Learning and Adaptation in Older Adults: An Overview of main Methods and Theories

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Abstract

The aim of the present article is to offer a broad overview of usual methods and dominant theories in the field, in order to make unfamiliar readers more aware of the current state of the art in this domain and to show how it can support future investigation on learning and adaptation in older adults. As our understanding of the aging process is closely linked to the methods used to investigate it, a first part is devoted to usual methods in this field and their potential limitations. It also highlights the necessity of a deeper involvement of older adults in all steps of research to have a richer understanding of the reality of aging, including social and cultural aspects. The second part presents predominant theories of the field, startingfrom a biological level (i.e., processing resources) to reach a psychosocial level (i.e., regulation's processes). The benefice of environmental support to aging in place, such as assistive technologies, as well as the wish of older adults to continue to learn new things is discussed in the conclusion.

Keywords: Older adults, learning, adaptation, daily living, state of the art

1. Introduction

At the beginning of the 20th century and until the end of World War II, France was the only country to present a significant proportion of elderly people, with 13 percent of its population being aged over 60. Nowadays, population aging is a typical feature of the demographic landscape in the EU-27, with an increase from 13.9 percent in 1991 to 17.5 in 2011, and an expected proportion of 25.6 in 2030 and 29.5 in 2060. The specific part of 80 and more is expected rising from 5 percent in 2010 to 12 in 2060 (European Commission, 2014; Eurostat, 2013). In the more industrialized regions, longevity is projected to increase from 77 years in 2005-2010 to 83 years in 2045-2050 and to 89 years in 2095-2100. Even though longevity is lower in less industrialized regions, the increase is real too: from 67 years in 2005-2010 to 75 years in 2045-2050 and 81 years in 2005-2010 (United Nations, 2013). Even though the increasing probability to live longer is a cheering prospect, the combination of retirement (usually around the age of 60-65) and the increasing risk of physical and cognitive impairments with age challenge the well-being of populations as well as the sustainability of public expenditures and distribution of public resources. Consequently, aging became a more and more frequent topic in social, engineering, economics or life sciences, making it a transversal dimension in theory and research (Ferring, 2018).

The wish of a majority of elderly people is to “age in place” and avoiding moving in nursing homes or other care institutions (Rioux, 2005). Aging in place is defined as the ability of older people to live in their own home and community safely, independently, and comfortably (World Health Organization, 2015). However, as previously reported, age-related changes affecting cognition but also physical and social functioning might threaten the capacity of older adults to stay safely and independently in their home and being socially involved in their community (Martin, Kliegel, & Rott, 2008). Efficient capacities to learn and

adapt will enable the person to deal with age-related changes as well as with environmental changes.

To deal with these challenges, this article aims at offering a broad overview of dominant theories in the field of learning and adaptation in older adults, in order to make unfamiliar readers more aware of the current state of the art in this domain. As understanding of the aging process is closely linked to the methods used to investigate it, a first part is devoted to usual methods in this field. The advantages and inconvenience cross-sectional and longitudinal designs are presented, but also the challenge of ecological assessments and self-evaluation, as well as the need for more user involvement and co-research. The second part of the article presents theories linked to learning and adaptation skills during aging. It starts from a biological level to reach a more psychosocial level, by detailing the following aspects: processing resources, strategy selection, habits and routines, and finally regulation's processes. The discussion comes up to some concrete approaches to support the wish of older adults of aging in place, such as assistive technologies, and will put in perspective with the hybrid mind approach.

2. Research Methods and Investigation: How or What are We Learning about Aging?

Developmental research has traditionally been conducted using cross-sectional and longitudinal designs (e.g., Robinson, Schmidt, & Teti, 2005); the investigation of the older adults' psychology does not escape this methodological differentiation and these two designs are presented in this section and their limits are discussed more in details by Säljö (this issue). We highlight ecological validity and self-evaluation as means to better understand the "age invariance paradox" often reported in the literature. Finally, we present the current developments regarding user involvement and co-research and how they can enrich research.

