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Selective Engagement of Cognitive Resources: Motivational Influences on Older Adults' Cognitive Functioning

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Abstract

In this article, I present a framework for understanding the impact of aging-related declines in cognitive resources on functioning. I make the assumption that aging is associated with an increase in the costs of cognitive engagement, as reflected in both the effort required to achieve a specific level of task performance and the associated depletion or fatigue effects. I further argue that these costs result in older adults being increasingly selective in the engagement of cognitive resources in response to these declines. This selectivity is reflected in (a) a reduction in the intrinsic motivation to engage in cognitively demanding activities, which, in part, accounts for general reductions in engagement in such activities, and (b) greater sensitivity to the self-related implications of a given task. Both processes are adaptive if viewed in terms of resource conservation, but the former may also be maladaptive to the extent that it results in older adults restricting participation in cognitively demanding activities that could ultimately benefit cognitive health. I review supportive research and make the general case for the importance of considering motivational factors in understanding aging effects on cognitive functioning.

Keywords

aging; cognition; motivation; adaptation; selectivity; adult development

Aging is associated with normative changes in many aspects of cognitive ability, reflecting decrements in basic skills, such as processing speed, working memory, executive functions, and episodic memory (Braver & West, 2008; Luszcz, 2011). An important question guiding much research on aging concerns the impact of these changes on everyday behavior, with a clear expectation that such changes should be reflected in deficits in everyday functioning. In spite of good evidence that most individuals will experience some form of cognitive decline in later life, the linkages between these declines and everyday functioning in healthy

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Editor's Note

This article and the two that follow arrived independently at *Perspectives* and were handled by three different action editors. We place them together because they coalesce around the theme that cognitive aging does not only include the well-documented declines but also includes protective compensatory mechanisms. The latter should be taken into account when considering the potential vulnerabilities that might (or might not) result from cognitive aging.

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older adults are not always clear. In fact, anecdotal evidence suggests that many older adults living independently in the community function quite effectively in everyday life. In addition, although research has shown that everyday competence is related to cognitive ability (for a review, see Allaire, 2012), prediction from standard ability assessments is far from an exact science, and empirical evidence highlights the absence of strong relationships between age and performance in domains where cognitive ability would presumably form an important foundation (e.g., job performance; McEvoy & Cascio, 1989; Schmidt & Hunter, 1998). In a recent review, Salthouse (2012) explicitly addressed this issue by asking why there are not greater consequences of normative declines in cognitive ability on everyday behavior. He suggested that relatively stable levels of functioning may reflect several factors, including increased reliance on established knowledge, the fact that everyday functioning may not require maximal levels of performance, the contributions of noncognitive traits (e.g., personality) to success, and accommodations to changes in ability.

A more general perspective on the apparent disconnect between empirical studies of cognitive change and everyday functioning is that it is, in part, reflective of adaptive processes in later life, with ability being just one in a constellation of determinants of behavior (e.g., Hess & Emery, 2012). In this article, I focus on another potential determinant of behavior: motivation. Note that expected relationships between general ability assessments and everyday functioning are predicated, in part, on the assumption that not only is there an overlap in the cognitive skills underlying each but that the perceptions of the task and the motivation to do well are also relatively stable across individuals and performance contexts. Research on aging, however, is increasingly calling these assumptions into question (Blanchard-Fields & Hess, 1999; Carstensen, Mikels, & Mather, 2006; Hess & Emery, 2012).

In this article, I present a theoretical perspective that highlights motivation as an important moderator of age differences in performance across contexts. To preview, I argue that aging is associated with an increase in the costs of cognitive activity. These costs, in turn, are assumed to influence the motivation to engage in cognitively demanding activities, as reflected in selection processes associated with directing and energizing functions.

Selectivity as an Adaptive Process

Adaptive functioning in adulthood can be understood, in part, through motivated selection processes. Although these processes are not necessarily related to changes in overall ability, they are reflected in various aspects of cognitive activity. Specific selection processes related to the directing (i.e., choice of activities, focus on specific environmental stimuli) and energizing (i.e., effort expenditure or degree of engagement) functions commonly associated with motivation are of particular interest in this regard, and several examples of adaptive selection processes can be seen in the existing literature on adult development. Such selection effects may occur in conjunction with changes in chronic developmental goals (i.e., relatively stable goals associated with specific periods of life). For example, socioemotional selectivity theory (Carstensen, Isaacowitz, & Charles, 1999) suggests that an increasingly limited future time perspective in later life results in a heightened focus on emotional well-being, with older adults choosing social partners and selectively focusing on stimuli in a manner designed to promote positive affect (Reed & Carstensen, 2012; but see Isaacowitz & Blanchard-Fields, 2012).

More relevant to present purposes is the extent to which the resources supporting cognition influence selection processes through changes in motivation. One perspective on this relationship derives from the selection, optimization, and compensation model (e.g., P. B. Baltes, 1997). Specifically, it has been argued that declines in physical and cognitive resources that limit the availability of resources for acquiring new skills are associated with a shift from motives focused on growth in young adulthood to ones centered on maintenance or loss prevention in later life (e.g., P. B. Baltes, Staudinger, & Lindenberger, 1999; Freund & Ebner, 2005). Thus, older adults adjust goal priorities in response to changing life circumstances, selectively engaging in activities focused on supporting current levels of functioning. Age differences in cognitive engagement appear to be tied to these goals. For example, Freund (2006) observed that older adults exhibited higher levels of persistence on a simple sensorimotor task when the focus was on maintenance (i.e., instructions to match an earlier achieved level of performance) as opposed to improvement in functioning (i.e., instructions to do as well as possible). The opposite was true for younger adults.

Selection processes may also arise, however, through a more basic mechanism associated with variations in motivation to engage in effortful cognitive activity in response to changes in characteristics of the cognitive system. In contrast to the specific age-related goals associated with the aforementioned characterizations of adaptive functioning, a case may also be made for the influence of more global goals having to do with conservation of cognitive resources. Such goals may be operative across the life span, but specific factors associated with aging—most notably the increased costs of cognitive engagement—may increase their salience in later life as well as their role in determining age differences in cognitive functioning. Proceeding from this perspective, I present a theoretical framework developed to characterize the relationship among aging-related variations in cognitive resources, motivation, and engagement in cognitively demanding activities. The focus on this relationship has arisen in an attempt to explain findings from our lab that demonstrate greater variability in performance in later life across task conditions that are similar in difficulty but vary in motivational implications. I then trace the development of this framework primarily on the basis of research from our lab.

Aging, the Costs of Cognitive Engagement, and Motivation

The proposed framework is grounded in the relatively simple notion that aging is associated with an increase in the costs associated with engaging in cognitively demanding activity. Costs refer to the consequences of such activity and can be reflected in both physical (e.g., glucose depletion) and psychological (e.g., feelings of fatigue) processes. In our research and theorizing, we have envisioned costs primarily in terms of effort expenditure and fatigue. Effort in this context is defined in terms of purposeful investment of mental energy, whereas fatigue reflects depletion of resources supporting performance (e.g., Wright & Stewart, 2012). Theories of cognitive energetics (see Tomporowski, 2008) suggest that effort and fatigue are both grounded in physiological processes (e.g., physical capabilities, sensory functions, cortical functioning), which, in turn, are negatively affected by aging processes.

Finally, I also assume that individuals monitor these costs at some level and that age differences in perceptions or experiences of these costs affect the motivation to engage in effortful cognitive activity. These motivational effects are hypothesized to have at least two specific results.

First, normative increases in the costs associated with effortful cognitive activity in later life will result in a general reduction in the intrinsic motivation to engage in activities that put demands on cognitive resources. This reduction in motivation results in a general decrease in involvement in such activities in everyday life. In other words, the age-related increase in costs is associated with a general decline in participation in cognitively demanding activities, with the effect being mediated by changes in intrinsic motivation.

