Avoiding Mixed Messages: Research-based Fact-checking the Media Portrayals of Voice User Interfaces for Older Adults

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Older adults (those 60+) are perceived by the mass media and academic literature to be a viable target market for voice user interfaces (VUIs). The mass media portrays VUIs as largely accepted by older adults already, ready to be easily incorporated into their lives, and able to provide many benefits for older adults. Furthermore, it is conveyed that external market and government trends support VUIs for older adults. However, the degree to which these claims are supported by scientific evidence is not yet known. Shedding light upon these gaps between mass media claims and academic literature is vital to the conscious design of VUI systems informed by adoption factors. What we found was that the mass media has made several claims that are supported by academic literature, many that are unsubstantiated, and a few that run contrary to scientific evidence. By reviewing patterns within these findings, we identify the types of knowledge gaps present in VUI design research, support for sociotechnical lenses for anticipating barriers to adoption, and a number of open issues that remain to be addressed when researching VUI adoption by older adults.

Keywords: older adults; voice user interfaces; sociotechnical

Introduction

It is often suggested that older adults (those 60 years or older) constitute a viable target market for voice user interfaces (VUIs) and that VUIs can provide many benefits for older adults. The mass media has been found to support this view, based on recent investigation on mass media's portrayals of VUIs for older adults (Sin, Munteanu, et al., 2021). The mass media was also found to suggest that older adults' perceptions, acceptance, and adoption of VUIs rest on issues of data privacy, trust in the organizations behind VUIs, life fit and benefits conferred by VUIs, and market and government actions. This messaging can directly and indirectly influence older adults' perceptions, and subsequent adoption, of voice user interfaces (Boothroyd, 2014; Rogers, 2010), much in the way that mass media has influenced adoption of other

technologies when they emerged, such as smartphones (Jaeheung Yoo et al., 2010) and television (Weber & Evans, 2002).

However, it is not yet known to what degree the claims made by the mass media about VUIs are supported by current academic research. It is possible that the mass media is propagating claims about VUIs that are not supported by academic literature. This is important because discrepancies between media messaging and academic findings may highlight aspects related to VUI adoption that are either not yet investigated by academic research or are portrayed in the mass media in a manner not supported by (or even contradictory to) scientific knowledge. Shedding light upon these knowledge gaps and addressing them are vital steps for the design of VUI systems in a manner that is conscious of factors that can influence VUI adoption (herein referred to as 'adoption factors') and sociotechnical influences of adoption (such as mass media messaging). Failure to design in a manner that sufficiently accounts for adoption factors can result in older adults' rejection of VUI systems and, perhaps, other forms of digital technology as well (D. Norman, 2013; Whitenton, 2018). Furthermore, unsubstantiated claims in mass media messaging may interplay with the commercial industry's development of VUIs, which is not only progressing much faster than academic-based research but may also be moving in a different direction than academia (Murad et al., 2019). The vigorous mass media messaging and industry push for "voice-first" devices may cause VUIs, which are positioned as greatly benefiting older adults, to instead further marginalize them with design features that exacerbate feelings of frailty, social isolation, and loneliness (Sin, Franz, et al., 2021; Sin & Munteanu, 2020).

For our investigation, we adopt a sociotechnical perspective (as opposed to issues of engineering performance or accuracy) of VUIs for older adults. The study of technology as sociotechnical systems (i.e., as systems with technological, social,

cultural, historical, economic, and political dimensions) accounts for forces external to the technology alone as drivers of technology design and development and emphasizes the role of humans in this process (Neves & Vetere, 2019). We account for this perspective by using the sociotechnical themes of adoption factors generated from the study by Sin et al. (2021) on media portrayals of VUIs for older adults.

Thus, in this paper, we present a comparative analysis (Esser & Vliegenthart, 2017) of discourse on voice-based conversational user interfaces in mass media (as surfaced in the paper by Sin et al., 2021) with the research findings in academic literature (e.g., those as surfaced by Sayago et al., 2019, and Stigall et al., 2019). We do this to try to understand how well mass media messaging aligns with academic literature and to gain a richer understanding of the sociotechnical factors affecting the perception and adoption of VUIs by older adults. By studying differences in themes between mass media messaging and academic literature, we can then start identifying the design and marketing implications involved in bridging this gap and minimizing barriers to adoption related to unmet expectations.

What we found was that the mass media has made several claims that are supported by academic literature, many that are unsubstantiated, and a few that run contrary to scientific evidence. By reviewing patterns within these findings, we identify the types of knowledge gaps present in VUI design research, support for sociotechnical lenses for anticipating barriers to adoption, and a number of open issues that remain to be addressed when researching VUI adoption by older adults.

Claims made by the mass media, whether supported or not by academic literature, can influence older adults' perception, expectations, and ultimate adoption (or rejection) of VUIs (Boothroyd, 2014; Strang & Soule, 1998; Yoo et al., 2010). In this paper, we highlight a gap between media messaging and academic evidence on

sociotechnical topics related to VUIs designed for older adults' use. This gap suggests paths for further investigation into the perception of and adoption factors related to VUIs for older adults. This will allow VUI designers, researchers, and developers to predict and design for the challenges that arise when trying to best incorporate VUIs into older adults' lives. Through bridging this knowledge gap, we work towards actively preventing design consequences, such as the risk of marginalizing older adults, and more thoughtfully intervening for more equitable and inclusive VUI design outcomes.

Contributions

This paper's core contribution is an understanding of how well mass media messaging is supported by academic design literature – that is, human-computer interaction (HCI) literature, which herein we refer to interchangeably with the terms 'academic research', 'academic findings', 'academic evidence', 'academic literature', and so on. Our analysis will bring to light the general factors influencing older adults' adoption of VUIs that might be understudied by current research or overplayed by VUI marketing. By connecting findings across domains in this manner, we aim to gain a deeper understanding of older consumers' perception and attitudes towards the adoption of VUI technologies, as these are influenced by such portrayals.

This paper provides a secondary contribution in the form of a richer understanding of the sociotechnical factors that should be considered when it comes to older adults' acceptance of, adoption of, and barriers to VUI use. By focusing on media influence as a sociotechnical factor of adoption, this paper also contributes to our understanding of how VUIs fit into the overall sociotechnical landscape of digital technology and technology non-use, non-participation, and adoption (Turkle, 2011; Waycott et al., 2016) of VUIs. To our knowledge, no prior research has compared a

synthesis of mass media messaging of VUIs with the findings of academic literature, especially of VUI use by older adults.

Background and Related Work

In this paper, we shed light upon aspects of the sociotechnical factor of VUI adoption that are lacking academic investigation. To the best of our knowledge, no research has yet been conducted comparing media messaging with academic knowledge in terms of technology adoption. However, in this section we will discuss a few key points related to prior work on the academic understanding of VUIs for older adults, media's understanding on this topic, and sociotechnical considerations in adoption.

