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Mapping the Older User’s Journey: Building UX with Theories of Cognitive Aging

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Mapping the Older User’s Journey:
Building UX with Theories of Cognitive Aging

submitted to
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by
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Mapping the Older User’s Journey:

Building UX with Theories of Cognitive Aging

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December 4, 2023
Abstract

The aging global population represents a pressing consideration for user experience (UX) designers. The field of cognitive aging research focuses on characterizing and explaining changes in cognitive functions, such as memory, attention, perception, and problem-solving that occur as people age. Understanding these changes is vital for crafting interfaces that cater to a broader demographic. With the hope of creating more inclusive digital interfaces, this thesis explores the application of three cognitive aging theories, Cognitive Reserve, Cognitive Load Theory, and Controlled Processing, in order to examine their implications for UX design. By integrating insights from these theories, designers can make digital interfaces more user-friendly for older and younger users alike. Practical design guidelines are proposed, covering ideas including feedback, simplicity, and information hierarchy. By embracing the nuances of cognitive aging and implementing age-inclusive design, designers can make digital experiences more intuitive and engaging for a wider audience, ultimately contributing to a more age-friendly digital landscape.

Keywords: UX Design, cognitive aging, cognitive reserve, cognitive load, processing
Introduction

In a world marked by technological advancements and an aging demographic, the intersection of ageist stereotypes, cognitive aging theories, and user experience design emerges as a pivotal consideration. The pervasive impact of ageist stereotypes on older adults extends far beyond societal perceptions, affecting not only psychological well-being but also physical health. In order to challenge these stereotypes and embrace a more inclusive environment, a shift is needed—one that shines light on the aging, advocates for universal design, and embraces the potential for continued learning. This shift is particularly pertinent in the realm of User Experience (UX) design, where understanding cognitive aging theories such as Controlled Processing, Cognitive Load, and Cognitive Reserve provides a crucial framework for changing the narratives around older adults. In order to understand the intricate relationship between an individual's cognitive processes and the design of digital interfaces, it becomes evident that accommodating age-related changes in processing speed, working memory, and cognitive flexibility is necessary. Designers educated on these theories can develop digital platforms that not only optimize performance, but also contribute to a connected and accessible digital environment for users of all ages. In this rapidly aging society, a focus on cognitive aging theories in UX design becomes paramount, ensuring that technological advancements cater to the diverse needs and abilities of users, including the demographic of older adults.
Ageist Perceptions and Cognitive Stereotypes About Older Adults

From the moment we are born, we embark on the journey of aging, a process that encompasses gaining maturity, increased responsibility, and the exploration of our identities as adults. While age is one of the most salient social categories shaping our self-perception and growth throughout life, the latter half of our lives often becomes associated with negative stereotypes regarding cognitive abilities, well-being, health, and physical functioning (National Institutes of Health, 2023; Kornadt & Rothermund, 2015). Ageism, characterized by stereotyping, prejudice, and discriminatory actions based on chronological age, emerges from these negative stereotypes (Iversen, Larsen, & Solem, 2009). Such ageist attitudes can lead to assumptions about one’s well-being, mental state, and physical capability, fostering the internalization of ageist stereotypes over time (Levy, 2009).

Although age stereotypes are prevalent, they are particularly accepted and normalized when directed towards older adults, as opposed to their younger counterparts (Weir, 2023). This societal acceptance of ageism is evident in various aspects, from anti-aging products to birthday cards featuring backhanded compliments about aging. Despite the increased risks of chronic diseases with age, most older adults maintain excellent cognitive functioning and overall good health (Weir, 2023). The positive aspects of aging, such as increased wisdom, conscientiousness, and improved emotional regulation, are often overlooked when talking about aging (Hummert, 2011).

The consequences of ageist stereotypes extend beyond societal perceptions. Not only are these stereotypes false, but they also carry harmful effects, particularly for older adults who are more prone to internalizing them. Whether expressed explicitly or implicitly, age
stereotypes contribute to lower self-esteem and confidence in older individuals (Orth, Trzesniewski, & Robins, 2010). The psychological and physical well-being of older adults is significantly impacted by these stereotypes, as shown by a 2018 study revealing that negative self-perceptions of aging are associated with a higher prevalence of expensive health conditions “which include heart disease, lung disease, diabetes, musculoskeletal disorders, and injuries” ultimately costing the United States $63 billion annually (Levy, Slade, Chang, Kannoth, & Wang, 2020).

In addition to physical well-being, society perpetuates negative stereotypes about older adults in regards to having a steep decline in cognitive functioning. Aging stereotypes are especially prevalent in cognitive aging where older adults are seen as more forgetful and less capable of learning novel information relative to younger adults in (Hummert, 2011). Many assume that with age, the ability to learn new things has come to an end. In truth, cognitive development continues throughout life and can potentially compensate for any age-related memory challenges in the future (Park, Lodi-Smith, Drew, Haber, Hebrank, Bischof, & Aamodt, 2014).