Second, I assume that the selectivity associated with cognitively demanding tasks is moderated by situational factors. Specifically, the greater costs associated with cognitive engagement in later adulthood will also increase the salience of the self-related implications (e.g., perceived benefits) of a given task, resulting in self-relevance having a disproportionate influence on engagement in later life. This increased effect of self-relevance in later life is at the heart of the *selective engagement hypothesis* that we have put forward in earlier articles (e.g., Hess, 2006; Hess & Emery, 2012), and the associated selectivity can be thought of as having adaptive consequences whereby older adults maintain engagement and high levels of functioning in important realms. Thus, I hypothesize that the self-related implications of a given task will interact with age in determining engagement, with the effect of factors such as personal relevance, self-presentation concerns, meaningfulness, and so forth being greater in older adults relative to younger and middle-age adults.

In the following sections, I present evidence relating to both the assumptions underlying the proposed framework (e.g., aging is associated with increased costs associated with cognitive performance) and specific hypotheses (e.g., older adults are more selective in task engagement). Note that *effort* and *engagement* are used relatively interchangeably throughout the article, reflecting the assumptions that engagement of cognitive resources requires the expenditure of mental effort and that degree of effort expended is a measure of engagement. Given these assumptions, engagement is viewed as cognitively demanding and is assessed by measures reflective of such demands. Note also that engagement in the present context is viewed from the perspective of the individual and may not necessarily reflect successful engagement with the task. That is, primary interest is in factors associated with degree of engagement of cognitive resources as individuals attempt to perform a task, independent of the degree to which these attempts result in successful performance.

Selective engagement of resources

In our lab, older adults serving as participants occasionally remark that their performance was probably poor because they did not care about the task. One interpretation of such comments is that these older individuals are trying to save face, and such statements represent a means of preserving their self-concept following public demonstrations of poor performance. An alternative interpretation is that this comment is a reasonably accurate characterization of adaptive mechanisms designed to conserve resources and maximize performance in valued activities. A central aspect of the present framework is the notion that the increased costs of effortful cognitive activity motivate older adults to be more selective than younger adults regarding the situations in which they will engage their cognitive resources. This selectivity is adaptive in terms of both (a) conserving cognitive resources and (b) maintaining levels of performance in important areas of function. This difference in engagement across contexts on the basis of self-relevance may, in turn, account for some of the previously discussed observations regarding the unexpectedly weak relationships between age and performance in meaningful everyday contexts.

One way in which we initially studied this aspect of selective engagement in our lab was by assessing the degree to which age moderates the effect of experimental manipulations of, or self-reports relating to, personal relevance or engagement in effortful cognitive activity. If personal relevance plays a stronger role in motivating behavior in older adults—as reflected in resource engagement—then relevance should be more strongly related to performance in older than in younger adults, with age differences attenuated as relevance increased. Assuming that a given task is within the capabilities of the individual, this relationship can be thought of in terms of the costs of cognitive activity moderating the slope of the function relating the degree of engagement to personal relevance: the greater the costs, the steeper the slope. Note here that not all experimental manipulations that differentially influence older versus younger adults' performance are relevant to the present perspective. For example, there are many cases in the literature in which providing guidance regarding memory strategies has a disproportionate benefit for older adults (for a review, see McDaniel, Einstein, & Jacoby, 2008). Although such effects may reflect increased effort, they may also simply reflect improvements in the effectiveness of strategies used by older adults. Thus, in the present context, primary interest is in situations in which experimental conditions affect engagement without providing guidance regarding specific processing strategies. Using the just-described strategy, we and other researchers have obtained evidence consistent with the notion of age-related selective engagement in a variety of tasks.

Person memory—In one set of studies from our lab, we focused on memory for behavioral information about people. Research with younger adults has shown an *inconsistency effect* in recall, such that behaviors that are inconsistent with a general impression of a person are remembered better than impression-consistent behaviors. This memory advantage for inconsistencies reflects the more extensive processing that such information receives as individuals attempt to reconcile the inconsistency (e.g., Hastie, 1984; Srull & Wyer, 1989). In earlier work, we observed that older adults were less likely to exhibit this effect, suggesting that their memory was more schema-dependent and that they were not engaging in the effortful encoding operations necessary to support memory of inconsistent or atypical behaviors (for a review, see Hess, 1990). We also observed, however, that older adults were capable of engaging in such processing; they were just less consistent in doing so (Hess & Tate, 1991). To examine the role of motivation in determining performance, we (Hess, Rosenberg, & Waters, 2001) had adults who were 20 to 83 years of age form an impression of either a young adult describing his experiences in his first job or an older adult describing his exploration of retirement housing. This variation in target descriptions was intended to serve as a manipulation of personal relevance to young versus older adults. The extent to which participants were held accountable for their responses was also manipulated by requiring them to either share their written impressions with other study participants in the same session, who then judged their accuracy (*high accountability*) or not (*low accountability*). When memory was tested under low-accountability instructions, the size of the inconsistency effect in memory for behavioral information decreased with increasing age (i.e., older adults were less likely to engage in inconsistency resolution), thereby replicating our previous findings. In contrast, this interaction was nonsignificant under high-accountability instructions, with the size of the (significant) inconsistency effect being constant across the age-range tested. Accountability has been shown to increase cognitive engagement (see Lerner & Tetlock, 1999), and it is assumed to do so by making self-presentation concerns salient. In this study, the accountability manipulation was focused on a skill (i.e., making social judgments) for which older adults have been shown to be quite adept, and for which there is no negative aging stereotype. Thus, the differential influence of accountability across ages is suggestive of older adults being more selective in engaging resources to support effortful cognitive operations.

We found further support for selective engagement in the same study when impression judgments were examined. Participants of all ages were more likely to ascribe positive than negative traits to the targets, reflecting the greater amount of positive versus negative behavioral information presented in the scenarios. However, younger adults were also more likely to ascribe traits that had specific behavioral referents in the target descriptions than those that did not, regardless of the target's age. This result suggests that in addition to the more general processing of evaluative information associated with behavior valence, younger adults also engaged in more effortful processing associated with inferring specific personality characteristics about the target from these behaviors. In contrast, this latter type of processing in older adults was related to the age of the target, with more specific trait attributions being made to the older than to the younger target. This selectivity once again supports the idea that older adults will be disproportionately more likely to engage resources in situations that are personally meaningful.

One concern that can be raised here relates to the validity of making inferences about resource engagement based on performance outcomes, which are not optimal indicators of effort expenditure. Effort may contribute to task performance by, for example, increasing level of involvement, maintaining task focus, or facilitating controlled processing. It is also true, however, that increased effort may not result in better performance. In several studies, we attempted to address this issue by examining process-level factors as opposed to performance outcomes, on the basis of the assumption that effort would be, in part, reflected in more efficient operation of basic controlled processing mechanisms.

One such study (Hess, Germain, Swaim, & Osowski, 2009) was a follow-up to our examination of person memory, in which we attempted to examine process-level effects using Jacoby's (1998) process-dissociation procedure. Through the use of specialized memory tasks, this procedure provides estimates of the independent influences of automatic versus effortful recollection processes on memory performance. We once again examined age differences in person memory under conditions of high versus low accountability, with particular interest in the degree to which age and accountability influenced recollection estimates. As expected, memory for inconsistent behaviors depended more on effortful

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recollection than did memory for consistent behaviors, and older adults exhibited lower levels of effortful recollection overall than did younger adults. Further, the effect of accountability was disproportionately stronger for older adults, with effortful recollection of inconsistencies being significantly higher under high-versus low-accountability instructions. Accountability had little influence on younger adults' performance or on the contributions of automatic memory processes to performance, regardless of age. Thus, this study provided evidence not only for selective engagement but also for its effect on age differences being observed primarily in the use of more demanding cognitive operations.

