Website Usability Across Age Groups: Examining the Effect of Adaptive Website Design for Changes in Cognition Associated with Aging

BY

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Abstract

Websites, and the internet as a whole, are an ever-growing presence in modern life, from research to banking to online shopping and more. Despite their relevance to people of ages, many website designs do not consider the cognitive changes that occur as we age, making them difficult for many older adults to use. While website design principles and elements that support older adults have been developed through prior research, the impact of these designs on other people who use websites – i.e., younger adults – has not been explored. As such, the current study examined the impact adaptive design principles have on usability for older and younger adults. Using two websites about COVID-19 – one designed to be adaptive for older adults, and the other conventional – we had participants complete a series of questions about the content of the website, measuring their accuracy and response time. After completing the questions, participants completed a usability scale to measure how usable they found the website to be. Unfortunately, a low number of older adult participants meant that we could not draw meaningful conclusions about the impact of website design on older adults. Overall, as we hypothesized, we found that website design had a limited impact on younger adults, although we also found some interesting trends in usability for younger adults that may indicate towards interactions of website design, age, and usability measures that needs to be explored further.

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Website Usability Across Age Groups: Examining the Effect of Adaptive Website Design for Changes in Cognition Associated with Aging

Older adults are a growing portion of populations across the globe. At the same time, the internet, accessed mostly through websites, is performing more and more services that are important for all adults to access, including online banking, shopping, jobs, etc. From 2007 to 2016, Internet use among adults aged 65 years old and up in Canada doubled from 32% to 68%, however, research indicates that cognitive changes associated with aging still creates a barrier for older adults when accessing the Internet (Davidson & Schimmele, 2019; Rahman et al., 2021).

Websites have been conventionally designed with only the capabilities of younger adults in mind, despite the fact that older adults tend to differ cognitively from younger adults in some consistent ways, even when aging healthily (Johnson & Finn, 2017). Conventional website design combined with the cognitive, perceptual, and motor changes we experience as we age often creates a website experience for older adults that can be confusing, frustrating, and inaccessible.

Past research has identified several different changes to website design to support the ways that older adults differ cognitively from younger adults. Less explored is the effect these adaptations may have on the other people that use the same websites as older adults, i.e., younger adults. It is generally thought that, since older adults seem to experience more 'limits' in their cognition as it relates to website usage, younger adults should, at worst, be unaffected by the adaptations for older adults, and, at best, benefit from them. However, this is not necessarily true. The differences in cognition between older and younger adults are varied, with

neither necessarily being better than the other. For example, it is possible that the information structure that older adults find the most usable is the least usable for younger adults. Therefore, this study aims to examine the differences in website usability older and younger adults may experience given a conventional website and an adapted website.

The Effect of Aging on Cognition

Aging affects many areas of cognition, including vision, motor skills, learning, memory, mental models, and spatial skills. While these changes in cognition interact with each other, it is possible to tease some areas of cognition apart, particularly as they relate to website usability.

Vision

Aging is associated with a variety of changes throughout the organs of the eye and the vision-related structures in the brain (Erdinest et al., 2021). As such, older adults may experience several changes to their vision.

One of those changes is decreased visual acuity, which can make small items hard to read (Erdinest et al., 2022). So, text and other websites elements (ex. buttons) should be large enough to be easy to read. How large the font appears depends on the size of the screen of the device the website is being accessed from and the distance and angle the user is viewing the screen from. Generally, though, the recommended font size for a computer screen is at least 12pt or 14pt if the user cannot self-select and adjust the font size. Devices with smaller screens like tablets and smartphones may warrant even larger font sizes (Carmien & Garzo, 2011; Hawthorn, 2000; Hou et al., 2022). In addition, simple fonts are usually the easiest for older adults to read (Carmien & Garzo, 2011; Hou et al., 2022).

Along with a general decrease in the acuity of vision, older adults may also experience a decline in peripheral vision, which is linked with inattention to the edges of a screen (Bergstrom, Olmsted-Hawala, & Bergstrom, 2014; Bergstrom, Olmsted-Hawala, & Jans, 2013). This means that information on the edges of a website is generally seen or attended to less and later by older adults than younger adults, which may make them slower when trying to find information or navigate a webpage. In particular, this means that they may take much longer to find and utilize webpage elements on the outer edges of the webpage, spending much more time on the centre than younger adults. To accommodate for this, important links may appear in both the main navigation menus (which are often on the right and top edges of a webpage) and embedded in the text within the centre of the webpage (Bergstrom, Olmsted-Hawala, & Bergstrom, 2014; Bergstrom, Olmsted-Hawala, & Jans, 2013).

Older adults may also experience decreased contrast sensitivity between colours - particularly for colours in the blue-green range – and more difficulty adapting to changes in lighting (Charness & Dijkstra, 1999; Carmien & Garzo, 2011; Erdinest et al., 2022; Hawthorn, 2000). So, if the lighting of a screen is dark, or if the colours used on website elements are similar to the background they appear on, it can be difficult for older adults to see what appears on the screen. Instead, colours should have a high contrast between them and take into account that certain colours, like blue and green, may appear particularly desaturated for older adults (Erdinest et al., 2021; Carmien & Garzo, 2011).

Finally, older adults may experience slower visual processing and visual search than younger adults (Habekost et al., 2013; Veiel et al., 2006). Although older adults tend to exhibit similar skills for visual search at higher levels (also known as ‘global’ or ‘intermediate’ visual

search) as younger adults, they tend to become much less efficient at processing and searching through small visual details (also known as 'local' visual search) (Bouhassoun et al., 2022) Therefore, dense, complex, or 'cluttered' websites can further slow visual processing by increasing the number of 'distractors' present when looking for a target element of the website, among other factors (Bouhassoun et al, 2022; Erdinest et al., 2021; Habekost et al., 2013; Hawthorn, 2000). This means that older adults may take longer than younger adults to browse and understand a website, or to find the information they are looking for.

Motor Abilities

As our vision changes as we age, so do our motor functions. Many older adults experience deficits in hand-eye coordination and fine motor control, which can make tapping items on a touch screens and complex, multi-finger inputs on touch pads more difficult (Kim et al, 2020; Seidler et al., 2010; Smith, Sharit & Czaja, 1999). In fact, older adults tend to perform much more poorly than younger adults when using a touch screen for dragging, scaling, and rotating an image, particularly on smaller touch screens (Chang et al., 2014). Similarly, older adults may struggle when using a touch pad on a laptop, which tend to be quite small.

Older adults also often find different gestures and touch inputs intuitive for an action than younger adults, choosing different buttons, swiping in the opposite directions to scroll, using single taps when younger adults use double taps, and using buttons when a younger adult would use keyboard shortcuts (Stoessel, 2020). This means it can take longer for older adults to figure out how to do something they want to do, using methods that take longer to interact with a website. Sometimes, they may also try to interact with a website incorrectly, such as scrolling in the opposite direction to what they intend. To achieve what they intended to do,

they must then undo the unintended outcome of their mistake before they can continue, taking more time and potentially being more frustrating.

Older adults may also find that their movements are slower and less consistent than those of younger adults (Osman, 2019). As a consequence, their clicks of a computer mouse may be slow, shaky, or overgeneralized – meaning that they may use a certain mouse click pattern more than appropriate to, like someone learning English using the suffix '-s' to pluralize all words – which may cause unintended interactions with computers (Osman, 2019). For example, an older adult may unintentionally hold a mouse click for longer than a younger adult would, producing a drag instead of the intended click (Osman, 2019).

Finally, older adults may have decreased strength and stamina for movement, meaning that repetitive or complex sequences of actions – for example, a long drag across a screen or a timed sequence of clicks – may tire them faster than for younger adults, making websites using these motions less accessible (Hawthorn, 2006). Input gestures should be simple, using few fingers and little movement. Older adults tend to perform better with more pointing and clicking/tapping actions than dragging actions, and, if possible, it may be beneficial to allow a dragging motion to be broken into multiple, smaller drags (Kim et al., 2020). Commonly used inputs should be in areas that are easy to get to, minimizing strain to reach them. Finally, time-outs should be avoided to accommodate for the slower movements of many older adults, which can also assist with the slower visual search older adults may experience.

Aging may interact with different types of input devices, such as touch screens, touch pads on laptop computers, or computer mice, in different and inconsistent ways between older adults (Kim et al., 2020). For example, many older adults struggle with large gestures that span

from one side of the computer screen to another when using touch screen, but not when using a mouse. This means that the devices an older adult uses to access a website may dictate exactly what aspects of interacting with a website they struggle with. So, websites must be designed to be resistant to these inconsistencies, and be accommodating for as many potential issues as possible.

Leaning and Skill Transfer

Beyond struggling with perceiving and physically interacting with a website, older adults may also struggle with learning how to use websites. Older adults tend to show less generalization and skill transfer than younger adults, which refer to the ability to apply what has already been learned to similar situations and therefore 'transferring' the skills learned in one task to another (Hawthorn, 2006). So, despite often having a greater domain knowledge, older adults may struggle to apply their knowledge to new situations. For website design, this means that even if an older adult is familiar with older technology and websites, they may still struggle with newer designs and formats. For example, many websites throughout most of the internet's history used a paged design, where users navigated through several webpages within one website using links or navigation menus. Now, to adapt to the smaller screens of the mobile devices that are becoming more and more popular for accessing the internet – like phones and tablets – websites are more often using single webpage designs that utilize long, scrolling pages to limit the amount of navigation between pages and therefore the use of menus. Menus are often now hidden behind buttons, such as the 'hamburger menu' icon.