Academic Understanding of VUIs for Older Adults

The academic understanding of VUIs is that their use is continually growing (McTear et al., 2016), especially when it comes to their applications by older adults (Quain, 2019b). The growing interest may be motivated by perceptions that VUIs have lower visual, auditory, physical, and motor-based barriers to the use (He et al., 2016; Vacher et al., 2015) and improved accessibility (Vacher et al., 2015) when compared to commonplace graphical user interfaces. Audio is a preferred modality for people without hearing impairments (Vacher et al., 2015). Thus, VUIs are believed to serve as a more accessible door to the digital realm, have a low barrier of entry compared to other input methods, and have the potential to be seamlessly incorporated in older adults' lives (Kowalski et al., 2019; Ziman & Walsh, 2018). Research indicates that older adults perceive VUIs positively (Stigall et al., 2019; Ziman & Walsh, 2018), and that VUIs can help older adults manage their health (Sidner et al., 2018), navigate the web (Singh, 2009), and develop social skills (Ali et al., 2018).

However, benefits conferred to older adults are only available should the technology be designed to maximize benefits for these users and also not digitally marginalize them by design (Sin, Franz, et al., 2021). In addition, we do not yet know how to design and evaluate VUIs in a manner that maximizes their benefits for older adults (Sayago et al., 2019). In particular, when it comes to the adoption of VUI technology by older adults, we still do not fully understand the perceptions and barriers to the use of VUIs and how they should be designed to interact with older adults (Sayago et al., 2019). More specifically, we still do not completely understand what older adults think about talking to devices, nor how to design VUIs that are catered towards their age group as opposed to VUIs for populations as a whole (Sayago et al., 2019).

It is important to acknowledge the small but growing body of literature investigating older adults' adoption of VUIs and technology from a sociotechnical perspective. This is because applying qualitative approaches grounded in a sociotechnical lens may be one way to address gaps in understanding users' perception and adoption of technology. There have been preliminary attempts to apply this lens to VUIs, for example, to the study of social robots (Turkle, 2011). In addition, recent work in both HCI (Clark, Doyle, et al., 2019; Stigall et al., 2019) and sociotech-oriented media (Sin, Munteanu, et al., 2021) literature has supported VUIs as promising technologies for improving the lives of older adults and has discussed their issues related to adoption. However, we are far from fully grasping all of the sociotechnical factors that come into play in older adults' acceptance of VUIs.

Mass Media Understanding of VUIs for Older Adults

Sin et al. (2021) investigated mass media portrayals of VUIs for older adults. From the understanding of the authors and ourselves, their paper is the only investigation

conducted on mass media portrayals of VUIs for older adults. Their inductive thematic analysis uncovered four major themes in the mass media messaging of voice user interfaces for older adults: perception and adoption of VUIs by older adults, embeddedness in older adults' lifestyles, changes that VUIs can bring to older adults' lives, and the impact of trends towards VUIs. The authors present these themes as aspects of VUI adoption by older adults (at least as far as the media is concerned) and as support for adopting sociotechnical approaches to the study and design of VUIs for older adults.

Comparative Analysis

Our approach is guided by comparative analysis research methods (Esser & Vliegenthart, 2017). The goal of comparative research is to look beyond individual cases (e.g., individual media claims) to draw conclusions about the similarities and differences between objects of analysis (e.g., in the case of this paper, between mass media messaging and academic literature).

Comparative analysis provides up to five key benefits. Briefly, these are: enhancing understanding of one's own society (understanding), heightening awareness of other systems (awareness), testing theories across diverse settings to evaluate the scope and significance of phenomena (generalization), preventing overgeneralization of scholars' own experiences and challenge claims (relativization), and providing access to alternative options and solutions (alternatives). In order to answer our research question, this paper's analysis leverages comparative analysis for the benefits of heightening awareness of academic knowledge in contrast with mass media messaging (awareness) and seeking options of adoption factors for the design community to consider (alternatives). Through this, we can identify knowledge gaps in academic literature

(through awareness) and know what adoption factors are available for consideration (through alternatives).

Sociotechnical Approach and Models of Inclusion

The sociotechnical approach to design considers in equal parts the technical, human, social, and organization factors of a product or service (Mumford, 2000). The goal is to better deliver value to end-users and stakeholders. In design research and practice, the sociotechnical approach serves as an alternative lens for the study, design, and evaluation of a product or service. Sociotechnical approaches to design remain difficult to accomplish and under-investigated (Baxter & Sommerville, 2011; D. A. Norman & Stappers, 2015). Only recently has design research begun investigating technology adoption by older adults in terms of sociotechnical factors (Waycott et al., 2016). This paper expands the sociotechnical perspective by investigating VUI adoption through the sociotechnical factor of mass media influences.

When considering adoption and barriers to adoption, it is important to talk about issues of access. In social studies of policy, economic, technical, and social barriers have been recognized as factors that can prevent people from fully engaging in, for example, health information infrastructures (Clement & Shade, 1998). Sociotechnical access models have been used as policy tools to highlight access gaps, areas of social need that may be missed by market forces acting alone, address the interplay of social and technical dimensions of development infrastructure, and address the full range of users of an information/communication infrastructure and the diversity of their life situations (Clement & Shade, 1998). The "Access Rainbow" model (Clement & Shade, 1998; Shade, 2010) is a sociotechnical tool for understanding what it means to provide "universal access" (effectively, digital inclusion) to online services. This model discusses digital inclusion on both the technical (carriage facilities, devices, software

tools, and content/services provided) and social aspects (service/access to the technical infrastructure, literacy/social facilitation, and governance). We consider this model in our Discussion as an exemplar of the applicability of sociotechnical models for the understanding of factors of older adults' adoption of VUIs.

Method

In this section, we discuss our approach to identifying the degree to which claims made in the mass media about VUIs for older adults (as identified by Sin et al., 2021) are supported by (or even contradict) academic design literature. Our approach can be summarized in two steps of 1) identifying mass media claims; and 2) interrogating each claim for evidence from academic literature articles.

Step 1: Identifying Media Claims

Claims made by the media on older adults' use of VUIs are sourced from the paper by Sin et al. (2021). As described in that paper, these claims were derived from inductive thematic analysis of relevant news articles from the following 10 western digital news sources: AARP (AARP.org), USA Today (USAToday.com), New York Times (NYTimes.com), Daily Mail (DailyMail.co.uk), Washington Post (WashingtonPost.com), The Guardian (TheGuardian.com), New York Daily News (NYDailynews.com), Los Angeles Times (LATimes.com), New York Post (NYPost.com), and San Francisco Gate (SFGate.com). AARP was selected due to its status as a leading organization targeted at adults aged 50 and up. The other nine news sources were selected for being the top newspapers by digital traffic (Pew Research Center, 2015). Articles were selected from the 10 news sources by using the following Google search query, which was designed to parallel an equivalent search previously conducted on academic articles (Stigall et al., 2019):

> site: <website URL address> ("voice user interface" OR "VUI" OR "conversational agent" OR "conversational interface" OR "conversation agent" OR "chatbot" OR "alexa" OR "google home" OR "siri" OR "cortana" OR "voice assistant" OR "virtual agent" OR "interactive voice response" OR "IVR") AND ("older Adult" OR "senior" OR "aging" OR "ageing" OR "elderly")

This query retrieved articles at the intersection of voice user interfaces (including Alexa, Google Home, Siri, and Cortana) and older adults. The search was set for articles published between September 20, 2018 (i.e., the date of the announcement of the 3rd generation of the Amazon Echo Dot) until February 1, 2020 (for articles from AARP) and August 1, 2020 (for all other articles). The authors screened out articles by using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) process (Moher et al., 2010). They analyzed a total of 98 news articles as result. Their analysis generated four major themes found across the media articles (Sin, Munteanu, et al., 2021). These were: older adults' current perception and adoption of VUIs, the degree to which VUIs can be embedded in older adults' lives, the changes VUIs can bring to older adults, and the impact of external forces on the VUI market on older adults' perceptions of VUIs. During the preparation for the analysis for our paper, we further inspected these themes for individual claims presented according to each theme. These claims are listed in Figures 1 to 4, where they are divided based on their level of support by academic literature. They are located in the Findings section under the subheading of the corresponding theme.