Attitudes—We have also examined the interplay between age and motivation in several studies in which the construction of attitudes was studied. In one study (Hess, Germain, Rosenberg, Leclerc, & Hodges, 2005, Experiment 2), we asked younger (22–46 years of age) and older (61–82 years of age) adults to evaluate pieces of legislation purportedly being considered in the state of North Carolina. In each case, the description of the legislation was preceded by the participant reading a "newspaper article" that provided either a positive or negative characterization of the legislator proposing the bill, which, in turn, served as an evaluative prime. It is important to note that the content of this article was irrelevant to the actual legislation. The extent to which participants were able to suppress this irrelevant evaluative information when constructing their attitudes was of primary interest, with such control assumed to be reliant on engagement of cognitive resources. We found that adults of all ages evaluated the legislators in a similar manner. However, this evaluative prime only affected the judgments of older adults, who exhibited higher levels of assimilation to the prime in their attitudes about the proposed legislation (i.e., the legislation was evaluated in a manner that was consistent with the valence of the prime). Significantly, this age-related assimilation effect was eliminated when the legislation being considered was rated by the participants as being high in personal relevance. In another study, in which a somewhat different task was used, high levels of social accountability attenuated age differences in source memory and the associated impact of to-be-ignored information on impression judgments (Chen, 2004).

In other research (Hess, Leclerc, Swaim, & Weatherbee, 2009), we examined the extent to which judgments about people (Experiment 1) or consumer products (Experiment 2) were influenced by relevant, but difficult to process, information (e.g., information quality) or by less relevant, but easily processed, information (e.g., quantity of information). Consistent with expectations drawn from the literature on cognitive aging, we observed that the attitudes of older adults were less influenced by the more difficult to process information than were those of younger adults. More important, self-reported interest in the task moderated age effects on performance. Specifically, the level of older adults' interest was positively associated with their degree of focus on difficult to process information. For example, in judging the guilt of an individual, older adults reporting high levels of interest increased the weight of the quality of evidence relative to quantity in making their assessment. Similar to younger adults, the judgments of these individuals were also less affected by self-reported interest. Thus, in line with our work on person memory, we obtained support for selective engagement by demonstrating that self-relevance or interest in the task—as reflected primarily in self-reports—had stronger effects with increasing age, and that greater interest in the task was associated with performance suggestive of more effortful processing.

Distractibility—As noted before, a critical piece of evidence in support of selective engagement relates to data demonstrating that age not only moderates performance outcomes but also the processes underlying those outcomes, such as executive functions. One component of such functioning has to do with inhibitory skills, which have been argued not only to decline with age but also to underlie changes in performance on a variety of tasks (Hasher, Zacks, & May, 1999). For example, older adults exhibit a disproportionate degradation in reading speed in the presence of distracting text (e.g., Carlson, Hasher, Connelly, & Zacks, 1995), particularly when it is meaningful in nature (e.g., words vs. strings of *X*s). This differential effect of distracting material across ages suggests that the efficiency of processing is disrupted by older adults' reduced ability to ignore irrelevant information. In three studies using a similar task (Germain & Hess, 2007), we found that older adults' reading speed and memory were significantly improved, and that age differences in performance were attenuated, when the passage content was relevant to their age group. (The distracting words were identical across texts and did not vary in age-relevance.) In other words, the processing efficiency of older adults was improved when personal relevance of the task was increased. The age-relevance of the content had a much weaker effect on the performance of younger adults. This finding is consistent with my proposed framework regarding age-related selective engagement of resources. In all three experiments, participants' ratings of personal relevance were in line with a priori determinations of the age-relevance of the passages, meaning that perceptions of personal relevance were differentially related to performance across age groups.

Information search—Another source of support for selective engagement comes from a study on decision making, in which young and older adults were asked to choose among eight alternatives (e.g., different cell phone plans). Information for each alternative was provided pertaining to six different attributes (Hess, Queen, & Ennis, 2013). We were interested in whether personal relevance and accountability influenced the complexity of information search (e.g., study time, amount of information sampled) prior to making a decision. As before, we found that accountability had a disproportionate influence on older adults' behavior, with search complexity— assumed to be related to effortful processing— being significantly greater under high-than under low-accountability conditions. In addition, personal relevance exacerbated this age effect, reflecting the combined effects of our two motivational manipulations.

Cardiovascular responses—We have recently begun to assess age differences in cognitive engagement by examining interactions between age and task demands in determining cardiovascular response. Research with young adults has demonstrated that aspects of cardiovascular response can be used as an alternative—and perhaps more direct—index of engagement. Behavioral systems require energy, making demands on the cardiovascular system (Kelsey, 2012). The energy requirements of the brain in particular account for a significant proportion of resting metabolic state (20%–30%; Saravini, 1999). Significantly, the brain has limited capacity to store energy and, thus, depends on energy substrates (e.g., glucose, oxygen) supplied by the bloodstream, and mental effort is associated with autonomic activation to support cerebral activity. Notably, this support is achieved primarily through control of blood pressure (Fairclough & Mulder, 2012).

Building on Obrist's (1981) active coping hypothesis, systolic blood pressure (sBP) has frequently been used as an index of engagement because of the fact that it is determined by myocardial contractility, which, in turn, is dominated by the sympathetic nervous system (Berntson, Quigley, & Lozano, 2007). A relatively coherent body of work across a variety of contexts supports the notion that sBP reflects task engagement (for reviews, see Gendolla & Wright, 2005; Wright & Gendolla, 2012) in that it exhibits systematic fluctuations in response to a variety of motivational factors. Sensitivity of sBP to context is also relatively well-preserved in later life (for a review, see Uchino, Birmingham, & Berg, 2010), with the range of sBP responses being less affected by age-related changes in physical structures than other measures sometimes used to assess engagement, such as heart rate (e.g., Turner, Mier, Spina, Schechtman, & Ehsani, 1999) and pupillometric response (e.g., Van Gerven, Paas, Van Merriënboer, & Schmidt, 2004). This maintained sensitivity and range of response potentially allow more direct comparisons across age groups (Hess & Ennis, in press).

On the basis of this information, we have used sBP responses to investigate age differences in motivational influences on engagement in two separate studies. In each one, community-residing young (20–40 years of age) and older (64–85 years of age) adults were given a memory-search task, during which sBP was collected continuously. Consistent with the selective engagement perspective, we found that sBP response (i.e., change from baseline) was greater for those reporting high levels of engagement in the task, with this effect being disproportionately greater for those in the older group (Ennis, Hess, & Smith, 2013). Similarly, we also found that sBP varied as a function of an experimental accountability manipulation that was designed to affect engagement, with the impact of this manipulation being significantly greater in the older than in the young group (Smith & Hess, 2013). Analyses of sBP in these studies controlled for possible confounds associated with potential differential response associated with baseline blood pressure and use of hypertension medication. In addition, participants in both age groups reported very low levels of stress and threat associated with the test session, thereby ruling out age differences in response to the test session as a potential alternative explanation. Finally, the observed age effects were related not only to experimental manipulations designed to affect motivation but also to self-reported engagement in the task. Thus, the results of these studies provide further support for the hypothesized age-related selectivity effects in which a measure of engagement reflecting activation of the sympathetic nervous system is used.