In addition to challenging stereotypes about cognitive decline, it is essential to address the specific realm of learning new technology among older adults. Unfortunately, ageist assumptions often extend to the belief that older individuals may struggle to adapt to and learn new technologies (Hummert, 2011). However, research has shown that older adults can successfully acquire and use new technologies, and doing so can have numerous cognitive and social benefits (Park et. al, 2014). As society becomes increasingly digital, the ability to engage with technology is becoming more integral to daily life. Older adults who embrace and learn to
use new technologies can enhance their cognitive flexibility, problem-solving skills, and overall mental well-being. Moreover, staying connected through social media, video calls, and online communities can mitigate social isolation, a prevalent issue among older populations (National Academies of Sciences, Engineering, and Medicine, 2020). It is important to acknowledge that older adults can continue to enhance their cognitive abilities as they learn and get comfortable with technology. Recognizing this potential helps combat ageist assumptions and can contribute to an inclusive attitude towards the capabilities of older adults (DeAngelis, 2021). Initiatives that promote digital literacy among older populations, along with supportive and accessible technology designs, can contribute to bridging the digital generation gap and empowering older individuals to fulfilling, connected lives in an increasingly technological world. Consequently, taking an empowering perspective that embraces the potential for continued learning is imperative to those in product design seeking to truly create accessible, ethical, and inclusive designs for older adults. Thoughtful design choices to assist age-related changes in capabilities ultimately empower universal access, serving individuals across the spectrum of ability at any age. In particular, cognitive aging theories such as Cognitive Reserve, Cognitive Load, and Controlled Processing provide frameworks for understanding these age-related changes and can be used to ultimately contribute to greater design that is usable for all.

**UX Design for Cognitive Aging**

**What is UX Design?**

UX Design, a term coined by Don Norman in 1993, is the process design teams use to create products or services that provide meaningful experiences to users. The design process
encapsulates the acquiring and integrating of the product, including aspects of branding, design, usability and function (IxDF, 2016). In addition to making the software usable, user experience includes marketing and sales. Think of when you use a digital product like an application on your phone. UX designers are thinking about what encompasses the full user journey, “a scenario-based sequence of the steps that a user takes in order to accomplish a high-level goal with a company or product, usually across channels” (Kaplan, 2023). The journey involves describing the specific and discrete interactions that make up a common user pathway through a product (Kaplan, 2023). Interaction design, computer science, graphic design, and psychology are just a few of the fields that contribute to the success of UX design.

**Importance of UX Design in the Technological World**

The field of User Experience (UX) Design has become more desired amongst companies especially with the shift to a more technological world. Companies are more inclined to invest in UX design because it “has a big impact on whether or not customers return—and whether or not they would recommend a product or service to their friends” (Stevens, 2022). Ecommerce is more convenient than ever for consumers of all ages, so a user’s experience on a website or app can, and will, impact their future use. This places an extreme importance on usability. With a growing age population in many countries, it is crucial that designers account for cognitive changes across the lifespan as they provide a different lens of understanding usability. By 2050, the world’s population of people aged 60 years and older will double to 2.1 billion (World Health Organization, 2021). To tap into the substantial purchasing power of this demographic and boost sales and revenue, it is crucial for companies to create products that serve the needs
of older adults (Bano et. al, 2015; Bano & Zowghi, 2015). Satisfaction amongst older adult consumers not only drives economic growth, it also fosters customer loyalty, reduces maintenance costs, and ensures regulatory compliance (Bano et. al, 2015). Designers have to consider a multitude of factors e.g. is a product suited for someone who has no experience with technology? Does the product account for the different cognitive changes that naturally come with age? Is the font size big enough? Is the product accommodating of users who use assistive technology? With a dedicated commitment to inclusive design, designers address most if not, all of these questions when developing a product.

As mentioned earlier, UX design is supposed to be centered around the user. There are five steps designers follow to produce the best user experience from start to finish- empathize, define, ideate, prototype, test (Patidar, 2021). This method allows for designers to emphasize user needs and behaviors in order to build products that can help all people (Patidar, 2021). I will discuss each in turn below.

**The Five Steps of Design Thinking Processes**

**Empathy**

*Empathizing* is the ability to understand the feelings of others, their motivations, and their experiences (Murtell, 2021). UX professionals are responsible for advocating on behalf of users and in order to do that, designers need to understand their frustrations, hopes, fears, limitations, abilities, and goals of a product (Kaplan, 2023). Some methods used during the *Empathize* phase include observations, interviews, and surveys which help designers to get preliminary information about what users need (Murtell, 2021). Empathy is critical in the sense
that it is the starting point for successful design thinking solutions, with the intention of getting
to know who it is you are solving a problem for. During this phase, every member of the design
team has to set aside their assumptions and gather real insights that are relevant to the
challenge and useful to the team (Murtell, 2021).

Define

The next phase for designers is to Define the problem based on the research, interviews,
and surveys gathered in the Empathize stage. Designers analyze patterns amongst users,
unexpected user pain points (areas of digital interactions with a product or service that cause
difficulty for users), and possible barriers that might come up in the future (Murtell, 2021). This
phase is essential for laying a solid foundation. Its primary purpose is to ensure that designers
share a common vision, purpose, and understanding of the customer needs and problems
(Murtell, 2021). Using this information, designers create a Problem Statement that encapsulates
all the needs and problems of users that will need to be addressed in the final product. A
Problem Statement should answer the who, what, where, when, and why of the problem,
allowing designers to set discovery goals and objectives for their product.

