Aging and Effort Expenditure: The Impact of Subjective Perceptions of Task Demands

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Engagement in cognitively demanding activities has a positive impact on cognitive health in older adults. Previous work, however, has suggested that the costs associated with engagement increase in later life and influence motivation. We examined how subjective perceptions of these costs varied with age and influenced task engagement. The following questions were of specific interest: (a) Are there age differences in subjective perceptions of cognitive costs? (b) What is the impact of these perceptions on engagement? We tested 39 older (ages 65–84) and 37 younger (20–42) adults on a working memory task. Systolic blood pressure reactivity (SBP-R; reflective of effort) and subjective perceptions of task difficulty were assessed. We found that age was associated with an increase in the perceptions of cognitive costs, and that these subjective perceptions had a stronger impact on older adults’ engagement than on that of younger adults. More important, this impact was specific to subjective perceptions of cognitive costs. The results provide further support for the hypothesis that increased costs associated with cognitive engagement influence older adults’ willingness to engage cognitive resources, and that these costs in part reflect subjective perceptions that are independent of objective task demands.

Research findings in the field of aging are coalescing around the conclusion that engagement in cognitively demanding activities is important for cognitive health (for review, see Hertzog, Kramer, Wilson, & Lindenberger, 2008). This conclusion is supported by both analyses of self-report data from longitudinal studies (e.g., Hultsch, Small, Hertzog, Small, & Dixon, 1999; Schoolder & Mulatu, 2001; Wilson et al., 2003) as well as intervention programs that focus on cognitive engagement (e.g., Carlson et al., 2008; Stine-Morrow, Parisi, Morrow, & Park, 2008). Given these findings, an important additional question relates to the individual and situational factors that determine whether or not individuals actually engage in cognitively beneficial activities in later life.

One potentially important factor relates to the costs of cognitive engagement. We have argued elsewhere that aging is associated with an increase in these costs, reflected in the effort required to cope with a specific level of objective task demands and with the consequences (e.g., fatigue, depletion) associated with sustained engagement (Hess, 2014; Hess & Emery, 2012). Research using cardiovascular (CV) response as an indicator of task engagement or effort expenditure (Ennis, Hess, & Smith, 2013; Hess & Ennis, 2012; Smith & Hess, 2015) has shown that aging is associated with an increase in overall response at all levels of objective task demands (e.g., size of the stimulus set in a memory-scan task), and that this age difference increases with increasing demands. In addition, sustained cognitive engagement is associated with relatively greater consequences for older adults in terms of fatigue-related increases in CV response (Ennis et al., 2013; Smith & Hess, 2015) and longer recovery periods (e.g., Ritvanen, Louhevaara, Helin, Väisänen, & Hänninen, 2006; Steptoe, Kunz-Ebrecht, Wright, & Feldman, 2005).

Selective Engagement Theory (SET; Hess, 2014) proposes that this aging-related increase in cognitive costs influences the motivation to engage in cognitively demanding activities. Specifically, given similar levels of presumed benefits across age groups for a given activity, the increased costs in later life result in a reduction in the ratio of benefits to costs for that activity. This has the general effect of negatively impacting older adults’ willingness to engage in demanding activities, potentially accounting for previously reported normative reductions in activity levels in later life (e.g., Buchman et al., 2014).

This perspective also suggests that the individual’s perception of these costs may be one determinant of their impact on engagement. Motivation Intensity Theory (e.g., Brehm & Self, 1989) argues that individuals will devote cognitive resources proportional to the task demands if the task is viewed as important and the individual believes that they have the capability to succeed. Research based on Wright’s (1996; Gendolla, Wright, & Richter, 2012) integrative model that melds motivational intensity theory with Obrist’s (1981) active coping model provides support for this by demonstrating systematic increases in CV responses (e.g., systolic blood pressure [SBP]) with objective task demands when motivation is high. Responses ebb at very high levels of demands, presumably

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reflective of disengagement when the task is perceived to be beyond one’s ability to perform. Taken together, these ideas suggest that subjective perceptions of task demands should be important predictors of engagement. Whereas these perceptions are likely to reflect actual objective task demands, they may also reflect hypothesized normative increases in cognitive costs experienced by the individual as well as beliefs about aging. For example, negative attitudes about aging may be associated with inflated perceptions of costs, which in turn may influence an individual’s self-assessment of their ability to perform. Thus, subjective perceptions should predict engagement above-and-beyond objective task demands. In addition, to the extent that these perceptions incorporate aging-specific beliefs about one’s ability, the “value-added” of subjective perceptions for prediction of engagement should be greater for older than for younger adults. Our previous work (e.g., Ennis et al., 2013) focused primarily on investigating systematic relationships between age, engagement, and objective task demands, with some preliminary examinations of general subjective perceptions. The overarching goal of the present study, however, was to expand this examination of subjective influences.