Other research—In the foregoing sections, I focused primarily on research conducted in our lab. Support for age-related selective engagement has also been found by other researchers in a variety of situations that involved manipulations designed to affect involvement as opposed to directing processing. In several recent studies, researchers have observed that task incentives have a disproportionate effect on older adults' performance. Specifically, age differences in a visual discrimination task were attenuated for stimuli associated with both positive and negative incentives (Spaniol, Voss, Bowen, & Grady, 2011), and older adults' use of an appropriate memory retrieval strategy was found to be more influenced by monetary incentives than was that of younger adults (Touron & Hertzog, 2009; Touron, Swaim, & Hertzog, 2007). Relatively few other researchers have examined how monetary incentives moderate age differences in performance, and such age-related, incentive-based effects are not always observed (e.g., Strayer & Kramer, 1994). This inconsistency in incentive-based effects may reflect a contrast with the more intrinsic personal relevance factors highlighted in the previous sections, with monetary incentives perhaps being less likely to lead to selective engagement unless they are interpreted in a personally meaningful fashion. Indeed, some research suggests that age differences in income lead older adults to devalue monetary incentives (e.g., Westbrook, Kester, & Braver, 2013), potentially decreasing their impact on performance.

Some studies have also observed that personal relevance moderates aging influences on memory performance. For example, age differences in memory are smaller for pictures that participants rated as personally relevant than for those rated as irrelevant (Tomaszczyk, Fernandes, & Macleod, 2008). The relevance of the task—as reflected in consistency with age-related social goals—has also been found to influence memory performance. For example, in one study, Adams, Smith, Pasupathi, and Vitolo (2002) found that older adults were more sensitive than younger adults to the testing context and that age differences in story recall observed under standard laboratory test conditions were attenuated when participants were instructed to tell the story to a young child. This latter situation is consistent with the knowledge transmission goal that is often associated with old age (e.g., Mergler & Goldstein, 1983).

Finally, in a somewhat different context, age-related selectivity effects have also been observed in two perspective-taking tasks that are commonly associated with age-related deficits in performance: emotion recognition and theory of mind—as assessed by the *faux pas* task (Zhang, Fung, Stanley, Isaacowitz, & Ho, 2013). In this latter task, recognition of inappropriate statements made in a social context is assessed, which requires assuming the perspective of other actors in that same context. For both tasks, a prime designed to promote closeness by highlighting the similarity of the participant with either the experimenter (theory of mind) or stimulus faces (emotion recognition) eliminated age differences observed in a control condition. In addition, promoting closeness increased the time that older adults spent viewing the stimuli, suggesting that the increased personal relevance associated with the target stimuli increased task engagement, which, in turn, facilitated recognition accuracy.

Discussion—Evidence consistent with the notion of age-based, situation-specific selective engagement has been obtained across a variety of tasks and outcome measures both in our lab and elsewhere. Note that selectivity effects are not specific to later life and can be seen in younger adults for whom, for example, personal relevance is positively related to engagement (e.g., Petty & Cacioppo, 1984). The studies reviewed here, however, suggest that task factors that relate to the personal meaning of the task—broadly defined—have a stronger influence on behavior in older than in young and middle-age adults. These effects were observed not only on task performance but also on process-related measures that may reflect degree of engagement more directly. The variability in performance across contexts is based on factors that have their primary impact on engagement or interest in the task (e.g., accountability, personal relevance) as opposed to experimental manipulations that provide guidance regarding processing. Thus, the observed age differences reflect the disproportionate importance of task relevance in determining the behavior of older adults rather than the attenuation of age differences brought about by contexts designed to compensate for age-related deficits in underlying cognitive processes.

The observed relevance effects also cannot be simply attributed to familiarity or knowledge, given that they were observed over a variety of conditions and that they are often observed when task content is held constant across experimental conditions (e.g., levels of accountability). Finally, the selective engagement effects were obtained not only in response to experimental manipulations of motivation (e.g., accountability) but also with respect to self-reported motivation. In addition, using manipulation checks in many of our studies (e.g., Germain & Hess, 2007; Hess et al., 2005, 2013), we found that the experimental conditions were associated with subjective ratings of personal meaningfulness or engagement, supporting their validity in reflecting some aspect of self-relevance.

Mechanisms underlying selective engagement

What then might be the specific mechanisms underlying these observed age-based selection effects on engagement of cognitive resources? One possibility is that the complexity of the tasks was more likely to tax older adults' resources than those of younger adults, thereby increasing the effects of self-relevance in later adulthood. Alternatively, younger adults may already be performing close to ceiling, leaving little room for variations in performance associated with motivational factors. Both possibilities suggest that the observed effects associated with age may just represent special cases of a more general ability-based phenomenon. However, although it is certainly true that under typical task conditions, demands are less likely to tax younger adults' cognitive resources, two observations provide evidence against a general ability-based explanation. First, in some studies (e.g., Hess et al., 2001; Hess, Leclerc et al., 2009), we have specifically examined the influence of ability on performance and found that the obtained age-related selectivity effects either were not moderated by ability or remained after controlling for individual differences in ability. Second, in those studies that included objective indices of performance that could be measured on some absolute scale (e.g., proportion of information recalled), younger adults were performing well below ceiling (e.g., Hess et al., 2001). Thus, age differences in ability relative to task demands do not appear to fully explain selectivity effects.

I propose an alternative explanation based on age differences in the costs of engaging in cognitive activity. The motivation to engage in specific activities is determined, in part, by perceptions of the benefits of engagement relative to the costs, as reflected in benefit–cost ratios (BCRs). Nonengagement occurs when BCRs fall below an individual's threshold of engagement or the point at which the costs no longer justify expenditure of resources. With this framework, age-related increases in the costs of cognitive activity (e.g., effort requirements, fatigue) may affect selection in at least two ways. First, at any given level of perceived benefit, the greater costs in later life will result in lower BCRs. This, in turn, reduces the probability that tasks with minimal-to-moderate perceived benefits will exceed the threshold of engagement for older adults (see Figure 1). Second, adjustments in the threshold of engagement may also occur, with older adults exhibiting increases in the criterion (i.e., minimum BCR) necessary to justify expenditure of cognitive resources. This adjustment can be thought of as a reflection of intrinsic motivation to engage in cognitively demanding activities, with reductions in motivation associated with elevated thresholds. Together, these two processes would account for both a general reduction in activity participation—through the reduction in the engagement threshold—and a reduced likelihood of engaging in low-benefit activities—through the change in BCRs—in later life.

The costs of cognitive engagement

The foregoing explanation for selectivity effects is based on the assumption that the costs of cognitive engagement increase in later adulthood. As indicated before, costs in the present context are considered primarily in behavioral terms, focusing on the effort that must be expended to perform a given task and the subsequent effects associated with depletion of resources (e.g., fatigue) following sustained effort. I assume that the cognitive effort required to achieve an objective level of task performance is disproportionately greater in old age and that fatigue effects associated with effort expenditure are also higher. This latter effect is, in part, due to the greater effort required by older adults to support performance, but it may also relate to age-related degradations in the physiological mechanisms associated with replenishing resources.

Behavioral evidence—The assumption that costs are greater for older adults is consistent with Craik's (1986) seminal conceptual framework for understanding the effects of aging on memory. He argued that aging was associated with a decline in cognitive resources, which, in turn, leads to decrements in older adults' performance in situations that require the use of self-initiated memory operations. On the basis of this perspective, for example, age decrements would be expected to be more prevalent in free recall tasks than in recognition tasks, reflecting relative differences in the use of active versus passive encoding or retrieval processes to support performance. The notion of self-initiated processing implies that the relative effort associated with memory processing increases with age, with support coming primarily from studies demonstrating that older adults are disproportionately affected by cognitive load or conditions of low environmental support (Craik & Anderson, 1999; Verhaeghen, Steitz, Sliwinski, & Cerella, 2003).

Several other types of behavioral evidence are consistent with an age-related increase in the costs of cognitive activity. For example, studies have shown that the increased effort required by older adults to process sensory information has a negative effect on memory performance (e.g., Murphy, Craik, Li, & Schneider, 2000; Tun, McCoy, & Wingfield, 2009). In this case, normative declines in sensory systems in later life appear to increase the cognitive resources required for the registration of information, resulting in depletion of resources necessary for subsequent encoding and retrieval operations. Vigilance research also finds that older adults' subjective ratings of workload (e.g., physical and mental demands) increase more than do those of younger adults over time, even in the absence of age differences in performance (Bunce & Sisa, 2002; Deaton & Parasuraman, 1993). In other words, even in the absence of changes in objective difficulty, older adults perceive the demands of the task increasing over time to a greater degree than do younger adults. This disproportionate increase in older adults' perceptions of workload can be viewed as reflecting greater fatigue or depletion effects, providing support for the notion that sustained engagement of cognitive resources in support of a specific objective level of performance is more consequential in later life.