Ideate

Ideating is when designers brainstorm solutions to the existing problems found in the
two previous stages. Design teams brainstorm using tools like mind-maps, Post-it notes, and
landscape mapping to create as many solutions as possible (Murtell, 2021). Design teams
preface this stage by creating an open and safe environment where all ideas are welcomed to
encourage people to think creatively and provide divergent ideas (Murtell, 2021). Designers then do a S.W.O.T (strengths, weaknesses, opportunities and threats) test of each idea before narrowing down what the best solution is for the users (Murtell, 2021).

**Prototype**

The fourth phase of the design process is Prototyping. This is the phase where designers turn their ideas into something tangible and testable on users (Patidar, 2021). This does not necessarily need to be the final version, but at least a version of a product that can be tested. Some examples include a retail experience that people interact with or as simple as updates to a pre-existing application. Designers create scaled-down versions of an entire product or specific features, depending on the goal of the project (Patidar, 2021). Prototypes help designers see what features work and what does not work, from first-hand user accounts. There are two types of prototypes: low-fidelity (lo-fi) and high-fidelity (hi-fi). Low fidelity prototypes are more simple models that provide a basic idea of what a product looks like (Patidar, 2021). A high-fidelity prototype, on the other hand, is a more complex and in-depth version of what a product looks like (Patidar, 2021). Both lo-fi and hi-fi prototypes are iterative and are updated as designers go along the designing process.

**Test**

Lastly, the Testing phase is where designers seek out participants to test and evaluate their most finalized prototypes (Patidar, 2021). Designers make note of things users like and do not like about the product, in addition to any other feedback about the usability of the product.
by observing how users interact with their products. They ask users to verbally walk-through their use of the prototype. By doing this, designers can understand what users say, do, and how they feel while interacting with a product (Kaplan, 2023). From these observations, designers make the final edits before sending it off to stakeholders. The process of designing a product is far from easy. It is quite complex and requires a lot of effort in small details. With the information gathered from these five steps, designers hone in on their understanding of user needs and develop tangible prototypes. To further understand the nuances of inclusive design, I will delve into the considerations and theories that can be incorporated in crafting products with a focus on the unique experiences of older adults.

**Designing with Older Adults in Mind**

Designers must be mindful of potential discomfort or resistance to new interfaces, ensuring that the testing environment is supportive and encourages open communication. Verbal walk-throughs, a common practice in testing, may need to be adapted to accommodate potential cognitive or sensory limitations among older users. Additionally, the diverse experiences and preferences within the older adult demographic require a careful selection of participants to ensure a representative testing pool (Kaplan, 2023).

Considerations of usability across the lifespan are fundamental to the success of UX design. Even though technological use has become increasingly prominent in our society, it does not mean that everyone is keeping up with the rapid advances constantly happening. A study done on older adults (65+) showed that they are enthusiastic about adopting new technological skills, but expressed apprehension in the lack of instructions and support (Vaportiz, Clausen, &
Gow, 2017). The themes emerged from the study were related to barriers, feeling disadvantaged, comparison to younger adults, and skepticism of newer technology overall (Vaportiz et al., 2017). Studies like these tell us that we need to pay extra attention to how our products address and interact with cognitive differences across the lifespan.

Cognitive aging theories can help designers understand how our cognition changes over time, and they can therefore apply that information to their designs. Research extensively delves into the topic of aging, and as the demand for UX design grows within companies, it is crucial to explore the intersections between these two fields. More specifically, the intersection of cognitive psychology and UX design is not a new concept. Theories such as Gestalt principles, Hick’s Law, and Retention theory are all principles that are commonly incorporated into UX design (Kohler, 2002). All three have helped designers to understand how to make easily digestible layouts for consumers, but these theories don’t necessarily encapsulate the relevance of cognitive aging theories. As mentioned before, older adults are eager to adapt to new technology, but it’s now on designers to find new ways to incorporate their needs into products (Kohler, 2022).

**Cognitive Aging Theories**

Navigating the realm of inclusive design for older adults necessitates a profound comprehension of cognitive aging theories that provide insights to the changes unfolding over the lifespan. Here, I highlight and discuss three: Controlled Processing, Cognitive Load, and Cognitive Reserve. I chose these three theories among the major theories of cognitive aging because they provide valuable perspectives into how users process information, manage cognitive resources, and ultimately affect how older adults engage with interfaces. These
theories not only shed light on these aspects, but also serve as a valuable tool for delving deeper into the well-being of older adults. Moreover, these theories provide implications for UX design, urging further investigation to better understand how these theories can inform design strategies catering to the cognitive needs of older adults. Understanding these theories, along with cognitive aging generally, is pivotal for designers seeking to create more enjoyable experiences for older adults.