2.1. Cross-Sectional and Longitudinal Designs

The comparison of groups of different ages is mainly related to a cross-sectional approach: at least two samples differing in age (e.g., 20 to 30 years old versus 65 to 75 years old) are compared simultaneously on one or several tasks. This comparison is supposed to mimic aging so that researchers do not have to wait for the participants to age (Achenbach, 1978). Advantages of cross-sectional design are to be convenient and quite inexpensive, with data rapidly available, making it useful to generate or test models and theories. However, they cannot inform us about the stability of a characteristic or process over time, some information being lost due to the use of average to create group means. Moreover, it is difficult to guarantee that the measurement instruments used for investigation are valid for each age group and measuring similar things (Robinson et al., 2005). However, the main limitation is probably that this methodological approach assumes that the participants of all groups are comparable at the exception of age, which is for example not compatible with a cohort effect (see also Säljö, this issue). Formal education is a good example of current potential cohort effects when comparing older adults (65 and more) and, even more, very old adults (80 and more) to younger ones. Indeed, for older generations, the access to formal education was much more infrequent and restricted than today. For example, nowadays in France, around 77 percent of a generation has access to the *Baccalauréat* (i.e., an academic qualification at the end of high school) whereas it was only 10 percent of a generation in the early 1960s (Dauphin, 2015). The number of formal education years is known to impact performance and behavior during aging, especially for cognition (e.g., Olivera, Andreoli, Leist, & Chauvel, 2018); comparing young and older cohorts becomes thus easily a conundrum. Additionally, cross-sectional designs are frequently used to draw longitudinal conclusions about intraindividual age-related changes by comparing interindividual differences, and this questions the validity of the conclusions (Robinson et al., 2005).

A safer approach of longitudinal age-related changes consists in the use of longitudinal designs in which data are repeatedly collected from the same participants (at least twice) over a period of time such as years or decades (Kausler, 1991). This direct investigation of intraindividual changes across time allows to make reasonable speculations about causality due to the examination of antecedents and consequences (Robinson et al., 2005). However, longitudinal studies have as weakness the strengths of cross-sectional designs: they are expensive and time consuming because they generally involved a high density of data. As they are following the real flow of the years, they give not direct insights about the studied aspect and request more time to observe potential age-related differences. Due to their duration over time, they are also very sensitive to experimental mortality/attrition, which refers to participants dropping out before the end of the study, due to a lack of interest, illness or death. A main risk is that participants who quit the study have different characteristics than the remaining participants, leading to a study sample not representative of the general population. In other words, older adults being involved in research protocols might represent the most motivated and "healthy" ones of their age group, and offer only a limited overview of the variety of their age category. Statistical analyses are often performed to compare participants who dropped out with those who stayed in the study in order to assure their comparability, or if this is not the case, to understand which characteristics might have made them leave the study. Another consequence of experimental attrition is the reduction of the statistical power of analyses that may affect the results validity. Lastly, practice effect due to performing several times the same tasks/assessments in the course of the study is also a matter of concern with longitudinal designs. Even if alternate forms (e.g., form A and form B of a vocabulary test) or tasks little sensitive to practice effect are frequently used to manage this risk, practice effect may partly explain why age effects are traditionally smaller with longitudinal than cross-sectional designs (Salthouse, 2010).

To conclude, longitudinal and cross-sectional designs can be mixed in (cross-) sequential designs that combine the cross-sectional and longitudinal approaches by following several age cohorts over time. This procedure increases the internal validity of assessments and makes the difference between age changes and normative history-graded events (Schaie, 1965).

2.2. Ecological Validity and Self-Evaluation

Whether the measurements are cross-sectional or longitudinal, it is necessary to ensure the ecological validity of the collected data. Ecological validity of assessments, that corresponds to the generalizability (i.e., extent to which assessment results relate to and/or predict behaviors outside the test environment) and the representativeness (i.e., extent to which the assessment conditions resemble everyday life contexts in which the behavior is expected to be) of an assessment (Dawson & Marcotte, 2017), is often confronted to the observation of an "age invariance paradox". Same observations regard cognitive functions: results from cognitive assessments made in laboratory are quite pessimistic about the cognitive functioning of older adults whereas observations of skills and daily life activities in this age population reveal few changes (Salthouse, 2012). This paradox refers to the fact that older adults have generally a more positive evaluation of their own aging and functioning than predicted by age-related changes observed during laboratory assessments. For example, despite age-related biological changes threatening physical, psychological and social functioning, older adults usually report little changes during life span and stable levels of well-being and life-satisfaction (Kanning & Schlicht, 2008).