A creative study by Westbrook et al. (2013) used an economic analysis to examine age differences in the perceptions of effortful cognitive activity, in the form of an *n*-back task. They found that older adults had lower subjective values for rewards associated with performance at all levels of task difficulty and that these subjective values decreased more quickly than they did for younger adults as difficulty increased. In other words, older adults required greater incentives for performing a difficult task than did younger adults, suggesting greater subjective perceptions of the costs of cognitive activity as we age.

Physiological evidence—Several types of physiological data can also be interpreted as being consistent with aging being associated with increased costs of cognitive activity. For example, older adults have been found to have stronger cortisol responses following a cognitive challenge than younger adults (e.g., Neupert, Soederberg, & Lachman, 2006; Steptoe, Kunz-Ebrecht, Wright, & Feldman, 2005), and they are also slower to recover from such stress-related responses (e.g., Seeman & Robbins, 1994). There is also evidence—primarily from animal studies— that glucose utilization in the brain during effortful memory activity is less efficient in later life, and restoration of blood glucose levels is more problematic (for a review, see Gold, 2005). These findings suggest that the physiological mechanisms supporting cognitive activity may be less efficient and that recovery from such activity (i.e., depletion effects) takes longer in later adulthood.

Neuroimaging research is also suggestive of older adults having to engage more resources to achieve the same levels of performance as younger adults (e.g., Cabeza et al., 2004; Cappell, Gmeindl, & Reuter-Lorenz, 2010), with more widespread cortical recruitment in older adults to achieve comparable levels of performance with young adults often being viewed as compensatory (Park & Reuter-Lorenz, 2009). However, such overrecruitment can also be viewed as an increased cost of cognitive activity in later life. For example, Cappell et al. (2010) demonstrated that, as demands of a working memory task increased, older adults recruited the same cortical resources as younger adults, but they did so at lower levels of task difficulty. This overrecruitment on the part of older adults at a given level of task difficulty could technically be viewed as a compensatory process. However, compensation is typically characterized as dealing with a deficit in which alternative (i.e., qualitatively different) means to support performance are used (Bäckman & Dixon, 1992). The similarity in underlying processes observed across age groups by Cappell et al. (2010) suggests that the same mechanisms are operative in supporting performance in younger and older adults as objective task difficulty increases; older adults are just engaging these resources at lower levels of task difficulty. Thus, this pattern of age difference can reasonably be characterized as reflecting the increased costs associated with achieving an objective level of performance in later life rather than a qualitative shift in processing.

Cardiovascular responses—Building on the earlier discussion, cardiovascular responses—with a particular focus on sBP—may be particularly useful for assessing age differences in the costs associated with cognitive activity. Increases in sBP have been shown to be associated with level of motivation, suggesting that it can be a reliable measure of engagement. Building on theoretical work by Obrist (1981) and Brehm and Self (1989), Wright (1996) has argued that sBP should also increase with task difficulty as long as the individual is motivated (i.e., perceives the task to be worthwhile) and believes successful performance is within his or her capabilities. Controlling for motivation and beliefs about ability should then allow some degree of assessment of individual differences in the effort required to perform at a specific level of objective task difficulty. There is substantial work supporting this perspective with younger adults (for a review, see Gendolla & Wright, 2005). sBP response can also be used to assess depletion or fatigue effects.[1] For example, sBP response on a subsequent task increases as the demands associated with an initial cognitive task increase (e.g., Wright et al., 2007; Wright, Stewart, & Barnett, 2008). This increase in response can be interpreted as representing fatigue, reflecting the increase in cognitive demand and additional effort needed to support performance following sustained cognitive engagement. This effect is similar to that in the physical domain. Specifically, when one engages in physical activity, muscles become fatigued, with individuals having to work harder to perform a subsequent physical task than they would have had they not engaged in the initial activity. The analogous increase in sBP can be viewed as a response to depletion of those resources necessary for actively coping with a cognitive challenge.

Although there has been little systematic aging research with sBP as an index of cognitive effort, in a meta-analysis, Uchino et al. (2010) found that aging is associated with an increase in sBP response to emotional challenges and that this age difference increases with the degree of active coping required by the task. In an attempt to build on the work with younger adults, we have recently conducted two studies in which we more systematically examined age differences in sBP responses in relation to task demands. If my ideas about aging and costs are correct, we would expect that (a) older adults will exhibit higher levels of effort (i.e., sBP response) at all levels of objective task difficulty; (b) this age effect will increase as difficulty increases; and (c) the effects of sustained engagement (i.e., depletion effects) will be more consequential for older adults, reflected in greater effort required to perform a subsequent task.

In our initial study (Hess & Ennis, 2012), we focused on the effects of age and task demands on effort and fatigue. Young (19–45 years of age) and older (62–84 years of age) adults engaged in an easy or difficult task for 5 min, followed by engagement in an additional, moderately challenging task for another 3 min. Consistent with expectations, older adults exhibited greater sBP response at each level of difficulty in the initial task, supporting our contention that they need to exert greater effort than younger adults to achieve a similar level of objective task performance. We also found that older adults' responses were disproportionately affected by task difficulty. When responses were examined in the second task, sBP responses increased in both age groups, with the increase being greater in those participants who had engaged in the difficult task first. For all participants, effort expenditure (as reflected in change in sBP from baseline) in the first task was positively associated with amount of effort exerted in the second task. Further, older adults exhibited

[1]Note that, depending on the context and other variables controlled, sBP can reflect multiple components of the proposed framework —including level of motivation, effort expended, and the costs of engagement—and thus is a relatively nonspecific indicator.

higher levels of sBP response in the second task than did younger adults, but the age effect was accounted for by age differences in effort in the first task. These latter two findings support my hypotheses that aging is associated with increases in depletion or fatigue effects (i.e., the relative increase in sBP following sustained vs. no or minimal engagement in a previous task) and that this increase is related to the greater levels of initial effort older adults need to expend to achieve performance comparable with younger adults.

A second study (Ennis et al., 2013) provided further evidence regarding the costs of cognitive engagement. Younger and older adults performed a memory search task in which the memory load was varied from 2 to 10 items. Once again, older adults exhibited greater SBP response at all levels of task difficulty, which can be viewed as reflecting a general increment in sympathetic activation associated with task engagement. We also found that older adults reported higher levels of subjective task difficulty than did younger adults, with these difficulty ratings predicting sBP responses. This relationship among age, perceived task difficulty, and sBP supports the notion that age differences in effort will be reflected in perceptions of costs. Finally, sBP responses increased for both age groups with task demands at the lower levels of task difficulty, and the slope of this function was greater for older adults. However, both groups exhibited a decrease in responses at the highest levels of difficulty, but this decline started at a lower level of difficulty for older adults. Previous work has demonstrated that such declines in sBP reflect disengagement as task demands begin to exceed individuals' perceived capabilities (e.g., Gendolla & Krüsken, 2001; Wright & Dill, 1993). Given that a similar effect was observed for performance (i.e., age-related decrements in accuracy were especially large at the highest levels of task difficulty), we interpreted the earlier tailing off of sBP responses in older adults as reflective of task demands exceeding capabilities at lower levels of difficulty relative to younger adults.[2] Cappell et al. (2010) observed a similar pattern of data in their study, with older adults exhibiting higher levels of cortical activation at moderate levels of task difficulty than younger adults, and lower levels of cortical activation at high levels of difficulty.