**Controlled Processing**

One framework for categorizing cognitive processes distinguishes between automatic and controlled processing (Whitman, Barrett, Coane, & Umanath, (accepted)). Controlled processing involves conscious and deliberate mental attention (Hammar, 2012), while automatic processing operates effortlessly and without conscious awareness (Schneider & Chein, 2003). Automatic processes occur without conscious effort (Whitman et al., (accepted); LaBerge & Samuels, 1974). For the purposes of this paper, I will focus on controlled processing and its role in various cognitive activities, such as problem-solving, decision-making, and complex or new tasks that require focused attention and deliberate thought (Schneider et. al, 2003). It involves the effective use of working memory, attentional resources, and executive functions to regulate and guide cognitive operations (Schneider & Shiffrin, 1977). This form of processing is particularly crucial when individuals encounter novel or challenging situations. (Schneider et. al, 1977; Blazer, Yaffe, & Liverman, 2015). One example of this is one who is learning cursive. If one is a beginner, there’s an intentional effort and a required attention to write, but over time and with practice, writing in cursive becomes more automatic and effortless (LaBerge et. al, 1974; Whitman et. al, (accepted)).
As we age, cognitive functions associated with controlled processing may exhibit changes, such as declines in processing speed and working-memory capacity (Rogers, 2019). These age-related alterations can impact the efficiency of controlled processing, potentially influencing an individual's ability to engage in tasks that demand intensive cognitive resources (Rogers, 2019). One study found that “a reasonable estimate is that an older adult (e.g., age 65+ years) will take roughly 1.5 to 2 times as long to complete an unfamiliar task compared to a younger adult (e.g., age 20 years) (Czaja, Boot, Charness, & Rogers, 2019). Such slowing extends to learning new tasks too. A study done by Paul Verhaeghen provided meta-analytic estimates for the relationships between older adults and a variety of mental processes or abilities critical to learning rate: “speed of processing, \( r = -0.53 \); working memory \( r = -0.42 \); and episodic memory performance, \( r = -0.38 \)” (2013). These large effect sizes tell us that older adults take about twice as long to complete complex tasks. In other words, the declines associated with cognitive aging are more apparent when tasks are of high demand and impose a burden on one’s cognitive abilities (Van Gerven et. al, 2002). In sum, for most older adults and for most types of information (e.g. reading, interpreting patterns, comparing spatial patterns, speed of recognizing letters and numbers), processing speed is slowed with age meaning that designers will need to accommodate this change (Czaja et. al, 2019). Processing speed is the building block of cognitive functions, so it’s imperative that designers consider the implications of slowed processing speed when creating interfaces for older adults. By recognizing processing speed as a foundational element of cognitive functions in older adults, designers can contribute more inclusive and accessible digital interfaces that align with the cognitive capabilities of aging populations.
Cognitive Load

Cognitive load refers to the amount of information one’s short-term or working memory can actively hold at any given time (Mestre, 2012). The inherent limited capacity of working memory is susceptible to overload, resulting in poor understanding, retention, and learning (Sweller, 1988). The three types of cognitive load— intrinsic, extraneous, and germane load— stems from the concept that humans have a restricted working memory (WM), constraining the rate at which information is processed (Paas, Renkl, & Sweller, 2003).

Intrins ic load refers to the inherent difficulty in processing information, regardless of how the information is presented (Pande, 2022). It includes two factors: the number of elements that are simultaneously working together needed to complete the task and the learner’s prior knowledge. If there are larger amounts of elements that a person needs to attend to at once, intrinsic load will be much higher compared to an activity with less elements. One example of this would be navigating a new website with numerous features. To utilize the website effectively, one must familiarize themselves with all its functionalities. Prior knowledge, on the other hand, also plays a fundamental role in how new information and existing information work together (Gerjets, Scheiter, & Catrambone, 2004). Older adults are considered knowledge experts due to their general knowledge continuing to increase with age (Umanath & Marsh, 2014). However, a notable challenge arises when their prior knowledge is tasked with deciphering both related and unrelated novel information (Hoyer, Rybash, & Roodin, 1989). In such scenarios, there is a risk that their existing knowledge bases may prove insufficient to effectively comprehend and navigate unfamiliar contexts (Perlmutter, 1978). This highlights the importance of designing learning materials that carefully consider the interaction of prior
knowledge and new information, particularly in contexts where the complexity of content can be adjusted to suit the learner’s capabilities.

On the contrary, extraneous load arises from the way learning materials are designed, demanding learners to allocate mental resources to aspects that are unrelated to the task at hand (Kalyuga, 2011). The addition of new information relies on referencing schema or mental models of pre-existing knowledge (Kalyuga, 2011). Poor instructional methods and unclear instructions contribute to high extraneous load, forcing learners to employ extra cognitive processes to sift through irrelevant information, ultimately hindering the learning process (Kalyuga, 2011). Extraneous load is closely tied to attention span, particularly affecting older adults who have decreased ability to inhibit irrelevant information which makes them more susceptible to distractions (Hasher, Zacks, & May, 1999). A study done by Connelly, Hasher, and Zacks (1991) revealed that older adults were significantly slowed in reading material with incorporated distractors (in different type fonts), particularly when the distractors were meaningful and related to the reading. Older adults are disproportionately impacted by external distractions, given the vulnerability of their working memory to an increased influx of environmental information (Hasher et. al, 1999). The coherence principle, a multimedia principle advocating for a combination of text and graphics, highlights that any information not conducive to learning, can be deemed as a distraction (Mayer, 2009). Such distracting information can interfere with the learner’s construction of mental models to represent the material (Mayer, 2009). This susceptibility can make them more sensitive to the design of user interfaces. In the realm of UX, understanding and mitigating extraneous load becomes crucial,
as it directly impacts the usability and effectiveness of interfaces for older adults, necessitating designs that minimize cognitive strain.

