Understanding the potential of technology to support enhanced activities of daily living (EADLs)

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W. A. Rogers, T. L. Mitzner, M. T. Bixter. Understanding the potential of technology to support enhanced activities of daily living (EADLs). Gerontechnology 2020;19(2):125-137; https://doi.org/10.4017/gt.2020.19.2.005.00 **Background** Much of past research has focused on the importance of ADLs and IADLs for successful aging in place, independence, and health. Current state of the science shows engagement in enhanced activities of daily living (EADLs) is also critical for quality of life and health outcomes. This term first appeared in Rogers, Meyer, Walker, and Fisk (1998) and has been a focus of subsequent research. Technology advancements have the potential to support EADLs and enhance the quality of life for older adults. **Research aim** Describe the history of EADLs and discuss a sampling of research studies focusing on technology supports for older adults' engagement in EADLs. The review focused primarily on research from the Center for Research and Education on Aging and Technology Enhancement (CREATE). **Methods** We provide a brief history of assessments of everyday activities. We then focus on EADLs, reviewing the citations of Rogers, Meyer, Walker, and Fisk (1998), and updating the definition of EADL. We discuss the relevance of these activities to quality of life. We provide a sampling of research on technology to support EADLs. **Results** EADLs encompass a range of everyday activities. We review technology support examples from the following categories: new learning and training for technology use; assistive and social robotics; telework; family caregiving; physical activity; digital gaming; social engagement and intellectual pursuits. We discuss the potential of autonomous vehicle technologies to support a broad range of EADLs. We describe the cross-cutting relevance of technology acceptance. **Conclusion** Technology developments can support EADLs and enhance the quality of life. Future research directions should include developing a valid and reliable measure of EADLs to determine where there are needs for interventions. Broader samples of older adults should be included in EADL technology research such as individuals aging with a disability. Additional focus should be on the long-term benefits of active engagement in EADLs.

Keywords: Technology, everyday activities, social engagement, quality of life

Introduction

Quality of life is a fundamental goal for individuals, regardless of age. Society can support this goal specifically for older adults through products, services, and environments that accommodate their needs. However, given the diversity of older adults, it is important to identify these needs across different individuals, everyday activities, and contexts. The Center for Research and Education on Aging and Technology Enhancement (CREATE; www.create-center.org) has endeavored to identify older adults' capabilities, limitations, preferences, and attitudes to guide the design of technology to support quality of life. Our goal in this paper is to trace the history of understanding everyday activities in general. We then focus on the category of enhanced activities of daily living (EADLs) to illustrate the potential of technology to enhance quality of life for individuals, as they grow older.

History of assessing everyday activities

Assessment of functional ability in older adults is required to determine proper levels of care and predict long-term assistance and caregiver needs. Moreover, any intervention designed to affect health and behavioral outcomes requires an accurate functional assessment. Recently, Charness (2019) provided a framework for behavioral interventions targeting impairments in

older adulthood, including the prevention of impairment, the rehabilitation of functioning, the augmentation of functioning, and the substitution for loss of functioning (the framework was labeled PRAS: Prevent, Rehabilitate, Augment, Substitute). Regardless of the intervention strategy chosen, reliable and valid assessments must be available to measure the performance of everyday activities objectively as a marker of functional ability. Everyday activities consist of a variety of tasks and behaviors that can be organized into the broad categories of activities of daily living, instrumental activities of daily living, and enhanced activities of daily living.

Activities of daily living

Activities of daily living (ADLs) are routine behaviors that most adults do on a daily basis without assistance. Examples include eating, bathing, dressing, toileting, being able to get in and out of bed or a chair without assistance, and maintaining continence. ADL levels are most often assessed by a checklist measuring the extent an individual can complete the specific activities without assistance, whether measured through observation or self-report by the individual or a proxy. The Katz Index of Independence in Activities of Daily Living (Katz, Downs, Cash, & Grotz, 1970) is one such measure that has remained popular and diagnostically useful over the past half-century.

Functional assessments of ADLs are particularly helpful when providing care for older adults facing chronic issues or physical deficits. Examples include geriatricians determining the level of care needed for older adults suffering from dementia or Alzheimer's disease, and occupational therapists tracking rehabilitation progress in patients recovering from a debilitating disease or event (e.g., stroke). The ability to perform ADLs is critical for independent living.

