

Algorithm Awareness as an Important Internet Skill: The Case of Voice Assistants

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Voice assistants have become increasingly popular as part of digital technologies that people use in their everyday lives. Research on Internet use has shown that people's online experiences are influenced by their level of know-how about the platforms they use. Extending the literature on Internet skills, this article focuses on people's algorithm skills in the domain of voice assistants. Are people aware of how algorithms influence what information they receive when using voice assistants? Drawing on 83 interviews conducted in 5 countries, we find that only a few participants explicitly mentioned the terms algorithms and artificial intelligence. Still, many seemed to be aware of the existence of automatic decision-making processes in voice assistants. This awareness was not necessarily based on their own experience with voice assistants, however. Rather, it was often a result of experiences with other digital devices and services such as Google Search, Facebook, Amazon, or smartphones, as well as information from social contacts and the media. We discuss the relevance of being aware of algorithms as one dimension of Internet skills.

Keywords: algorithm skills, algorithm awareness, Internet skills, voice assistants, users, interviews

Voice assistants like Apple's Siri, Amazon's Alexa, and Google Assistant have become increasingly popular and are used by many millions of people daily (Apple, 2018; Bohn, 2019). Little research from the field of communication has focused on how people approach these devices, in particular, what skills they have concerning such devices. What makes voice assistants an especially interesting object of investigation is the role algorithms play in their use. Hargittai and Micheli (2019) list the "awareness of how algorithms

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influence what people see" (p. 113) as one of 10 dimensions of Internet skills. In voice assistants, algorithms detect when a person begins to speak, convert audio to text, interpret the user's intention, find an answer, and convert it back to audio (Amazon, 2018; Ford & Palmer, 2019). Additionally, when a user asks for information, instead of a list of options, like on Google Search, the user is presented with only one selected piece of information. This makes the user even more dependent on the algorithmic selection than with search engines and other recommender systems.

Algorithmic information-selection processes often remain hidden from users. One reason is that manufacturers develop voice assistants as devices that are particularly easy to use (Amazon, 2020; Apple, 2020; Google, 2020). Instead of having to learn to operate the device by pressing buttons or entering keyboard commands, users can (ideally) speak with a voice assistant just as they would with another human. Apple presented its voice assistant Siri in 2011 with the words "your device will figure out what you mean and help you get what you want done" (The Unofficial AppleKeynotes Channel, 2013, 0:54). According to Apple, the users can rely on the voice assistant to recognize and execute their commands (through complex algorithmic information-selection processes) and do not need to be bothered about details. Additionally, companies have an interest in keeping the functioning of their algorithms secret to maintain their competitive advantage and protect their algorithms from manipulation (Introna & Nissenbaum, 2000; Kemper & Kolkman, 2019; Kitchin, 2017).

While previous research has explored people's awareness of algorithms primarily with regard to social media news feeds (Bucher, 2017; DeVito, Birnholtz, Hancock, French, & Liu, 2018; DeVito, Gergle, & Birnholtz, 2017; Eslami et al., 2015; Rader, Cotter, & Cho, 2018; Rader & Gray, 2015) or from the perspective of human-computer interaction (Ammari, Kaye, Tsai, & Bentley, 2019; Auxier, 2019; Lahoual & Frejus, 2019; Lau, Zimmerman, & Schaub, 2018; Manikonda, Deotale, & Kambhampati, 2018; Pridmore et al., 2019), we base our study on scholarly work about Internet skills and ask: Are people aware of and understand how algorithms influence what information they receive when using voice assistants?

Voice Assistants: A Basic Primer

At the time of this writing, numerous different voice-controlled devices are available on the popular market: assistants on smartphones, smart speakers, smart-home devices, desktops, laptops, tablets, and cars (Hoy, 2018; Lardinois, 2018). In this article, we use the term "voice assistants" to refer to everyday "speech-driven interaction systems" (Ammari et al., 2019, p. 3) "that can interpret human speech and respond via synthesized voices" (Hoy, 2018, p. 81). There are, for example, voice assistants designed to help older adults master their everyday life (e.g., make video calls or set medication reminders; McNichol, 2019) or voice assistants that are installed in student dorms to help students organize and manage their life in college (Miles, 2019). According to the manufacturers of popular voice assistants, hundreds of millions of such devices have already been sold (Apple, 2018; Bohn, 2019; Bronstein, 2020). It should be noted that many products, for example, the smartphones by Apple and Google, are now automatically delivered with a preinstalled voice assistant so their ubiquity is not necessarily due to conscious consumer purchasing (Bohn, 2019).