The overestimation of age effects by objective assessments could be explained by the fact that laboratory assessments of cognitive performance traditionally offer tests which require discrete responses to single events that often fail to mimic the complexity of cognitive

functioning during daily life behaviors. In addition, most tests are kept deliberately abstract in order to minimize the role of differential experience that would complicate comparison across people (Salthouse, 2012). However, laboratory assessments of cognitive skills appear to be partly predictive of the daily life functioning (e.g., Tomaszewski Farias et al., 2009; Vaughan & Giovanello, 2010) and in consequence relevant.

The progressive development of computerized assessments in place of paper-and-pencil tests questions the ecological validity of the results and their representativeness. Computerized tests save costs and time, offer accurate recording of responses, including response speed, and a more standardized assessment by reducing the examiner bias. As mentioned by Säljo in this issue, technological developments have been enormous in the last decades and more and more older adults are engaging in computer and internet-related activities. Data suggest that computerized tests are quite well tolerated by older adults but the lack of familiarity of some older people with computers and some anxiety related to their use can result in a drop in performance (Zygouris & Tsolaki, 2015). As young adults are generally more familiar than older people with computer use, studying aging by comparing the performance of young and older adults on computerized tests can create artificial differences and a cohort effect, especially for tasks requiring quick responses. However, as the adults of today have grown up using computers and other technological devices, future older adults will be very familiar with technology, reducing the current discrepancy between ages.

Tasks characteristics are not the only potential source of overestimated age-differences, as illustrated by memory complaints. Low confidence in their own memory capacities is very common in elderly people, with the proportion of them complaining about their memory performance going from 15 percent to 40 (Cutler & Grams, 1988; Howieson et al., 2015). At first sight, it could be interpreted as reflecting the decrease of objective memory performance during aging. However, deeper investigations reveal that memory complaints appear to be

more influenced by factors such as depression, concerns about aging or age-based memory stereotypes than objective memory performance (e.g., Pearman, Hertzog, & Gerstorf, 2014). It thus highlights the necessity to be very careful about how research protocols or clinical assessments are introduced to older adults in order to avoid biased results and conclusions. For example, Rahhal et al. (2001) showed that older participants are less efficient than young participants only when the instruction emphasizes the memory aspect of the task (Armstrong, Gallant, Linggian, Patel, & Wong, 2017).

2.3. Co-Research and User Involvement

The previous subsection highlighted the necessity to take into consideration real life contexts and the subjective aspects when investigating age-related aspects. The growing interest for co-research and user involvement approaches stems from the same observation, and calls for a larger involvement of communities in knowledge creation (Buffel, 2018). In order to face current societal challenges, a growing interest favors a direct involvement of the first concerned in research: users and general public. The scope is to conduct research "with" or "by" users, rather than "for" or "about" them, by involving them ideally in all the steps of the research design (problematic, data collection, dissemination, etc.). It is close to several concepts, including co-research, participatory research, inclusive research, co-production, co-production and co-creation. This user-involvement is expected to be a means to reach the unique user/customer experience that will benefit to the production of policies or products fitting their real needs, especially in the case of complex health or social challenges. This kind of research has been slower to develop for older adults than other users' groups, but there is now a growing body of research involving older adults as "co-researcher" alongside academic researchers (Littlechild, Tanner, & Hall, 2015).

Involving users in research impacts the research content and problematic, in particular because they can offer insights into the identification of relevant topics or bring academic researchers to modify their interpretations of the findings. Regarding data collection, involving older adults as co-researchers during interviews of other older adults appears beneficial due to their ability to communicate and empathize with the interviewees given their age-related common experience. It is often reported as offering a supportive and relaxed interview situation, enabling most participants to feel more understood and maybe being more open and offering richer data (e.g., Buffel, 2018; Warren & Cook, 2005). In addition, co-researchers may point out or deepen relevant topics occurring during interviews that were not perceived as such by the academic researcher.

Co-researcher involvement implies that they receive a training that have a time and economic cost which has to be anticipated in the preparation of the project (Warren & Cook, 2005). These trainings benefit to reduce some barriers to the involvement of older people in research: power imbalance and communication issues between co-researchers and academic researchers (language barriers, nature and ethic of research); co-researchers' lack of confidence and unfamiliarity with research (Fudge, Wolfe, & McKevitt, 2007). Regarding motivation of older adults to become co-researchers, maintaining an active post-retirement lifestyle, commitment to their community and making something change, sense of purpose and self-confidence, learning from each other are frequently reported (Buffel, 2018; Fudge et al., 2007; Littlechild et al., 2015).