Instrumental activities of daily living

Instrumental activities of daily living (IADLs) are activities that are not essential for basic health and survival but are still necessary for maintaining independence and thus critical for older adults who wish to age in place. Examples are cleaning and maintaining the house, dealing with finances, managing medications, and movement within the community. Because these activities are more complex in their neuropsychological profile than ADLs, accurate assessments are particularly valuable in diagnosing mild cognitive impairment and early dementia (e.g., Ciro, Anderson, Hershey, Prodan, & Holm, 2015; Cornelis, Gorus, Beyer, Bautmans, & De Vriendt, 2017). In these circumstances, older adults may not be exhibiting functional deficits in ADLs, but may nevertheless be facing challenges regarding IADLs that are predictive of more serious functional decline. The Lawton Instrumental Activities of Daily Living Scale (Lawton & Brody, 1969) remains commonly used as a method for assessing IADLs. Similar to measures of ADLs, individuals are ranked on their ability to perform a variety of IADLs without assistance. One difficulty with activity checklists is that older adults differ in the IADLs they perform regularly, raising the probability that a given scale with a limited number of activities might misdiagnose an individual older adult. As a result, extended IADL scales have been developed that include a greater variety of activities that attempt to better capture the full suite of instrumental everyday activities performed by older adults (e.g., Fieo, Manly, Schupf, & Stern, 2014; Mathuranath, George, Cherian, Mathew, & Sarma, 2005).

Enhanced activities of daily living

There remained a need for a systematic classification of everyday activities that go beyond simply maintaining independence in older adulthood. Previously, there was a recognition that many 'luxurious' items of functioning were not measured by traditional IADL scales (Reuben & Solomon, 1989). In the early 1990s, the idea of advanced ADLs was proposed to describe engagement in discretionary or voluntary activities (Reuben, Laliberte, Hiris, & Mor, 1990; and Wolinsky & Johnson, 1991).

In the late 1990s, we conducted a study to identify the challenges that older adults faced in performing everyday activities, to specify the needs and requirements for technology interventions (Rogers, Meyer, Walker, & Fisk, 1998). The participants were older adults living independently in the community and the majority of the frustrations they were reporting could not be classified as ADLs or IADLs. Consequently, we introduced the concept of enhanced activities of daily living (EADLs) to refer to the more advanced everyday activities that are required to maintain an active lifestyle in a changing environment (Rogers, Meyer, Walker, & Fisk, 1998). We defined EADLs very broadly as "the ability to adapt to a changing environment…willingness to accept these new challenges and to learn" (p. 1). We found that the older adults we interviewed were engaged in hobbies, new learning (often related to technology), social engagement, and other activities that contribute to their quality of life.

Figure 1 shows the citation count for the Rogers et al. (1998) since it was first published. This figure illustrates the adoption of the EADL term and the continued recognition that older adults engage in a broad range of activities, beyond ADLs and IADLs. In light of our review, we have updated our definition of EADL to be participating in daily activities that lead to fulfillment, well-being,

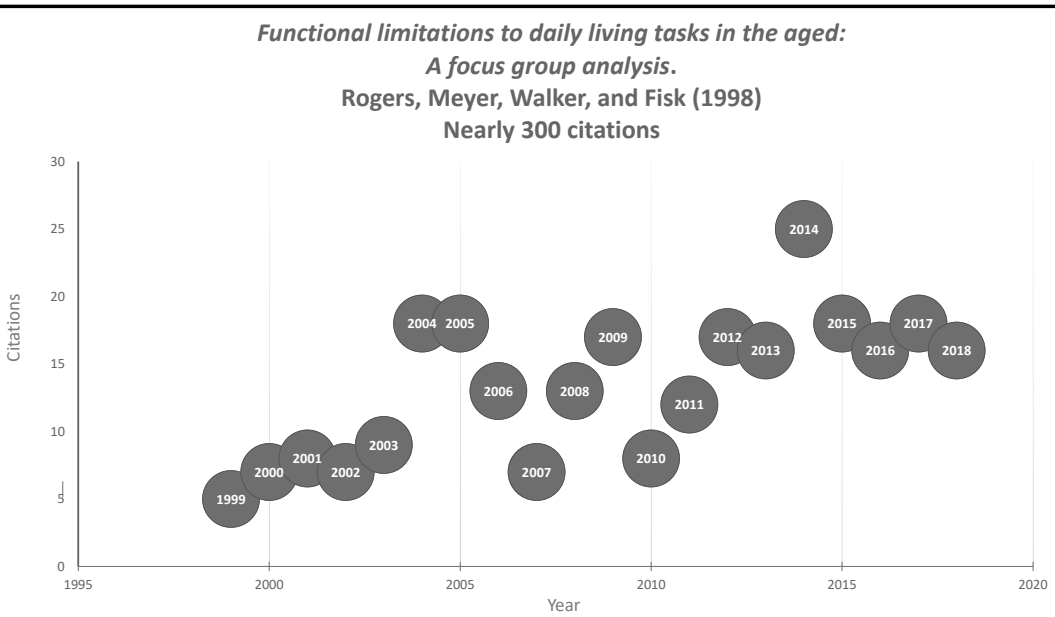

Figure 1. Historical perspective of citation counts for the origination paper for Enhanced Activities of Daily Living (EADLs; Rogers et al., 1998). Total citation count was 292 in June 2020.

quality of life, happiness, or social engagement.