Older adults also tend to learn how to use websites in different ways than younger adults, which affects how learnable - and therefore, how usable - a website is (Mahmud et al.,

2020). Both older and younger adults engage in trial-and-error behaviour when learning how a website works, but younger adults tend to take more 'risks' and tend to engage in more discovery learning (Johnson & Finn, 2017). Older adults are also generally affected more by errors they make when learning than younger adults or children, getting more discouraged or experiencing greater set-backs (Mahmud et al., 2020).

Older adults tend to look for more support when learning to use the internet, although they prefer independent learning (Pang et al., 2021). So, they focus on supports they can access on their own, including searching online for help, YouTube tutorials, and using 'help' options when available (Pang et al., 2021). That said, many older adults identified flaws in these resources: YouTube tutorial videos may be too long to easily follow along to – potentially in part due to the decreased working memory some older adults experience - and help options can use language that is too complex and technical, or provide only very basic information that is not an issue for older adults (Pang et al.,2021). Only when independent learning is not available do they then look for one-on-one support, usually from people their lives (Pang et al., 2021).

Memory and Prior Knowledge

Along with changes in learning ability and preferences, many people tend to experience changes in memory as they age. Many people report anecdotally that they seem to be able to remember less as they get older, and that is, to an extent, supported in research. The way memory changes as we age can be somewhat complex, and interplays with other cognitive functions, but, over time, our memory does decline in some areas. Older adults tend to have a reduced capacity for working and short-term memory, as well as 'less effective' long-term

memory storage and retrieval (Chevalier, Dommes, & Martins, 2013; Griffen, 2015; Hawthorn, 2006; Osman, 2019).

A reduced capacity of working and short-term memory can manifest in a few ways. First, older adults may show reduced accuracy on complex, multi-step tasks when compared to younger adults, as the number of steps and details exceed their working memory capacity (Rama et al., 2001). Unless the task is easily broken into steps, it can become overwhelming.

A reduced working memory can also be problematic when comparing information across several places, which requires holding information in memory while navigating the website (Etcheverry et al., 2012; Griffen, 2015; Hawthorn, 2006; Rama et al., 2001). This encompasses remembering what has been previously found on a website or retaining the context and meaning of a long sentence or paragraph (Hawthorn, 2006). Instead, designers should aim to avoid over-burdening memory, keeping tasks and information as concise as possible, or providing tools with which to break down the task into sub-steps. Providing some sort of summary of tasks completed or information searched may also be beneficial.

Long term memory is a bit more of a complex issue. In some tests of long-term memory, such as recognition tests, older adults perform just as well as younger adults, but they perform much worse than younger adults in other long-term memory tests, such as recall tests (Hawthorn, 2006; Johnson & Finn, 2017; Osman, 2019). Generally, website design should avoid situations that call for recall. For example, websites should avoid asking users to recall information from another webpage, instead presenting that information directly while citing the source of that information.

Consensus among studies seems to be that different types of long-term memory decline at different rates, if they decline at all (Hawthorn, 2006). Generally, long-term memory is split into components, with procedural memory for remembering how to perform tasks, semantic memory for factual information, episodic memory for specific events, and prospective memory, which is the ability to remember to remember, such as remembering to remind yourself about an appointment (Hawthorn, 2006). Overall, it seems that procedural and semantic memory decline less than episodic and prospective memory, allowing older adults to possess a greater domain knowledge than younger adults and retain tasks they have already learned (Hawthorn, 2006).

Another thing to consider is prior knowledge. Differences in prior knowledge can affect how people interact with a website; often, people can search and understand a website better when it is on a topic that they are familiar with (Sanchiz et al., 2017). It is possible that the greater domain knowledge older adults often possess may help them navigate websites on familiar topics.

On the other side of prior knowledge is familiarity with websites in general. Overall, older adults tend to be less familiar with websites, and therefore have less knowledge of standard practices and conventions for websites, making it more difficult to figure out how the website works or how to navigate it (Griffen, 2015). One popular example is the ‘hamburger menu’ icon, which abstractly represents the concept of a menu using three horizontal lines. Many older adults do not recognize what the symbol is supposed to mean, but many younger adults – being more familiar website conventions – easily recognize the purpose (Griffen, 2015; Pang et al., 2021).

Mental Models

Prior knowledge and skill transfer are also a factor in the development of our mental models, which can therefore also be affected by aging. A mental model refers to the concept a person holds about what something is, or, for website purposes: how an interaction occurs (Roth et al., 2010). For example, when shopping, you know that you'll enter the store, pick your items from the shelves, and then bring them to be rung up and paid for at the check-outs. These are general expectations that exist for most stores, regardless of what they sell.

A mental model of how to interact with a website is developed from experience with other websites and similar interactions offline (Vaughan & Dillon, 2006; Wagner et al., 2014; Zhou et al., 2017). For example, to develop a mental model for shopping online, we can combine our mental model for shopping from above and the mental model we have for websites. So, you might expect that online shopping includes some two-dimensional analogue of browsing shelves and adding items to your shopping cart, then checking out. This model will guide how you expect to interact with the website, including what menus, buttons, and other website elements you expect to see, or how you interpret different website elements. A button with an icon of a shopping cart makes much more sense within this mental model – it likely indicates your online shopping cart – than it would in another situation, in which the button may seem nonsensical.

Due mostly to the difference in prior knowledge and experience online, older adults can have fairly different mental models for webpages compared to younger adults (Zhou et al., 2017). This makes many websites less intuitive to use for older adults, meaning they may understand less about how to interact with a given website and therefore take longer and make

more mistakes when using the website. Older adults may also have mental models from older technology that conflict with new technology, such as expecting an explicit menu of items along the top and left of a page, and instead finding a long scrolling page with a hidden menu in a 'hamburger icon' (Griffen, 2015; Lim, 2009). Beyond having different mental models, older adults may also struggle more with developing new mental models, likely due to deficits in spatial navigation and spatial memory due to aging making it more difficult to develop a new model of the abstract space a website exists in (Wagner et al., 2014).

Combining their deficits in mental models with their decreased familiarity with icons and terms used conventionally for websites, it is possible for older adults can find websites disorienting, confusing, and without logical organization. As a result, some older adults tend to prefer more concrete, straightforward designs that are closely connected to what they are supposed to represent, like a news website that emulates the design of a newspaper (Vaughan & Dillon, 2006; Zhou et al., 2017). In fact, some studies have found that older adults much prefer designs that integrate some extended metaphor that is familiar to them, such as a mailbox and an address book (Zhou et al., 2017).

Spatial and Navigational Abilities

Navigation forms a large part of how we interact with webpages, from mentally mapping webpages on a website and how to travel between them to where information appears on a page. Unfortunately, navigation and spatial skills tend to decline with aging (Osman, 2019; Wagner et al., 2014). Older adults tend to exhibit poorer memory for where objects are in space than younger adults. This affects the creation and maintenance of metal maps for abstract, online spaces – like a website – and therefore affects how easily older adults

can navigate a website (Wagner et al., 2014). This can result in disorientation, where the user cannot find what they wanted or where they can go from their current location on the webpage (Osman, 2019).

The structure of a website can also impact how well older adults are able to interact with it. While website structure should be as simple as possible to reduce load on spatial memory, there is also some evidence that the manner in which information is structured within a website can affect how usable older adults found it to navigate (Dekkers et al., 2021; Fang & Holsapple, 2007). For example, one study by Dekkers et al. (2021) found that a website that presents information in a linear or 'tunnel' structure may increase the perception of relevance of a topic, when compared to a website that presents information in a 'hierarchical' structure that presents information as hierarchies of major topics and the minor topics associated with them. The same study also found that a 'matrix' design that presents the user with all possible topics in the navigation on one page may make the user feel more in control when using a website than a hierarchical design does. However, none of the designs affected the information that the user gained from the website, just the user's subjective experience when using the website (Dekkers et al., 2021).

Attention

Finally, aging is generally associated with a decreased ability to focus attention (Hawthorn, 2006). This may make it more difficult to perform several tasks when interacting with a website, including visual search, ignoring distractions such as ads, and multitasking (Hawthorn, 2006).

Older adults tend to experience more incidences of cognitive blindness during visual search than younger adults (Veiel et al., 2006). Cognitive blindness refers to when someone fails to see something on a website when it is present or 'right in front of you'. Essentially, older adults are more likely to simply miss what they are looking for on a website than younger adults, meaning they take longer overall to complete tasks.

Older adults also tend to struggle with focusing attention when distractions are present (Sa-nga-ngam & Kiattisin, 2020). For website design, this means that ads, moving images, or unexpected videos may distract an older adult from their task more than they would for a younger adult. An older adult may then take time to get back on task, or more easily forget their task when distracted (Sa-nga-ngam & Kiattisin, 2020).

