Maximizing the impact of cognitive engagement interventions for older adults

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Abstract

In the past few decades, there has been a surge of research on cognitive interventions to increase cognitive abilities in older adults, many of whom experience age-related cognitive and functional declines. It has become increasingly clear that although cognitive interventions with older adults can increase cognitive abilities that are directly targeted in the training program, increasing untrained cognitive abilities and abilities related to daily life activities has not been as effective as originally anticipated. Instead of taking a pessimistic view that it is impossible to substantially increase cognitive and functional abilities across a variety of domains in older adults, we propose that cognitive interventions could benefit from developing theory-driven research programs, especially by incorporating findings from earlier in the lifespan and models of behavior change, to optimize intervention gains in later adulthood. Moreover, intervention gains also can be increased by taking into consideration participant characteristics, situations, and preferences when designing interventions. Instead of considering these factors as "noise," they provide meaningful information about differences in individual experiences in the past, present, and future. This chapter focuses mostly on cognitive engagement interventions, which are holistic interventions employing real-world skills and tasks. After briefly reviewing the current state of the literature, we discuss ways in which researchers have begun to investigate how to maximize the impact of engagement interventions on cognitive abilities and functional independence (i.e., the ability to perform daily activities independently). In addition, we consider unique cognitive, social, and environmental aspects of the older adult that can be leveraged for maximizing the impact of cognitive engagement interventions.

Maximizing the impact of cognitive engagement interventions for older adults

Brief overview of cognitive intervention research

A fundamental aspect of successful aging is maintaining functional independence (i.e., the ability to perform daily tasks independently), as well as maintaining the cognitive abilities required to perform daily tasks (e.g., Depp & Jeste, 2006; Rowe & Kahn, 1997). The goal of cognitive intervention research with older adults is to determine ways of maintaining or increasing cognitive abilities and functional independence over the long-term, because many older adults experience declines in both (e.g., Dodge et al., 2006; Park & Reuter-Lorenz, 2009). Although genetic and epigenetic factors impact the trajectory of cognitive abilities and functional independence across the lifespan (see Roth et al., 2009), environmental influences pose the intriguing possibility that unfavorable trajectories can be altered in non-invasive ways (see Hertzog et al., 2009; Kramer et al., 2004).

Whereas little is known about improving functional independence in non-demented, physically-able older adults who do not need to re-learn how to perform daily tasks, research on improving cognitive abilities in healthy older adults demonstrates that skill learning and real-world activity engagement are important. Correlational studies with normal older adults and "superagers" have shown that greater frequency of engagement in cognitively challenging activities, such as playing complex sports or board games, relates to better cognitive outcomes (e.g., Hultsch et al., 1999; Ihle et al., 2015; Wilson et al., 2007; although see Salthouse, 2006). Carlson et al. (2012) provided evidence that for older adults, variety in activity type is more important for cognitive outcomes than frequent engagement in cognitively challenging

activities. Although there are fewer intervention studies compared to observational studies on this topic, intervention studies provide more compelling evidence that engaging in mentally challenging activities leads to increased cognitive outcomes, as opposed to the reverse relationship (see Hertzog & Nesselroade, 2003). Two primary types of intervention studies investigate increasing cognitive abilities in older adults: cognitive engagement interventions (real-world task engagement, e.g., Park et al, 2014; Stine-Morrow et al., 2014) and cognitive training interventions (targeting specific cognitive abilities, such as working memory, inductive reasoning, speed of processing, and other fluid abilities, e.g., Anguera et al., 2013, Ball et al., 2002; Jaeggi et al., 2008; Willis & Schaie, 1986). In a cognitive engagement intervention (SYNAPSE), Park et al. (Chan et al., 2016; Park et al., 2014) demonstrated that learning one new challenging skill (photography, quilting, or iPad literacy), or learning two challenging skills sequentially, improved older adults' episodic memory on a word list-learning task. Park et al. reasoned that such memory improved because this ability is central to the real-world skills included in the study. The Senior Odyssey project engaged older adults in team-based creative problem solving tasks, and found increases in divergent thinking, a key component of creative problem solving (Stine-Morrow et al., 2014). Stine-Morrow and colleagues also found that the intervention group increased in the openness personality trait (Jackson et al., 2012). Cognitive training, a more traditional approach compared to real-world skill learning (Hertzog et al., 2009; Park et al., 2007), rests on the theory that training isolated cognitive abilities (e.g., inhibition, working memory, processing speed) in specific contexts should directly lead to cognitive improvements in daily activities for functional independence. Both types of cognitive interventions typically show that trained abilities improve (be it a real-world skill or a computer

task), whereas untrained abilities typically do not improve (e.g., Shipstead et al., 2012; Simons et al., 2016; Stine-Morrow et al., 2014).