In our study, we presented young and older adults with a working memory task—letter-number sequencing—that varied over trials in terms of the number of to-be-remembered items. Throughout the task, we recorded SBP, which has been shown to be sensitive to effort mobilization (e.g., Gendolla et al., 2012) and that we have argued is a valid index for examining age differences in task engagement or effort expenditure (Hess & Ennis, 2014). After each level of objective task demand (i.e., memory-set size), participants rated their subjective perceptions of task demands using a well-validated measure of subjective workload: the NASA Task Load Index (TLX; Hart & Staveland, 1988). This instrument assesses mental, physical, and temporal demands as well as effort expenditure, frustration, and perceptions of performance. This procedure allowed us to examine associations between objective task demands, subjective perceptions of task demands, and engagement as well as age differences therein. We used the data from this study to then address a set of specific issues.

First, we were interested in whether age differences existed in the perceptions of task demands, and the extent to which such differences varied as a function of the dimension of demand assessed. To do this, we examined ratings of the six TLX subscales. Only two of these subscales—mental demands (e.g., how complex was the task?) and effort (e.g., how hard did you have to work?)—appear to reflect the cognitive costs as defined in SET, whereas the other subscales, such as temporal demands (e.g., how much time pressure did you feel?) appear less relevant. We hypothesized that ratings on all subscales would reflect objective task demands (i.e., positive association with memory-set size), and that age differences would be greater for those scales that specifically assess task demands (e.g., physical demands) as opposed to affective responses (e.g., frustration). We further hypothesized that the scales that tapped into cognitive costs as conceptualized within SET—mental demands and effort—would show the greatest sensitivity to age.

Our second research issue focused on the effects of both objective task demands and subjective assessments of difficulty on effort expenditure. Consistent with past research, we predicted that effort would increase with both age and objective task demands, but decrease at the highest task demands as the difficulty becomes too great and participants disengage from the task (i.e., withdraw effort). We further predicted that subjective assessments of demands would have a similar relationship to engagement as objective ones and that they would account for additional variance in effort expenditure above-and-beyond objective demands. Given our aforementioned assumptions regarding determinants of subjective demands, we also predicted that these subjective perceptions would have a stronger impact on engagement patterns in older than in younger adults and that this age-related effect would be specific to ratings of mental demands and effort. We also predicted that older adults would be more likely than younger adults to withdraw effort at high levels of perceived task demands, where they presumably would infer that their ability to perform would be compromised.

Method

Participants

Participants were community-based volunteers recruited via newspaper and online advertisements. Self-reported uncontrolled hypertension was used as an exclusionary criterion, and participants whose SBP exceeded 160 or diastolic blood pressure (DBP) exceeded 100 during a pretest screening in the lab were dismissed from further participation (N = 5). The data from an additional eight participants were excluded because of equipment/measurement issues. The final sample included 39 older adults (19 women) 65–84 years of age and 37 younger adults (20 women) 20–42 years of age. Each participant was paid $30.

Measures and Equipment

Engagement. The CNAP Monitor 500 HD (CNSystems Medizintechnik AG, Graz, Austria) was used to collect continuous measures of blood pressure and heart rate (HR) through use of a finger cuff that measures finger arterial pressure. The device—in concert with a BIOPAC MP150 system (BIOPAC Systems, Inc., Goleta, CA)—recorded measurements of finger arterial pressure that were converted into predictions of Brachial artery blood pressure. The technology used in the CNAP has demonstrated reliability and validity (e.g., Jeleazcov, Krajinovic, Münster, Birckholz et al., 2010).