Related results were also obtained in a recent study by Schapkin, Freude, Gajewski, Wild-Wall, and Falkenstein (2012). Using an *n*-back task, they found that older adults exhibited stronger increases in sBP response than did younger adults as the working memory demands of the task increased. They also found that recovery—as reflected in return of sBP to baseline—was diminished in older adults (see also Steptoe et al., 2005).

These studies provide support for the validity of sBP as a means of assessing the costs (i.e., effort, fatigue) of cognitive activity in older adults and its potential utility for examining age differences therein. A potential obstacle for both of these research objectives, however, is the possibility that the observed age effects simply reflect increased reactivity to stressors in older adults (e.g., Uchino, Holt-Lunstad, Bloor, & Campo, 2005). Several findings, however, do not support this interpretation. First, SBP responses were systematically associated with task demands—both objective and subjective—and were observed to diminish at high-

[2]Note that older adults continued to exhibit higher sBP responses as a group even at the highest levels of difficulty. This, along with continued relatively high mean levels of performance (i.e., accuracy), indicates that the decreasing trend in sBP response reflected inconsistent engagement or an increase in the proportion of participants disengaging.

difficulty levels, in which individuals might withdraw effort because of increases in the BCRs. Stress responses would be expected to be relatively constant rather than displaying such systematic relationships to task variables. Second, in studies in which subjective ratings were also obtained (e.g., Ennis et al., 2013), there was little evidence that either young or older adults reported being particularly stressed or concerned about being evaluated. Instead, participants reported moderate levels of challenge, with older adults reporting greater levels—a finding consistent with present ideas regarding age differences in the costs associated with achieving a specific level of performance. Finally, the testing contexts in these studies are dissimilar to those used in studies of stress reactivity, in which factors such as time pressure or competition are routinely employed. Consistent with the just-discussed subjective reports, the tasks used in the reviewed studies were designed to represent cognitive challenges that were within the capabilities of both younger and older adults. Although the work regarding sBP responses is promising, more research certainly needs to be done with sBP response as a measure of engagement, particularly in terms of relating responses to subjective perceptions of the costs of cognitive effort and further eliminating alternative explanations for observed age effects.

Discussion—When taken together, the studies reviewed in this section provide evidence consistent with the general assertion that aging is associated with increases in the costs of cognitive activity. Using a variety of measures, older adults relative to younger adults exhibit higher levels of activation or require more resources to achieve equivalent performance at a given level of objective task difficulty. In addition, older adults also exhibit more depletion of cognitive resources, as reflected in both physiological responses (e.g., sBP, brain glucose levels, cortical activation), subjective reports of task difficulty, and performance outcomes. Admittedly, the interpretation of the observed effects associated with, for example, cortisol responses and cortical activation is speculative and is impeded by the fact that studies rarely collect multiple measures. There does appear to be, however, a relatively consistent pattern emerging across these contexts. In addition, in cases in which multiple measures have been assessed, there is evidence for similarity in age-related responses (e.g., assessments of cortisol and sBP responses by Steptoe et al., 2005). In future studies, researchers who explicitly attempt to establish linkages among the various measures, task factors, and motivation would obtain important results in bolstering the argument that these effects are reflective of the costs of cognitive activity.

Interrelationship of costs, motivation, and engagement

Given evidence regarding age differences in motivation to engage and the costs of cognitive engagement, a remaining question is whether there is a relationship between the two. In the physical domain—where exercise has been shown to be positively related to cognitive health (e.g., Colcombe & Kramer, 2003; Voelcker-Rehage, Godde, & Staudinger, 2010)—changes in stamina, muscle strength, and body integrity in later life may increase the demands and costs of physical activity, leading older adults to limit such activity (e.g., Neupert, Lachman, & Whitbourne, 2009). A similar scenario is proposed in the cognitive domain. Increasing age in later adulthood is associated with reduced participation in cognitively demanding activities, with some evidence of this age effect being particularly true in discretionary (i.e., nonobligatory) activities (e.g., intellectual, cultural, and social activities; M. M. Baltes &

Lang, 1997; Jopp & Hertzog, 2007; Lang, Rieckmann, & Baltes, 2002; Mitchell et al., 2012; Salthouse, Berish, & Miles, 2002). In addition, older adults with greater cognitive resources are more likely to participate in cognitively demanding activities in everyday life (e.g., Hultsch, Hertzog, Small, & Dixon, 1999; Lang et al., 2002; Schooler & Mulatu, 2001), and older adults in general are less likely to engage in activities rated high in cognitive demands (e.g., Rousseau, Pushkar, & Reis, 2005; Salthouse et al., 2002). To the extent that ability and ratings of difficulty reflect the costs of cognitive engagement, these findings are consistent with the present framework in suggesting that age-related declines in cognitive resources are associated with increasing selectivity, both in terms of overall levels of activity as well as types of activity.

In addition to the association between costs and activity participation, I propose that this relationship is mediated, in part, by the negative effect of these costs on motivation. In other words, increases in the costs of cognitive engagement in later life should be associated with concomitant shifts in intrinsic motivation to engage in cognitively demanding activity, which, in turn, will predict involvement in effortful cognitive activities in daily life. A further corollary of these relationships is that improvements in cognitive efficiency (e.g., training effects) resulting in declines in costs associated with activity may increase levels of intrinsic motivation, with concomitant benefits in cognitive engagement in everyday life.

Unfortunately, researchers have not systematically examined all components of this motivation-mediated relationship in the same study, particularly with respect to relationships involving costs, as I have defined this construct. However, support for subcomponents of this relationship can be gleaned from existing research. For example, several researchers have examined the relationship between activity participation and need for cognition, which has been characterized as an intrinsic motivational variable reflecting the degree of enjoyment associated with engaging in complex cognitive activity (for a review, see Cacioppo, Petty, Feinstein, & Jarvis, 1996). These researchers have found that need for cognition is positively associated with older adults' engagement in effortful activities in everyday life using both cross-sectional (e.g., Bye & Pushkar, 2009; Parisi, Stine-Morrow, Noh, & Morrow, 2009; Soubelet & Salthouse, 2010; von Stumm, 2012) and longitudinal (Baer et al., 2013) data. The activities assessed by both Baer et al. (2013) and Bye and Pushkar (2009) involved cognitively demanding, discretionary activities. Thus, the relationship between need for cognition (which is interpreted as one aspect of motivation) and participation not only reflects the general decline in activity participation but also suggests that this decline is selectivity associated with those activities that placed demands on cognitive resources.

Particularly relevant for present purposes is evidence for associations between the costs of cognitive activity and motivation. If it is assumed that costs are reflections of underlying resources (e.g., poor health will mean fewer available resources, making engagement more costly), then evidence of a negative link between costs and motivation can be inferred from studies in which such resources are found to be closely linked to intrinsic motivational states associated with complexity of processing in later adulthood (e.g., Hess, Waters, & Bolstad, 2000; Labouvie-Vief, Chiodo, Goguen, Diehl, & Orwoll, 1995). For example, we (Hess et al., 2000) assessed *personal need for structure*, which measures the motivation to cognitively structure one's world in a simple and unambiguous manner, suggesting it reflects low motivation for engagement in complex thought (Neuberg & Newsom, 1993), in groups of young, middle-age, and older adults. We found that greater need for structure was more strongly associated with lower scores on measures of ability (e.g., working memory, vocabulary), health, and education in older adults than in the other two age groups. We also examined the linkage between resources and intrinsic motivation in a larger sample of 548 adults ranging from 21 to 85 years of age (Hess, 2001). Age was negatively associated with health and cognitive resources, and these latter two factors were negatively associated with need for structure (e.g., poor health was associated with higher need for structure scores). In addition, we observed that need for structure was negatively associated with self-reported engagement in everyday activities and that need for structure accounted for the age-based relationships between resources and participation.