Maximizing cognitive intervention outcomes via optimizing the scientific approach

Researchers have begun to ask and investigate how cognitive interventions could be optimized to maximize cognitive and functional gains (e.g., Deveau et al., 2015; Jaeggi et al., 2014; Wu et al., 2017). Cognitive engagement interventions, in particular, have been relatively effective in terms of high retention rates and participant satisfaction (e.g., mentoring children, Carlson et al., 2009), and increasing trained and untrained skills in the short term (e.g., episodic memory, visual processing, planning; Bugos et al., 2007; Noice et al., 2014; Park et al., 2014; Stine-Morrow et al., 2008).

One way to better understand why some cognitive engagement interventions work better than others is to break down the activities into components so that these components can be implemented in future interventions. One way to break down activity components is by separating task goals into mental, physical, and social aspects (e.g., Karp et al., 2006). This approach highlights the importance of engaging in these three areas for increased overall well-being (e.g., Fried et al., 2013; Rebok et al. 2011). This approach also addresses underlying commonalities between different types of activities. However, categorizing real-world tasks in this manner may be subjective and unclear, such as whether playing basketball is considered primarily cognitive and physical, or also social. Moreover, the activities that would lead to maximal gains is debatable and likely to be different among individuals (e.g., Bielak, 2010).

Another way to consider intervention components is to consider their relevance to learning. It has been argued that learning is at the core of cognitive improvement (Deveau et al., 2015), especially in terms of generalizing from a trained ability to an untrained ability. Learning in cognitive training interventions typically involves learning how to engage in computerized cognitive tasks, whereas cognitive engagement interventions involve learning real-world skills. In terms of learning from computer-based cognitive tasks, Deveau et al. (2015) suggest that engaging selective attention, reinforcement, multisensory training stimuli, and varied training stimuli would increase interest and the amount and variety of engagement, thereby increasing cognitive abilities. Cognitive engagement interventions involving real-world skill learning, such as learning photography, can be inherently interesting and purposeful for older adults (see Park et al., 2014). It has been proposed that learning in older adults from both cognitive training and engagement interventions leads to the ability to compensate for any neural or functional decline (Scaffolding Theory of Aging and Cognition; Park & Reuter-Lorenz, 2009; Reuter-Lorenz & Park, 2014).

Recently, Wu et al. (Nguyen et al., 2018; Wu et al., 2017) proposed that instead of a direct link between increasing cognitive abilities and maintaining or increasing functional independence, perhaps learning new real-world skills underlies functional independence in a dynamic environment. For example, as technological advances become more and more frequent (e.g., Charness & Boot, 2009), learning how to use new technology devices and procedures is becoming more of a necessity for maintaining functional independence. This approach aligns with research on emerging adulthood, showing that real-world skill learning (e.g., for a career) is at the core of long-term functional independence (e.g., Arnett, 2000;

Darling-Hammond et al., 2014; Noom et al., 2001). The skills required to maintain functional independence in a dynamic environment are constantly evolving, as is the context for interventions. When millennials become older adults, they will have grown up with the internet and be more used to computer tasks and technological advances, compared to Baby Boomers. This issue will impact how future cognitive interventions are designed and delivered.

Besides maintaining or increasing functional independence, Wu et al. (2017) propose that another outcome of learning new real-world skills is increased cognitive abilities required by the complex skills, which often include a system of cognitive abilities. Wu et al. list six factors (Table 1), inspired by child development research, that may help maximize the impact of learning new real-world skills in older adulthood. Although this new lifespan approach still remains to be tested, it offers a theory-driven alternative to maximizing cognitive interventions.