Finally, *germane load*, refers to the mental resources dedicated to acquiring and automating schema in long-term memory (Debue & van de Leemput, 2014). Unlike intrinsic load, which stems from the inherent complexity of the learning materials, and extraneous load, which involves unnecessary cognitive processing due to poorly designed instructional materials, germane load is considered beneficial (Pande, 2022; Kalyuga, 2011). It encompasses the mental resources directed towards understanding and integrating new information, contributing to the creation of cognitive structures that facilitate long-term retention and transfer of knowledge (Paas, van Gog, & Sweller, 2010. In sum, germane load represents the cognitive investment needed to deepen comprehension and build connections between new information and existing cognitive structures (Paas et. al, 2010). It is noteworthy that older adults, on average, face challenges in accessing and linking related pieces of information stored in memory, which can impact their ability to form cohesive mental models or integrate information effectively during cognitive tasks (Naveh-Benjamin, 2000). These cognitive changes can have implications for learning, decision-making, and problem-solving. In the context of UX design, understanding these challenges is crucial for creating interfaces that accommodate the potential limitations in memory retrieval for older users. This aspect of cognitive load is particularly relevant in instructional design and user experience, as it guides designers in developing interfaces that not only present information effectively but also encourage users to actively process that information.
**Cognitive Reserve**

*Cognitive reserve* refers to the mind’s resilience, or its ability to efficiently utilize brain networks (Stern, 2002). More specifically, it encapsulates the “many ways that neural, cognitive, and psychosocial processes can adapt and change in response to brain aging, damage, or disease, with the overarching effect of preserving cognitive function” (Valenzuela, 2019).

Reserve acts as a protective mechanism that allows individuals to better endure the impact of neurological impairments, such as Alzheimer's disease or other forms of dementia (Nelson, 2022). Cognitive reserve manifests as a result of a combination of factors such as education, intellectual engagement, and complex mental activities throughout life (Tucker & Stern, 2011). Cognitive reserve is both an active and passive buffer meaning that it involves the brain’s ability to adapt and reorganize, promoting cognitive flexibility when presented with difficult tasks.

Individuals who utilize their brain networks more efficiently or possess the ability to "activate alternative brain networks when faced with greater cognitive demands" may exhibit higher levels of cognitive reserve (Stern, 2002). Alternatively, cognitive reserve examines the capacity to utilize alternative strategies to solve a problem when the typical approach is not as effective (Stern, 2002). One example of this is solving a complex math problem that requires addition of large numbers. Most often than not, people will use a calculator, but if one is not available, then one would have to resort to doing that addition by hand. The cognitive abilities that one would use to enter the numbers on the calculator would be much different from the abilities one would use to manually solve the problem.

When faced with difficult or novel tasks, the brain makes an active effort to make up for any difficulties by utilizing either neural networks or cognitive paradigms that are less likely to
be disrupted. (Stern, 2009). Both older and younger adults use the same networks to mediate task performance yet, for older adults, they reap fewer benefits from engaging these networks (Stern, 2009). Stern suggests that while the aging brain does show adaptability by activating alternate neural circuits in order to handle tough cognitive tasks, the degree to which this compensation actually leads to tangible gains in task performance seems to lessen among older populations (2009). This relationship highlights the connection between aging and cognitive reserve: while the brain attempts to lessen the effects of unfamiliarity or complexity, age-related cognitive decline affects how well these mechanisms work (Stern, 2002).

Unlike other cognitive aging theories, cognitive reserve accounts for how damage to the brain can affect an individual’s cognitive function. This is particularly crucial as nearly 40% of older adults may experience some form of brain damage, so the relevance of cognitive reserve lies in its ability to shed light on how their mental processes evolve in the presence of such damage (Nelson, 2022). As we age, the likelihood of accumulating neural damages rises (Nelson, 2022). However, the impacts of similar neurological damage vary from person to person. By modeling residual neural processing capacity and efficiency as a protective mechanism, it provides insight on why real-world functioning (e.g. continuous learning and cognitive stimulation) may remain intact longer despite diagnostic brain imaging showing progressive damage (Pettigrew & Soldan, 2019). In essence, the cognitive reserve hypothesis shifts the focus from dwelling on cognitive losses to highlighting what cognitive abilities remain available. By emphasizing the importance of what is preserved, the cognitive reserve hypothesis introduces a positive perspective on cognitive aging. This perspective encourages a proactive approach to maintaining cognitive health through activities that promote ongoing learning and
mental engagement (Pettigrew & Soldan, 2019). As a result, understanding the nuances of how older adults navigate challenges is essential for developing UX interfaces that optimize performance and enhance cognitive reserve. It provides an evidence-based framework for conceptualizing variability in older adults' capabilities and can give insight on how to avoid unnecessary mental taxation. Designers can leverage this understanding to enhance the usability of digital platforms for older adults. As the role of technology continues to grow in daily life, ensuring that digital interfaces are universal becomes increasingly important for fostering a connected and accessible digital environment for users of all ages.