The scope of EADL activities is difficult to circumscribe because there is a wide variety of potential activities that fit the definition. *Figure 2* illustrates some of the categories of EADLs as well as example activities for each category. These categories reflect the variety of everyday activities involved in maintaining a healthy and active lifestyle. Individuals will of course differ in the particular activities from which they derive meaning and enjoyment. As such, functional assessments of EADLs that are the most personally relevant for an individual, compared to other activities of daily living scales, might serve as an earlier predictor of subsequent impairment or decline. For example, longitudinal data found that most of the activities demonstrating decline during mild cognitive impairment were considered leisure activities (Hedman, Nygård, Malinowsky, Almkvist, & Kottorp, 2016). Therefore, a better classification and assessment of leisure activities, including EADLs, is a promising area for future research.

The widespread proliferation of technology into daily life, most notably information and communication technologies (ICT), has made everyday technology use a requirement to successfully perform a wide variety of EADLs. For instance, in the paper of Rogers et al. (1998) where the term first emerged, EADLs were often related to learning to use new technology. Moreover, there are significant relationships between everyday technology use and everyday activities, and this relationship strengthened over time in a sample of older adults with mild cognitive impairment (Hedman et al., 2016). These findings motivate the need to incorporate technology in the design, implementation, and delivery of EADL interventions, aligning with the PRAS framework developed by Charness (2019). Moreover, it is necessary to include challenges with technology use in any future EADL checklist or measure.

Benefits of EADLs for quality of life and health outcomes

The need to support EADLs is becoming a more critical concern given the growing body of literature showing the benefits of engaging in such activities, such as improvements in quality of life (QoL). The World Health Organization defined QoL as "an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns" (WHOQOL Group, 1994, p. 551). A high QoL reflects a positive subjective perception of the aging process. WHO developed two instruments for measuring the quality of life (the WHOQOL-100 and the WHOQOL-BREF) that reflect this broad-ranging concept impacted by the person's physical health, psychological state, personal beliefs, social relationships and their relationship to features of their environment (Carr, Higginson, & Robinson, 2003). Whereas ADLs particularly relate to the dimension of physical health, EADLs chiefly relate to dimensions of social relationships (e.g., personal relationships, social support) and relationships to features of their environment (e.g., opportunities for acquiring new information and skills, participation in

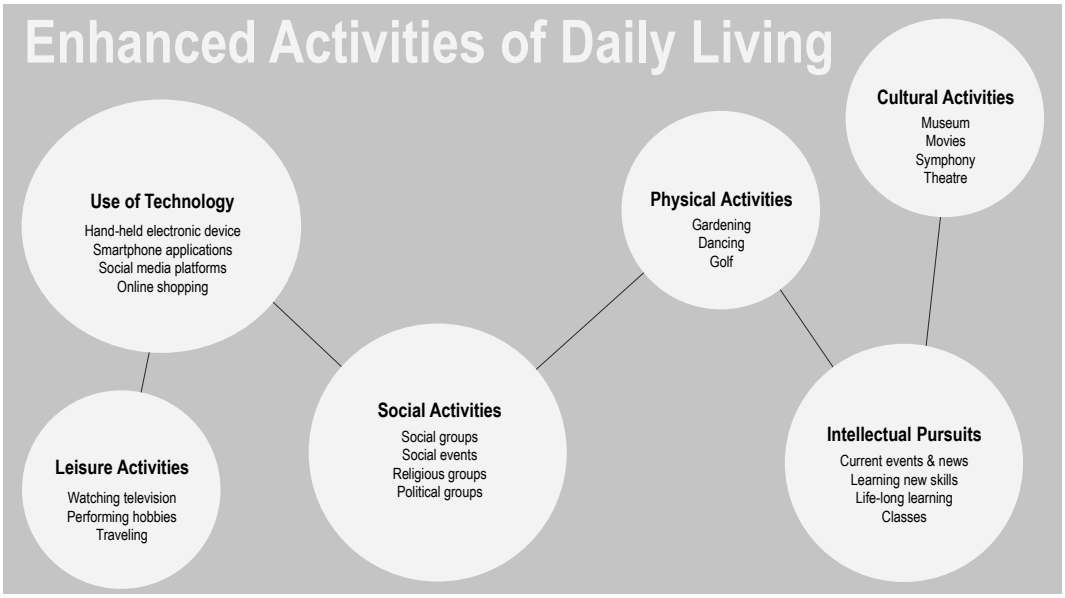

Figure 2. Example categories and exemplars of Enhanced Activities of Daily Living (EADLs). This is a non-exhaustive list as there are many activities that can be considered EADLS.

and opportunities for recreation and leisure).

Engaging in EADLs is important for positive health outcomes. The WHO defined health as "A state of complete physical, mental, and social well-being not merely the absence of disease…" (International Health Conference, 2002, p. 983). Given this definition, the WHO acknowledged the importance of measuring improvement in the quality of life-related to health care, in addition to changes in the frequency and severity of diseases. Indeed, QoL is a significant predictor of all-cause mortality (Netuveli, Pikhart, Bobak, & Blane, 2012; Steptoe & Wardle, 2012). Therefore, EADL engagement may impact health outcomes directly as well as indirectly through improvement in QoL.