Working memory. The primary task of this study was a modified version of the letter-number sequencing (LNS) task used in the Wechsler Adult Intelligence Scale-III (WAIS-III; Wechsler, 1997). Participants were presented with a random combination of letters and numbers. The participant then repeated each series by participants whose SBP exceeded 100 during a pretest screening in the lab were dismissed from further participation (N = 5). The data from an additional eight participants were excluded because of equipment/measurement issues. The final sample included 39 older adults (19 women) 65–84 years of age and 37 younger adults (20 women) 20–42 years of age. Each participant was paid $30.
letters) sets, with six separate sets at each level. Performance was calculated by the proportion of correct letter-number strings completed at each level of difficulty.

**Cognitive ability.** To characterize the sample, verbal ability and perceptual speed were assessed using the WAIS-III vocabulary and digit-symbol-substitution subtests. We also used the plus-minus task and Stroop tasks to assess task-switching and inhibition, respectively.

**Intrinsic motivation.** We used the 29-item Intrinsic Motivation Inventory (IMI) as a manipulation check (see below). This multidimensional instrument assesses participants’ subjective experience during task performance (Ryan, 1982) and consists of five major subscales: interest-enjoyment, perceived competence, effort-importance, perceived choice, and tension-pressure.

**Subjective perceptions.** Subjective perceptions of task demands were assessed with an online version (Sharek, 2009) of the NASA-TLX (Hart & Staveland, 1988) consisting of six subscales: mental demand, physical demand, temporal demand, performance, effort, and frustration. Participants used the computer mouse to position a cursor on a rating scale ranging from very low to very high (poor to good on the performance scale), with the ratings then translated into scores ranging from 1 (very low/poor) to 100 (very high/good).

**Procedure**

Participants completed sets of questionnaires sent to their homes, including a basic demographic questionnaire, the SF36 health survey (Ware, 1993), and several questionnaires unrelated to the present study. Upon arriving at the laboratory, participants had their blood pressure screened using a HEM-780 automatic blood pressure monitor (Omron Health care, Inc., Kyoto, Japan). Next, the CNAP was attached to the index and middle finger of the participant’s nondominant hand. After initial CNAP calibration, cardiovascular baselines were established over a 5 min period, during which participants were free to read magazines provided by the lab. Half of the participants in each age group were originally assigned to a condition intended to promote engagement. Those in the control condition were given standard instructions for completing the LNS task. Participants in the experimental condition were given additional information regarding the cognitive-health benefits of engaging in cognitively demanding activities. Unfortunately, examination of scores on the IMI interest-enjoyment subscale—that traditionally has been used as a measure of intrinsic motivation—revealed no significant effects because of age or task instructions (ps > .08), suggesting the manipulation was ineffective. In addition, no significant effects because of instructions were obtained in analyses of engagement. Thus, we decided to exclude this variable from further consideration.

The LNS task was then described, and five practice trials were administered using a variety of difficulty levels. Participants proceeded through the eight levels of the main task, beginning at the easiest level and proceeding incrementally to the most difficult level to systematically examine disengagement. On each trial, stimuli were presented sequentially on a computer screen, one item every second, following which participants provided oral responses recorded by the tester. CV responses were assessed continuously during testing. After each level of difficulty, participants completed the NASA-TLX. At the end of the task, sensors were detached, participants completed the IMI, and the additional cognitive tasks were administered. Finally, participants were debriefed and compensated.

**Data Preparation**

CV responses were recorded continuously using Biopac AcqKnowledge software. Means and SDs were derived for the initial baseline period and during performance at each level of LNS difficulty for SBP. Responsivity (SBP-R) was used as our measure of effort/task engagement, and was calculated by subtracting baseline from mean responses at each level of task difficulty.2

**Results**

**Participant Characteristics**

A series of age-group comparisons performed on our background variables revealed age-related variations in ability (i.e., increases in vocabulary, decreases in speed, task-switching, and inhibition) and health that were generally consistent with normative trends in the literature (see Table 1). The one somewhat surprising finding was the significantly lower baseline diastolic blood pressure (DBP) in the old when compared with the young. This may have reflected the relatively large number of older adults (43.6 vs. 8.1% young adults) taking medication to control blood pressure.3

**Performance**

Before addressing our primary questions, we examined performance on the LNS task to provide a backdrop for the subsequent analyses. An Age Group (young vs. old) × Set Size (2–9) analysis of variance (ANOVA) on the proportion of correct responses over the six trials at each level of objective task demand (see Figure 1) revealed expected decrements in performance associated with both age, $F(1, 74) = 12.37, p = .001, \eta^2_{p} = .14$, and set size, $F(7, 518) = 496.31, p < .001, \eta^2_{p} = .87$. An interaction between age and set size was also obtained, $F(7, 518) = 2.73, p = .009, \eta^2_{p} = .04$. Specifically, as task demands increased initially, age differences also increased, but the age effect disappeared at set sizes of 8 and 9 items, where performance was very poor in both