Step 2: Investigation for Evidence from Academic Literature

Our aim was to answer our research question: "To what degree are the claims made by mass media supported by (or contradict) academic design literature?" In other words, given the themes presented by the media (Sin, Munteanu, et al., 2021), we aimed to

identify how these themes are depicted in the scientific design literature and to identify any contradictions.

Thus, we investigated each of the claims identified from the media articles by searching for relevant findings from academic articles on older adults' perceptions of VUIs. It is important for us to note that our aim was not to collect an exhaustive list of papers of relevant VUI articles, in the manner that has been conducted previously for VUIs (Clark, Doyle, et al., 2019) or older adults' perceptions of VUIs (Stigall et al., 2019). As such, we did not seek ourselves to exhaustively search for all articles related to VUIs for older adults across a multitude of databases. Instead, we aimed to search for articles related to the claims with the goal of identifying contradictions.

We wish to acknowledge the papers that grounded our search for academic reflections on the media claims. These articles can be found in the ACM Digital Library, thus are reflective of the knowledge and concerns of the academic design community, and were consulted for their reach and breadth of topics covered and/or their relevancy to our research question. The first of these articles is an important literature review paper by Stigall et al. (2019) on older adults' perception of VUIs, which corresponds to our research topic of the media's perception of VUIs for older adults. This paper acted as a steppingstone to find for relevant academic literature on older adults' perceptions of VUIs (largely relevant to media articles for Theme 1: Perceptions of Adoption of VUIs by Older Adults) and VUIs' benefit for older adults (largely relevant to media articles for Theme 2: Embeddedness in Older Adults' Lifestyles and Theme 3: Changes that VUIs Can Bring to Older Adults' Lives). The second grounding article was a seminal analysis paper by Sayago et al. (2019) outlining unresolved questions in the design and understanding of VUIs for older adults. This paper featured subsections that identified knowledge gaps and provided references to

additional papers related to older adults' perceptions and barriers to VUI use (relevant to Theme 1 and Theme 2) and how VUIs should talk to older people (relevant to Theme 2). Finally, a paper on a study conducted by Pradhan et al. (2020) on older adults' perceptions of use of voice assistants also directly corresponded to our research topic of the media's perceptions of VUIs for older adults.

For each claim, we identified whether existing evidence supported, denied, or was not substantial enough to back up the claim. As an example of the evidence seeking process, we can turn to the first claim in Theme 1, which is "Older adults are potential key users of VUIs". For this, we inspected each of the grounding papers above for evidence or mentions of papers relevant to the claim. When we found evidence related to the claim, we included it in our findings for the claim. When we found papers potentially related to the claim, we inspected those (secondary) papers for evidence and further (tertiary) papers inductively and included in the findings relevant evidence that we found. We did not search for further relevant papers past the tertiary papers due to an assumption that data saturation would be achieved by this point. Once the evidence collection process was completed, we reviewed the evidence for each claim to determine the respective level of support.

Findings

In this section, we provide an in-depth comparison of the themes pertaining to VUIs for older adults in media, as presented in (Sin, Munteanu, et al., 2021), versus the evidence and thinking from academic literature. We identify and discuss the similarities and differences in messaging.

Theme 1: Perceptions of Adoption of VUIs by Older Adults

Analysis of mass media messaging has shown that the mass media speaks about older

adults' perceptions and use of VUIs (Sin, Munteanu, et al., 2021). Specifically, it paints the picture that older adults are a potential target market for VUIs, but that the adoption and perceptions of VUIs has been mixed and linked to social and ethical issues, needs for data privacy, and trust in the institutions behind VUIs. Figure 1 summarizes the key points about the claims made by the mass media related to these topics and their level of support from academic knowledge. These points are expanded upon in this section.

Key points where…	***Mass Media Claims Pertaining to Theme 1: Perceptions of Adoption of VUIs by Older Adults***
A) … Academic knowledge supports mass media claims	• Older adults are potential key users of VUIs. • Barriers to older adults' adoption of VUIs exist. • There are societal and ethical implications of VUI design. • VUIs should have off switches.
B) … Academic knowledge on the mass media claim is lacking or does not exist	• Older adult users need to adapt to speech expected by VUIs in order to interact with them. • VUIs can help older adults in sensitive situations (e.g., depression, suicidal ideation, domestic abuse) • VUIs are an "instant hit" in older adult communities. • Instructions, guides, and wizards are helpful for onboarding older adults to VUI use. • Data privacy is important for VUI adoption by older adults.
C) … Academic knowledge differs from mass media claims	None.

Figure 1: Summary table of alignment between mass media claims and academic knowledge for Theme 1: Perceptions of Adoption of VUIs by Older Adults.

Claim: Older adults are potential key users of VUIs

The media aligns with academic literature when it comes to seeing older adults as potential key users of VUIs. Academic work on VUIs for older adults presumes that VUIs are more natural and usable for older adults than other (e.g., graphical) interfaces. These views have been confirmed in research that employs participatory approaches such as interviews and field deployments of commercially available VUIs (Pradhan et al., 2020). Work such as that by Ziman & Walsh (2018) has found VUIs to have the

potential to increase the usability of digital systems for older adults, especially for those whose motor skills or vision may decrease as they age or those who aren't confident in their typing capabilities (Constantin et al., 2019; Hosseinpanah et al., 2018; Kowalski et al., 2019; Schlögl et al., 2013). Furthermore, other work has demonstrated the benefits of anthropomorphism for navigating past design problems that are present in traditional user interfaces (DiSalvo & Gemperle, 2003), and that older adults are willing to accept a virtual assistive companion in both their current and future life because they expect themselves to need it more as they become older (Tsiourti et al., 2014). As a result of these advantages, both the media (Burns, 2019) and academic research (Brewer & Piper, 2017; Singh, 2009) sees VUIs as bridging gaps in technology literacy and making older adults more capable users of digital spaces.

Claim: Barriers to older adults' adoption of VUIs exist

Both the media and academic design literature acknowledge the barriers to adoption and full use of VUIs, such as barriers related to digital literacy and experience. The media remarks that lack of experience with technology is a barrier to the full use of VUIs due to initial resistance to new technology (Burns, 2019). Academic work reinforces these findings by pointing out that, although VUIs are acknowledged by older adults to be easy to use and learn, they prefer keyboard systems due to the time needed to learn how to use voice-activated technology such as virtual agent assistants and voice/touch interfaces (Ali et al., 2018; Ziman & Walsh, 2018). Academic work further builds upon this by pointing out the impact of low digital literacy on awareness of smart speaker voice assistant device capabilities (Pradhan et al., 2020).