However, academic researchers have sometimes the feeling that co-researchers do not pick up on significant issues. Academicians have also to be willing to share professional power and challenge traditional roles and methods (Littlechild et al., 2015). In addition, whereas the involvement of patients and public in health-related research is usually advocated as a way to give a voice to minority groups or underinvestigated research topics (e.g., very old

adults, ethnic groups, LGBT), older adults "who decide to participate are those who are already engaged and are, perhaps, the group which needs empowering the least (Fudge et al., 2007, p. 499). This lack of representativeness can also appear during participants' recruitment, elderly co-researcher relying on their own networks and tending to recruit people similar to themselves (Littlechild et al., 2015), as well as during data collection, with for example the presence of tensions between the activist attitudes of co-researchers and the lifestyles of interviewees, that may contribute to reinforcing a fault line between "active" and "non-active" older adults (Buffel, 2018).

In conclusion, user-involvement in aging research appears as an efficient means to enrich existing data and to approach age-related social challenges. It requests to be very careful at each step of the research to allow for a large representativeness and true participation of older adults in the process, and not only a tokenistic involvement aiming only at fulfilling funding and research ethics committees' requirements (Gove et al., 2018).

This brief overview of specific research designs and users' involvement in aging studies aimed at giving a better understanding of the methodological ground leading to the current main theories related to psychogerontology presented in the next section.

3. Theories on Learning and Adaptation during Aging

According to Lowe and Sandamirskaya (2018), learning corresponds to changes within an organism that enables more effective behavior within its environment, whereas adaptation entails behavioral adjustments to environmental change that may or may not be the direct products of learning. As highlighted by the ecological theory of aging (e.g., Lawton, 1983), an efficient adaptation (i.e., in terms of autonomy and wellbeing) is linked to a good person-environment fit, that is, when older adults' competences correspond to the demand of their environment.

For a long time, understanding of aging has been limited to a biological perspective reporting growing older as a time-dependent series of irreversible, progressive and cumulative declines in functioning that lead to associate old age with loss, decline and reduced adaptation capacities (Säljö, this issue; Zittoun & Baucal, this issue). However, it does not fit with the previously mentioned "age invariance paradox" making most older adults reporting good levels of well-being and life satisfaction. The bio-psycho-social perspective, including aspects such as lifestyle or social environment, offers a more global and comprehensive understanding of old age and people's adaptation to it. In this section, we present several concepts linked to learning and adaptation capacities during aging, starting from a "biological level" to reach a more "social level" of it, by detailing the following aspects: processing resources, strategy selection, habits and routines, and finally regulation processes. With this approach, we aimed at offering a comprehensive and multi-level overview of various age-related aspects of learning and adaptation that are interconnected.

3.1. Processing Resources theory regarding Cognitive Aging

Cognitive functioning (e.g., attention, memory) strongly supports learning and adaptation processes, and a large part of investigation in the field of psychogerontology has been devoted to cognitive aging. A dominant explanation of age-related cognitive changes refers to changes regarding basic information-processing capacities due to neurological changes (Park et al., 1996).

The metaphor of processing resources has been largely used to illustrate how age-related changes in basic information-processing capacities might impede on more complex cognitive activities (e.g., memorizing complex new information, using Information and Communication Technologies). The three most frequent capacities mentioned in the literature regard reduced processing speed, reduced capacities of working memory and reduced

attentional capacities. First, according to the processing speed approach, an age-related slowing in the execution of cognitive operation explains age differences in more complex cognitive task. Indeed, as many treatments need to be performed in a limited time, a slowing reduces the capacity to process information simultaneously (Salthouse, 1996; Finkel, Reynold, McArdle, & Pedersen, 2007). Second, the working memory capacity approach posits that the age-related decline of working memory impedes further treatments given that working memory is a limited capacity system for maintaining and manipulating information (Baddeley, 1986; Emery, Hale, & Myerson, 2008). Thirdly, the approach related to attention, postulates that age-related declines regarding selective attention (i.e., ability to focus on relevant information while ignoring irrelevant information) as well as divided attention (i.e., ability to process information from different locations or to switch between tasks) capacities have a negative impact on cognitive performance (e.g., Zacks, Hasher, & Li, 2000).