Table 1. Six factors for triggering cognitive development across the lifespan, as proposed by Wu et al. (2017).

Open-minded input-driven learning	Learning completely novel information
Individualized scaffolding	Receiving tailored help from knowledgeable instructors
Growth mindset	Belief that abilities are fostered, rather than innate
Forgiving environment	Learning in an environment free of stereotypes and being allowed to make mistakes

Serious commitment to learning	Learning for survival
Learning multiple skills simultaneously	Learning at least two or three real-world skills simultaneously

To begin to investigate this approach Wu and her colleagues (Leanos, Coons, Rebok, Ozer, & Wu, 2018) have developed a new questionnaire to assess broad learning in adulthood because the proposed theory (Wu et al., 2017) hypothesizes that broad learning, which fosters engagement and cognitive development during infancy and childhood, may also do so in adulthood.

Another way of maximizing the impact of engagement interventions is by integrating theoretically-driven models of behavior change targeting multiple risk factors for cognitive, physical, and functional declines (Lachman et al., 2018; Michie, Johnston, Francis, Hardeman, & Eccles, 2008; Michie, van Stralen, & West, 2011). Existing engagement interventions typically have not been explicitly developed against a clear theoretical backdrop of behavioral change. However, there is evidence that lifestyle interventions informed by theoretically driven behavior-change models are more successful and lead to stronger and more enduring changes (Michie & Abraham, 2004). Thus, it is recommended that complex engagement and lifestyle interventions should be based on a unifying theory of health-related behavior change (Michie et al., 2008, 2011). To be maximally effective, such interventions should include established behavioral techniques such as goal setting, decreasing barriers to change, improving self-monitoring, having access to information and facilities, and maintaining motivation (Locke & Latham, 2002; Middleton, Anton, & Perri, 2013). A current example of this approach is a

pragmatic randomized controlled trial investigating whether novel Lifestyle Management Programmes that offer health-promoting information and practical behavior change techniques that can be implemented in daily life can reduce dementia risk (Kim, McMaster, Torres, Cox, Lautenschlager, Rebok et al., 2018)

Maximizing cognitive intervention outcomes via optimizing the individualized approach

Besides optimizing the scientific approach to maximize intervention outcomes, researchers also have considered unique cognitive, social, and environmental aspects of older adults to individually tailor interventions for maximal gains. Participants differ in many ways prior to participating in an intervention, one of which is motivation level. Motivation predicts engagement in cognitively demanding everyday activities, with older adults being increasingly selective in the engagement of cognitive resources in response to age-related declines (Baltes, Lindenberger, & Staudinger, 2006; Hess, 2014; Hess, Growney, O'Brien, Neupert, & Sherwood, 2018). Older adults demonstrate intrinsic motivation by preferring to engage with, learn from, and remember information that interests them (e.g., McGillivray et al., 2015; Torres & Beier, 2018; Wolfgang & Dowling, 1981). Higher intrinsic motivation is related to more engagement and investment in post-retirement activities (e.g., Ennis et al., 2013; Hopkins et al., 2006; Stephan et al., 2008).

For intervention studies, motivation can determine whether older adults sign up to participate and how they engage with the intervention activities (Boot et al., 2013; Jaeggi et al., 2014; Katz et al., 2014; 2016; Zhao et al., 2018). Some participants may be highly motivated and be willing to put in a great deal of effort into an intervention, whereas others may be less

motivated and may expect to see rapid improvements with little effort. If the intervention requires a great deal of effort, then those in the latter category may be more likely to drop out of an intervention study. Although some attrition is unavoidable with older adult populations, it is important to maintain low attrition rates, especially related to motivation, to minimize biased samples in the final analyses. Some have suggested that providing an orientation session that conveys the reason for conducting the intervention and the importance of their participation in their assigned group helps with retention (e.g., Goldberg & Kiernan, 2005).