Our understanding as researchers of how voice assistants work in detail is based on the limited information companies make public. In the case of Amazon Echo and its Alexa, we know that voice assistants

use microphones to monitor their surroundings to identify when a user mentions their specific “wake word” (“Alexa”). It signals to the voice assistant to record and stream the voice commands to the Alexa Voice Services cloud (Ford & Palmer, 2019). In the cloud, speech-recognition software converts the audio into text. Afterward, language-understanding software converts the text into an interpretation of the user’s intention. Then, thousands of Alexa’s abilities, so-called skills, built by the system’s developers as well as third-party creators, are checked to find the best possible response to users’ requests. This is converted back into audio form by using text-to-speech synthesis. In addition to the specific information based on the request, the software also takes context information into account such as the type of device in use, location, and personal information (e.g., who is speaking) about the user (Amazon, 2018; Ford & Palmer, 2019). While helpful as a basic primer, it is important to acknowledge that the above description (a) applies only to Amazon’s Alexa; (b) is based on information the company decided to share with the public; and (c) provides limited insight into the ongoing development of both that particular product and voice assistants more generally.

Internet Skills, Algorithm Awareness, and Voice Assistants

Research on Internet use has argued that studying people’s skills is paramount to understanding how they incorporate technologies into their lives (Hargittai, 2008; Litt, 2013). Having certain Internet skills means being able to access and use the extensive possibilities the Internet offers from finding information to communicating with others (Büchi, Just, & Latzer, 2016; Hargittai & Micheli, 2019; Haythornthwaite, 2007; Knobel & Lankshear, 2008; van Deursen, 2010). Considerable scholarship has found that an important aspect differentiating people’s online experiences is their level of know-how about the platforms they use (e.g., Blank & Lutz, 2016; Hargittai, 2002). Research in different national contexts has identified a positive relationship between people’s Internet skills and the potential benefits they may reap from their Internet uses (Büchi, Festic, & Latzer, 2018; Hargittai & Litt, 2013; Hofer, Hargittai, Büchi, & Seifert, 2019). In their review of two decades of research on Internet skills, Hargittai and Micheli (2019) identified 10 dimensions of Internet skills, one of which is what they called “awareness of how algorithms influence what people see” (p. 113). They described this as follows:

Those who understand that algorithms play a role in what content they see can both adjust their expectations and use strategies to find content in a way that sidesteps constraints imposed by platforms (Hargittai, 2000). Those who lack such awareness and understanding are more at the mercy of what sites are made available to them most prominently. (Hargittai & Micheli, 2019, p. 114)

This is an important skill, as the way users interact with algorithms can influence what information they receive, and what information other people and institutions receive about them (Berg, Burg, Gombović, & Puri, 2018; Gillespie, 2014), which eventually affects what outcomes people derive from utilizing algorithm-based devices.

Scholars have started investigating people’s awareness of algorithms. The majority of these studies focus on social media news feeds (Bucher, 2017; DeVito et al., 2018, 2017; Eslami et al., 2015; Rader et al., 2018; Rader & Gray, 2015). Others have looked at algorithms in news platforms (Powers, 2017), e-commerce sites (Klawitter & Hargittai, 2018), and online dating (Sharabi, 2020). Using data from a representative survey

of U.S. adults in 2017, one study investigated people's knowledge about the role of algorithms in search engines (Cotter & Reisdorf, 2020), finding that experiences with search engines—both frequency and breadth of use—were a strong correlate of algorithmic knowledge. In a representative survey of Norwegians, participants were asked to rate their knowledge and awareness of algorithms themselves; 40% of respondents felt that they had no awareness of algorithms (Gran, Booth, & Bucher, 2020).