3.2. Strategy Selection and Adaptation

Beside basic information-processing capacities, our adaptation to a changing world is closely linked to the use of efficient strategies, to our capacity to select them according to the context, and to learning new ones when necessary. The concept of strategy adaptivity defines the capacity to choose the best strategy according to task characteristics, strategy characteristics, and self-competencies (Siegler & Lemaire, 1997). Among other aspects, this adaptivity is influenced by previous experience of success and reinforcement learning (Payne, Bettman, & Johnson, 1993; Rieskamp & Otto, 2006).

Regarding memory, several studies revealed that older adults generally initiate effective strategies less spontaneously and with less benefit on their learning performance than younger adults (Lemaire, 2016). Many memory programs based on learning new strategies have been developed in order to improve the memory functioning of older adults during daily life, but

show a controversial benefit on long-term (Ball et al., 2002). For example, O'Hara et al. (2007) observed that 93 percent of the participants report using memory strategies immediately after the training, but this proportion failed at 40 percent five years after its end. It can be explained by the balance between the perceived benefit of the strategy use on the memory performance and the cost of the cognitive effort linked to the implementation of this strategy, leading to drop strategies perceived as too effortful as regard of their efficacy (Mata, Schooler, & Rieskamp, 2007; Tournier & Postal, 2011b). Learning and long-term adoption of new strategies could also be affected by a lack of confidence of older adults in their memory skills (Touron, 2015).

3.3. Habits and Routines

Habits and routines benefit to daily functioning by consuming few cognitive resources and using strategies perceived as efficient. At a cognitive level, the distinction between automatic and controlled cognitive operations help understand this benefit. Typically, a new action (e.g., using a mobile phone) requires controlled processes that slowly transforms into automatic processes with practice. Contrary to controlled processes, automatic processes have the characteristic to occur without intention, without necessarily giving rise to awareness, and without interfering with other processing. Assuming that the cognitive system has limited resources, the automatic occurrence of basic mental operations leaves a maximal level of resources for more complex operations and the performance of dual tasks, such as for example talking while walking (Hasher & Zacks, 1979). Contrary to controlled processes, automatic ones maintain well during aging, even though some areas such as gross motor movements and fine motors skills seem to require more attention in old age (Roger & Fisk, 2001).

At a more behavioral level, habits share this characteristic of low resources consumption. Habits can be defined as a more or less fixed way of thinking, willing or feeling acquired through previous repetition of a mental experience (Andrews, 1903). More recently, the concept of routinization has been developed to define the performance of behaviors or activities in the same rhythm or way over time. The increase of routines during aging could correspond to a coping strategy aimed at dealing with difficulties and stress linked to novel situations (Bouisson, 2002). By avoiding novelty and relying on strategies and actions perceived as efficient, routines increase confidence. Investigations about memory revealed that older adults with higher scores at a self-reported routinization scale report more anxiety related to memory performance and use more memory strategies (Tournier & Postal, 2011a).

If routines might benefit to adaptation by relying on behaviors that have been successful in the past, an excess of routines could make behaviors quite inflexible and reduce adaptation to novelty by reducing the diversity of stimuli and the need to perform complex reasoning or varied strategies. A cross-sectional study revealed that older adults with high self-reported routinization show lower performance on a measure of cognitive flexibility (i.e., divided attention) than older adults with lower self-reported routinization whereas it was not the case for younger adults (Tournier, Mathey & Postal, 2012). A longitudinal investigation would be necessary to test the assumption that routinization could affect flexibility skills during life-span. Some insights are offered by an interventional study that compared a control group to an experimental group involved in in a program of stimulating cognitive activities during a period of 10-12 weeks. This program included home-activities (e.g., creative drawing activities, word-logic puzzles, word manipulation) as well as some in-lab sessions involving origami, board games and other creative activities. Cognitive performance (e.g., memory, visual-spatial ability, cognitive flexibility) was tested before and after the intervention and increased in both groups (i.e., test-retest effect). However, this increase was higher in the

experimental group, leading authors to conclude that "increasing the opportunities of older adults for engagement in new and challenging pursuits can lead to much more flexible and adaptive thinking than might be expected based on the standard view of cognitive aging (Tranter & Koutstaal, 2008, p. 200).