**Optimizing UX Design for Older Adults**

As the field of UX design continues to evolve, there is a growing recognition of the importance of considering the cognitive aspects of users, particularly in the context of cognitive aging and how our cognition changes over the lifespan. This area has become increasingly pertinent as populations age and more older adults engage with technology daily. It is projected that by 2050, 1 in 6 people in the world will be over the age of 65 (Cire, 2021). In order to create interfaces that are not only functional, but inclusive and enjoyable for users of all ages, it is imperative that designers draw key insights from cognitive aging theories. Understanding age-related shifts in cognition through theories like Controlled Processing, Cognitive Load and Cognitive Reserve, can foster better usability and engagement for users of all ages. These frameworks explain how our processing, mental workload capacities, and multi-tasking abilities evolve as we get older. Accounting for these changes can encourage UX solutions tailored to
older adults that foster better usability and engagement. As UX designers go through the five step design thinking process, consistently factoring in cognitive aging considerations allows them to proactively address limitations and leverage strengths of maturing minds. This empowers the creation of inclusive interfaces usable for diverse users, regardless of age or ability. With these theories in mind, I will go through each step in the design process, restate their definitions and incorporate concrete steps specifically tailored to address the cognitive needs of older adults.

**Empathize**

As a reminder, the first stage that designers follow to produce the best user experience is *Empathizing*. This means understanding users’ frustrations, hopes, fears, limitations, abilities, and end goals when engaging with a product, particularly older adults (Kaplan, 2023). Empathy, in this context, goes beyond merely acknowledging these challenges; it involves a profound appreciation for the lived experiences of older adults, enabling designers to craft solutions that address their specific needs. These challenges can range from the wide range of diversity in terms of varying levels of technological literacy, cognitive abilities, and overall preferences within this demographic (Orth et. al, 2010). This diversity necessitates a nuanced approach to UX design, ensuring solutions that cater to a broad spectrum of abilities. It's worth noting that the average age for UX designers is 38, potentially limiting the breadth of challenges considered, particularly those faced by older users (Chan, 2023). Older adults can offer unique perspectives shaped by their direct experiences navigating technological solutions later in life. Recognizing this inherent limitation is crucial for ensuring that ideation processes are more holistic to the
diverse needs and experiences of older adults. Expanding age diversity within the field of UX by bringing on more older adult designers would lend this critical viewpoint directly into conceptualization and solutions mapping. Older UX designers could leverage their experiences with age-related changes in vision, motor skills, cognition. Additionally, with the decrease in controlled processing over time, older UX designers can shed light on the intentional and effortful mental activities that influence user interactions (Hammer, 2012). Moreover, they can draw on personal frustrations around using technology to drive more conversations around empathetic and user-centered design. This approach would integrate the challenges experienced by older users more organically into design thinking, promoting the inclusion of older adults as UX designers and normalizing their presence in the field. Having these frameworks to guide age-inclusive digital experiences also helps normalize older adults as a vital target demographic deserving of a seat at the design table. Research shows that diversifying teams, including on age, enhances creativity, innovation and product quality (Deloitte, 2021). Making UX teams age-inclusive fosters more comprehensive and effective ideation catered to users of all ages.

Define

During the second step of the design process, Defining, designers are looking to clarify and hone in on problems that users may potentially face (Murtell, 2021). Not only must designers identify the physical and cognitive challenges, they also have to navigate the emotional dimensions that influence the older adult user experience. Potential usability issues that could arise as older adults interact with digital interfaces might encompass difficulty
reading text due to insufficient font sizing or challenges in deciphering the meaning of icons used in design layouts (Murtell, 2021). Furthermore, designers attempt to anticipate potential barriers that older adults may face in the future. By considering notable age-related changes in the lifespan, designers gain crucial insight into the precise challenges older adults confront when engaging with products. This acknowledgment ultimately prompts designers to actively seek insights into the unique challenges faced by older users, fostering a more comprehensive and effective defining process (Pew Research Center, 2021).

A prominent area of discussion and research within the domain of cognitive aging relates to changes in processing speed and efficiency. As mentioned earlier, controlled processing requires conscious and deliberate mental attention and plays a role in various cognitive activities, such as problem-solving, decision-making, and encountering complex or new tasks (Hammar, 2012; Schneider et. al, 2003). All three of these cognitive processes are essential to how older adults, and users in general, engage with user design interfaces therefore it is important that designers are able to take careful consideration when designing. With the decrease in processing speed and efficiency associated with aging, UX designers must proactively think of solutions that compensate for and address these cognitive shifts amongst older populations. An effective strategy is to introduce information gradually, revealing details progressively to prevent information overload (Mahesh, 2023). This is beneficial for older adults, considering their potential issues with working memory (Mahesh, 2023). As individuals age, there is a tendency for a decline in working memory capacity, making it more challenging to process and retain large amounts of information simultaneously. Introducing information gradually acknowledges the limitations of working memory by recognizing its finite capacity for
processing and holding information. Designers can break down complex information into smaller, digestible segments, allowing users to focus on and process a manageable amount of information without overwhelming their cognitive resources (Mahesh, 2023).