In line with struggling to focus attention, older adults tend to be less proficient at multitasking than younger adults (Hawthorn, 2006). This means that tasks requiring divided attention, such as balancing attention between a website and a source of help, may be difficult for older adults to perform. Multitasking ability may also affect older adults when they are balancing learning new skills with performing old ones due to the divided attention necessary for performing a task and the steps necessary for the new skill (Hawthorn, 2006; Pang et al., 2021; Sanchiz et al., 2017).

Website Design Elements to Consider for Older Adults

In summary, many older adults experience differences in cognition compared to younger adult across several different areas of cognition, including vision, such as decreasing acuity of sight, and motor abilities, such as slower and shakier movements. Older adults also tend to be different than younger adults when it comes to learning and skill transfer, showing

less skill transfer and generalization, as well as differences in memory and the prior knowledge they possess. Learning and memory affect the mental models older adults build and utilize to interact with websites, as do changes to their spatial and navigational skills. Finally, older adults tend to struggle more with focused attention, which can affect many other areas of their cognition, like their ability to perform a visual search.

It is possible to adapt certain aspects of website design to accommodate for these differences in cognition. We can consider the size of and spacing between elements to accommodate for vision, motor, and attentional changes, or the use of certain symbols and word choices as it relates to differences in vision and prior knowledge. The overall structure of a website can affect user perception and judgement of the usability of the website, as well as how quickly a website can be learned and how much it demands from memory and navigational skills. Finally, the memory and navigation cues imbedded into the website design can affect how effectively a user can utilize a website by supporting the deficits in working memory and navigational skills that older adults may experience. Together, website structure and cues can affect the mental models that older adults develop.

Size and Space

The size of and spacing between elements on a website can impact how easy it is to interact with. As visual acuity can decline with age, fonts, symbols, and other elements should be large enough to be seen easily. Although screen size and user position can affect how large an element appears, it is recommended that fonts are at least 12pt or 14pt if the user cannot adjust the font size themselves (Carmien & Garzo, 2011; Hawthorn, 2000; Hou et al., 2022). If a website is meant to be viewed on multiple, drastically different screen sizes – such as a laptop

computer verses a mobile smartphone – then the website should be designed to adjust the font according to screen size. Although there is no standard sizing of other website elements, they should be kept to a minimum size comparable to 12pt font to be seen easily. This size recommendation is not a fixed requirement, though, as how large a font will appear to the user depends on the size of the screen it will be seen on and how far away that screen is expected to be from the viewer. For example, a computer monitor and a tablet may require different font sizes to make the text appear readable.

Interaction elements – buttons, text fields, drop-down menus, etc. – should not only be large enough to be seen, but also large enough to be interacted with. Since many older adults generally need larger items to accommodate for a shaky or imprecise hand, cursors and their effective ('hot') footprint around interaction elements should be large so that a user can easily select the element (Osman, 2019).

The space between elements is also important for compensating for motor and visual changes together. If two buttons are close together, it can be difficult for an older adult to select the one they intend to use, even if the buttons are fairly large. So, interactable elements should be spaced far enough apart to allow for only the intended item to be selected (Osman, 2019). Beyond that, a cluttered or 'dense' webpage is generally difficult to parse and understand. More minimal, well-spaced webpages generally support visual search and navigation, which in turn can support older adults' mental models, learning, and memory.

Symbols, Text, and Word Choice

First and foremost, all symbols – icons, text, etc. – on a webpage should be fairly simple. It is best to avoid ornamental or decorative fonts, and to keep icons from being overly complex (Carmien & Garzo, 2011; Hou et al., 2022). This allows for the best legibility for older adults.

It should also be considered that, generally, older adults lack experience with modern website conventions, including jargon and icons. For example, in recent years, more minimal designs have become popular, such as the 'hamburger menu' icon. The 'hamburger menu' icon uses three horizontal lines to indicate a menu, but this design is only abstractly associated with what a menu looks like or does. As a consequence, it is not uncommon for older adults to be confused about its purpose, and therefore struggle with interacting with websites that use it (Griffen, 2015). Instead, more straightforward designs that clearly indicate what they are supposed to represent are usually more usable for older adults. So, a more effective alternative to the hamburger menu icon would be clearly labelling a menu as 'Menu'. Or, as an alternative, previous studies have identified that icons that closely resemble something that it shares a purpose with, such as an address book used to symbolize a button to access someone's contact list, can be effective for older adults (Zhou et al., 2017). However, the universality of some concrete symbols need to be considered – for example, it is possible that not all younger adults would know what an address book is meant to represent, as they are less common to see used in recent years.

Icons can also apply metaphors, although results may be mixed. For example, over time, settings have become symbolized with a gear or cog on most computing devices, despite computers entirely lacking gears to 'set'. In fact, gears are far from the interface most users use

to change the settings on their devices. However, it has become a visual metaphor borrowed from mechanics. Admittedly, the efficacy of this visual metaphor needs to be studied, but it is generally reported as being less problematic than the hamburger menu icon.

Website Structure

Getting into higher-level design elements, the structure of a website can influence how easy it is to learn, search, and navigate a website, and may impact on the user's attitude.

At a more global scale, the structure of a website can refer to the overall scaffolding for information and webpages in a website. This includes deciding what information is presented where, and how different webpages or chunks of information connect to each other. Certain website structures have been shown to support users in different ways: a more linear structure that guides the user through the topic from a beginning to an end generally makes the topic seem more personally relevant, while a 'matrix' design that presents the user with all their options and lets them direct the ordering and how to navigate tends to provide more of a perception of autonomy to the user (Dekkers et al., 2021). One website structure older adults preferred the least is a hierarchical structure, in which webpages – and information in general – are collected into hierarchies (Dekkers et al., 2021; Hawthorn, 2006). Thus, website designers should consider the goal they have for their website and information, and which design will best support their goals. For example, if the website is intended to guide a user through a course on a topic, a linear structure may work best, while a matrix structure is likely more fitting for a website that is meant to be browsed. The manner in which information is structured on a page may also assist with attention deficits, as important items can be prioritized in the structure to reduce the focus and search required to find them.

At a smaller scale, the structure of website can refer to how individual webpages are laid out. For example, in deference to the decreased peripheral vision some older adults experience, you generally want to avoid putting important elements that the user should attend to quickly in the periphery of a webpage (Bergstrom, Olmsted-Hawala, & Bergstrom, 2014; Bergstrom, Olmsted-Hawala, & Jans, 2013). Instead, they should be placed more centrally. A website should also maintain a coherent theme and organization, and reduce distractions as much as possible.

Navigational and Memory Cues

The ability to navigate a website well can be affected by many factors, and differences in memory, mental models, spatial skills, learning, and attention may all play a role. This means that providing robust support for navigation in a website's design is incredibly important. While the website structure plays a part in adapting to changes in navigation skills and memory with age, there are additional design elements we can include to further support older adults.

First, a website should have a clearly marked 'safe' place (usually the home page) that a user can return to if they get disoriented. Many modern websites will return to the homepage if the website logo (often along the top of the screen) is clicked, however, this is a convention that not all older adults will be familiar with. So, the home page (or other safe page) should be obvious and easy to navigate to, for example, with a 'home' button that is easy to locate.

The navigation structures of a website, such as menus, should also be obvious and easy to use. Hiding menus behind buttons – such as the 'hamburger menu' button – can be confusing and unclear. Websites should also explicitly mark where the user currently is within the webpage and the path to that location so that the user has a reminder of how they

traversed the website, lightening the load on memory and assisting in building an accurate mental model and map of the website. These navigational cues help orient older adults within the abstract space of a website, making the website less confusing and more usable.

Since older adults may be more prone to distraction than younger adults, also having reminders of what task they are performing on the website can be beneficial for keeping them on task and reducing the impact of distractions (Hawthorn, 2006).

The Current Study

In summary, as we age and areas of our cognition – such as vision, memory, and navigational skills – change, certain aspects of website design may become less usable. In response, previous research has identified that it is possible to alter some aspects of design, such as website structure and lay-out, navigational tools, and word choices, to make websites more usable for older adults.

While the effect of these design adaptations on usability for older adults is fairly well documented in current research, less explored is whether these adaptations for older adults affect usability for younger adults. So, the goal of the current study is to explore the effect of adaptive design elements for older adults across both age groups, with a focus how they affect website usability for younger adults.

To measure usability, we use three metrics: a usability score from a self-report survey adapted from the System Usability Scale from Brooke (1995); a measure of response time when answering questions using the website; and a score for the accuracy of responses to questions using the website.

First, we expect to see that older adults find an adaptive website design to be more usable than a conventionally designed website without design accommodations, with better self-reported usability scores, faster response times, and somewhat higher accuracy – we expect that accuracy may not be affected as strongly by website design, as the websites should be usable enough to find information on regardless of design. This will establish that the adapted design used in the study is effective in increasing usability for older adults compared to the conventional design.

Second, we expect that younger adults will outperform older adults when using a website regardless of website design, consistently answering questions more quickly, and more accurately. This is due to that fact that older adults tend to experience decreased visual processing time, slower visual searches, and slower movements when compared to younger adults, which will likely slow the performance of older adults when using websites. However, even though an adapted website design is intended to increase website usability for older adults, it is not necessarily about equalizing performance between older adults and younger adults; instead, the focus is on making websites more usable than they were to older adults.