3.4. Aging and Regulation

The hypothesis that using routines to cope with daily life activities are in the line of the continuity theory of aging (Atchley, 1989). According to it, older adults preferentially use well-known schemes, actions or purposeful activities because they know they are able to implement them, their expertise to use them allowing compensation in some extent of age-related losses. It is not very far from the notion of "sphere of experience", that refers to "an experiential unit that a person can recognize as "the same" over time, place, and relationships, and usually includes specific activities, modes of relating to others, range of feelings, aspects of one's identity or positioning, and certain specific knowledge or know-how" (Zittoun & Baucal, p. 9, this issue; see also Zittoun, Grossen, & Tarrago, this issue). Very influential in the literature, the model of selection, optimization and compensation (SOC, Baltes & Baltes, 1990) goes along the same line. Selection refers to the specific choice of a subset of significant activities or domains made according to the person's needs or interests (e.g., meeting friends each Saturday evenings in a restaurant). Optimization is deciding to take on behaviors that will enhance the abilities the individual still has (e.g., taking more time for achieving the same journey by walking, even though driving would have been quicker). Finally, compensation involves using resources —— people's resources or others' resources — to achieve desired outcomes (e.g., using a stick to walk in case of balance difficulties). Available resources (e.g., physical, psychological, social, economic) are essential to allow older adults to adapt smoothly to age-related changes and preserve their well-being by

minimizing weakness and maximizing strengths (Baltes, Lindenberger, & Staudinger, 2006; Jopp & Smith, 2006). This life-span approach highlights the importance of minimizing weakness and maximizing strengths by considering humans as innovative and embedded in a dynamic environment (Shearer, Fleury, Ward, & O'Brien, 2012). It also emphasized the benefit of experience and knowledge accumulated during life span which are also found in the concepts of older adults' wisdom (see Säljö, this issue) or the maintenance of cognitive competence due to expertise (Salthouse, 1990), and participate to explain the age invariance paradox mentioned previously. However, this approach is regularly criticized to give a normative way of what aging should or should not be, but also to only focus on the individual's ability to cope with ageing and without considering the processes at work in ageing in a given environment (see Zittoun, Grossen, & Tarrago, this issue).

Ferring (2018) highlights that life satisfaction in old age is more related to the interpretation and evaluation of age-correlated impairments and losses than to their objective presence, this subjective evaluation being influenced by needs and aspirations of the person as well as by socially shared stereotypes of old age in a given society. This social component is included in the socio-emotional selectivity theory describing the life course dynamics in the use of self-related knowledge (Carstensen, 1992). It posits a motivational switch during lifespan regarding how individuals deal with information. Perceiving their lifespan as decreasing, older adults would invest more in what is the most important for them in the present, and less in acquiring new knowledge in the long term, whereas younger adults, who still need to develop a large thesaurus of life knowledge, would present the inverse pattern. It offers an explanation to the observation that older adults tend to focus more on positive than negative information (i.e., positivity effect), whereas the opposite pattern is generally observed in younger adults (Mather & Carstensen, 2005). This positivity effect is observed

through various attentional and memory tasks (for a review, Reed, Chan, & Mikels, 2014), making some age-related differences disappear (Tournier, Jordan, & Ferring, 2016).

4. Discussion

The present article aimed at offering a broad overview of dominant theories in the field of learning and adaptation in older adults. Regarding cognitive aging, a dominant explanation of age-related cognitive declines refers to neurological changes that reduce information-processing resources (Park et al., 1996). The slowing of processing speed, the decrease of working memory capacity and the decrease of attentional capacities, often reported in the aging literature (Baddeley, 1986, Salthouse, 1996; & Zacks et al., 2000), might jeopardize learning and adaptation of older, for example by affecting their selection of the most efficient and adapted learning strategies (Lemaire, 2016). To deal with these changes, older adults might rely more on routines and habits that require fewer processing resources, and increase their confidence by relying on strategies and actions that were perceived as being efficient so far (Bouisson, 2002; Tournier & Postal, 2011a). In the same vein, the continuity theory of aging posits that older adults preferentially use well-known actions or purposeful activities because their expertise allows, to some extent, compensation age-related losses (Atchley, 1989). This underlying idea of compensation is also present in the influential SOC model that highlights that environmental resources can compensate at least in part the decrease of internal resources (Baltes & Baltes, 1990). The allocation of resources appears also modified by aging. According to the socio-emotional selectivity theory, because they perceive their lifespan as decreasing, older adults invest more resources in what is the most important for them in the present and focus more on positive than negative information in order to preserve their wellbeing (Carstensen, 1992). The access to the complexity and various levels of learning and adaptation during aging is closely linked to the assessment methods. More