Claim: Older adult users need to adapt to speech expected by VUIs in order to interact with them

Another barrier recognized more strongly by the media than in academic design literature is the need for older adults to adapt to the speech expected by VUIs in order to interact with them. The media views this barrier as a matter of learning how "your new personal assistant likes to be talked to" (Saltzman, 2019b). It is only in later academic literature that it has been found that older adult users can learn to cope with the speech style required to interact with VUIs and handling errors, as discovered in a longitudinal study of older adults' perception and use of voice assistants (Kim & Choudhury, 2021) – granted this is opposed to many designers' views that systems should adapt to users rather than the opposite. However, the media places more emphasis than academic literature on the challenge of interacting with VUIs if an older adult has an accent (Saltzman, 2019b), while academic literature has mainly focused on issues of speech recognition more broadly (e.g. in work by Wulf et al., 2014, on the applicability of speech-only interaction in the everyday life of older adults).

Claims: There are societal and ethical implications of VUI design; & VUIs can help older adults in sensitive situations (e.g., depression, suicidal ideation, domestic abuse)

Furthermore, both the media and academic literature has acknowledged the societal and ethical implications of VUI design. Questions posed by a news article (Baig, 2019) include the degree to which VUI "emotions" are preprogrammed should be emphasized to users, whether VUIs should replace human relationships, and the degree to which VUIs can and should be used to comfort people, especially those who are alone. Similar questions have appeared in academic literature within some discussions in the sociotechnical research space, such as in the use of the PARO Therapeutic Robot for companionship (Turkle, 2011). However, the design community still has yet to

address such issues which stem largely from factors of anthropomorphism (Sayago et al., 2019). Additionally, the media has also suggested that VUIs can help people in sensitive situations, such as depression, suicidal ideation, or domestic abuse (Robertson, 2019), and this is not an angle that has been explored by academic design literature.

Claim: VUIs are an "instant hit" in older adult communities

The media has described cases of VUIs being an "instant hit" in older adult communities (McNichol, 2019), describing cases of the introduction of Amazon Alexa into senior communities increasing usage of tablet computers from less than 40% to 80%. Academic design literature does not have work to corroborate nor explain such phenomenal influences of VUIs. If anything, recent academic literature has spoken about older adults in independent living communities abandoning VUIs due to seeing them as purely a gimmick after a year of use (Trajkova & Martin-Hammond, 2020). VUIs have also been described to help older adults feel more connected to their senior housing communities through information retrieval tasks such as finding information on the day's meal options and activities (McNichol, 2019); such uses of VUIs to keep connected with housing communities have yet to be explored by the academic design research.

Claim: Instructions, guides, and wizards are helpful for onboarding older adults to VUI use

The use of instructions, guides, and wizards to help older adults onboard onto VUIs has also been underexplored in academic literature. On the other hand, perhaps to help lower barriers of adoption, news articles have mentioned the availability of apps that act as "guides on how the elderly can use Amazon Alexa" (McNichol, 2019) and even serve as guides themselves on how to set up VUIs (e.g., articles by Quain, 2019; Saltzman, 2019c, 2019d, 2019b). However, older adults' perceptions and needs of these

apps and processes required to set up VUIs has not yet been explored by academic design literature. Much of the academic design literature has focused on the uses of VUIs and not as much on the onboarding process. We do not know where older adults turn to for help with VUI set up or if they need assistance in the first place, and how these ultimately play into their adoption (or abandonment) of VUIs.

Claims: Data privacy is important for VUI adoption by older adults; & VUIs should have off switches

The media also raises concerns for older adults about privacy, which has been an issue that has surfaced in academic design literature but not to the degree that is highlighted in the media. Where the media and design literature aligns is in older adults' concerns about conversations being heard, with the media pointing out that "millions are reluctant to invite the devices and their powerful microphones into their homes out of concern that their conversations are being heard" (Lloyd, 2019); meanwhile, academic literature emphasizes the need for older adults to be in control over their interactions with VUIs, including being able to turn the systems off, playing a crucial role in the acceptability of VUIs and related technologies, through studies of proactive smart devices in homes, general smart home interfaces, and virtual assistive companions (Mäyrä et al., 2006; Tsiourti et al., 2014; Ziefle & Wilkowska, 2010). However, not as much academic design literature has studied specifically the impact of data privacy on VUI acceptance and adoption, while several news articles raised concerns over what the institutions behind VUIs may be using with any data processed by VUIs (Associated Press, 2019, 2020; Fleming, 2019; Kakulla, 2019; Magra, 2019; Quain, 2019a). We do not know what is at play when designing for privacy or how to go about designing for privacy in VUIs for older adults, although there is work on understanding privacy

concerns with VUIs for the general population (Alanwar et al., 2017; Fruchter & Liccardi, 2018; Orr & Sanchez, 2018; Pradhan et al., 2020; Zeng et al., 2017).

In summary, when it comes to commentary on older adults' existing perception and adoption of VUIs, the academic design literature has evidence to support mass media's claims about the potential of older adults to be key users of VUIs, barriers to adoption related to digital literacy and experience, the challenges related to adapting to speech required to interact with VUIs, and ethical implications of the anthropomorphic aspects of design. However, academic design literature still falls short in elucidating how accents interplay with challenges in adapting one's speech and how to design for potential sensitive situations involving older adults (e.g., depression, suicidal ideation, or domestic abuse). We also do not fully understand how existing programs may have already successfully incorporated VUIs into communities of older adults, what the onboarding or set up process looks like for older adults or if reading materials help, and how data privacy concerns play into older adults' perception and adoption of VUIs.

Theme 2: Embeddedness in Older Adults' Lifestyles

According to the mass media, older adults' adoption of VUIs is connected with the VUIs' ability to become embedded in their lives (Sin, Munteanu, et al., 2021). VUIs are portrayed to have interaction features that meet older adults' needs, but need to also support mobile (or non-mobile) needs, be compatible with other devices owned by the older adult, account for older adults' access to social support to use the VUI, and consider limits of VUI devices' usefulness. Figure 2 summarizes the key points about the claims made by the mass media related to these topics and their level of support from academic knowledge. These points are expanded upon in this section.

Key points where…	***Mass Media Claims Pertaining to Theme 2: Embeddedness in Older Adults' Lifestyles***
A) … Academic knowledge supports mass media claims	• VUIs are a natural means for older adults to communicate with technology. • Visual feedback (e.g., lights) and customization of VUI behaviour is important. • Challenges in VUI voice-recognition, comprehension, and communication styles are barriers to VUI use by older adults.
B) … Academic knowledge on the mass media claim is lacking	• VUIs are more helpful if they can distinguish an older adult user's voice amongst many, have follow-up features, and allow users to change their speaking rate. • VUI design needs to account for life on-the-go versus stationary. • It is important for VUIs to be able to integrate with other devices and digital services. • Social/tech support is important for acceptance and adoption of VUIs. • VUI devices' need to charge, sound quality, availability of tech/customer service support, and previous experience with similar technologies are relevant to older adults' adoption of VUIs.
C) … Academic knowledge differs from mass media claims	None.