There are likely many pathways by which engaging in EADLs may improve QoL and health outcomes. Here we provide examples from the literature of the association between EADLs and QoL and health outcomes (or of the pathways of social relationships, and cognitive and physical leisure activities).

Social relationships

Social relationships are a component of many EADLs, including participating in social activities, playing games with friends, and caring for friends and family members. A rapidly-expanding body of research supports a significant association between social relationships and health outcomes, including mortality. A meta-analysis of 148 studies (308,849 participants) demonstrated a 50% increased likelihood of survival for participants with stronger social relationships (Holt-Lunstad, Smith, Layton, 2010). In another study, social isolation predicted mortality over 7 years of follow-up for a national sample of 6,500 older men and women, even after accounting for demographic factors, baseline health, and mobility (Steptoe, Shankar, Demakakos, & Wardle, 2013). Social connection has been associated with specific health conditions and biological markers indicating the risk of preclinical conditions. There is consistent and compelling evidence supporting the association between quantity or quality of social relationships with a range of conditions, including cardiovascular, neoplastic, and other common aging-related diseases (Penwell & Larkin, 2010; Yang & Kozloski, 2011; Yang, McClintock, Kozloski, & Li, 2013).

Cognitive and physical leisure activities

EADLs encompass many cognitive and physical leisure activities. In an analysis of population-based data from over 13,000 individuals, participation in a wide range of leisure-time activities was associated with a significant decrease in mortality risk, as compared to non-participation (Paganini-Hill, Kawas, & Corrada, 2011). Interestingly, reduced mortality was associated with less physically demanding activities as well as traditional physical activities involving moderate exertion. These findings suggest that engagement in both types of leisure activity has a robust protective effect on mortality risk.

One of the most studied EADLs in the context of health benefits is engaging in physical exercise. Leisure physical activities (e.g., walking, dancing, gardening, hiking, swimming, golfing) and other

types of exercise, and the associated cardiorespiratory fitness, reduces mortality, as well as a wide range of cardiovascular impairments (Berry et al., 2013; Hill and Olson, 2008; Shiroma and Lee, 2010; Lee, 2010). Physical activity is a protective factor for diseases such as cardiovascular disease, stroke, diabetes, and some types of cancer (WHO, 2018). Physical activity is associated with improved mental health (Schuch, Vancampfort, Richards et al., 2016), delay in the onset of dementia (Livingston, Sommerlad, Orgeta et al., 2017), and improved quality of life (Camboim, Nóbrega, Davim et al., 2017).

Less physically demanding leisure activities may provide benefits through cognitive-stimulation. Participating in cognitive leisure activities (e.g., reading newspapers and books; listening or playing music; doing crosswords and puzzles; playing games; new learning) has consistently been shown to be associated with reduced mortality (Jacobs, Hammerman-Rozenberg, Cohen, & Stessman, 2008), risk of cognitive aging (Moussard, Bermudez, Alain, Tays, & Moreno, 2016), as well as reduced risk of dementia and cognitive impairment (Yates, Ziser, Spector, & Orrell, 2016). Neuropsychological characteristics of capacity for change and plasticity suggest engaging in enriching cognitive activities may contribute to successful aging (Mora et al., 2007).

EADL technology research examples

Given the value of EADL engagement to quality of life, this class of activities must be considered when developing new technologies. As illustrated in Figure 2, EADLs span a broad range of activities. To illustrate research in this area, we provide an admittedly selective review of projects that have been conducted by CREATE researchers over the years. Given that this special issue is in honor of Neil Charness, one of the inaugural CREATE members, we thought this approach was fitting. However, we are fully aware that excellent research has been conducted by others in these domains.

New learning and training for technology use

Even if designers endeavor to make new technologies 'intuitive' there is nearly always a need for training and instructional support, perhaps especially for older adults. Intuition is based on prior knowledge and experience, which together provide a mental model of how to use something. Older adults are typically slower adopters and have less experience with a broad range of currently emerging technologies putting them at a disadvantage. Moreover, complex systems with multiple steps and a variety of options will likely require training.

Early work in CREATE illustrates these concepts well. We analyzed the steps required for a presumably 'simple' medical device (Rogers et al., 2001). Through a task analysis of a common blood glucose meter designed for home use, we found that contrary to the advertisement that it was as easy as 1, 2, 3, it actually had 52 total steps that were necessary for proper use. Perhaps not surprisingly, older adults had difficulty using the meter properly, even with the instruction manual provided by the manufacturer (Mykityshyn et al., 2002). However, the provision of training using instructional videos improved performance for older adults (resulting in them performing as well as younger adults) both initially as well as after a two-week retention interval.

Health self-management can be considered an EADL in several ways. First, the ability to monitor one's health variables and make decisions about health regimens directly contributes to the quality of life. Moreover, family caregiving may require an understanding of healthcare technologies to support a loved one with a chronic condition. In addition, older adults are very willing to use new apps (Harrington et al., 2018) and activity trackers (Preusse et al., 2017) to set goals for exercise and support their health and wellness. However, they do report use challenges that could potentially be remediated with additional training. Moreover, this general principle of instructional support pertains to all classes of technologies, beyond the realm of healthcare. Older adults may have less – or different – experiences and will benefit from instructions and training to use new technology.