Finally, we hypothesize that younger adults will not be affected negatively by an adapted website design. That is, younger adults will either find an adapted website more usable and show increased performance when using the adapted website compared to a conventional website, or will find it no more or less usable and show similar performance when compared to a conventional website design. We hypothesize this given that younger adults are likely to have more experience with different website designs, and tend to be able to generalize their skills

and mental models for websites better than older adults. So, they are more likely to be resistant to different designs.

The outcome of this study could offer insight into whether younger adults can be affected detrimentally by website design principles meant to accommodate older adults, and, if so, which design principles can be problematic. Overall, this could inform the design and re-design of websites as we move towards websites that are more accessible to all users.

Method

Participants

We recruited two groups of participants for this study: a younger adult group between the ages of 18 and 35 years old, and an older adult group that was above the age of 60 years old. All participants in this study were healthy adults, had normal-to-corrected vision, spoke English fluently, and resided in Canada. Participants with a diagnosis of neurological or sensation/perception disorder were excluded from analyses.

Overall, 74 people participated in the study (17-75 years old). Four participants did not report an age, and therefore could not be placed in an age group. They were subsequently excluded from analyses.

Sixty-one participants were younger adults (18-35 years old, mean age = 19.08, *SD* =1.496). Eighteen younger adult participants identified as male, and 43 identified as female. The majority of younger adults were completing an undergraduate degree (*n* = 52), and received credit towards an introductory psychology course in compensation.

Due to the low number of older adults participating in the study, the older adult group was redefined to include all adults over the age of 35 years old. This augmented older adult group had six participants (37-75 years old, mean age = 59.2, *SD* = 13.84), five of which identified as female and one that identified as male. At minimum, they had completed a grade 11 education (*n* = 3), which some having completed undergraduate (*n* = 1) or graduate degrees (*n* = 1). In compensation for participating in the study, they received the chance to win one of five $10 gift cards to Tim Horton's.

Materials

Task Websites

There were two websites used during the experimental task: an 'adapted' website that had been designed to accommodate for the cognitive changes associated with aging, and a 'conventional' website that was not. The websites possessed the same information, but presented it in different ways.

To control the potential effect of familiarity with a topic on website navigation and question answering, we used a topic that both older and younger adults living in Canada are likely to have a similar level of familiarity with: COVID-19 and the public health measures taken in Canada during the COVID-19 pandemic. This included: what COVID-19 and it's variants are; symptoms of COVID-19; types of tests for COVID-19, and when and how to get tested; types of vaccines, how they work, and who is recommended to be vaccinated; travel; and an update on the 'current situation' for COVID-19 across Canada, including national death and infection counts, and any federal public health measures still in place. At the time (January 2023), Canada had put in place a temporary travel advisory for travelers coming from the People's Republic of China, Hong Kong or Macao (Public Health Agency of Canada, 2023).

This information was sourced from the Public Health Agency of Canada, Canadian provincial government websites (such as the Government of New Brunswick website) and resources (such as LibGuides from Nova Scotia), the Canadian Public Health Association, the United States' Centers for Disease Control and Prevention (CDC), the World Health Organization (WHO), John Hopkins Coronavirus Resource Center, and the Harvard Gazette. A complete bibliography is available in Appendix A.

Beyond the same information, both websites also used similarly sized fonts and buttons, similar high-contrast colours, and minimal elements on pages. Neither website had images or videos. Overall, the main differences between the two websites were how information was organized and the navigational structures available to users.

The conventional website had all the information in sections on one long, scrolling page, with a menu to the side to be used to navigate to different areas of the page. The menu contained only high-level navigation, letting users navigate between general topics like 'Public Health' and 'Vaccines', but nothing more specific within these general topics. However, since the webpage contains all the information in one page, it is possible for users to navigate the website without using the menu. The menu element would track and highlight which topic the user was in regardless of if the user used the menu to navigate the website or not, but the menu offered no more than this limited context of location within the webpage. An example of the conventional website can be seen in Figure 1.

To a degree, the conventional website was designed to mimic website designs that are common for mobile devices such as tablets and phones, which are becoming more and more common to see within the growing number of websites online that are meant to be accessed both on mobile devices and more traditional computers like laptops and desktop computers.

The adapted website presented the information in separate pages with a more detailed navigation structure. A menu at the top of the screen allowed users to navigate general topics, which had one or two webpages each. When multiple pages were used to separate topics within a general topic, a drop-down menu was used in the top-menu to allow users to select

Figure 1

Screenshot from the Conventional Website

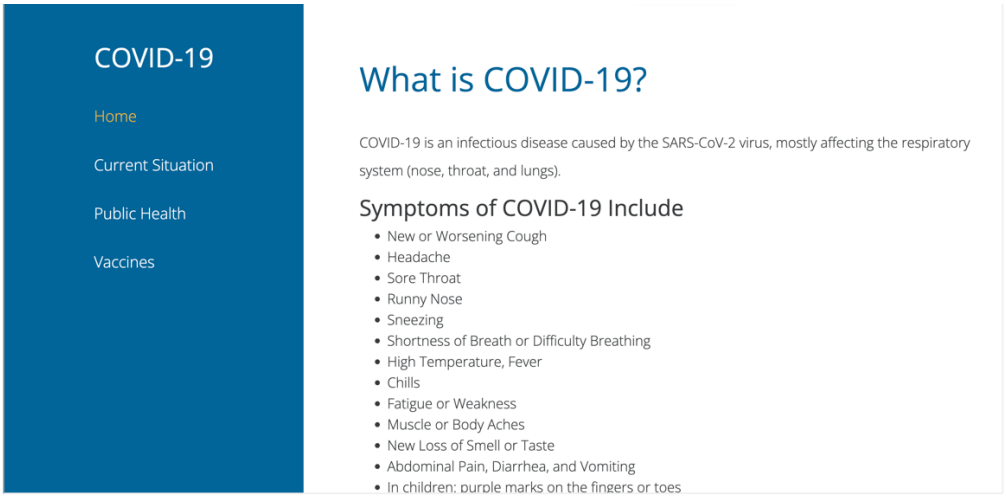
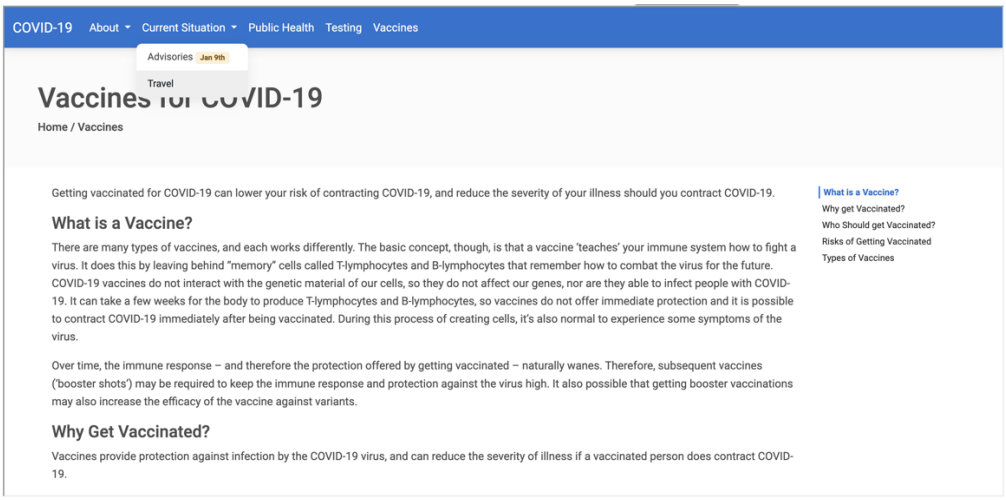


Figure 2

Screenshot of the Vaccines Webpage from Adapted Website



Note. The menu item 'Current Situation' has been selected, showing the drop-down menu options for specific topics within the general topic.

these more specific topics, such as the 'Current Situation' tab having both 'Advisories' and 'Travel' topics in a drop-down menu. Finally, each webpage used a sub-menu to the right of the screen that allowed users to navigate the sub-topics on the page. For example, the page for 'Vaccines' had the sub-topics 'What is a Vaccine?', 'Why get Vaccinated?', 'Who Should get Vaccinated?', 'Risks of Getting Vaccinated', and 'Types of Vaccines' (Figure 2).

The adapted website also used 'breadcrumbs', which is a line of text underneath the menu that details which topics or pages were traversed to reach the page a user is currently on. This was paired with highlighting for the webpage the user is currently located on in the menu to give context cues of where the user was located within the website.

In contrast to the conventional website, this design offered greater support for navigating the website information and building a mental model of where to find information on the website. It also utilized a paged-website design (as opposed to a design with one long, scrolling page) that may be more familiar to older adults, as many websites online would utilize this design in the past before mobile devices became popular for browsing the internet.