1 Instructions in the experimental condition were as follows: “Research has shown that adults of all ages benefit when they perform complex tasks that test the limits of their mental abilities. For example, compared with participation in routine activities, engaging in problem solving activities, complex game play, and demanding work environments has been shown to have benefits in terms of maintaining or even improving one’s cognitive ability. This study is part of an ongoing research program in which we are exploring various aspects of these ideas.”

2 Systolic blood pressure (SBP) is regarded as a more direct index of active coping or task engagement than are diastolic blood pressure (DBP) and heart rate (HR; e.g., Obrist, 1981), and our previous work has supported this by illustrating more systematic associations of task demands and motivation to systolic blood pressure responsivity (SBP-R) than to either of these measures (e.g., Hess & Ennis, 2012). Thus, our focus was on SBP-R.

3 Medication use did not affect older adults’ cardiovascular (CV) responses in any analysis.
and between-person (7 to 47%; pant) revealed significant within-person (53 to 93%; responses across all set sizes) moderation of missing data. Fully unconditional models performed on multilevel modeling (MLM) to examine the impact of age and nonindependence of responses for each scale because of the consistent sequential order in which they were collected, we used nonindependent models as a referent) as a Level 2 variable, along with all cross-level interactions. As seen in Table 2, responses increased with task demands on all six scales, although the effect was particularly strong on the mental demands, effort, and performance scales. In addition, older adults had significantly higher responses than young adults on the three scales—mental, physical, and temporal demands—explicitly tapping into task demands as well as on the effort scale. Several interactions were also obtained. For mental demands, the age difference disappeared at the highest levels of objective task demands, but this might reflect a scaling effect as the ratings of both groups approached ceiling. For both physical demands and frustration, age differences increased with set size, whereas the interaction for performance ratings was of the cross-over type.

In summary, and consistent with expectations, subjective estimates by both young and older adults were systematically associated with objective task demands, and older adults’ estimates were significantly higher than those of younger adults on scales explicitly tapping into task demands. Inconsistent with expectations, however, was the fact that the strength of the age effect (i.e., b) was not necessarily stronger for ratings tapping into mental demands and effort than for other dimensions (physical, temporal) associated with task demands.

### Engagement

To address our second major question regarding the relationship between engagement—as reflected in CV responses—and subjective perceptions of task demands, we followed procedures from our earlier work (e.g., Ennis et al., 2013) using MLM. A fully unconditional model examining SBP-R values across all set sizes (eight data points for each participant) revealed significant ($p < .001$) within-person (30%) and between-person (70%) variance.

### Effects of subjective task difficulty

Before examining subjective task difficulty effects, we performed a preliminary analysis with the same models used to examine TLX scores to determine if age effects similar to those identified with other types of cognitive tasks (e.g., Ennis et al., 2013; Hess & Ennis, 2012) were obtained with the LNS task. Grand-mean-centered baseline SBP was also included as a covariate to control for its possible impact on range of response. This analysis revealed a significant effect because of age group, $b = 4.58, t(73) = 2.76, p = .007$, along with significant linear and quadratic effects of set size: $b = −.39, t(528) = −2.34, p < .01$, and $b = −.32, t(528) = −7.06, p < .001$, respectively (see Figure 3). Specifically, older adults had significantly (ps < .03) higher levels of responsiveness at all set sizes, and SBP-R increased initially to meet increasing task demands, but exhibited significant declines for both age groups at the largest set sizes—and most difficult levels of the task. Although the Age × Set Size interaction was not significant ($p = .69$), pairwise comparisons between levels within age groups revealed significant decreases in

### Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Young adults</th>
<th>Older adults</th>
<th>Age difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>30.9 SD 5.6</td>
<td>72.6 SD 6.7</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Education</td>
<td>16.6 SD 1.8</td>
<td>16.3 SD 1.9</td>
<td>.47</td>
</tr>
<tr>
<td>SF36 physical health</td>
<td>47.6 SD 3.9</td>
<td>41.6 SD 5.9</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>SF36 mental health</td>
<td>41.0 SD 5.1</td>
<td>46.8 SD 5.7</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>52.2 SD 7.8</td>
<td>55.7 SD 6.4</td>
<td>.03</td>
</tr>
<tr>
<td>Digit-symbol substitution</td>
<td>90.2 SD 17.0</td>
<td>67.3 SD 13.6</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Plus-minus task</td>
<td>22.1 SD 16.7</td>
<td>33.8 SD 24.5</td>
<td>.02</td>
</tr>
<tr>
<td>Plus-minus task</td>
<td>9.5 SD 5.0</td>
<td>19.0 SD 7.5</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Systolic blood pressure</td>
<td>120.8 SD 12.4</td>
<td>126.4 SD 14.4</td>
<td>.08</td>
</tr>
<tr>
<td>Diastolic blood pressure</td>
<td>77.0 SD 9.6</td>
<td>71.6 SD 9.2</td>
<td>.02</td>
</tr>
<tr>
<td>Heart rate</td>
<td>78.6 SD 10.9</td>
<td>73.7 SD 12.9</td>
<td>.08</td>
</tr>
</tbody>
</table>

Note. Plus-minus scores reflect difference between time to complete a page of alternating operations and that for a page of single operation arithmetic problems. Stroop scores reflect the difference between the time taken to name a page full of incongruent stimuli and that for a page of congruent stimuli.

### Figure 1

Mean performance on the letter-number sequencing (LNS) task as a function of age and objective task difficulty (i.e., set size).
SBP-R for the older adults beginning between set sizes 6 and 7 \((p = .003)\), whereas significant decreases between levels did not occur until set size 8 for the young \((p = .006)\). This provides support for the expectation that older adults would disengage from the task at an earlier level of objective task demand than would younger adults.

**Effects of subjective task demands.** We next examined the impact of subjective task demands on engagement. Of specific interest were responses to the mental demands and effort scales since these tapped into constructs most relevant to our conceptual framework. Correlations between the two ratings ranged from .63 to .93 across the eight levels of task difficulty, and the correlations between these two scales were higher at each set size than were those between ratings on any other two scales. Thus, we decided to form a composite index by standardizing scores for each scale and then obtaining the mean of the two resulting \(z\) scores at each level.

![Mean ratings by age group and objective task difficulty for each Task Load Index (TLX) subscale. The old group is represented by the dashed line.](image)

Table 2

<table>
<thead>
<tr>
<th>Effect</th>
<th>Mental demands</th>
<th>Physical demands</th>
<th>Temporal demands</th>
<th>Effort</th>
<th>Performance</th>
<th>Frustration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>46.85***</td>
<td>9.13***</td>
<td>32.86***</td>
<td>44.22***</td>
<td>45.19***</td>
<td>30.32***</td>
</tr>
<tr>
<td>Age</td>
<td>7.83*</td>
<td>10.49**</td>
<td>8.91*</td>
<td>9.26*</td>
<td>8.14</td>
<td></td>
</tr>
<tr>
<td>Difficulty_linear</td>
<td>11.85***</td>
<td>2.24**</td>
<td>7.81***</td>
<td>9.70***</td>
<td>11.86***</td>
<td>8.35***</td>
</tr>
<tr>
<td>Difficulty_quadratic</td>
<td>−0.06</td>
<td>0.18</td>
<td>0.19</td>
<td>0.19</td>
<td>−0.24</td>
<td>0.34*</td>
</tr>
<tr>
<td>Age (\times) Difficulty_linear</td>
<td>−2.34*</td>
<td>2.17</td>
<td>0.23</td>
<td>−0.70</td>
<td>−3.13*</td>
<td>0.47</td>
</tr>
<tr>
<td>Age (\times) Difficulty_quadratic</td>
<td>−0.35</td>
<td>−0.16</td>
<td>−0.06</td>
<td>−0.24</td>
<td>−0.15</td>
<td>−0.44*</td>
</tr>
</tbody>
</table>

*Note.* Scores on each scale could range from 0 to 100. MLM = multilevel modelling; TLX = Task Load Index.