**Ideate**

After assembling the data gathered into a clear problem statement, designers then move onto the *Ideate* phase, where they brainstorm ways to address those unmet needs (Murtell, 2021). The ideation stage marks the transition from identifying problems to crafting solutions and is usually a creative process to help designers from feeling restricted in their thought processes. One thing designers can do is set themes from what they learned in the previous phases to provide guidance while ideating. One theme could be the active period of the interface. Interfaces are most effective for older adults when they remain on the screen for a duration that allows them to actively engage (Zhou, Yuan, Huang, Zhang, & Kaner, 2022). As previously mentioned, older adults' processing speeds with new learning is roughly 2 times slower compared to a younger adult (Czaja et. al, 2019). The declines associated with controlled processing are heightened when faced with a novel task (Van Gerven et. al, 2002). Aligning the digital experience with the controlled processing speeds for older adults is crucial for older adult satisfaction (Jansen, 2020). Designers can enhance this alignment by introducing interactive questions that allow older adults to customize the time spent on specific interface elements with a particular part of the interface. By doing so, not only do designers engage users at a comfortable pace but also acknowledge and accommodate the declines in processing speed associated with aging.
Prototype

The fourth phase of the design process is prototyping, where designers create testable lo-fi or high-fi versions of a product (Patidar, 2021). Prototyping is extremely valuable in the design thinking process as it allows designers to compile everything they have learned from the three previous stages and put it into a sample version of the product (Patidar, 2021). When designing for older adults during the prototyping phase, additional considerations may arise. Older individuals may have different comfort levels and familiarity with various types of prototypes, impacting how effectively they can interact with and provide feedback on the designs. Low-fidelity prototypes might be more accessible for those who are less tech-savvy, while high-fidelity prototypes may pose potential challenges for individuals who are not accustomed to more complex interfaces. In particular, for older users with limited experience using advanced technology, the level of detail and interactive elements incorporated into these prototypes can cause high levels of cognitive load due to the novelty and complexity of these sophisticated designs (Sweller, 1988). In order to prevent cognitive overload, designers can provide clear and concise directions, break down complex tasks, and present information in an organized manner. Creating prototypes that clearly show users the step-by-step process is key to helping older adults with insufficient or adequate prior knowledge to organize the incoming information effectively (Mayer & Moreno, 2010). The role of one’s prior knowledge is an important one. When older adults interact with new prototypes, they are often being exposed to unfamiliar interfaces for the first time. This means they need to make sense of new information and systems while simultaneously drawing connection to their prior knowledge (Hoyer et. al, 1989). However, their prior knowledge of older adults may or may not help them
when attempting challenging, novel tasks within these prototypes (Hoyer et al, 1989). More specifically, the concept of intrinsic load examines how one’s prior knowledge comes into play when dealing with a new task (Pande, 2022). For older adults, the challenge lies in determining which parts of their prior knowledge are applicable versus not when faced with new interfaces (Hoyer et al, 1989; Perlmutter, 1978). Incorporating feedback messages can alleviate this issue. Offering feedback linked to real-world situations allows older adults to grasp the essential skills involved without the need to discern the relevance of their prior knowledge (Czaja et al., 2019). The integration of real-world scenarios ensures that feedback is not only immediate but also relatable, enhancing the learning experience by providing practical context and aiding in the application of newfound skills in everyday situations (Czaja et al, 2019). It is crucial that these feedback messages are conveyed in straightforward language, clearly identifying the issue and offering constructive solutions, all while incorporating relatable real-world scenarios (Czaja et al., 2019). Messages on actions like scrolling, double-clicking the mouse, or dragging helps make sure older adults understand basic skills and contribute to more positive encounters with digital technology. The implementation of immediate feedback ensures that older adults not only perform these basic tasks, but also comprehend the underlying skills involved.

