-3514.89.6.852.
- Murphy, E. (1982). Social origins of depression in old age. *British Journal of Psychiatry, 141*, 135–142. doi:10.1192/bjp.141.2.135.
- Neuberg, S. L., & Newsom, J. (1993). Individual differences in chronic motivation to simplify: Personal need for structure and social-cognitive processing. *Journal of Personality and Social Psychology, 65*, 113–131. doi:10.1037/0022-3514.65.1.113.
- Parisi, J. M., Stine-Morrow, E. A. L., Noh, S. R., & Morrow, D. G. (2009). Predispositional engagement, activity engagement, and cognition among older adults. *Aging, Neuropsychology and Cognition, 16*, 485–504. doi:10.1080/13825580902866653.

- Preacher, K. J., Zyphur, M. J., & Zhang, Z. (2010). A general multilevel SEM framework for assessing multilevel mediation. *Psychological Methods, 15*, 209–233. doi:10.1037/a0020141.
- Psychological Corporation. (1997). *WAIS-III administration and scoring manual*. San Antonio, TX: Harcourt Brace & Company.
- Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (2nd ed.). Thousand Oaks, CA: Sage.
- Salthouse, T. A. (1992). What do adult age differences in the Digit Symbol Substitution test reflect? *Journal of Gerontology, 47*, 121–128. doi:10.1093/geronj/47.3.P121.
- Salthouse, T. A., & Babcock, R. (1991). Decomposing adult age differences in working memory. *Developmental Psychology, 27*, 763–776. doi:10.1037/0012-1649.27.5.763.
- Salthouse, T. A., Berish, D. E., & Miles, J. D. (2002). The role of cognitive stimulation on the relations between age and cognitive functioning. *Psychology and Aging, 17*, 548–557. doi:10.1037/0882-7974.17.4.548.
- Schaie, K. W., Willis, S. L., & Caskie, G. I. L. (2004). The Seattle Longitudinal Study: Relationship between personality and cognition. *Aging, Neuropsychology, and Cognition, 11*, 304–324. doi:10.1080/13825580490511134.
- Segrin, C., & Rynes, K. N. (2009). The mediating role of positive relations with others in associations between depressive symptoms, social skills, and perceived stress. *Journal of Research in Personality, 43*, 962–971. doi:10.1016/j.jrp.2009.05.012.
- Sharp, E., Reynolds, C. A., Pedersen, N. L., & Gatz, M. (2010). Cognitive engagement and cognitive aging: Is openness protective? *Psychology and Aging, 25*, 60–73. doi:10.1037/a0018748.
- Shelton, J. T., Elliott, E. M., Hill, B. D., Calamia, M. R., & Gouvier, W. D. (2009). A comparison of laboratory and clinical working memory tests and their prediction of fluid intelligence. *Intelligence, 37*, 283–293. doi:10.1016/j.intell.2008.11.005.
- Sobel, M. E. (1982). Asymptotic intervals for indirect effects in structural equations models. In S. Leinhardt (Ed.), *Sociological methodology 1982* (pp. 290–312). San Francisco, CA: Jossey-Bass.
- Soubelet, A., & Salthouse, T. A. (2011). Personality–cognition relations across adulthood. *Developmental Psychology, 47*, 303–310. doi:10.1037/a0021816.
- Turner, M., & Engle, R. (1989). Is working memory capacity task dependent? *Journal of Memory and Language, 28*, 127–154. doi:10.1016/0749-596X(89)90040-5.
- Vess, M., Routledge, C., Landau, M., & Arndt, J. (2009). The dynamics of death and meaning: The effects of death-relevant cognitions and personal need for structure on perceptions of meaning in life. *Journal of Personality and Social Psychology, 97*, 728–744. doi:10.1037/a0016417.
- Ware, J. E. Jr. (1993). *SF-36 health survey*. Boston, MA: The Health Institute, New England Medical Center.
- Webster, D. M., Richter, L., & Kruglanski, A. W. (1996). On leaping to conclusions when feeling tired: Mental fatigue effects on impression priming. *Journal of Experimental Social Psychology, 32*, 181–195. doi:10.1006/jesp.1996.0009.
- Werner, C. M., Sansone, C., & Brown, B. B. (2008). Guided group discussion and attitude change: The roles of normative and informational influence. *Journal of Environmental Psychology, 28*, 27–41. doi:10.1016/j.jenvp.2007.10.002.