An example of the importance of instructional support for a broader class of technology comes from the PRISM study. PRISM is the Personal Reminder Information and Social Management computer system designed to support social connectivity; procedural and prospective memory; knowledge about topics and resources; and access to community resources (Czaja et al., 2015, 2018). In the PRISM multi-site, randomized controlled trial, CREATE researchers examined the impact of this computer system on social isolation, social support, and well-being for a large and diverse sample of older adults who lived alone in the community and were at risk for social isolation. These individuals ranged in age from 65-98 years old and had minimal computer experience (none of them had a computer in their home). With training, all of these individuals learned to use this multi-faceted computer system. Although it was explicitly designed for older adults, it was nevertheless a complex system. Participants learned to use email; search the internet; play games; use a calendar; find and display their previously-stored photos; and access information about the community and national resources. In addition to the benefits of less loneliness and in-

creased perceptions of social support, findings from the PRISM study indicated that there was an increase in computer self-efficacy, proficiency, and comfort with computers.

Assistive and social robotics

As individuals experience age-related perceptual, motor, and cognitive declines, their needs for assistance increase, not just for ADLs and IADLs, which has been the traditional focus of assistive technology, but for EADLs as well. Assistive technology has the potential to augment the capabilities of older adults, thereby supporting their independence and reducing caregiver burden. Robots hold much promise to provide multi-functional, adaptable, and intelligent support to enable older adults to engage in EADLs.

With any type of support, whether it be from a human or a robot, it is important to respect the recipient's autonomy. Autonomy refers to one's perception of control (Ryan, 2006) and is associated with quality of life (Wahrendorf et al., 2010). For a robotic assistant to support an individual's autonomy it must be consistent with their needs and preferences. CREATE researchers have conducted a series of studies focused on understanding older adults' needs, preferences, and attitudes about robotic assistance (Beer, Prakash, Smarr et al., 2017; Mitzner, Chen, Kemp & Rogers, 2014; Mitzner, Tiberio, Kemp, & Rogers, 2018; Smarr, Mitzner, Beer et al., 2014). In multiple studies, older adults have demonstrated openness and positive attitudes about robots assisting them with a wide range of everyday tasks (e.g., Beer, Prakash, Smarr et al., 2017; Smarr, Mitzner, Beer et al., 2014). However, when asked to choose between a robot or human assistant, older adults' preferences depended on the nature of the task. For EADLs, they preferred robot assistance to human assistance for tasks such as getting weather and news, reminders about daily activities, finding information about hobbies, and learning new skills. They preferred human assistance over robot assistance for entertainment and communicating with friends and family. These findings demonstrate the older adults prefer to have robots assisting with certain tasks rather than replacing humans for all everyday tasks. These preferences can be used by robot developers to drive innovation in the types of tasks that future robots are capable of supporting and to increase the likelihood of adoption when robots are more widely available.

CREATE researchers have also explored older adults' attitudes about therapeutic or companion robots, which have the potential to support the EADL of caregiving. This work focused on a robot called, PARO, whose appearance, sounds, and behaviors were modeled after those of a baby harp seal (Shibata & Tanie, 2001). Older adults had positive attitudes towards PARO, perceived it to be easy to use, and useful for both themselves and others (McGlynn, Kemple, Mitzner, King, & Rogers, 2017). When left alone with PARO almost all participants interacted with it, with some having significant interaction, mostly in the form of speaking to it (i.e., social interaction). Moreover, social support was one of the uses participants identified when asked about how they might use it.

Telework

As the population of the United States and many other industrialized countries becomes older over the next century, older adults are projected to increase their share in the labor force as well (Toossi, 2006, 2015). Technology will play an important role in accommodating this transition. Teleworking refers to the ability to work for an organization without having to travel to a central office or location. Instead, teleworkers can perform their duties and tasks remotely, including from the comfort and security of their own homes. With the proliferation of information and communication technologies (ICT) over the past few decades, and the reduction in the cost of remote communication, teleworking is becoming a preferred mode of work for many full- and part-time workers. For older adults who may no longer have the physical ability or desire to commute to work, or who wish to work part-time with a flexible schedule that accommodates their needs, teleworking is an opportunity for many older adults to continue their participation in work-related daily activities.