specifically, we often observe a strong discrepancy between data issue of laboratory assessments and self-reported evaluation: laboratory assessment generally reports larger age-related changes and negative impacts on quality of life than older adults' self-assessments. It advocates taking even more into consideration the ecological validity of collected data, as well as involving older adults more in the whole research process. The underlying assumption is to do research with older adults rather to do research about older adults, in order to have a better understanding of the needs and wishes of older adults, and to focus more on their strengths than on their age-related losses. The currently predominant theories that have been described in this article tend to take the individual and his/her abilities as a main unit of analysis, which can be perceived as too simplistic and not taking enough in consideration the impact of cultural and social practices on aging (see Säljö, this issue).

In line with continuity and SOC theories, older adults rely on a full range of goal-directed behaviors such as compensating or adapting the environment deployed to keep autonomy despite the decrease of physical, sensorial or cognitive capacities. The role of environment (i.e., physical, spatial, and technical) appears still overlooked in gerontological research (Wahl, Iwarsson, & Oswald, 2012). Assistive technologies are an exception and their use as a solution to support older adults in their daily life is gaining more and more interest. Assistive technologies are devices aiming at maintaining and/or enhancing the functional capabilities, safety, social participation or quality of life of people with disabilities (e.g., mobility aids, hearing aids, safety system). These are often referred as efficient tools to help older adults maintain their autonomy and consequently live in their own home (e.g., Yusif, Soar, & Hafeez-Baig, 2016). Even though several studies show a positive impact of assistive technologies (Agree, 2014), numerous barriers to assistive technologies adoption have been listed in the literature, including a lack of confidence in being able to handle them, the fear of stigma, or a lack of suitability for daily use (e.g., Peek et al., 2016; Yusif et al., 2016). Even

though new generations of older adults will be more familiar with technologies, they will still encounter specific challenges to learn to use new technologies and tools. Peek et al. (2016) highlighted the necessity of taking into account the impact of the social environment on the selection and use of technologies while aging in place, an aspect that is quite eluded in current technology acceptance models. Older adults are often concerned by their skills to handle technologies, especially ICT and smartphones, anticipating their need for assistance and regular practice. This information is usually offered by their family and social network, showing them or writing them notes about how to use the new devices. However, even though they appreciate this support, older adults sometimes feel that their relatives explain too quickly and that this prevents them from asking for support on future occasions. Therefore, to benefit from technologies as daily-life support, it is necessary that technology suppliers, professional caregivers and organizations, policy makers as well as family members take into account the complex psychological and contextual factors affecting the use of them in older ages (Peek et al., 2016). The interest in new technologies to support aging brings us back to the notion of hybrid minds developed by Säljö in this issue and how technologies can act as cognitive amplifiers to go beyond the biological competences. For example, a person with memory problems and difficulty with orientation could compensate for them thanks to the use of a specific app.

The maintenance of social engagement is a key aspect of aging. It can be related to the idea of engagement in an active lifestyle that, according to Rowe and Kahn (1987, 1998), belongs to the criteria of successful aging, in addition to the avoidance of disease, and the maintenance of physical and cognitive functioning. However, lay older adults appear having a more optimistic view than researchers do. Whereas around 50 percent of older adults define themselves as aging successfully, the use of Rowe and Kahn criteria identifies only 15 percent to 20 percent of the elderly population as having a “successful aging” (Strawbridge,

Wallhagen, & Cohen, 2002). When interviewed about what constitutes and is important to successful aging, older adults perceived the adaptation to psychological and behavioral life changes (e.g., realistic self-appraisal, focusing on the present) as more important than the absence of disabilities (Reichstadt, Sengupta, Depp, Palinkas, & Jeste, 2010). They also highlight the need to continue trying out and learning new things that are of personal interest and enjoyment (one of the interviewees commented: "Every time we do something new, it's a new adventure and you have to learn new skills and you have to be adventurous. So I have reinvented myself a dozen times and this is a new reinvention… and it suits fine", p. 571) as well as the importance of seeking intellectual stimulation (e.g. crossword puzzles) that are viewed as beneficial to "keeping the mind sharp." Several interviewees also mentioned their need to feel that they are giving to others and contributing to society. This included activities such as volunteering and helping other people that are associated with feelings of fulfillment, stimulation, and social interaction (see also Hviid, this issue).