Other studies indirectly touch on the topic of algorithm awareness by focusing on people's understanding of specific algorithmic processes. One study looked at the beliefs of 21 high-school-educated adults about how companies make inferences from their data (Warshaw, Taft, & Woodruff, 2016). Some participants assumed that companies specifically look for certain demographic information while others stated that companies use algorithmic systems to analyze user behavior to personalize content. The researchers also found that participants with higher household incomes were more likely to be in the latter group.

To sum up, most scholarly work on algorithm awareness focuses on the algorithms of specific platforms (e.g., the Facebook newsfeed algorithm), asks people directly about their perception of algorithms, or indirectly addresses aspects of the topic. Although not always explicitly stated as such, these studies are all cases of investigating people's Internet skills. In this article, our focus of Internet skills is on people's awareness of how algorithms influence what information people get from voice assistants.

People's Experiences With Voice Assistants

In 2019, the Pew Research Center reported that a quarter of all U.S. adults say they own a smart speaker and that smart speakers are more popular with younger people than with older ones (Auxier, 2019). An industry report based on data from U.S. Internet users in March 2018 stated that people use voice assistants mainly for simple activities like asking basic questions or checking the weather and news ("Consumer Intelligence Series," 2018). Scholarly work about people's experiences with voice assistants is often based on qualitative methods and comes from the field of human-computer interaction (see Clark et al., 2019, for a review). Such studies mostly focus on people's use of these systems (Ammari et al., 2019; Lahoual & Frejus, 2019; Purington, Taft, Sannon, Bazarova, & Taylor, 2017) and related privacy concerns (Lau et al., 2018; Liao, Vitak, Kumar, Zimmer, & Kritikos, 2019; Manikonda et al., 2018; Pridmore et al., 2019).

A study based on interviews with 14 voice assistant users found that half of the participants did not know about all the capabilities of their voice assistants (Luger & Sellen, 2016). Some respondents wondered how such systems process queries and what voice assistants do with the information they collect. Respondents who defined themselves as technically knowledgeable had more realistic expectations of voice assistants' capabilities and mentioned higher motivations for solving occurring problems than those with fewer experiences. Myers, Furqan, Nebolsky, Caro, and Zhu (2018) developed a voice-controlled calendar manager and reported on how 12 university affiliates who all "self-identified as having a technical background" (p. 3) interacted with it. The authors found that the participants' mental model of the voice-controlled system affected their ability to achieve desired objectives. The common method among these studies is that their data are collected from people with extensive experiences with voice assistants. Our project contributes to this line of work by (a) examining both experienced and less-experienced people's awareness of how voice assistants work; (b) drawing on a more diverse population; and (c) interviewing a larger number of respondents than

has previously been the case. While doing so, we specifically investigate people's awareness and understanding of how algorithms influence what people see, an important dimension of Internet skills.

Methods

To investigate people's algorithms skills with respect to voice assistants, we draw on semistructured in-depth interviews we conducted in summer 2019 in five countries. We did not recruit on having extensive experiences with voice assistants, as we wanted to have a diversity in people's exposure to the technology for three reasons. First, people may come into contact with voice assistants even though they do not own such a system (e.g., when they spend time with friends or family members who have one). Second, we were interested in what awareness nonusers have. Third, it allowed us to compare the skills of people with different levels of experiences with a type of technology that is explicitly advertised as not requiring special skills to use. The questions on voice assistants were part of a longer interview related to people's awareness of algorithms more generally (Hargittai, Gruber, Djukaric, Fuchs, & Brombach, 2020).

We decided not to ask people explicitly about processes of algorithmic decision-making in voice assistants to not prompt them to think about the role of algorithmic processes without them having thought of it on their own and having brought it up themselves. Instead, we asked them questions about how certain elements of voice assistants work.