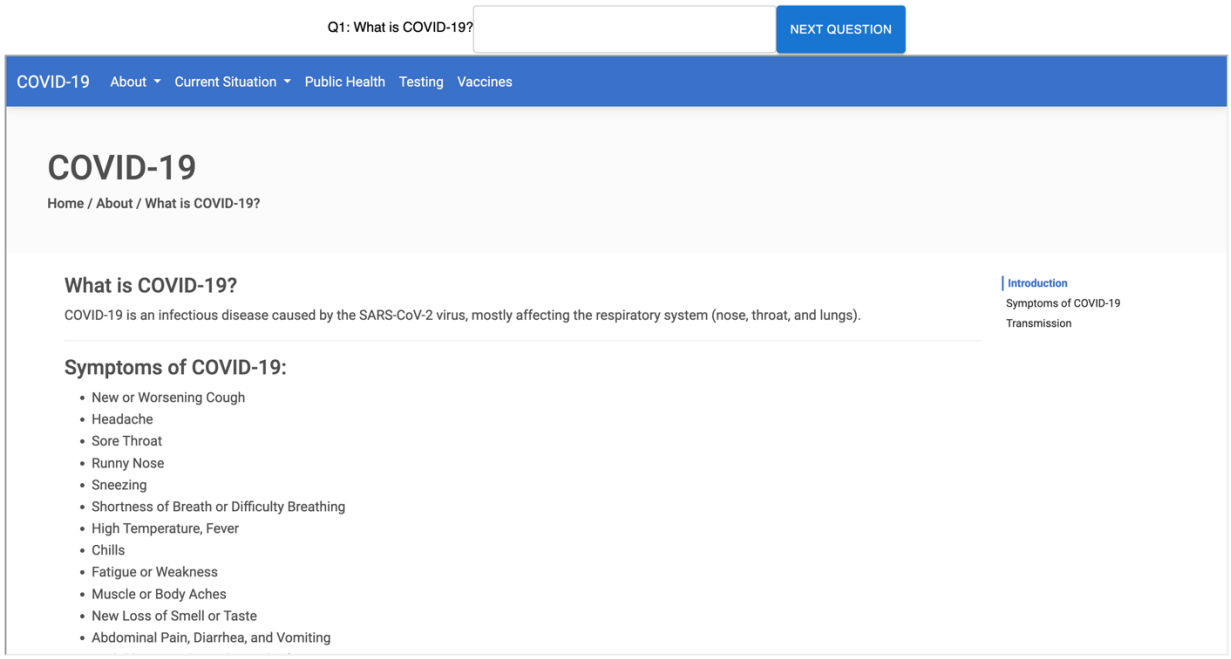
Search Task Questions

First, participants were given an overview of the study. They were instructed that they were to answer a series of questions using a website, with questions appearing one-at-a-time with a textbox for their answer and a 'Next Question' top of a screen and the website at the bottom of the screen (Figure 3).The website they were presented with was either the conventional or adapted website depending on which condition they were assigned to.

The questions all related to the COVID-19 information presented in the websites, and varied across three complexity levels. Level one questions involved simple fact-finding

Figure 3

Screenshot of Study Website During Search Task



Note. This is a trial using the adapted website. The conventional website would appear in the same location for trials in which it is used.

questions, for which the participant had to perform minimal navigation to find an answer to. For example, “What are two symptoms of COVID-19?”, which is answered at the top of both websites and therefore viewable with very little navigation. Level two questions were similar, but would take more navigation and were less immediately clear to answer, such as “What are the types of tests for COVID-19?”. This question uses keywords that match less clearly with those labelling the website sections, and takes some parsing of the text to answer. Level three questions were open-ended questions, for which the participant would have to navigate to and integrate information from multiple places on the website. One example is “A person has tested positive for COVID-19 using a rapid-test. What should they do?”. These questions are intended to reflect more-so the types of questions that participants may use a website resource to answer in reality.

There were seven questions in total, and the questions were presented in the same order for each participant. A full list of the questions used is available in Appendix B. For analysis, participant responses were encoded for accuracy by a researcher, and the length of time taken for participants to respond to each question was recorded.

Usability Survey

After completing the website task, participants completed a survey to evaluate the usability of the website. We used a version of the Short Usability Scale (SUScale) developed by Brooke (1995), which has been shown to give a fairly accurate image of system usability while taking a minimal amount of time. The survey has participants rank their agreement with a series of statements about the usability of the website such as "I found the website unnecessarily complex" and "I needed to learn a lot of things before I could get going with this

website" on a five-point scale from Strongly Disagree to Strongly Agree. The full survey is available in Appendix C.

These ranked responses were then transformed into a score ranging from zero to one hundred, where lower scores indicate greater reported usability.

Procedure

The study was administered remotely through a web application that guided participants through the study. First, participants were shown a consent form. Following the consent form was a demographics survey where participants were asked to fill out information on their age, gender, education, confidence and comfort with technology, as well as any deficits in sensation, perception, and/or mobility that affect their daily life.

After completing the demographics survey, participants were directed to the experimental task. The task was broken into two steps: a 'search task' that involves navigating a given website to respond to a series of questions about the information on the website, and a subsequent survey for the participant to evaluate how usable they thought the website they used during their task was.

For the search task, participants were presented with either the adapted or conventional website and the first of the series of questions. Once they answered the question, they were presented with the next question, and so on for all of the search task questions described above.

After completing the search task, the participants completed the version of the System Usability Scale (Brooke, 1995) described above. Once they completed the SUScale survey, they were shown a debrief letter that outlined their compensation and how to find out more

information about the study, as well as resources to handle any distress that dealing with the topic of COVID-19 may have caused them.

Results

Two participants who reported that they did not speak English fluently or that have had been diagnosed with a neurological disorder were excluded from the analyses. Search task questions that did not have answers were excluded as well, although the participant and any search task questions they answered were included in the analyses.

The SUScale survey responses were summarized into a usability score as described by Brooke (1995), while the length of time to respond to each of the task questions were condensed into an average time per question measure, and accuracy scores for each question were collated to create an overall accuracy score. The SUScale score was out of 100, with lower scores indicating higher reported usability, while the accuracy score was marked out of six, with higher scores indicating higher accuracy. Time per question was measured in seconds, with lower times indicative of faster responses and therefore higher usability.

First, a 2x2 ANOVA was performed to analyse the interaction of age group, website design, and the average time per question, which found a significant effect of age group, $F(1, 68) = 4.675$, $p = .034$, $\eta^2 = .064$, but no significant effect of website design, $F(1, 68) = 2.692$, $p > .05$, or a significant interaction between the two, $F(1, 68) = .014$, $p > .05$. The average time per question was significantly longer for older adults ($M = 65.56$ seconds) than younger adults ($M = 42.52$ seconds). A pre-planned t-test was also performed on average timer per question to analyse usability for older adults using the conventional website ($M = 69.22$ seconds) and older

adults using the adapted website (*M* = 59.15 seconds), which showed no significant difference, *t*(8.683) = -.360, *p* > .05. Results for average time per question are presented in Figure 4.

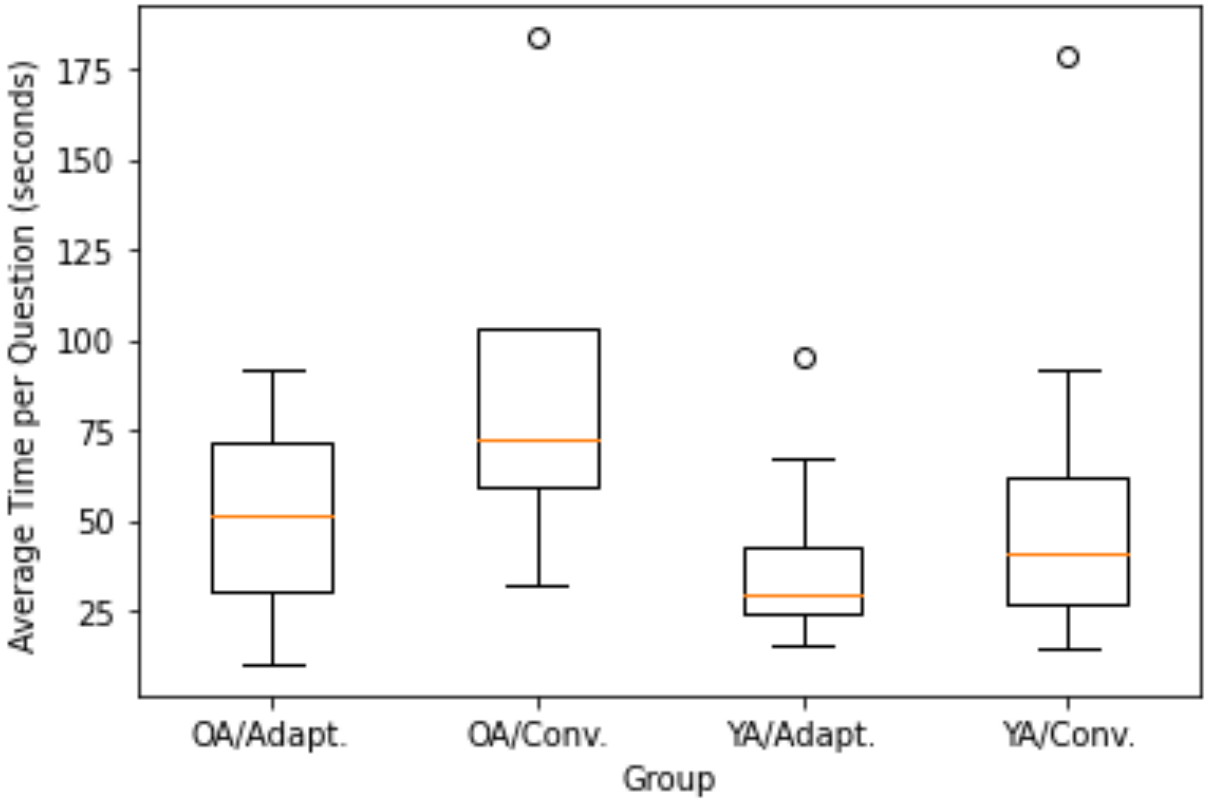
The same analyses were performed for accuracy score. Another 2x2 ANOVA analyzing age group, website design, and accuracy score was performed, which also showed a significant effect of age group, *F*(1, 68) = 14.685, *p* < .001, η^2 = .178, and no significant effect of website design, *F*(1, 68) = .789, *p* > .05, or any significant interaction between age group and website design, *F*(1, 68) = .453, *p* > .05. Accuracy score was significantly lower for older adults (*M* = 4.9) than younger adults (*M* = 5.9). A pre-planned t-test comparing accuracy scores for older adults using the conventional (*M* = 4.86) and adapted (*M* = 5.0) websites found no significant differences in accuracy score between the website designs, *t*(8.698) = .131, *p* > .05. Results for accuracy score are presented in Figure 5.