Figure 2: Summary table of alignment between mass media claims and academic knowledge for Theme 2: Embeddedness in Older Adults' Lifestyles.

Claim: VUIs are a natural means for older adults to communicate with technology

Academic design literature supports various claims (McNichol, 2019; Saltzman, 2019c, 2019d) by the media that VUIs are seen as a natural means for older adults to communicate with technology. For example, an academic pilot study involving Google Home found this device to be hands-free, time and energy saving, natural, requiring little to no training, and usable by older adults at their own pace without fear of being rushed or interrupted (Kowalski et al., 2019).

Claims: Visual feedback (e.g., lights) and customization of VUI behaviour is important; VUIs are more helpful if they can distinguish an older adult user's

voice amongst many, have follow-up features, and allow users to change their speaking rate; & Challenges in VUI voice-recognition, comprehension, and communication styles are barriers to VUI use by older adults

The media also praises interaction features, with only a few of them being investigated in academic research for their contributions to older adults' perception and acceptance of VUIs. The inclusion of lights on VUIs as supplemental feedback has been remarked by both the media (Palmer, 2019; Saltzman, 2019c) and academic research on voice-controlled smart home use with older adults to be important (Vacher et al., 2015). The ability to customize behaviour of the VUI is seen by both the media (Lloyd, 2019) and academia, in the contexts of virtual agent doctors and virtual assistive companions (Constantin et al., 2019; Tsiourti et al., 2014) as beneficial. However, for many other interaction elements lauded by the media, usefulness and acceptance for older adults have yet to be explored or validated by academic design literature. The media has commented on the ability of VUIs, such as that of Google Home, to distinguish voices from a crowd to serve "a truly personalized experience" (Saltzman, 2019a), however there is not yet any academic research to study older adults' perceptions of this feature. The media also applauds follow-up features (like those in the Amazon Alexa and Google Home) and tactile interactions (e.g., in Siri), but there is no academic design literature available yet to explore how these features can and should be designed for older adults' use. Lastly, the media also praises the ability for a smart speaker to change its speaking rate as a benefit for increasing older adults' comprehension of VUIs' speech (Lloyd, 2019). However, the impact of VUI speaking rate on older adults' comprehension of the device is not an element yet explored by academic research.

Claim: VUI design needs to account for life on-the-go versus stationary

The mass media also suggests that the consideration of whether a VUI supports a life on-the-go, versus being limited to one's home, as an important factor for older

adults' adoption of a VUI (Foster, 2019; Schofield, 2020). However, this aspect of a device's ability to support mobility remains unexplored in academia.

Claim: It is important for VUIs to be able to integrate with other devices and digital services

The ability of VUI devices to integrate with other devices, named "interoperability" in one news article (Adler, 2020), and services is often mentioned by the media as a significant selling point of VUIs (Adler, 2020; Foster, 2019; NY Times, 2019; Quain, 2019b), however this aspect as related to perception and adoption of VUIs by older adults remains under-investigated by academic literature. Only recently has academic researchers begun studying the impact of VUIs to integrate with email (Brewer et al., 2016), social networking services (Brewer & Piper, 2017), and information services (Pradhan et al., 2020). Academic literature has yet to fully study the integration of online calendars (Quain, 2019b), smart thermostats (NY Times, 2019), home security systems (Birdsall, 2020; Cericola, 2020), vacuum cleaners (Birdsall, 2020), electric outlets (Birdsall, 2020), and faucets (Adler, 2020) into VUIs.

Claim: Social/tech support is important for acceptance and adoption of VUIs

The impact of social support is also brought up by the mass media as a factor in older adults' use and adoption of VUIs that is under-addressed in academic literature. News articles discuss ways to "not become [older adults'] tech support" (Alcántara, 2020) so that a nice gift does not "[end] up becoming your next headache, or worse, a long-distance project" (Alcántara, 2020). However, the impact of VUIs introduced in older adults' lives on their social networks and social support is not understood in academic design literature. We do not yet know, either, how to design VUIs for older adults to best set them up independently.

Claim: VUI devices' need to charge, sound quality, availability of tech/customer service support, and previous experience with similar technologies are relevant to older adults' adoption of VUIs

Finally, there are numerous limitations of VUIs remarked upon by media articles that remain uninvestigated and unaccounted for by academic research. The bulk of explorations of limitations to VUIs outlined in mass media and explored by academic literature is in those related to voice-recognition, VUI comprehension capabilities, or communication styles. Here, academic literature agrees with news media that "Alexa, Siri and Google Assistant are pretty dumb" (Quain, 2019b). Academic work has sought to investigate to limited degrees issues of knowing what to say to VUIs (Sayago et al., 2019), remembering what to say (Pradhan et al., 2020), structuring dialog in a manner that can be accepted by VUIs (Ali et al., 2018; Constantin et al., 2019; Sidner et al., 2018; Vacher et al., 2015; Ziman & Walsh, 2018), the extent at which VUI interactions should be conversational (Clark, Pantidi, et al., 2019), and the need for strategies to overcome communication breakdowns (Schlögl et al., 2013). On the other hand, academic research has yet to study the influence on adoption by older adults of factors such as VUI devices' need to charge (Schofield, 2020), their sound quality (Schofield, 2020), tech/customer service support for VUIs (Foster, 2019), and abandonment of previous similar technology (termed in the media as the "box problem" of products that were never opened or were ultimately abandoned) (Adler, 2020).

Overall, the ability of VUIs to fully become embedded in older adults' lives is a topic upon which the mass media praises about the devices, but for which academic literature support is lacking. The mass media and academic literature agree that VUIs are a more natural way for older adults to communicate with technology, that there are some interaction features that increase ease of use, and that there are still limitations in communication with VUIs. On the other hand, academic literature support remains

rocky for mass media's claims about older adults' perceptions of some interaction elements (such as follow-up features and speaking rate), mobility of VUIs, the ability of VUIs to connect with other devices and services, social support, and a handful of limitations including device charging, tech/customer service support, and history of technology abandonment.

Theme 3: Changes that VUIs Can Bring to Older Adults' Lives

The mass media promotes the benefits and transformations that VUIs can bring to older adults' lives (Sin, Munteanu, et al., 2021). Specifically, the mass media portrays VUIs as potential solutions for health management, decreasing social isolation and loneliness, increasing independence, and enhancing safety and security. Figure 3 summarizes the key points about the claims made by the mass media related to these topics and their level of support from academic knowledge. These points are expanded upon in this section.

Key points where…	*Mass Media Claims Pertaining to Theme 3: Changes that VUIs Can Bring to Older Adults' Lives*
A) … Academic knowledge supports mass media claims	• VUIs can be used to help older adults manage their medications. • Older adults bonding with VUIs may help alleviate social isolation and loneliness. • It is helpful that VUIs can provide immediate responses and have no issue repeating themselves. • VUIs reduce barriers to online services that result from lack of digital literacy. • VUIs can help older adults maintain daily routines and improve leisure time activities.
B) … Academic knowledge on the mass media claim is lacking or does not exist	• VUIs can be helpful for older adults living with dementia. • Connecting older adults to government services is a helpful application of VUIs. • VUIs can help older adults manage existing relationships to help prevent social isolation and loneliness. • VUIs can help older adults connect with the departed so as to alleviate feelings of loneliness and isolation. • VUI-enabled smart homes increase older adults' independence. • VUIs can be used to complete tasks and chores such as scheduling deliveries of groceries and medicine.
C) … Academic knowledge differs from mass media claims	• VUIs help with memory issues (media); current VUIs are not reliable enough to support memory issues (academia). • VUIs can help older adults remain independent by performing tasks and chores for them (media); VUIs performing these tasks for them may risk lowering their level of autonomy, encouraging a "lazy" lifestyle, and provoking degradation of health (academia).