Testing

The final phase of the design process is Testing, where designers seek out participants to test their prototypes from potential users (Patidar, 2021). The most important part of this step is gaining feedback on the usability of the product. Similar to the Empathize phase, designers can recruit older adults with ranging degrees of comfortability with digital technology. As designers
prepare prototypes for user testing, they have opportunities to incorporate extensive tutorials, helpful hints, and on-screen guidance when users are first interacting with the prototype (Czaja et. al, 2019). Designers could facilitate tutorial workshops with test groups focused on building digital literacy and comfort with technology. This process is called scaffolding which sequences the learning or tasks so that high levels of support are provided early and progressively lowered toward the end of a particular set of tasks (Czaja et. al, 2019). The goal is to provide users with high levels of assistance early on when new concepts are introduced, but gradually transition them to more independent work by the end (Czaja et. al, 2019). Czaja found that older adults are more willing to participate in co-design activities when they are given appropriate guidance (2019). In order to properly scaffold, it is important to stay within their zone of proximal development (ZPD). The ZPD was coined by Lev Vygotsky which looks at three different regions a learner can be in. The regions range from easy to learn (“What I can learn on my own”), intermediate (“What I can learn with help”), and too difficult to learn (“Beyond my reach”) (1978). Within the ZPD, learners can direct support from another person or through technology that provides them with tools to succeed (Jansen, 2020). The ZPD can help designers to understand how to create interfaces that are challenging, yet stay within their learning threshold (Jansen, 2020). This plays a unique role in improving cognitive reserve, the mind’s ability to efficiently utilize brain networks (Stern, 2002). For older adults though, the brain networks used to cope with challenging tasks may diminish with a decline in cognitive ability (Stern, 2002). Ensuring that older adults can adapt to and benefit from technology in a manner that aligns with their evolving cognitive abilities can ultimately promote sustained mental agility and well-being throughout their digital interactions. Moreover, designers can incorporate
options for adjustable customization and adaptability within interfaces (e.g. controlling text size, offering multimodal options, assistive technology). For example, older adults who are less familiar with technological interfaces might find value in features such as voice-guidance or detailed labels offering explanations for various components of the interface (Reuter-Lorenz & Park, 2014). By doing so, users are challenged while having full autonomy in their pace of learning which can empower older adults to tailor their digital interactions based on their preferences and cognitive strengths (Girardot, 2023). These approaches not only improve immediate usability but also align with the goal of promoting cognitive reserve by encouraging continued engagement with technology in a way that is both enjoyable and supportive of cognitive well-being.

On another note, streamlined and straightforward designs reduce the likelihood of prototypes containing distracting or irrelevant information, thereby aiding in the mitigation of unclear directions. This becomes especially crucial in adult-oriented design, where convoluted instructional models contribute to an increased extraneous load (Kalyuga, 2011). Simplistic and straightforward designs reduce the likelihood of distracting or irrelevant information, thus aiding in the avoidance of unclear prototypes. This is particularly important when designing for adults as unclear instructional models heighten their extraneous load (Kalyuga, 2011). As mentioned before, extraneous load represents the resources directed towards understanding and integrating new information (Kalyuga, 2011). Being that it is also closely tied to attention span, this factor impacts older adults due to their diminished capacity to inhibit irrelevant information making them more susceptible to distractions (Hasher, Zacks, & May, 1999). Furthermore, germane load, representing the cognitive resources invested in knowledge
storage, plays a pivotal role. (Pande, 2022). To effectively maximize germane load, designers must create prototypes that minimize intrinsic and extraneous load. Recognizing the inverse relationship between intrinsic/extraneous load and germane load underscores the importance of reducing the former to enhance the latter. This approach enables users, including older adults, to allocate cognitive resources more effectively (Klepsch et al., 2017).

**Conclusion**

In conclusion, the prevalent impact of ageist stereotypes on older adults extends beyond societal perceptions, influencing psychological well-being and physical health. Challenging these stereotypes by recognizing the positive aspects of aging, advocating for more universal design initiatives, and embracing the potential for continued learning can foster a more inclusive and empowering environment for older adults, ensuring more ethical design considerations in an increasingly technological world.

With these considerations in mind, integrating cognitive aging theories, such as Controlled Processing, Cognitive Load, and Cognitive Reserve provide a framework to changing the narrative around older adults. Controlled Processing encompasses the conscious, effortful mental activities older adults engage in when navigating tasks, while Cognitive Load refers to the limitations on an individual's cognitive resources; concurrently, Cognitive Reserve delves into the relationship between an individual's life experiences and their cognitive health (Hammar, 2012; Mestre, 2012; Stern, 2002). Understanding the impact of age-related changes in processing speed, working memory, and cognitive flexibility is crucial in creating interfaces
that accommodate the cognitive needs of older adults. Designers can leverage these insights to develop digital platforms that optimize performance, minimize cognitive strain, and contribute to a connected and accessible digital environment for users of all ages.

By tailoring products and services to accommodate the needs of the aging population, companies not only demonstrate a commitment to inclusivity but also tap into the vast economic potential of a diverse consumer base. As society continues to age rapidly, embracing cognitive aging theories in UX design becomes more paramount, ensuring that technological advancements benefit users of all ages and abilities.

Inclusivity should be a focal point, acknowledging diverse cognitive profiles and designing interfaces that cater to varying processing speeds, working memory capacities, and cognitive reserve levels. Exploring the integration of cognitive aging theories and UX design transcends the conventional five-step design processes. Cross-disciplinary collaboration among cognitive psychologists, gerontologists, and UX designers is necessary for a comprehensive understanding of cognitive aging and innovative design solutions (Girardot, 2023). Additionally, conducting more studies centered around older adults using technology provides designers with valuable insights into both the cognitive and physical needs of this demographic. Intergenerational design workshops can also help to bridge the gap between younger and older generations, allowing learning to be longitudinal. Embracing these future directions ensures that technology aligns with the cognitive capabilities and general needs of older populations, fostering a well-connected and accessible digital environment for users of all ages and abilities.
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