Mann-Whitney U-tests were used to analyse SUScale score compared against age group and website design, which revealed no significant impacts of age group, *U* = 426.00, *p* > .05, or website design, *U* = 675.00, *p* > .05. To analyse an effect of the interaction of age group and website design on SUScale score, a Kruskal-Wallis test was run using four groups representing the 2 (age group) x 2 (website design) design. No significant effect of group on SUScale score was found, *H*(3) = 1.078, *p* > .05. A pre-planned Mann-Whitney U-test was performed to compare SUScale score for older adults using the adapted (*M* = 28.75) and conventional (*M* = 25.0) designs, which was also insignificant, *U* = 5.500, *p* > .05. Results for SUScale score are presented in Figure 6.

The lack of significant differences in usability – across all usability metrics – for older adults using the adapted and conventional website designs contradicts the hypothesis that

Figure 4

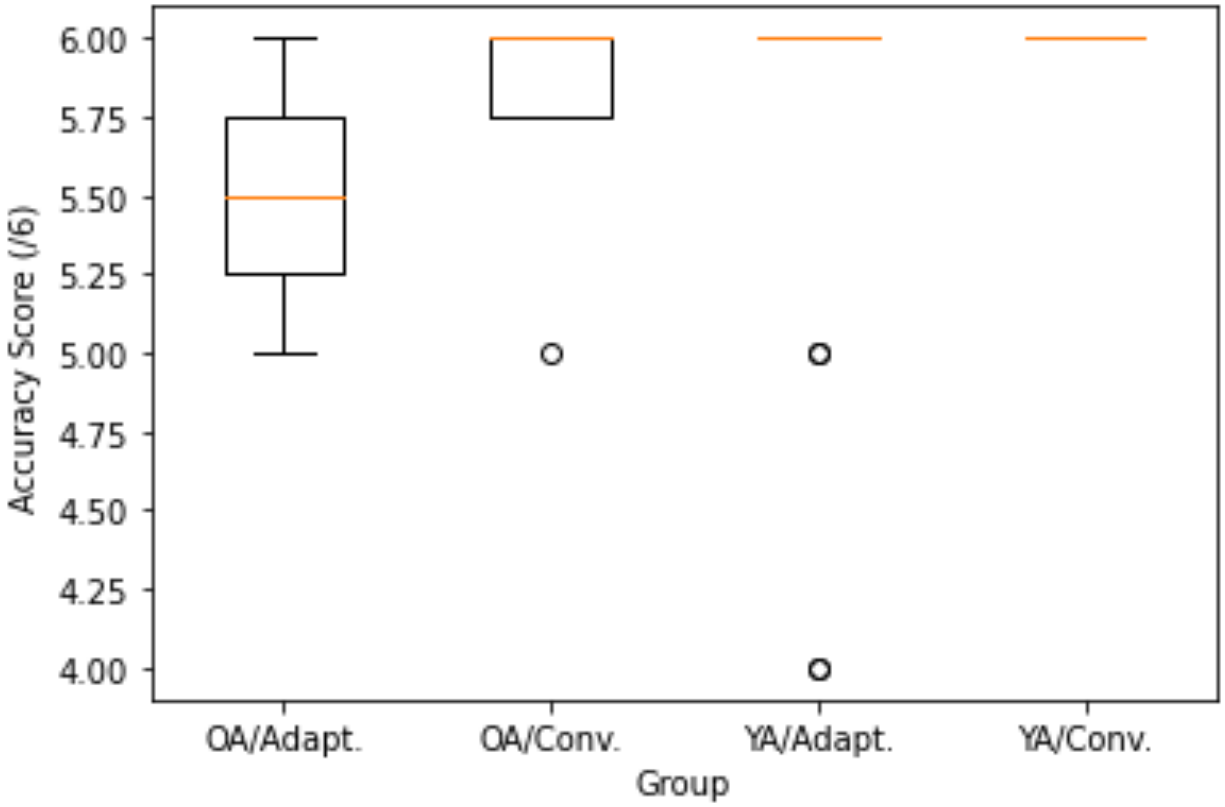
Average Time per Question (in seconds) for Older and Younger Adults Using the Adapted or Conventional Website Design During the Search Task



Note. 'OA' is used to refer to 'older adults', 'YA' refers to younger adults, 'Adapt.' refers to the adapted website design, and 'Conv.' refers to the conventional website design.

Figure 5

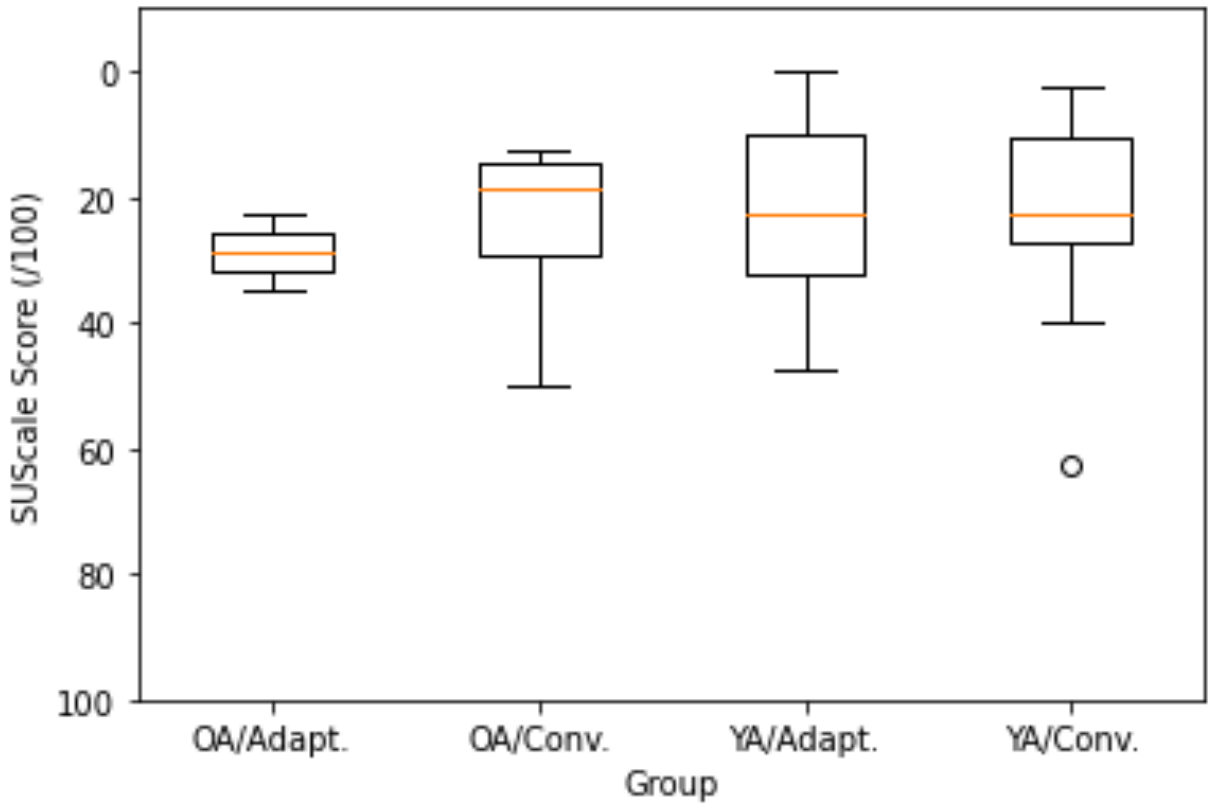
Accuracy Score (out of 6) for Older and Younger Adults Using the Adapted or Conventional Website Design During the Search Task



Note. 'OA' is used to refer to 'older adults', 'YA' refers to younger adults, 'Adapt.' refers to the adapted website design, and 'Conv.' refers to the conventional website design.