In an attempt to more clearly examine causal links, we used longitudinal data to examine how changes in health, ability, motivation, and activity participation are linked (Hess, Emery, & Neupert, 2012). Data were obtained from 332 adults (ranging from 20 to 85 years of age at initial test) who were tested 2–6 times, with an average of 2 years between testing. Motivation to engage in complex cognitive activity was assessed with a composite of need for structure and need for cognition scores, which are negatively correlated (e.g., Cavazos & Campbell, 2008; Neuberg & Newsom, 1993). We first examined how changes in resources, broadly defined (i.e., ability, health, sensory functions), were associated with changes in motivation, and we found positive associations involving physical and mental health, sensory functioning, and verbal ability. We also found that changes in motivation were positively associated with changes in ability (working memory, speed) and self-reported engagement in everyday cognitive and social behaviors. Finally, consistent with expectations, we observed that changes in motivation partially mediated the relationship between changes in resources and effortful cognitive activities. For example, declines in physical health predicted declines in speed and working memory, and motivation partially mediated this relationship. An interesting side note here is that the mediation relationships involving motivation and cognitive ability were stronger when ability was considered as an outcome as opposed to a resource. This influence of motivation on the assessment of ability suggests that age-related variation observed on cognitive tests may not just reflect normative changes in ability but concomitant changes in the motivation to engage in the test as well. We also found that the predicted association between changes in physical health and motivation was stronger in old age, providing some evidence for a strengthening of the relationship between resources and motivation in later life.

Although these studies provide data that are consistent with the hypothesized relationships among costs, intrinsic motivation, and activity participants, they are limited by the relatively indirect assessment of costs based on resources. Two recent studies, however, provide more direct evidence regarding the relationship between costs and motivation. In the previously discussed work by Westbrook et al. (2013), they also examined the relationship between need for cognition and perceptions of costs. Individuals high in need for cognition (reflecting more motivation for complex thought) attached higher levels of subjective value to more demanding tasks than did those low in need, indicating a greater willingness to engage in such tasks. In other words, need for cognition was negatively related to perception of costs. We also obtained evidence of a more direct relationship between the costs of effortful cognitive activity and need for cognition. Specifically, need for cognition was found to be negatively associated with sBP responsivity during a cognitively demanding task, with this effect being significant for older, but not younger, adults. These results are consistent with the notion that high cognitive costs—as suggested by high sBP responses—are associated with reduced intrinsic motivation to engage in complex cognitive activity and that the motivational consequences of cognitive costs are especially strong in later life.

In conclusion, the evidence reviewed here is generally supportive of the notion that the increased costs associated with effortful cognitive activity are associated with declines in the motivation to engage in such activity. This motivation, then, appears to partially mediate the actual engagement in such activities. Several issues should be considered, however, in weighing this evidence in relation to the proposed framework. First, there is only one study (Ennis et al., 2013) in which the relationship between costs—as defined here—and motivation was directly examined. In the other cases, variations in the costs of cognitive activity were inferred on the basis of factors such as health status or ability. It is not unreasonable to assume that such factors determine or are reflective of costs, but future researchers examining this construct in a more direct fashion would facilitate testing of the model.

Second, the manner in which intrinsic motivation has been assessed might be considered problematic, with the aforementioned measures perhaps not being optimal for assessing the desired construct. In our research, we use personal need for structure and need for cognition as indices of motivation to engage in cognitively demanding activities. Whereas need for structure is associated with a desire for certainty and simple structures, and is associated with less complex ways of processing information, its relationship to motivation for complex cognition is somewhat indirect. Although the simple structures preferred by those high in need for structure may, for the most part, involve cognitive processes that place relatively low demands on resources, it is also possible that individuals may occasionally work hard to achieve the structure in an effort to reduce ambiguity. Need for cognition appears to tap into the desired construct more clearly and has been defined in a manner that is consistent with our use. For example, Cacioppo et al. (1996) stated that “individuals high in need for cognition are characterized by high intrinsic motivation to exercise their mental faculties” (p. 239). Some, however, have characterized this construct in terms of a preference, which may not reflect the drive typically associated with motivation. Even if need for cognition is reflective of simple preferences, however, the nature of these preferences is likely to affect selection processes.

Given the hypothesized negative association between cognitive costs and motivation, one might expect normative increases in the former to be associated with age-related declines in intrinsic motivation. Researchers using need for structure (and the related construct, need for cognitive closure; Webster & Kruglanski, 1994) and need for cognition have generally found small declines with age (e.g., Blanchard-Fields, Hertzog, Stein, & Pak, 2001; Cornelis, Van Hiel, Roets, & Kossowska, 2009; Hess, 2001; Salthouse et al., 2002). These weak associations involving age may reflect the relatively select nature of older adult volunteer samples used in the studies reviewed. Of potentially more importance is the stronger positive link between motivation and personal resources in later life relative to young adulthood found in some studies (e.g., Hess et al., 2000) as well as observed positive relations between changes in resources and motivation, which are also stronger in older adults (Hess et al., 2012). These different patterns of correlations across ages suggest that intrinsic motivation may be based on different factors at different points in adulthood, perhaps explaining the previously reviewed age differences in the impact of motivational factors. For example, some have argued that fatigue effects observed in young adults (for a review, see Hagger, Wood, Stiff, & Chatzisarantis, 2010) may not have a physiological basis (e.g., glucose depletion; Gailliot & Baumeister, 2007) but rather may reflect changes in motivation as individuals reassess the BCR of continued task engagement over time (Kurzban, Duckworth, Kable, & Myers, 2013). This may not necessarily be the case in later adulthood, in which—as suggested by research reviewed in the previous section—normative changes in physiological structures underlying effortful cognitive activity may make engagement more consequential in later life.

Finally, the studies reviewed here focused primarily on associations involving intrinsic motivation, which within the previously discussed benefit–cost analysis is likely to be associated with general thresholds of engagement affecting overall levels of activity engagement. Unfortunately, there have been no studies in which the relationship between cognitive costs and situation-based selective engagement was specifically addressed (e.g., the differential effects of self-relevance across age groups). Obviously, more systematic work is needed to examine this relationship, with researchers using benefit–cost analyses ideally suited to do so.

Conclusions

I have presented a general motivational framework to help explain adaptive processes associated with older adults' cognitive functioning. Focusing on the simple propositions that individuals are motivated to conserve resources and that the costs of cognitive activity increase in later life, in this framework I propose that, relative to younger adults, older adults become more sensitive to the contexts of performance and more selective in their allocation of cognitive resources to support performance. This selectivity may help to explain the apparent discrepancy between laboratory-based assessments of cognitive ability and everyday functioning in later adulthood. Specifically, I propose that mismatches in motivational levels across these two contexts might reduce the strength of association, partially accounting for the imperfect relationship found in some studies. For the most part, selective engagement may be viewed as an adaptive process, as older adults adjust their levels of participation to be in line with the costs of such engagement and to conserve resources to maximize performance in the most personally relevant situations. These motivation-based processes advocate for a broader perspective in understanding adult age differences in cognitive performance. Consistent with life-span contextual views of cognitive change (e.g., P. B. Baltes, 1987; Hess, 2005), in the present framework, I argue for consideration of interactions among the individual's life context, cognitive resources, and motivation as determinants of both performance in a particular context and variation across contexts.