Data Collection

We interviewed 83 people with diverse backgrounds in five countries: the United States (28), Germany (22), Bosnia (13), Hungary (11), and Serbia (9). We chose these countries because members of our research team spoke the language of these countries fluently and were able to conduct interviews in person using respondents' native languages. Moreover, we sampled purposefully from countries with different levels of diffusion of voice assistants (Holt, 2018) to get diversity on that as well. The goal here is not to conduct comparative analyses but rather to move beyond the countries that are most commonly included in research about algorithm skills (e.g., the United States). We recruited our participants using our personal social networks, and then through snowball sampling. Each respondent received US\$20 or the equivalent purchasing-parity value in the local currency for participation. Interviews ranged from 17 to 68 minutes and mostly took place in urban areas (57), with a fifth (18) conducted in suburban towns, and 13 in rural communities. The participants did not know before the start of the interview that it would be about their understanding of voice assistants or algorithmic processes more generally. In the recruitment process, we described our research interest as a study focusing on the Internet experience of adults. We did this to avoid biasing against or toward people who may want to or explicitly not want to discuss algorithms, voice assistants, or the other focus areas of our study (maps, videos, and product searches).

Interview Protocol

The first question we asked about voice assistants was whether respondents had heard of such devices and whether they could name some examples. We prompted persons who had problems answering this question by mentioning voice assistants like Siri, Alexa, and Google Assistant. If someone told us that

they had never used a voice assistant before, we asked them to answer our questions based on their assumptions about such systems. Next, we asked the following questions:

- What kind of tasks can a voice assistant help you with?
- Is your voice assistant listening to everything someone says all the time, or only in certain situations?
- What kind of question would you never ask your voice assistant?
- Can you explain to me how you think the process works when you ask the voice assistant a question?
 - FOLLOW-UP: How do you think the voice assistant comes up with the responses?
- In your opinion, what does your voice assistant know about you?
- What do you think the system of your voice assistant does with the information you share with it?
 - FOLLOW-UP: What do you think, is this a good or bad thing?
 - FOLLOW-UP: How do you feel about the voice assistant knowing things about you?
- Have you thought about any privacy implications of using such assistants?
 - IF YES: Can you give me some examples?

At the end of the interviews, the participants completed a short survey. We used this to gather basic demographic data (year of birth, gender, education, and employment status). All interviews were transcribed and translated into English so that the entire research team could participate in the analysis.

In this article, we focus on the questions concerning people's experiences with voice assistants and their awareness of algorithms. While there were questions about privacy and data protection issues in the interviews, these are not the focus of the present article.

Analysis Procedure

We developed the coding scheme based on the interview questions and refined it until we no longer encountered cases that seemed as relevant answers to our questions, but which the existing coding scheme could not yet accommodate. Next, three coders (from among the coauthors) independently coded each interview. After comparing their respective codings, we discussed differences, and created a new coded version that we used for the analysis. We used the comment function in Microsoft Word for coding the data, and then transferred the coded quotes to Microsoft Excel using the DocTools ExtractData add-in for Microsoft Word (Fredborg, 2018). We sorted the codes in Excel, analyzed the coded material, and continuously wrote memos based on our analysis. In a second step, we used the qualitative data analysis software MAXQDA to compare different groups of participants (e.g., by experience level). The results section below is based on a systematic write-up of the analysis.

Of the 83 interviewees, 28 (34%) resided in the United States (U.S.), 22 (27%) in Germany (DE), 13 (15%) in Bosnia (BA), 11 (13%) in Hungary (HU), and nine (11%) in Serbia (RS). Throughout the recruitment process, we aimed for a stratified sample on gender and age. A total of 42 women and 41 men took part in our study. Their ages ranged from 19 to 78 years, with 40 as the mean. Just over half completed

a college degree or more. Participants' occupations included housekeeper, pharmacist, forester, college and graduate students, a caterer, an industrial designer, a politician, some retired people, and many more.

Results

The Relationship Between Experience and Awareness

Participants varied considerably in their level of experiences with voice assistants. Sixty participants told us that they do not explicitly use voice assistants (i.e., they do not consciously use them, although they may be at times exposed to them through their networks and their locations), while the remaining 23 said they use voice assistants at least sometimes. Twenty-four participants mentioned that they owned an Apple device with its voice assistant Siri, seven owned Google Assistant, four owned both Alexa and Siri, three owned Amazon's Alexa, one participant Microsoft's Cortana, and one Logitech's Harmony Hub. Seven participants said they had a voice assistant on their smartphone, tablet, or computer, but did not mention which kind it was. Although only 23 participants reported currently *using* a voice assistant, 47 *owned* a voice assistant, which shows the complex nature of classifying use in this domain given that ownership, use, and experiences do not map onto each other in a straightforward manner. Even among nonowners, people had experimented with and been exposed to voice assistants through friends and family members.