Figure 3: Summary table of alignment between mass media claims and academic knowledge for Theme 3: Changes that VUIs Can Bring to Older Adults' Lives.

Claim: VUIs can be helpful for older adults living with dementia

The topic of health is one that is the benefit that is most addressed by both mass media and academia, although support for some of mass media's claims is limited. The mass media sees VUIs as a means to help older adults living with dementia to manage their medication intake (Mitchell, 2019); on the other hand, academic research has investigated the use of VUIs for managing medications, but not with older adult users

living with dementia and with technical difficulties with voice recognition posing as a barrier (Portet et al., 2013; Reidel et al., 2008). (That said, academic research has found the multimodal input of VUIs and head gestures to be promising for the monitoring of older adults living with dementia (Yamanaka et al., 2016).)

Claims: Connecting older adults to government services is a helpful application of VUIs; & VUIs can be used to help older adults living manage their medications

The usefulness of commercially available VUIs to connect older adults users to government health information services is also mentioned by mass media (Associated Press, 2019; Siddique, 2019) but understudied from the perspective of academic design research. While communities of medical general practitioners are interested in and concerned about the societal, ethical, and design implications of connecting to government services through VUIs (S. Brown, 2019; Chambers & Beaney, 2020), academic literature has only went so far as to explore the direct benefits (i.e., with limited integration of greater societal influences) of VUIs for older adults' health (Stigall et al., 2019), such as in cases of health information seeking (Brewer et al., 2021; Pradhan et al., 2020; Sin & Munteanu, 2020), exercise (Bickmore et al., 2005), doctor's visits (Constantin et al., 2019), and telehealth benefits (Sin & Munteanu, 2019).

Claims: Older adults can bond with VUIs, VUIs can help older adults manage existing relationships, & VUIs can help older adults connect with the departed, with all three of these helping older adults prevent and alleviate feelings of loneliness and isolation

The mass media also portrays VUIs as helpful for addressing social isolation and loneliness, although not all the uses they promote have been fully explored by academic community. The media has considered this topic from the perspective of bonding with the VUIs (Adler, 2020; Baig, 2019; Robertson, 2019), helping older adults manage their

connections with other people (Brewster & Farrell, 2019; D. Brown, 2020; Knorr, 2018; Quain, 2019b; Reeve, 2020; Saltzman, 2019c, 2019d), and reminiscing (D. Brown, 2020). While academic research has explored applications of VUIs for digital companionship (Chung et al., 2019; Kim & Choudhury, 2021; Sidner et al., 2018), less academic investigation has been conducted on the uses of VUIs to connect older adults with other people. Some studies have been done to investigate VUIs for helping older adults with email (Brewer et al., 2016) and participating in online communities (Brewer & Piper, 2017). However, less inquiry has been conducted on uses surfaced by the mass media such as letting others know when one is running late (Saltzman, 2019c) or the social aspects of calling family members through VUIs to better stay connected (Brewster & Farrell, 2019; Himmelsbach et al., 2015; Knorr, 2018; Reeve, 2020; Saltzman, 2019d). Furthermore, academic design research has yet to study the implications of VUIs used to connect older adults to loved ones who have passed on; yet, the mass media presents the case of a Super Bowl commercial showing an elderly man using Google Assistant to remember his late wife, thus already presenting VUIs positively as approachable and useful devices for older adults (D. Brown, 2020; Lapin, 2020).

Claims: VUI-enabled smart homes increase older adults' independence; it is helpful that VUIs can provide immediate responses and have no issue repeating themselves; VUIs can help older adults maintain daily routines and improve leisure time activities; & VUIs reduce barriers to online services that result from lack of digital literacy

The mass media has also promoted a promise of VUIs to help older adults live more comfortably and independently. Some of the aspects the mass media promotes are supported by thinking and evidence from academia. For example, news articles highlight the ability of VUIs to provide immediate responses and that VUIs have no

issue with having to repeat themselves (Burns, 2019), and older adults' appreciation for this phenomenon is echoed in academic work exploring the use of voice-based virtual agent doctors (Sin & Munteanu, 2019). VUIs are also seen by media as reducing barriers to online services resulting from a lack of digital literacy (Magra, 2019), which is a perspective that is also supported by academic literature (Pradhan et al., 2020; Singh, 2009). Some recent work involving Wizard-of-Oz studies have also demonstrated the use of VUIs to help older adults maintain daily routines and improve leisure time activities (Opfermann et al., 2017).

Claims: VUIs help with memory issues (media); current VUIs are not reliable enough to support memory issues (academia); & VUIs performing these tasks for them may risk lowering their level of autonomy, encouraging a "lazy" lifestyle, and provoking degradation of health

However, some of mass media's claims of VUI benefits for independence seem to conflict with findings or concerns in academia. For instance, the mass media praises VUIs for help related to memory issues (Saltzman, 2019d), while in-home deployments of VUIs have found reminders to be less used due to failures of the technology or forgetting to set reminders (Pradhan et al., 2020). The mass media also seems to ignore the dilemmas found in research about VUI systems meant for increasing independence risking harm upon older adults' level of autonomy by encouraging a lazy lifestyle and provoking the degradation of health, as found in studies of smart homes for older adults and virtual assistive companions (Portet et al., 2013; Tsiourti et al., 2014).

Claims: VUIs can help older adults remain independent by performing tasks and chores for them (media); & VUIs can be used to complete tasks and chores such as scheduling deliveries of groceries and medicine

The media may also overstate the benefits of VUI-enabled smart homes for increasing older adults' independence (Cericola, 2020), safety, and security (Burns,

2019; Ianzito, 2020; Mitchell, 2019; Robertson, 2019). Academic research still questions the reliability of speech-processing for older adults' home use, for example as found in studies of voice-controlled smart homes (Vacher et al., 2015). Academic investigation on older adults' use of VUIs in smart homes and as related to independence is only beginning (Ammari et al., 2019; Callejas & López-Cózar, 2009; Kowalski et al., 2019; Pradhan et al., 2020), discoveries are still in the process of being made about how to acceptably incorporate proactive information technology for managing smart homes (Koskela & Väänänen-Vainio-Mattila, 2004; Mäyrä et al., 2006; Portet et al., 2013), and there still exist gaps in knowledge of how to design VUIs for older adults in smart homes (Callejas & López-Cózar, 2009; Hamill et al., 2009; Koskela & Väänänen-Vainio-Mattila, 2004). Further still, there are some uses of VUIs advertised by the mass media which has not been fully investigated in academic literature, such as scheduling deliveries of groceries and medicine through Amazon (Boss, 2018; Fernandez, 2019).