Figure 6

SUScale Score (out of 100) for Older and Younger Adults Evaluating the Adapted or Conventional Website Design



Note. 'OA' is used to refer to 'older adults', 'YA' refers to younger adults, 'Adapt.' refers to the adapted website design, and 'Conv.' refers to the conventional website design. Recall that lower scores (closer to 0) indicate higher usability.

older adults would show better performance and usability when using the adapted website compared to the conventional website. However, the findings that younger adults show significantly better performance in average time per question and accuracy support the hypothesis that younger adults would outperform older adults regardless of website design.

Another set of analyses were run for each of the usability measures to compare usability for younger adults using the adapted website against younger adults using the conventional website. A Mann-Whitney U-test for SUScale score, $U = 5.500$, $p > .05$ found no significant difference, however, t-tests for accuracy score and average time per question found borderline-significant differences. Accuracy scores for younger adults using the adapted website ($M = 5.78$) were lower than accuracy scores for younger adults using the conventional website ($M = 6.0$), $t(26.000) = 2.000$, $p = .056$. At the same time, younger adults using the adapted website ($M =$ 35.54 seconds) had a faster average time per question than younger adults using the conventional website ($M = 48.07$ seconds), $t(54.275) = 1.912$, $p = 0.061$.

Interpreting only the significant differences – or lack thereof – these results indicate support for the hypothesis that younger adults would not be negatively affected by website design, either demonstrating improved or similar usability to when they use the conventional website. If we consider the borderline-significant tests, however, the outcomes both support and don't support the hypothesis. Younger adults do show improved or similar usability as measured by SUScale score and average time per question, but accuracy scores seem to be negatively affected by website design.

Finally, a set of Spearman correlations were performed to examine the relationship of the three usability measures used in this study. They indicated that the SUScale score is not

significantly correlated to the average time per question, $r = -.135$, $p > .05$, nor are accuracy score and average time per question significantly correlated., $r = .0$, $p > .05$. SUScale score and accuracy score, however, are significantly correlated, $r = -.377$, $p = .001$, with lower SUScale scores – which indicate higher usability – correlating to higher accuracy scores.

Discussion

Using a website designed to adapt to the cognitive changes experienced by older adults and a website with a 'conventional' design that does not consider older adult cognition in its design, we examined the impact of age and website design on usability as measured through a self-reported survey of usability (the SUScale) as well as the average time taken to answer questions and the accuracy of responses to those questions during a website search task.

We had three hypotheses for this study. First, that older adults would show greater usability – in any of the three usability metrics we used – when using the adapted website compared to when using the conventional website. This would establish, first, that the website designs used in this study were significantly different, and, second, that one website used design elements that adapted for older adult cognition. The results of the study, however, showed no significant effect of website design on usability for older adults or otherwise, nor did comparisons of usability for older adults using the adapted website and older adults using the conventional website show a significant difference in any of the usability metrics used here.

The second hypothesis was that younger adults would outperform older adults for both the adapted and conventional website designs. This was supported by the study results, which showed a significant effect of age on accuracy score and average time per question with older adults taking more time to respond to questions and scoring lower on accuracy than younger

adults. That said, age did not seem to significantly affect SUScale score, which could indicate that user judgements of the usability of a site are independent of age or, to an extent, accommodate for cognitive abilities.

And, finally, we hypothesized that usability would not be affected negatively by the website design for younger adults – that is, younger adults would show either greater or similar usability when using the adapted website or the conventional website. The results indicated that website design did not affect the usability measures, and direct comparisons of usability for younger adults using the adapted website and younger adults using the conventional website showed no significant differences for any usability metric used in the study, although it did show trends that indicate both increased and decreased usability when using the adapted website. However, it should be considered that the website designs used in this study do not seem to be significantly different in usability for older adults, meaning that this study may not have tested with an accurate adapted or conventional website. More likely, the small sample size of older adults and the inclusion of people above the age of 35 years old in the older adult group obscured any significant effect of website design.

Usability Between Age Groups

We expected that younger adults would surpass older adults in our measures of usability regardless of website design, which was supported by the study results, to an extent. While average time per question and accuracy were affected by age, and both accuracy and average time per question indicated greater usability for younger adults compared to older adults, SUScale score was not significantly different between age groups.

Even though average time per question, the accuracy score, and the SUScale score were all intended to measure usability, it is not necessary that they all measure the same aspects of usability, or that their outcomes be closely linked. In this study, there seemed to be a division of 'performance' and 'subjective' measures of usability, with accuracy score and average time per question quantifying how well users interacted with a website, or how they performed when using a website, and SUScale score evaluating how users perceived the website. Beyond these divisions, there could be distinctions between each individual measure. For example, features that encourage faster use may lead to less accuracy, as users may skim quickly through the website without necessarily needing to take the time to understand the content well. In the same thread, features that make a website faster to use – as measured by average time per question – may not make the website feel more usable subjectively – measured by SUScale scores. In fact, we found no significant correlation of SUScale scores and average time per question, which implies that the time taken to use a website to achieve a task is not associated with the subjective evaluation of the usability of that website.

For the most part, it should be considered that different usability metrics may examine different aspects of usability. It is possible that there are design elements that could affect website use performance – which average time per question would be sensitive to – that the user would not perceive as affecting usability. For example, a study by Trukenbrod et al. (2020) identified that the subjective experience of time, or how long a user thought they took to complete a task, is one of the factors users consider when judging the usability of a website. We can then consider that an older adult's perception of how long the website task took them to complete may be comparable to a younger adult's perception of how long the website task

took them to complete. Within this framework, they then both judged the website task to be approximately the same level of usability relative to their expectations or prior experience with websites.

Other aspects of expectations may affect judgements of usability, such as what the users were told about the website (Stojmenovic et al., 2018). Essentially, if told to expect a website that is 'ugly and hard to use', users will perceive a website as uglier and harder to use than they would if they were not given that expectation (Stojmenovic et al., 2018). Nonetheless, while participants in the current study were informed that they were completing a usability task for the purpose of examining the interaction of usability, age, and website design, they were not aware of whether they had been assigned the adapted or conventional website. So, participants should not have been affected by descriptions of the website contained within the study.

It is possible that older adults and younger adults tend to hold different expectations for websites, perhaps from their prior experiences with websites, so that they judge usability of websites to have roughly equal usability even when older and younger adults do not have equally usable experiences by other measures.

Despite the lack of relationship between average time per question and SUScale score, we did find a significant correlation of SUScale and accuracy scores, with lower SUScale scores being indicative of higher accuracy scores. Recall that a 'lower' SUScale score indicates higher usability, so the more usable a participant rated a website, the greater probability that they more accurate when using the website to respond to questions. It could be that the ability to find accurate information that is relevant to the user's goal on a website may be considered

with more weight when making judgements about usability. So, a user that can find information relevant to their task more easily is both likely to be more accurate and find the website more usable.

There are a number of factors that could be responsible for this relationship, including familiarity. Familiarity has already been identified as a factor in reported usability by previous studies, where users that are more familiar with the topic of a website tend to find the website more usable (Sanchiz et al., 2017). Familiarity with a topic may also lead to greater accuracy of responses, as users with a stronger background in a topic have some point of reference for how accurate they are and the context of the response. For example, one participant responded incorrectly to the question "What is COVID-19?" by stating that COVID-19 was a type of flu. While COVID-19 may have a number of symptoms in common with influenza (the 'flu'), it is caused by a different virus, and therefore is not a type of influenza. Someone more familiar with the details of COVID-19, or diseases and viruses in general, is more likely to know this distinction between influenza and COVID-19, and therefore more likely to be more accurate when answering this question. They may also be more likely to understand the context of the topic headers used to navigate the website, such as "Transmission", and therefore are more likely to find the website more usable. Familiarity with COVID-19 as a topic was not analyzed in this study, though, so a conjecture cannot be drawn from the results of this study.

The difference in the relationship of response time or accuracy with reported usability may be a result of user expectations, as although changes in older adult cognition may make aspects of websites less usable, they do not necessarily make them entirely inaccessible. For example, changes in vision and attention may make visual search of webpages for relevant

information slower, but those changes do not make it impossible to perform an effective visual search. As such, older adults are likely to expect that they will frequently take longer to complete a task than a younger adult, and, therefore, they do not consider the extra time they took, on average, to answer questions using the website to be a fault of the website's usability. Faults in accuracy, which may be due to being unable to find the target information on a website, is then more likely to be considered a fault of the website design, making the website less usable. The results of this study cannot meaningfully inform whether the ability to find accurate information with a website affects judgements of usability, though, as participants in this study were not informed of the accuracy of their responses during the task, nor was user confidence in the accuracy of their responses to the questions analyzed. Further research should explore the relationships of different usability metrics, and what aspects of usability they may reflect. In particular, it may be beneficial to examine what participants found most usable about different website designs, which this study didn't consider.