Motivation is particularly important for long-term behavior change, such as for physical exercise (e.g., Lachman et al., 2018; Thøgersen-Ntoumani & Ntoumanis, 2006). Intrinsic motivation may be particularly important for activity engagement after the intervention (see Lachman et al., 2018), which can be essential for sustaining or even enhancing intervention effects. However, very few cognitive interventions have been able to follow up their participants past a few months after the end of an intervention. One notable exception with thousands of participants is the ACTIVE cognitive training study with 10-year follow-up measures (Rebok et al., 2014). Although the follow-up measures are comprehensive, including functional independence measures, it is unknown which activities the participants were motivated to engage in (and actually engaged in) after the intervention to sustain the intervention effects for more than 10 years. Moreover, perhaps participants in the intervention group increased in their self-efficacy (belief in one's ability), which led to more engagement in cognitively challenging activities after (or perhaps even during) the intervention. This information is important because it is unlikely that the 6-week intervention itself directly produced 10-year effects, but rather sustained engagement in challenging activities.

Besides considering different initial motivation levels, a number of studies have demonstrated the importance of taking into account participants' initial cognitive abilities. Both cognitive engagement and cognitive training interventions have reported magnification or Matthew Effects, where older adults with higher cognitive functioning before the intervention have more gains by the end of the intervention (e.g., Langbaum, Rebok, Bandeen- Roche, & Carlson, 2009; Stine-Morrow et al., 2014). For example, Rebok et al. (2013) reported that higher education and better self-rated health were associated with greater gains in memory performance after mnemonic training in the ACTIVE study. This effect may be linked to the participants' motivation level and overall enjoyment of the intervention tasks, as well as education levels. However, there are other findings suggesting that engaging in cognitively stimulating activities is not simply a matter of the "rich getting richer." For instance, Ihle et al. (2015) reported that for older adults with lower educational levels attained earlier in life, engaging in cognitively stimulating activities in midlife may have a compensatory benefit on cognitive functioning in old age. Carlson et al. (2008) reported that older adults with lower baseline executive functioning showed the greatest gains in executive functioning and memory following their participation in the Experience Corps program, a high-intensity volunteer senior service program for older adults in elementary schools. Karbach et al. (2017) investigated executive control training in children, young adults, and older adults, and found that individuals with lower cognitive abilities at pretest showed larger training and transfer benefits after the training. Willis and Caskie (2013) found that older participants with lower levels of education exhibited greater training effects on various measures of reasoning and problem solving compared with those with higher education in the ACTIVE study. Similarly, Clark et al. (2016)

showed that the effects of ACTIVE speed of processing training differed by educational level, with the effects being 50% greater in older adults with less than a high school education compared with those with 16 or more years of education. Thus, older adults with lower educational levels or lower baseline cognitive ability may have the most room for improvement from engaging in cognitively stimulating activities and interventions in adulthood.

Another starting point to consider is level of resources, particularly income level. The cognitive costs of poverty and lack of resources (Mani et al., 2013) may hinder older adults' ability to engage in activities with positive cognitive stimulation. For example, older adults with low income may be less likely to engage in an intervention or drop out, and they also may benefit less when they join because of many other demands on cognitive resources and time, such as paying overdue bills or taking care of many grandchildren. Moreover, while in the intervention, older adults with lower income levels may not be able to participate in other activities that are secondary to the intervention (but highly beneficial), such as meeting for lunch and an art show with the other intervention participants outside of intervention hours. Only interventions that offer purposeful activities (e.g., mentoring children in need), stipends for participating to offset costs, and removal of other barriers to participation, such as offering childcare, can attract more low-income elderly participants. For example, the Experience Corps was able to do so by creating opportunities to make a difference and give back to their local communities and provided participants with a modest monthly stipend for volunteering. In the end, testing hypotheses with diverse samples, both in terms of demographic diversity, as well as individual constraints and preferences, would allow findings to be more generalizable.

In order for cognitive engagement interventions to have their widest impact, they need to be inclusive of those who are historically at risk for greater cognitive impairment, namely those with limited access to health care and other resources, such as low SES and ethnic minority elderly (Carlson et al., 2008). Evidence suggests that minority older adults and those with lower incomes are less likely to enroll in health promotion programs and interventions (Levkoff & Sanchez, 2003; van der Bij, Laurant, & Wensing, 2002). In a recent review, Tzuang et al. (2018) reported that ethnic minority older adults are disproportionately underrepresented in cognitive training intervention studies, limiting our ability to reduce racial disparities and improve cognitive health at a population level. Given the rapid demographic shift to a racially and ethnically more diverse older population, a deeper understanding of race/ethnicity related factors in intervention research may lead to the development of more culturally sensitive and effective cognitive engagement interventions (Tzuang et al., 2018).