In summary, evidence from academic literature exists to support mass media claims of the benefits of VUIs for older adults in terms of improved health, decreased social isolation and loneliness, increased independence, and boosted safety and security. However, some claims made by the mass media pertaining to each of these topics remain unsupported; these include assertions that VUIs can help older adults access public health services, connect with loved ones and those departed, and manage daily chores and tasks. Furthermore, academic evidence suggests that the mass media may be overstating the benefits of present-day VUIs for maintaining older adults' routines through reminders and ignoring the health risks of support by VUI systems.

Theme 4: Impact of Trends Towards VUIs

The mass media highlights the impact of external societal forces as influencing older

adults' perception and adoption of VUIs (Sin, Munteanu, et al., 2021). Specifically, the media points to the emerging market for VUIs, the influence of government policies, and the impact of the digital divide. Figure 4 summarizes the key points about the claims made by the mass media related to these topics and their level of support from academic knowledge. These points are expanded upon in this section.

Key points where…	***Mass Media Claims Pertaining to Theme 4: Impact of Trends Towards VUIs***
A) … Academic knowledge supports mass media claims	None.
B) … Academic knowledge on the mass media claim is lacking or does not exist	• Commercial interest supports issues relevant to older adults. • VUIs can and should be used to bring government services to older adults. • Cost is a factor of VUI adoption. • Internet access is a factor of VUI adoption.
C) … Academic knowledge differs from mass media claims	None.

Figure 4: Summary table of alignment between mass media claims and academic knowledge for Theme 4: Impact of Trends Towards VUIs.

Claim: Commercial interest supports issues relevant to older adults.

The mass media remarks upon the growing commercial interest in using VUIs to address issues relevant to older adults such as underfunded care homes (Fernandez, 2019), access to health services (Associated Press, 2019), and loneliness (Palmer, 2019). News articles discuss the interest of global brands (Maheshwari, 2018), industry research (Bell, 2018), and the tech giants behind VUIs (Lloyd, 2019) to use VUIs to reach older adult audiences. Meanwhile, academic design literature is only beginning to connect academic and industry VUI designers and developers together, for example in recent academic conference workshops (Murad et al., 2021), and have yet to investigate

how commercial interest and branding interplays with VUI design and older adults' VUI adoption.

Claim: VUIs can and should be used to bring government services to older adults.

The mass media has also emphasized the role of government support when writing about VUIs for use by older adults. VUI use by older adults connected to government initiatives includes the interaction with public transportation (Natanson, 2019), national health services for health information (Associated Press, 2019; Magra, 2019), and social support (Associated Press, 2020). Yet, little to no academic design literature has investigated such applications of VUIs and the degree to which government support influences adoption. We do not yet know what role VUIs play in the provision of electronic government services, how to design VUIs to potentially support an e-government, and how to build VUI systems that do not marginalize or drive older adults away from VUIs and other digital technology or services (Sayago et al., 2019; Sin, Franz, et al., 2021). Yet, the mass media promotes the promise that VUIs "addresses the challenge that seniors and customers with disabilities . . . have locating a Metrobus stop and knowing when their desired bus will arrive" (Natanson, 2019), will be "especially useful for seniors citizens, blind people and others who find it hard to access the internet while also easing pressure on doctors" (Associated Press, 2019), and "has reduced human contact in welfare services while still providing governments with a tool to prevent elderly residents from dying alone" (Associated Press, 2020).

Claim: Cost is a factor of VUI adoption

The mass media also raises concerns related to the digital divide that are currently unaddressed in academic literature. Academic design literature often tackles issues of access from a usability (accessibility) perspective, and less often from the

angle of cost and infrastructure access. Media articles have noted cost as a barrier to VUI-enabled robots designed to target loneliness (Baig, 2019) and staying connected with family (Schofield, 2020). However, we do not yet fully know the degree impressions of price affect older adults' perceptions and willingness to adopt VUIs, despite research indicating that price/cost is a recognized in various adoption models as a barrier to older adults' adoption of other digital technologies such as ambient assistive technology, traditional phones for email, health information technology, telehealth, and wireless sensor networks (Alsulami & Atkins, 2016; Brewer et al., 2016; Kavandi & Jaana, 2020; J. F. Lu et al., 2014; Steele et al., 2009).

Claim: Internet access is a factor of VUI adoption

The lack of internet access is also an issue raised in the media (Young-Powell, 2019), yet much design research is still with older adult participants who have wireless internet connections (Brewer et al., 2016; Pradhan et al., 2020).

Overall, the mass media comments on the impact of commercial, government, and the digital divide when it comes to older adults' use of VUIs. However, academic design research has yet to investigate these external forces and trends, and we do not yet know how they may interplay with designing for VUI adoption. Academic design literature towards the understanding of the impact of trends towards VUIs is the weakest amongst that of the four themes that emerged in research (Sin, Munteanu, et al., 2021) on media factors of adoption.

Discussion

We now return to the aim posed in the start of this paper: how well do mass media portrayals of VUIs align with and are supported by academic research evidence? From our analysis of the research findings corroborated with themes presented in mass media,

we have identified several claims made by the mass media that are supported, several that are unsubstantiated, and even a few that conflict with academic evidence. In this section, we discuss trends in the findings and what they suggest in relation to academic design research. In doing so, we also provide practical suggestions on the research and design of VUIs for adoption. Specifically, we discuss how the findings serve as a reflection of knowledge gaps in current VUI research, benefits of sociotechnical lenses for anticipating barriers to adoption, and open issues for older adults' acceptance and adoption of VUIs.

Findings as a Reflection of Gaps in Current VUI Research

Patterns within the types of claims in each category (i.e., whether academic evidence supported, was lacking, or conflicted with mass media messages) reflect upon the type of academic research that is being conducted.

To start, every theme except for Theme 4 (on the impact of external societal forces) had mass media claims that were supported by academic knowledge. This suggests that most academic design literature has not exposed in as great a depth as the mass media the societal implications of VUIs for older adults (which were the focus of Theme 4). In particular, we do not yet fully understand how commercial interest interplays with older adults' adoption of VUIs, how to design for e-governments that employ VUIs, and the impacts of cost and (lack of) internet access on VUI adoption.

Next, all of the themes had mass media claims that lacked academic evidence. These claims span a range of factors from technical aspects (e.g., a VUI's sound quality) to social aspects (e.g., the potential for VUIs to connect older adults to loved ones). Sociotechnical frameworks can be used to organize these findings, and we expand on this in the upcoming section "Open Issues for Older Adults' Acceptance and Adoption of VUIs." Lastly, mass media claims that disagreed with academic literature

were only found for Theme 3 (the benefits that VUIs can bring to older adults). This may be a reflection of the tendency for technology (including VUIs) designed for older adults to be built with the goal of improving their lives in some way (Stigall et al., 2019; Waycott et al., 2016).

In summary, the patterns in the types of mass media claims that did and did not yet have academic research support indicate that we still lack understanding of societal implications of VUIs for older adults, that sociotechnical models are helpful for categorizing under-addressed adoption factors, and that research of VUIs for older adults has largely focused on improving older adults' lives.