To the extent that increasing costs lead to general declines in motivational levels, with a concomitant decrease in demanding activities that may ultimately be beneficial to cognitive health in later life, changes in general selectivity might also be viewed as maladaptive even if the overall goal of resource conservation is achieved. (Note that this is not too different from the challenges of motivating individuals to engage in physical exercise.) Although there is empirical support for the "use it or lose it" hypothesis (cf. Hertzog, Kramer, Wilson, & Lindenberger, 2009), in relevant studies, researchers have focused primarily on the consequences of cognitive activity on performance. However, there has been relatively little emphasis on examining the reasons as to why older adults increase or decrease their engagement over time or the circumstances under which they do so. Specifically, why do some older adults engage, whereas others withdraw, when faced with declining cognitive abilities in later life? In many ways, answering this question is just as important as understanding behaviors associated with maintaining cognitive health given that people must first be motivated to engage in such behaviors before they can be effective. To this end, the present framework has relevance for understanding the reasons for disengagement while providing potential insights regarding the design of prevention and intervention programs. For example, focusing older adults on the personal relevance of the task would be expected to increase engagement, enhance compliance, and perhaps avoid the downward spiral resulting from nonparticipation.

In the present framework, I focus somewhat uniquely on the costs of cognitive activity as a primary explanatory factor, with mental effort and its consequences being the primary determinant of costs. Although mental effort is often used as a metaphor for cognitive resources in the aging literature (Salthouse, 1988), the construct has not been clearly distinguished empirically from other conceptualizations of cognitive resources thought to underlie aging effects on performance, such as working memory (e.g., McCabe, Roediger, McDaniel, Balota, & Hambrick, 2010; Park & Payer, 2006; Salthouse, 1996). I argue, however, that effort is not synonymous with other resource constructs, in that it reflects exertion and thus may not be directly reflected in typical performance outcomes. This less-than-perfect relationship suggests that mental effort may be capturing important characteristics of the aging cognitive system not reflected in other resource measures. I further assume that mental effort is tied to physical costs, with individuals monitoring these costs in making decisions to engage or withdraw resources. Perhaps the most novel aspect of the present perspective is the proposal that change in effort associated with cognitive activity in later life can not only be used to explain age differences in performance but also a variety of motivational phenomena (e.g., situational selectivity, chronic intrinsic motivation, task disengagement) that underlie individual and contextual variability in performance.

The present framework also appears to suggest a relatively straightforward translation of cognitive costs into these motivation-related phenomena. It is reasonable to assume, however, that there will be individual characteristics that moderate this translation. One interesting possibility relates to beliefs about aging, which are associated with various aspects of functioning and outcomes in later life (for a recent review, see Hummert, 2011). For example, negative attitudes about aging in young and middle adulthood are associated with poorer memory performance in later life, particularly for individuals for whom the negative age stereotype is viewed as self-relevant (Levy, Zonderman, Slade, & Ferucci, 2011). Within the current framework, such effects might be explained by stereotypes moderating the perception of cognitive resources, including the costs associated with cognitive engagement. These costs might be more salient to those with more negative attitudes, leading to a lower probability of engagement in cognitively demanding activities and concomitant negative effects on cognitive health. Consistent with this idea, researchers studying cognitive interventions have emphasized the important moderating role that beliefs about aging might play in long-term success of such interventions. For example, a memory-training program that was focused on increasing self-efficacy beliefs was associated with significant changes in both beliefs and performance (e.g., West, Bagwell, & Dark-Freudeman, 2008). Most important, more beneficial long-term effects of the intervention were positively associated with self-efficacy beliefs. Related results were obtained by Carretti, Borella, Zavagnin, and De Beni (2011), who found that *need for cognition* predicted long-term benefits associated with a memory intervention. These findings suggest that aging-relevant attitudes and associated motivational states may influence the levels of effort devoted during the intervention.

Although the current focus has been on the effect of costs of cognitive activity on engagement in particular tasks or level of effort, the consequences might be observed in other ways as well. For example, older adults might selectively focus attention on those aspects of a specific task that might be most associated with effective performance. This type of selectivity is illustrated nicely by Castel and colleagues (Castel, Benjamin, Craik, & Watkins, 2002; Castel et al., 2011; Castel, Murayama, Friedman, McGillivray, & Link, 2013), who used a memory task in which different levels of incentives were associated with different items, and the participant's goal was to earn as many points as possible on the basis of the items recalled. Castel observed that older participants recalled fewer items than did younger adults, but they exhibited similar or greater selectivity in their focus on high versus low items. This pattern of age effects suggests that older adults may also adapt to changes in cognitive costs by reducing task complexity through focusing on the most important information.

Consistent with other perspectives regarding age-related selectivity, the consequences of increased cognitive costs in later life could conceivably also be characterized in terms of restricting the number of goals. As noted earlier, the selection, optimization, and compensation model suggests that loss-based selection processes are dominant in later life, characterized by restructuring of goal hierarchies due to limitations in resources necessary for maintenance of functioning. In contrast, in the present framework, I address more general relationships involving costs of cognitive engagement and the effects on motivational processes. However, the hypothesized responses to age-related increases in costs could be a precursor to such restructuring of goals, perhaps promoting the proposed shift from growth to loss-based goals.

In conclusion, I have outlined a framework for understanding age-related changes in motivational process associated with cognitive activity and the role of these motivational processes on various aging-related phenomena. The proposed processes build on other notions of selectivity in the field of adult development in an attempt to understand how individuals react and adapt to changes that occur in later life. The framework is not meant to supplant previous perspectives regarding aging and selection-based adaption functions but rather is meant to build on these perspectives and to enrich the understanding of adaptive processes in later life.

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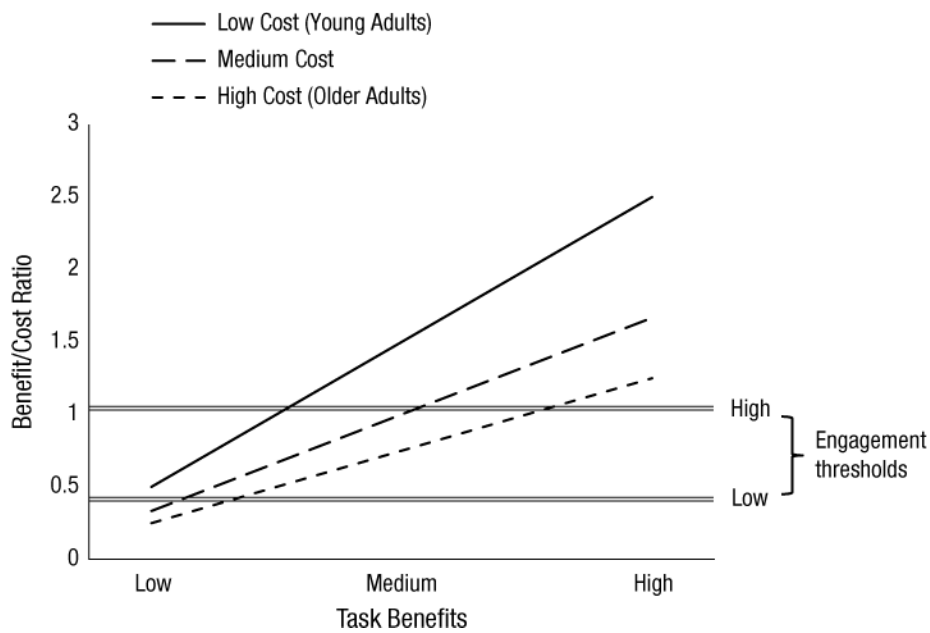

Fig. 1.

Benefit–cost ratios (BCRs) associated with tasks that vary in level of costs (low, medium, high) and benefits to the individual. These same lines can be viewed as representations of BCRs for the same task across age groups, with the costs associated with performance assumed to be lower for younger adults than for older adults. Resource engagement is assumed to be more probable for tasks with BCRs above the engagement threshold than for those below. Two hypothetical engagement thresholds are also depicted (High, Low; see the label on the far right side of the figure), with higher thresholds hypothesized to be associated with aging. Hypothesized increases in costs and engagement thresholds in later life result in fewer tasks falling above the threshold for engagement as well as increasing levels of discrimination between tasks with high versus low-to-moderate benefits.