Improvements in cognitive abilities via cognitive engagement interventions might also be affected by social factors. For example, participating in an intervention study might be a diversion from participants' daily routines and lend special meaning and purpose to their engagement (see Bures et al., 2016). Being engaged in a meaningful activity with a social appraisal component (i.e., evaluations of events are dependent on others' thoughts and reactions) might help older adults invest more cognitive resources in that activity, and sustain their engagement over longer periods of time. Having social resources in the form of a large social network might also contribute to intervention effects by improving people's ability to take advantage of environmental complexity (e.g., Hughes, 2010; Stine-Morrow et al., 2014). Indeed, anecdotally, older adult participants in cognitive engagement interventions often cite

the social component (i.e., getting to know new people) as one of the most important aspects of their intervention experiences, and one of the main reasons they continue to participate in the intervention.

Recommendations for future research

Based on our current understanding of how to maximize cognitive engagement interventions, we offer the following recommendations for future research. First, including measures of activity engagement after the end of the intervention will be critical for developing a better understanding of how an intervention affects later activity engagement to sustain effects over the long-term. Second, given that the ultimate goal of cognitive interventions is to increase the likelihood of maintaining functional independence, more cognitive interventions could include a measure of functional independence along with existing follow-up measures. More research also is required to test the hypothesized link between increased cognitive abilities and functional independence.

Third, an important point of consideration for intervention studies is the targeted source of cognitive and functional decline. There are clearly multiple sources of decline, from neurobiological factors, such as decreased likelihood of neuroplasticity, declining brain structure and effectiveness (Grady, 2012; Raz & Rodrigue, 2006) to decreased social factors (e.g., perceived social isolation, Cacioppo & Hawkley, 2009; negative stereotypes, Levy et al., 2016; Robertson, King-Kallimanis, & Kenny, 2016). The targeted source of the problem determines the intervention approach. For example, if the focus of a theoretical approach is cognitive decline from naturally-occurring genetic and epigenetic factors, then the intervention

would be best suited to alter genetic and epigenetic factors. However, most cognitive (behavioral) interventions thus far have aimed to mitigate cognitive decline resulting from presumably genetic and epigenetic factors. Wu et al. (2017) proposed that another driver of cognitive and functional decline that is often overlooked is not learning real-world skills required for thriving in a dynamic environment, such as learning how to use new technological devices. Interventions based on that approach would be best suited to expose older adults to useful real-world skills. Clarifying the targeted driver of cognitive decline and the theoretical framework would benefit cognitive intervention research. Moreover, if researchers can identify the origin of the driver of cognitive decline using a developmental lifespan approach, it would potentially be easier to target the driver and symptoms earlier in the lifespan.

Fourth, the more precise cognitive training approaches could be better integrated with the more naturalistic cognitive engagement intervention approaches. Cognitive engagement interventions have included task analyses to identify more precisely which cognitive abilities are trained in particular skills (e.g., Czaja et al., 2003). Cognitive training approaches have started to integrate more engaging, naturalistic contexts in the computer tasks (e.g., Deveau et al., 2015). Future research on this integration may be able to harness the benefits of both approaches.

Conclusions

A great deal of research has been conducted in the past few decades to demonstrate the potential for increasing cognitive abilities targeted in an intervention. However, it is still unclear how to increase a variety of cognitive abilities and functional independence across the long term in a diverse population of older adults. As medical advances allow us to prolong life,

there is a growing need to maximize the impact of cognitive interventions into later life. Unique cognitive, social, and environmental aspects of the older adult can be leveraged for maximizing the impact of cognitive engagement interventions. Moreover, taking a lifespan developmental perspective may increase the impact of an intervention via targeting an origin of a driver of cognitive decline. Aligning functional expectations for healthy older and younger adults also raises the bar for what it means to be a successful ager. Cognitive interventions also could benefit from developing theory-driven research programs that incorporate models of behavior change. Mitigating or delaying cognitive and functional decline, or even promoting cognitive development, would prolong successful aging for as many older adults as possible.

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