\(p < .05\) \quad **p < .01\) \quad ***p < .001\).
of difficulty. These were then substituted for set size as a Level 1 predictor in our models. In addition to the significant age effect, $b = 6.08$, $t(72) = 3.51$, $p = .0008$, significant linear and quadratic effects of TLX scores were obtained: $b = -1.28$, $t(520) = -2.52$, $p = .01$, and $b = -8.4$, $t(520) = -2.15$, $p = .03$. Of greater interest was a significant Age $\times$ TLX quadratic interaction, $b = -1.48$, $t(520) = -2.61$, $p = .009$. Follow-up analyses using the older adults as the referent revealed that this interaction was because of the quadratic effect being much larger in this group, $b = -2.32$, $t(520) = -5.70$, $p < .0001$. Consistent with our predictions, older adults exhibit much stronger responsivity to changes in perceived task demands than do younger adults, in terms of both the initial response to increases in TLX scores (i.e., from 2 and 1 SDs below mean TLX) and the decreases (i.e., disengagement) observed at higher levels of perceived demands (i.e., 1 and 2 SDs above the mean; see Figure 4).

To more specifically investigate age differences in responsivity and disengagement, we examined the linear effects of TLX scores at each of the five points indicated on the abscissa in Figure 4. TLX was positively associated with SBP-R in the old group at both 2 and 1 SDs below the mean ($bs = 7.85$ and 3.77, respectively; $ps < .0001$), whereas the effects for the young group were not significant ($bs = 1.81$ and .40, respectively; $ps > .23$). The Age $\times$ TLX interactions were also significant at each point ($bs = 6.04$ and 3.37, respectively; $ps < .01$), indicating that the increases in responsivity with the increase in TLX were greater for the old than for the young. The impact of TLX became negative for both groups at mean TLX, although the effect was only significant for the young: young—$b = -1.27$, $p = .01$; old—$b = -.73$, $p = .15$. The interaction was not significant ($p = .44$), however, suggesting that the two age group were experiencing similar effects at this point. At 1 and 2 SDs above the mean, significant negative effects of TLX were found for both the young ($bs = -2.61$ and -3.47, respectively; $ps < .04$) and old ($bs = -4.87$ and -8.40, respectively; $ps < .0001$) adults. The Age $\times$ TLX interaction was only significant, however, at 2 SD above the mean $b = -4.97$, $p = .03$, indicating that although both age groups exhibited apparent disengagement, the degree of disengagement was considerably greater for the old at the highest levels of perceived difficulty.

To determine if age-related engagement patterns were differentially sensitive to the aspect of subjective workload being tapped by the TLX scales, we examined four additional sets of models in which the ratings of cognitive costs were systematically replaced with standardized ratings from each of the remaining four scales: physical demands, temporal demands, performance, and frustration. In contrast to the preceding analyses, the only significant effect involving age that emerged from these analyses was the main effect. Consistent with expectations, this suggests that age-related engagement patterns are specific to subjective perceptions relating to cognitive costs.

Finally, to determine the degree to which these subjective estimates of task demands contributed uniquely to the prediction of engagement, we repeated the above analyses including set size—linear and quadratic components—and their interactions with age as additional predictors. The linear and quadratic effects of set size continued to be significant, but the previously observed linear and quadratic effects of TLX scores now were no longer significant ($ps > .08$). Given that young adults comprised the referent group, these results indicate that controlling for objective task demands reduced the impact of TLX ratings on their engagement to non-significance. More important, the Age $\times$ TLX quadratic interaction continued to be significant in this model, $b = -1.89$, $t(516) = -3.04$, $p < .003$. Updating the model to make the older group the referent resulted in a significant quadratic effect of TLX scores, $b = -1.13$, $t(516) = -2.58$, $p = .01$, for that group. Thus, subjective perceptions of task difficulty were only predictive of engagement above and beyond the impact of objective task demands for older adults.

**Discussion**

Building on previous work examining adult age differences in the factors influencing cognitive engagement, we sought to explore

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*Figure 3. Estimated systolic blood pressure responsivity (SBP-R) as a function of objective task difficulty (i.e., memory-set size).*

*Figure 4. Estimated systolic blood pressure responsivity (SBP-R) as a function of composite Task Load Index (TLX) score (represented in terms of SDs from the mean). Note that objective task difficulty was not controlled for in calculating these estimates.*

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4 Similar effects were obtained when mental demand and effort scores were used individually as predictors.
the role of subjective perceptions of task difficulty. Research with younger adults suggests that they will expend effort in a given task to the extent that the task is perceived as worthwhile and they believe success is possible (for review, see Gendolla et al., 2012). We investigated the possibility that perceptions of task difficulty may vary with age, and that these perceptions may play an important role in determining individual and age differences in levels of effort expenditure.