The wish to continue to learn new skills and staying involved is also observable in older adults that no longer belong to the category of what could be considered as "successful aging". Dementia is a progressive or chronic syndrome in which cognitive functions are altered beyond what might be expected from normal cognitive aging. It impedes the ability to perform everyday activities, especially due to the increasing difficulty to learn new information. Despite it, interviews with people living with mild dementia revealed their wish to continue learning new things and the fact they are interested in assistive technologies (even if they regard these as mainly useful for people with more severe dementia). However, their priority is for human company and assistance when needed and they view their social network as crucial to wellbeing and coping. They want to continue to be who they are despite their condition. This includes having more opportunities to take decisions and to perform activities for themselves, and they often feel that the main limitation to perform activities independently

or with some support is often not their abilities as such but the worries of their caregivers. Having a sense of empowerment is also a priority for them and they want to retain the feeling of being useful to their relatives (e.g. taking care of grandchildren, knitting) despite the diagnosis of dementia (Tournier et al., 2018). However, being useful/giving meaning to life, social contact and self-determination are among the unmet needs reported by people living with dementia (Schölzel-Dorenbos et al., 2010).

The potential impact of technology on social engagement during aging has been strongly featured during the COVID-19 pandemic. In this period of physical distancing, communication via telephone or video calls has been largely used to preserve social contacts. However, aspects such as hearing loss, cognitive impairments as well as unfamiliarity with new technology may compromise their use in older adults (Steinman, Perry, & Perissinotto, 2020). Even if the proportion of older adults using the internet is growing fast, on the whole, they still have less access than younger people to communication technologies such as video-chat apps that support social contacts. This digital divide (i.e. the gap between age groups in terms of access to and use of ICTs) varies markedly between different countries. For example, in Romania or Greece, approximatively 80 percent of people aged 65-74 reported never having used a computer, whereas this proportion was below 20 percent in countries such as Sweden, Norway or the Netherlands (Eurostat, 2019). In addition, older men tend to have a more open attitude than women to ICTs, which may be due to having had more exposure to new technologies in their workplace.

Beside this cultural aspect, the perceived usefulness of ICTs has also an impact on their use. In 2018, 45 percent of people aged 65-74 in the European Union reported using the internet to send or receive e-mails, but only 19 percent mentioned using it for telephone or video calls (Eurostat, 2019). We can assume that the latter percentage will increase because of the COVID-19 pandemic, showing to older adults the potential interest of this function and to

their relatives the importance of supporting them in this process. Currently, a risk is that older adults feel doubly excluded, first from physical contact and second by digital exclusion from societies that mainly rely on digital events to maintain social participation during the COVID-19 pandemic. It adds up to the COVID-19 related portrayal of all older adults being frail, helpless and unable to contribute to society (Ayalon et al., 2020).

These observations highlight the necessity to increase access to ICTs for everyone and the importance of family members and friends in supporting older people to keep using ICT (Seifert, Cotton, & Xie, 2020). The wish to stay in touch with children and grandchildren using video telephony is a strong motivation to use computers and mobile phones. Children and grandchildren are also a resource when older adults need advice about how to use their new technology devices, even if they are sometimes worried about asking too much of their relatives. Whereas children are sometimes perceived as pressuring them too much to buy technological devices (often because they are worried about their parents), the enthusiasm of grandchildren for computers was perceived as a strong incentive to buy one. Grandchildren can also be very helpful about how to use a computer or smartphone, to install applications or even to demonstrate unknown possibilities (Luijkx, Peek, & Wouters, 2015). Accordingly, learning how to use a mobile phone (i.e., making calls, answering call, writing text messages, etc.) was facilitated in participants with larger families, especially by the presence of grandchildren (Mori & Harada, 2010). This kind of support is not limited to the family circle. For example, as mentioned in the Murakami article (this issue), younger classmates can be a support for older adults who registered to a formal education certificate whereas ICT learning did not exist in their own university days.

To conclude, even though some biological age-related changes can reduce learning and adaptation skills with aging, some mechanisms such as compensation or the reliance on environmental support these dynamics. In addition, older adults keep the wish and need to

continue to learn new things, and it is important that society offer them enough opportunities (e.g., social and cultural activities, age-friendly environment) to express this need. As highlighted by articles of the present special issue, older adults' capacities are not only defined at an individual level, they are also emerging from interactions with sociocultural contexts, discourses, and policies and institutions in place.

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