Ultimately, however, younger adults did outperform older adults for accuracy when answering questions with a website and for the average time taken to answer the questions, as we expected based on the previous literature. At the same time, it seems that the measures of usability used in the current study are sensitive to different aspects of usability, potentially due to the different expectations held by older and younger adults, or how different aspects of a user's experience when using a website may factor into their judgement of usability.

Usability Between Website Designs

Before assessing if an adapted or conventional website design affected younger adults, we had to establish that the website designs used in this study were representative of an

adapted website that had been designed to accommodate for the cognitive changes that older adults experience and a website that has a more conventional design, respectively. To evaluate the designs, we analyzed the performance of older adults between the adapted and conventional website designs. If the designs were valid representatives of adapted and conventional designs, then we would expect see that the older adults found the adapted website significantly more usable than the conventional website. Unfortunately, the results of this study did not show any significant difference in usability for older adults using the adapted website and older adults using the conventional website, for any metric of usability. Since prior studies have documented a significant effect of adaptive website design on usability for older adults, we must consider what aspects of this study's design could have influenced this outcome.

Principally, this study used a small sample size of older adults, and ultimately included participants older than 35 in the 'older adult' group. The grand majority of prior studies in the area of website usability and the cognitive changes associated with aging note the benefit of adaptations only at approximately 60 years old or older. Most studies on healthy aging also identify that adults that are younger than 60 years old are usually not experiencing the same significant deficits to cognition that older adults over the age of 60 years old are, meaning that any participants in the older adult group of this study that were younger than 60 years old were unlikely to find the accommodations included in the adapted website helpful or necessary. As such, any potential difference in usability for older adults between the two websites may have been obscured.

Had we observed no significant difference in usability between the website designs with a larger sample size, it is possible that the website designs used for this study were in some way not successful in emulating an 'adapted' and 'conventional' website. Based on the design choices and trade-offs made for the websites in this study, it is possible that both website designs contained adaptive elements of different kinds, making the designs somewhat similar from a usability perspective. For example, the long, scrolling design of the conventional website could emulate a 'tunnel' or linear website design that has been shown to improve aspects of perceived usability, like satisfaction and the perceived personal relevance of the website topic, compared to a more hierarchical design, which is what was used in the adaptive website (Dekkers et al., 2021; Trukenbrod et al., 2020).

Both websites also shared a number of low-level design choices in common, like similar fonts, larger text sizes and buttons, and minimal distractions with no pictures or images. At the limited level of complexity offered by the websites used in the current study – which had no images, videos, or ads, and a constrained volume of information – it could be that these low-level aspects may be more relevant for usability than the higher-level design choices about navigation and website structure that were focused on. This includes perceived usability, as measured by the SUScale score, and quantitative measures of usability, like average time per question and accuracy. Future research would then be needed to evaluate the effect of lower- or higher-level design choices on usability.

Additionally, the use of average time per question, rather than analyzing time for each question or level of question complexity, could have disguised some of the effects of website design. That it, certain questions – especially the more complex questions – could have

captured the effect of adaptive website elements better than the simpler questions, as the complex questions were designed to require greater use of the website interface and more cognitive resources. By collating the times for all questions – and therefore all question types – into the average time per question measure, there is the possibility that there were variances in usability between website designs that were negated. This could then have contributed to insignificant differences in usability between website designs for older adults. Even if the website designs are validated when using a larger sample, it would be beneficial to consider the level of complexity of questions as a factor in differences in usability in future work.

Regardless of reason, the lack of significant differences in usability for older adults between the adapted and conventional designs has implications for the results of the rest of the study. Predominantly, it means we cannot claim that one website contained 'adaptive' or 'conventional' elements.

Younger Adults and Website Design

The main goal of the current study was to explore the effect of a website design adapted to the cognitive changes that older adults experience. We hypothesized that younger adults would be either benefit from or be unaffected by the adapted website design, as they are likely to be able to have and effectively utilize greater experience with websites through more productive generalization and mental models. Overall, the results of this study found that there were no significant differences in usability between younger adults using the adapted and conventional website design. Yet, although the results of the current study indicate that younger adults were unaffected by the different website designs, there are a few factors that need to be considered.

First, we found trends that showed that average time per question and accuracy score can be different between younger adults using the adapted and conventional website designs. While younger adults using the adapted website were largely faster than younger adults using the conventional website, which would imply that the adapted website is more usable than the conventional website, accuracy scores were lower for younger adults using the adapted website than those using the conventional website, which would indicate that the adapted website is less usable than the conventional website. It is possible that faster response times were related to lower accuracy rates, with participants that responded more quickly being less careful to ensure that their responses were accurate. Yet, accuracy scores and average time per question were not correlated significantly – negatively or positively – in our results. In total, these trends illustrate a relationship between the usability measures and website design elements used in this study that needs to be studied further.

Second, we found that older adults were not affected by the website designs used in the current study. While there could be more than one reason for this outcome, it means that we cannot claim that one website is adaptive and the other conventional. Further, we then cannot make an inference about the effect of the 'adapted' or 'conventional' website designs on younger adults, and, therefore, whether elements that are adaptive to older adults are detrimental to younger adults or not. So, although the results of this study indicate that younger adults may be resistant to design elements used to accommodate the cognitive changes older adults experience, it is still possible that younger adults may be negatively affected by adaptive design elements, especially considering the trend of lower accuracy when

using the adapted website. Accordingly, further research is necessary to effectively study the effect of adaptive website design principles on younger adults.

Even without knowing if the website designs were conventional or not, we can say that younger adults were able to find information on the 'adapted' website largely as quickly and accurately as on the 'conventional' website. They also perceived the websites to be approximately equally usable. So, younger adults seemed to be mostly resistant to the design principles and features used in this study, including a hierarchical design, a long, scrolling, 'tunnel' design, and different degrees of navigational cues, among other things. Therefore, in the future, these design elements can be utilized without concern for a detriment to usability for younger adult users.

Limitations

The current study has a number of limitations; chief among them is the limited number of older adult participants. Despite attempts to compensate for the small number of older adult participants, ultimately, there are too few older adults to really draw conclusions. This small number of older adults also contributed to an imbalance in numbers of participants in each age group – with 61 in the younger adult group and six in the older adult group –which could have affected outcomes, skewing or obscuring certain results.

The website design for this study could also be a limiting factor. The insignificant difference in usability for older adults between website designs puts forward the possibility that the designs used for this website are in some way invalid examples of 'adapted' and 'conventional' design, which limit the credence that can be assigned to the findings of this study. The websites used for the study were also not necessarily true to reality, as they lacked

more complex features like images, videos, and ads, which are often common on modern websites.

Beyond the confounding factors of website design and participant numbers, the design of the study could be a limitation. First, the study was administered remotely, with little control of participant environment or supervision of participants. To an extent, the lack of control over environment emulates how users would be using websites in reality, however, it leaves room for uncertainty. For example, it possible that some participants did not complete the study using the task website provided to them. Since the topic of COVID-19 is probably familiar to all participants – which is part of the reason why it was selected – participants may have been able to answer the task questions without using the task website, rendering the measurements of usability ineffectual.

Finally, the study utilizes a goal-based search of a website to determine usability. While other studies have identified that the method of having users explore a website – whether goal-directed or a less guided browsing-based method – do not significantly affect the perceived usability of a website, a goal-directed approach may or may not translate well into other contexts (Dames et al., 2019).

Conclusion

Overall, the current study found some evidence that younger adults may be resistant to design elements used when adapting websites to older adult cognition, showing limited differences in perceived or quantitatively measured usability between an ‘adapted’ and ‘conventional’ website design. In application, these findings offer some perspective of how

different website design choices may affect users of different age groups and how usable the website is perceived to be.

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Appendices

Appendix A

References for Website Information

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Appendix B

Website Search Task Questions

Instructions:

On the next page you will be shown a website and a set of short-answer questions. Your task is to answer the questions to the best of your abilities using information from the website. The questions will vary in difficulty and length, and may require you to use information from multiple places in the website to answer.

The questions will appear one at a time at the top of the screen, with the website at the bottom of the screen. Once you answer a question, press the “Next Question” button at the top right of the screen to proceed to the next question.

Once you have answered all the questions, the “Next Question” button will say “Finish” and will bring you to a short survey about how easy it was to use the website during the task.

Questions:

1. What is COVID-19?
2. What are two symptoms of COVID-19?
3. Are there vaccines available for COVID-19? (yes/no)
4. What are two types of vaccines for COVID-19?
5. What are the types of tests for COVID-19?
6. What are two public health measures taken against COVID-19?
7. A person has tested positive for COVID-19 using a rapid-test. What should they do?

Appendix C

Adapted SUScale Questions

Please answer the following questions about your experience with the website you just used on a scale of 1 to five, with 1 being 'Strongly Agree' and 5 being 'Strongly Disagree':

1. I think that I would like to use this website frequently.
2. I found the website unnecessarily complex.
3. I thought the website was easy to use.
4. I think that I would need the support of a technical person to be able to use this website.
5. I found the various functions in this website were well integrated.
6. I thought there was too much inconsistency in this website.
7. I would imagine that most people would learn to use this website very quickly.
8. I found the website very cumbersome to use.
9. I felt very confident using the website.
10. I needed to learn a lot of things before I could get going with this website.