To ensure that telework is a viable option for older adults who wish to remain working or who desire to reenter the workforce, managers need to hold positive attitudes towards the employability of older workers as teleworkers. CREATE research was among the first to investigate this issue (Sharit, Czaja, Hernandez, & Nair, 2009). Over 300 persons in managerial positions were questioned about their attitudes towards telework, the work-related attributes that are important when deciding whether to allow a worker to telework and how older and younger workers compared on these work-related attributes. Positively, older adults were rated higher on many attributes that were seen as important characteristics in a teleworker, including trustworthiness, reliability, time-management, maturity, and experience in the work activity. Less positively, older workers scored lower on other relevant work-related attributes, such as technology skills and the ability to make adjustments to work. These latter results appear to tap into certain age-based stereotypes that older adult workers are less able to adapt to technological change to

accomplish work-based tasks, which is not necessarily borne out in the empirical literature. For example, older adults have demonstrated proficiency in being able to perform a simulated customer service teleworking task, especially after a few days of training (Sharit, Czaja, Hernandez, Yang, Perdomo, Lewis, Lee, & Nair, 2004). Taken together, this research demonstrates that managerial decisions regarding older teleworkers must not be based on stereotypes and that training strategies for older teleworkers should be in a place that takes into account the characteristics of individual workers.

Teleworking benefits older adults who wish to remain in the labor force in a variety of ways. (See Sharit, this volume, on the new older worker.) Telework may help older adults remain financially independent by supplementing retirement savings. In addition, participation in work-related EADLs (e.g., learning new technology skills, mentoring) can be a source of meaning and fulfillment for older adults, contributing to their general level of well-being and quality of life. As the next cohort of older adults enters retirement age with a greater history of using technology earlier in their work career, they will be even more likely to possess the skills and knowledge necessary to complete many telework tasks. As a result, technology will play an integral component in the performance and support of work-related EADLs during older adulthood in the near future. Furthermore, teleworking provides the ability to continue working in the face of other personal demands, such as caregiving responsibilities.

Family caregiving

Caregiving is one aspect of productive engagement (Bass, Caro, & Chen, 1993), and thus can be considered an EADL. A large number of older adults are caregivers, caring for a spouse or other family member (often a grandchild). AARP (2012) reported that ~43.5 million caregivers have provided unpaid care to an adult or child in the last 12 months and 34% of them were over the age of 65.

Technology has tremendous potential to support the psychosocial needs of dementia caregivers given the challenges they often face in being able to leave the persons they are caring for at home. Czaja et al. (2013) explored the benefits of videophone technology for minority caregivers (Hispanic American and African American) in the Miami area. They assessed the benefits of the intervention over 5 months and found decreased caregiver burden and increased perceptions of social support. Perhaps most relevant to the idea of caregiving as an EADL, Czaja et al. found that perceptions of the caregiving experience itself were more positive after the intervention. Moreover, the caregivers felt that their caregiving skills had improved and they found the technology easy to use.

These data illustrate the potential to use technology to support caregiver needs. The psychosocial intervention included education and skills training for critical caregiver risk areas such as safety, social support, addressing problem behaviors, depression, and caregiver health. The opportunity for learning new information and developing new skills are also examples of EADLs that were supported by this technology intervention.

Physical activity

Despite the numerous health and quality of life benefits of engaging in physical leisure activities, data from the most recent U.S. Census indicate that older people are not meeting the minimum goals: 60% of those aged 65-74 and 70% of those over age 75 do not meet the minimum U.S. Federal Physical Activity guidelines (Schiller, Lucas, & Peregoy, 2012). Moreover, many older individuals are classified as 'inactive' meaning that they are not engaging in any activities beyond baseline daily activities: 27% of those aged 65-74, and 35% of those over age 75 (Watson et al., 2016). Lack of participation in physical activities can be attributed to a wide variety of barriers, including the inability to travel to public activity centers, due to physical limitations, poor weather conditions, or lack of transportation (Rimmer, Wang, & Smith, 2008).

Exergames could provide an opportunity for older adults to engage in leisure physical activity from their homes. Gaming interfaces are typically designed for young end-users; if older adults perceive them to be difficult to use or not useful, they are not likely to adopt them. CREATE researchers explored the barriers and facilitators to exergame use by older adults (Barg-Walkow, Harrington, Mitzner, Hartley, & Rogers, 2017). Participants interacted with two exergames and were interviewed about their perceptions of the system. They perceived the interfaces to be difficult to use. Nevertheless, they were open to adopting exergames because they perceived them to be useful for increasing their physical activity. Given older adults' overall positive perceptions of the usefulness of exergames, designers should address the usability issues for this user group. In doing so, older adults will be more likely to adopt exergames and use them as an added and convenient method for engaging in leisure physical activity.

Digital gaming

Leisure activities are the activities usually performed after work-related activities and other responsibilities are completed. As such, leisure activities often provide entertainment value

and enjoyment to individuals. Video gaming is one popular form of leisure activity, with about 50% of American adults (age 18+) engaging in gameplay (Duggan, 2015). However, older adults play digital games or self-identify as 'gamers' at a much lower rate than younger adults. One might surmise that this is solely due to older adults having less interest in video games. Yet, many older adults self-report an interest in digital games, particularly games that are intellectually stimulating (e.g., educational and puzzle games; Blocker, Wright, & Boot, 2014).