Sociotechnical Lenses Can Anticipate Barriers to Adoption

When comparing mass media claims to academic literature, we paid attention to contradictions. We found two mass media claims, both under Theme 3, for which academic evidence ran opposite to claims by the mass media. The first of these two claims finds the mass media advertising that VUIs can help older adults manage memory issues through reminders, while academic literature has empirical evidence to show that VUIs are not reliable enough for older adults to use for such purposes. When studying the academic literature that details this reasoning, we find that the two concerns related to reminders are forgetting to set the reminder and distrust of the technology for important tasks (Pradhan et al., 2020). These coincide with sociotechnical factors of technological contexts as found by Waycott et al. (2016), where they found that non-participation in technology interventions is connected with limitations related to old age, in spite of older adults' initial enthusiasm to give technology features a try. It is important to note that such designs, which surface limitations present in older adult users, may not only lead to non-adoption, but also come to embody their experience of digital exclusion and marginalize users through the

very technology meant to benefit them (Sin, Franz, et al., 2021; Waycott et al., 2016).

The second contrary claim finds the media lauding the ability of VUIs can perform tasks and chores for older adults to help them live independently, while the academic understanding has presented evidence that older adults perceive reliance on VUIs as "lazy" and a risk towards older adults' health and quality of life. The conflict within this second claim challenges initial perceptions of VUIs to promote independence is a "good" thing for all older adults. It is a reminder that we cannot always predict how people will respond to new technologies and that personal circumstances may contribute to non-adoption of a technology. This also coincides with the sociotechnical factors of personal contexts as found by Waycott et al. (2016). In their analysis, the authors found that introducing a social isolation intervention may not always be ethical or non-disruptive to older adults' lives in other ways.

The conflicts in these two claims pertain to factors that have been predicted in previous research employing sociotechnical perspectives. What this suggests is that, despite inaccurate claims by forces (e.g., the mass media) that influence public opinion, adopting a sociotechnical lens can help us anticipate older adults' actual perceptions of VUI technologies, which may lead to their ultimate non-adoption. Through this, we can work to incorporate into VUI designs features that might help combat their resistance to these technologies.

Open Issues for Older Adults' Acceptance and Adoption of VUIs

Comparison of mass media claims on VUIs for older adults with academic literature has exposed some research areas relevant to VUI adoption that are currently under-investigated. Sociotechnical frameworks can be used to organize these claims, and we have done so with in Figure 5 according to the "Access Rainbow" (Clement & Shade, 1998; Shade, 2010). This model is useful for operationalizing the factors

remaining to be addressed by academic design research (as identified in the Findings section); it also demonstrates the power of sociotechnical models for furthering the understanding of factors of older adults' adoption of VUIs.

ACCESS RAINBOW FACTOR	RELEVANT MASS MEDIA CLAIM (THAT LACKED ACADEMIC EVIDENCE)
GOVERNANCE	• Data privacy is important for VUI adoption by older adults.
LITERACY/SOCIAL FACILITATION	• Instructions, guides, and wizards are helpful for onboarding older adults to VUI use. • Social/tech support is important for acceptance and adoption of VUIs. • VUIs are an "instant hit" in older adult communities.
SERVICE/ACCESS PROVISION	• Commercial interest supports issues relevant to older adults. • VUIs can and should be used to bring government services to older adults. • Connecting older adults to government services is a helpful application of VUIs.
CONTENT/SERVICES	• It is important for VUIs to be able to integrate with other devices and digital services. • VUIs can help older adults in sensitive situations (e.g., depression, suicidal ideation, domestic abuse) • VUIs can be helpful for older adults living with dementia. • VUIs can help older adults manage existing relationships to help prevent social isolation and loneliness. • VUIs can help older adults connect with the departed so as to alleviate feelings of loneliness and isolation. • VUI-enabled smart homes increase older adults' independence. • VUIs can be used to complete tasks and chores such as scheduling deliveries of groceries and medicine.
SOFTWARE TOOLS	• VUIs are more helpful if they can distinguish an older adult user's voice amongst many, have follow-up features, and allow users to change their speaking rate.
DEVICES	• VUIs design need to account for life on-the-go versus stationary.

	• VUI devices' need to charge, sound quality, availability of tech/customer service support, and previous experience with similar technologies are relevant to older adults' adoption of VUIs.
CARRIAGE FACILITIES	• Cost is a factor of VUI adoption. • Internet access is a factor of VUI adoption.

Figure 5. The mass media claims lacking academic evidence organized according to the "Access Rainbow" sociotechnical model (Shade, 2010).

By organizing the open issues into sociotechnical models such as the "Access Rainbow", we can easily communicate the types of issues that remain under-addressed when it comes to open issues for older adults' acceptance of VUIs. Each of the seven factors can be adapted to further our understanding of VUI adoption.

To start, in terms of technical aspects, the factor of carriage facilities pertain to the infrastructure needed to carry information, such as access to internet. For this, academic literature has yet to fully address issues of cost and internet access in relation to VUI adoption. The factor of devices looks at the VUI device itself; for this, we find a number of design factors that influence perceptions of VUIs. Software tools relates to the features of the programs on the VUI device, and what benefits they confer. Content and services available on VUIs need to be "affordable, reliable, usable, diverse, secure, and privacy-enhancing in order to meet quality-of-service standards" (Shade, 2010).

In terms of social infrastructure, services and access provision is concerned about the organizations that provide VUI services and access to users. Literacy and social facilitation relates to the skills that older adults need to take full advantage of VUIs. Finally, governance concerns how decisions are made when it comes to development and operation of VUI systems.

In summary, Figure 5 provides a list of the open issues that need to be addressed for a full understanding of older adults' acceptance and adoption of VUIs. These claims can be operationalized into sociotechnical factors of governance, literacy/social facilitation, service/access provision, content/services, software tools, devices, and carriage facilities. Future academic research can consider further investigating the social consequences of VUI design and the applicability of sociotechnical models for organizing the understanding of older adults VUI adoption factors.

Conclusion

In this paper, we studied the themes presented in mass media about VUIs for older adults in order to find out to what degree claims made in the media were supported by, unsubstantiated by, or even contradicts, academic knowledge on this topic. Our findings indicate that the mass media has made several claims that are supported by academic literature, many that are unsubstantiated, and a few that run contrary to scientific evidence. By reviewing patterns within these findings, we identify in the Discussion the types of knowledge gaps present in VUI design research, support for sociotechnical lenses for anticipating barriers to adoption, and a number of open issues that remains to be addressed when researching VUI adoption by older adults.

By conducting this investigation, we uncover the knowledge gaps in academic research various adoption factors addressed by mass media, which is a sociotechnical influence of VUI adoption. Our analysis not only contributes to our understanding of open issues of VUI adoption by older adults but is also informed by and adds to our understanding of sociotechnical factors for VUI adoption. This broadens existing understanding of older adults' VUI adoption to include social aspects such as service and access provision, literacy and social facilitation, and governance. By identifying previously under-addressed adoption factors, we can begin to bridge this knowledge gap

within academic literacy. Subsequently, we can better predict and design for the challenges that may appear when building VUI systems for use by older adults. By accounting more comprehensively for older adults' perceptions and expectations, we are better equipped to practice more equitable and inclusive design.

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