In addressing our first research question, we observed that ratings on all six dimensions of the TLX were systematically related to objective task demands in both age groups. In addition, and consistent with expectations, older adults had generally higher ratings relative to younger adults on the four dimensions thought to specifically tap into experienced task demands—mental demands, temporal demands, physical demands, and effort. We had further speculated that the differences between groups would be greatest for subjective perceptions of cognitive costs (i.e., effort, mental demands) as conceptualized within SET, but there was little evidence that age effects varied dramatically across these four TLX dimensions.

However, in line with expectations associated with our second research question, we did find that subjective perceptions of effort and mental demands were predictive of engagement, whereas other perceived aspects of workload associated with the task were not. In addition, these ratings were more predictive of engagement in older than in younger adults in that subjective perceptions predicted performance only in the former group when objective task demands were controlled. For older adults, SBP responses increased initially as ratings of task demands increased, suggestive of intensification of effort expenditure with subjective perceptions of difficulty. SBP decreased, however, at high levels of perceived difficulty, a trend that we interpret as disengagement from the task (e.g., Richter, Friedrich, & Gendolla, 2008; Wright, Dill, Geen, & Anderson, 1998) as older adults’ perceptions of their ability to be successful decrease at high levels of perceived task demands. In contrast, objective task demand (i.e., memory set size) was the primary predictor of younger adults’ level of engagement.

These two sets of results are generally consistent with SET (Hess, 2014), which assumes that cognitive costs are important determinants of engagement and that age-related increases in such costs influence levels of engagement in cognitively demanding tasks. Using SBP response as a reflection of resource mobilization, we extended prior findings (Ennis et al., 2013; Hess & Ennis, 2012) of an age-related increase in effort across all levels of objective task demands to a working memory task. The present study further expands upon this previous work by illustrating the role played by specific subjective perceptions of task demands that are reflective of the costs of cognitive engagement. Age differences in these perceptions appear to capture the hypothesized age-related increase in actual cognitive costs, suggesting awareness on the part of older adults of normative changes in demands on cognitive resources. More important, these perceptions of workload influence engagement above-and-beyond the impact of objective difficulty, and their accentuated impact on engagement in older adults suggests that subjective perceptions of task difficulty may be particularly influential on selection processes associated with engagement of cognitive resources. That is, not only are hypothesized actual physiological costs predictive of engagement, but also the additional meaning imparted by the individual to their experience and the task. This meaning, in turn, may be particularly important in determining level of engagement (and disengagement). Of specific relevance to SET is the fact that the ratings of task demands most predictive of engagement were those associated with mental demands and effort. Of the six TLX scales, these two dimensions appear most closely aligned with the SET-based conceptualization of the cognitive costs associated with performing cognitively demanding tasks, which are thought to both increase with age and impact engagement.

In conclusion, the present study provided new insights regarding factors that influence older adults’ engagement in and performance on cognitively demanding tasks. Consistent with previous research, older adults exhibited higher levels of effort than younger adults at all levels of objective task demands. We also demonstrated, however, that subjective perceptions of task difficulty varied with age and accounted for additional age-related variability in engagement. Older adults’ perceptions of task demands were not only sensitive to objective aspects of task demands (i.e., memory set size) in a manner similar to young adults, but they also appeared to incorporate the experience of their own efforts during task performance. This resulted in additional elevation of perceptions of demand, which could be interpreted as reflecting age-related normative trends observed for both effort expenditure and performance. Within SET, it is assumed that older adults incorporate the costs associated with engaging in a specific activity when calculating benefit/cost ratios that are ultimately used to determine engagement. Our finding that workload ratings predicted older adults’ level of effort expenditure independent of task difficulty suggests this cost calculation reflects not only objective aspects of the task, but subjective experiences associated with engagement as well. Although speculative, beliefs (e.g., control, ability) or attitudes about aging may influence perceptions of workload, thereby accentuating the impact of task difficulty on engagement. This also implies that individual differences in these factors may predict willingness to engage in cognitively demanding tasks in later life. A greater explication of these factors is essential to our understanding of the factors that affect older adults’ engagement in the types of activities that may be most beneficial for cognitive health in later life.

References


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