Actual gameplay preferences and behavior in an older adult sample were identified in the PRISM trial (Czaja et al., 2015; 2018). The PRISM system presented older adults with eleven different video games to play (e.g., solitaire, memory, word search, crossword, poker). Daily usage behavior was collected from participants over the one-year trial. Sustained and active gameplay was observed in the sample, with older adults playing a game on approximately 42% of the days the PRISM system was accessed (M = 84 days; Boot et al., 2018). However, there were different clusters and typologies of gamers, such as older adults who played a variety of games versus older adults who overwhelmingly played a single game. These results demonstrate that with proper access and training, older adults exhibit a spontaneous desire to engage in gameplay as a leisure activity, but that noticeable individual differences exist in digital gaming preferences that must always be taken into account.

Digital gaming in the PRISM system had additional technological benefits for older adults. For example, playing digital games significantly predicted later use of other system features. The opposite effect was also observed, where prior use of other system features significantly predicted later gaming. These results illustrate the reciprocal role technology can play in supporting a variety of EADLs. Computers with internet access and smartphones are platforms through which many different types of EADLs can be performed, including intellectual activities (information searches, eReading), social activities (E-mailing, video chatting), and leisure activities (gameplay). As a result, exposure to and training on these platforms has the potential to unlock a diversity of EADLs for older adults who are currently non-users of the technologies. See Boot (this volume) for a more elaborated discussion of digital gaming.

Social engagement and intellectual pursuits

Older adults may have reduced social networks as they grow older, as they retire, relocate, or perhaps outlive their friends. A recent review indicated that loneliness increases especially for individuals over age 75, who have poor health, live alone, or few close family and friends (Hawkley, Wroblewski, Kaiser, Luhmann, & Schumm, 2019). Nevertheless, they retain the desire to remain connected with people who have shared interests (Harris et al., 2020). There is a high prevalence of social isolation among older adults with normal cognition as well as those experiencing mild cognitive impairment (MCI). Social engagement video technologies provide novel opportunities for social interaction that can help reduce the feelings of social isolation and positively impact health and quality of life. However, these technologies are rarely designed to accommodate the interest, capabilities, and concerns of older adults, and especially not individuals with MCI.

Working with a company called OneClick.chat, we have explored the potential of this video chat technology to provide social engagement opportunities for older adults with and without MCI (described in Nie et al., in press). This video chat platform connects people with common interests (e.g., books, movies, travel) to share conversation and reminisce. It can also support educational discussions (e.g., art history, cooking) to enhance new learning opportunities. As such, this video chat platform supports multiple aspects of EADL activities (i.e., social, intellectual, new learning). OneClick.chat was not initially designed for older adults in general or those with MCI. We redesigned the system to meet their needs, based on usability assessments directly with older adults (with and without MCI), as well as heuristic evaluations and cognitive walkthroughs with their specific needs in mind. We interviewed participants about their preferences for topics, people, and group size when using OneClick, as well as their attitudes toward the usability and usefulness of the system. We then conducted a small-scale four-week experiential field trial using OneClick for social engagement. Participants were open to meeting new people of all ages. Their three favorite topics were books, health, and family. Their ideal group size was 3-6 people. Their attitudes toward the system were positive, as they perceived the system as easy to use and useful for social engagement. Individuals with MCI had more technical issues and required additional assistance to use the system. Nevertheless, pre to post comparisons of questionnaire data in this feasibility study revealed positive changes in quality of life and reduced loneliness. This work demonstrates that social engagement technology has the potential to benefit social health and quality of life among older adults with and without MCI. With consideration of usability issues, preferences, and instructional support needs of older adults, especially those with MCI, such technologies can be effectively used at home.

Autonomous vehicle technologies

Driving a car remains the main mode of transportation for most adults, with personal vehicles involved in approximately 87% of daily trips in the United States (U.S. Department of Transportation, 2017). As such, losing the ability to drive due to physical impairment can severely disrupt participation in EADLs during older adulthood, whether it is participation in social activities such as meeting up with friends, or attending intellectual and cultural events in the surrounding community. Technology can serve to support EADLs in older adults who have either lost the ability to drive or reduced their driving frequency due to safety concerns. Autonomous vehicles hold particular promise, due to their potential in providing a safe, inexpensive, and reliable mode of transportation that increasingly relies less on the physical input of the passenger. Yet, older adults self-report higher levels of hesitation towards autonomous vehicles compared to younger adults (e.g., Kyriakidis, Happee, & de Winter, 2015). Clearly, for the anticipated benefits of autonomous driving technologies to be realized, a better understanding of the factors that affect attitudes towards autonomous vehicles is needed first.

To accomplish this goal, recent work by CREATE researchers has focused on identifying predictors of autonomous vehicle attitudes (Charness, Yoon, Souders, Stothart, & Yehnert, 2018). Participants completed a series of items that probed beliefs, perceptions, and attitudes towards autonomous vehicles (e.g., "I think that autonomous vehicles can never be safer than those driven by humans."). Factor analysis revealed the following three components: (1) concern with autonomous vehicles, (2) eagerness to adopt autonomous vehicle technology, and (3) willingness to relinquish driving control. Certain demographic variables were associated with these attitudes, with males and younger adults exhibiting more positive attitudes towards autonomous vehicles. Moreover, knowledge and personality traits emerged as significant predictors of attitudes, such that prior knowledge of autonomous vehicles and more openness to experience, as an example, was associated with more positive attitudes. Taking these and related individual differences into account will be necessary for any future campaigns that aim to increase acceptance and adoption of autonomous vehicle technologies.

Technology acceptance

Technology acceptance has been a strong theme for CREATE research. Technology acceptance is typically operationally defined as the behavioral intention to use or adopt a technology. Technology acceptance is the precursor to adoption and therefore can reveal insights about why an individual does or does not adopt a particular technology. CREATE research has provided substantial evidence to counter stereotypes that older adults do not like or are fearful of technology. This work has revealed a complex and dynamic relationship between older adults' characteristics and their attitudes about technology and identified predictors of older adults' acceptance and adoption of a variety of technologies related to well-established models of technology acceptance (e.g., Unified Theory of Acceptance and Use of Technology; UTAUT; Venkatesh et al. 2002; 2013).

In the PRISM multi-site, randomized clinical trial described above (Czaja et al., 2015; 2018), earlier use of the system, executive functioning, and computer efficacy predicted long-term use (Mitzner, Savla, Boot et al., 2018). Understanding predictors of acceptance guides deploying technologies in a way that promotes acceptance. With regard to PRISM, these findings indicate that providing opportunities to develop efficacy and gain positive experience with computer technologies may increase the likelihood of adoption.

CREATE researchers have also explored older adults' acceptance of social communication technologies, which may be able to bridge barriers to social engagement for older adults (Bixter, Blocker, & Rogers, 2018; Bixter, Blocker, Mitzner, Prakash, & Rogers, 2019; Quan-Haase, Mo, & Wellman, 2017). These technologies may be able to support older adults' participation in EADLs, such as communicating with family and friends, even when they are distant geographically, and participating in other social activities, such as sharing information and resources related to a hobby. In a group interview study, users and non-users of social communication technologies separately discussed facilitators and barriers to adopting such technologies. Some of the findings were captured by the well-established model of technology acceptance (i.e., UTAUT). That is, social connectedness, entertainment, and/or information sharing were discussed as benefits to using these technologies (i.e., performance expectancy). However, the UTAUT was not sufficient in fully capturing part of the discussions that centered on the trust of social networking sites, including privacy and security concerns. These results suggest it may be necessary to broaden the UTAUT to fully predict older adults' adoption of communication technologies. The findings can also inform product development and design implementation aimed at increasing older adults' adoption rate of social communication technologies.

Conclusions and next steps

There is a growing understanding of the breadth of activities that older adults engage in every day. To capture this range, and to augment the traditional

categories of ADLs and IADLs, we proposed an updated definition of EADLs: participation in daily activities that lead to fulfillment, well-being, quality of life, happiness, or social engagement.

This admittedly selective review of technology to support EADLs has illustrated quite clearly the value of technology for supporting these activities. It is important to consider older adults holistically: as a group they are diverse and each individual has a unique constellation of desired activities that will enable them to feel they have a high life quality. One notable gap in the literature is a valid and reliable measure of EADLs. We need to develop an accurate metric for assessment to be able to assess where an intervention is needed.

Another gap in the literature is the understanding of how EADL performance may be influenced by individuals with impairments of vision, hearing, or mobility. Persons living with a disability are no less interested in maintaining their EADLs, but their impairments may pose additional demands that impede their ability to engage in these activities (Mitzner et al., 2019). Moreover, individuals with mild cognitive impairment, traumatic brain injury, or other chronic conditions such as Parkinson's may face specific EADL challenges that are not being addressed when considering what their support needs are. Individuals who move to an assisted living facility often do so because they have ADL and IADL support needs (Mitzner et al., 2014). Nevertheless, they can benefit and are interested in learning to use new technology that can support EADLs as nicely illustrated by Cotten, Yost, Berkowsky, Winstead, and Anderson (2016).

There are limited data on the long-term benefits of different EADL technologies and interventions, with some notable exceptions such as the PRISM project (Czaja et al., 2015, 2018). Future efforts should focus on identifying the broader impacts on health and well-being when EADLs are supported for older adults. Moreover, when designers and thought leaders are pondering ideas for future developments, EADLs must be considered part of the landscape for enabling older adults (e.g., Rogers & Mitzner, 2017). Understanding initial acceptance attitudes can predict the long-term adoption of emerging and future technologies.

CREATE researchers have focused on how technology can support older adults' participation in EADLs, covering all facets of use from design to training to acceptance and integration into daily activities. Along with research in the field of gerontechnology more broadly, these efforts have provided guidelines to increase the usefulness and usability of EADL-focused technology as well as to support their deployment. Older adults continue to be somewhat ignored as end users for the design and marketing of new technology. However, our research efforts clearly illustrate both the value of technology to support their needs as well as the willingness of older adults to adopt and learn to use technologies that can enhance their quality of life.

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