Analyses suggest that participants who regularly used a voice assistant did not necessarily seem to have more skills than participants who did not use a voice assistant. For example, a 41-year-old woman from Hungary who was neither owner nor user of a voice assistant had a nuanced understanding of such services. She had a detailed idea of how voice assistants answer questions (compared it with a Google Search) and explained that voice assistants collect data to personalize the user experience and to provide targeted advertising.

Similarly, a 21-year-old male student from Germany knew about several voice assistants (i.e., Siri, Alexa, Google Assistant, and Cortana) despite having limited personal experiences himself, saying, "I think I've almost never used a voice assistant before. Because they usually misunderstand me and don't do what I want." Among other things, he explained in detail how voice assistants provide responses to commands, mentioning that the query "would run through an algorithm."

The corollary of this is that having regular experiences with voice assistants was not necessarily synonymous with in-depth awareness. For example, one woman (68, U.S.) was in constant contact with an Alexa device in her living room, because her husband had bought it and used it regularly, yet she herself rejected the device and said, "I never use it. I do not trust her at all." While the participant knew very well what Alexa could be used for (awareness of what is possible), probably because she saw her husband use it every day, her other skills were limited. She could not, for example, explain how a voice assistant processes a query or what role personal data play in the use of voice assistants (i.e., little awareness of how algorithms affect what information people receive from voice assistants).

These examples show that users' experiences with voice assistants do not (alone) determine whether or not they have a broad range of voice assistant skills. Especially with regard to skill dimensions

such as awareness of how algorithms influence what information people receive, factors other than experiences seem to play a role.

Awareness of the Existence of Algorithms

Of the 83 participants interviewed, 12 explicitly mentioned algorithms in their answers. An additional seven referred to artificial intelligence in connection with voice assistants. Most of these 19 participants mentioned algorithms or artificial intelligence when they answered our question about how voice assistants process queries. For instance, one respondent (male, 28, U.S.) said, "When it [the voice assistant] gets those keywords, it'll start, through an algorithm, the search process." One woman (66, U.S.) said, "It's some type of set of algorithms back on the server," and one man from Hungary (55) noted, "I assume they are trying to get the right answers from a big pile of data using artificial intelligence."

Many others did not explicitly mention terms like "algorithms" or "artificial intelligence," but still showed some form of awareness of processes influencing what information people receive when using voice assistants. A 22-year-old man from Bosnia mentioned, for example, how voice assistants use intelligent voice-recognition software: "I think that it is listening based on its recognition system." One 28-year-old woman from Germany talked about systems identifying keywords in questions: "It would probably pull out the keywords from this question and then give me an answer accordingly." Several participants said that voice assistants would automatically search the Internet to find and select an answer ("It probably looks up results and stuff online, then chooses the most popular one"; male, 19, U.S.). Participants also suggested that voice assistants intelligently use information about the user to come up with a response. For instance, one participant (male, 41, BA) said, "I believe that all that information about you is used, that a database exists . . . it knows what you're searching . . . and so they can easily get to an answer." Several participants surmised that voice assistants collect data based on people's usage behavior—for example, the apps they use (e.g., Spotify or a weather app: "like that I really care about the weather a lot; what kind of music we listen to"; female, 39, U.S.), the questions they ask ("most likely all the questions directed at it are stored somewhere"; male, 55, HU) or their tone of voice while speaking a command ("It knows your tone of voice"; male, 48, U.S.). Some respondents also explained how voice assistants analyze data to learn about people's usage behavior and then use that to improve the system's usability so that the voice assistants become better in understanding voice commands resulting in more relevant and personalized answers.

Our analysis shows that there were different forms of awareness of algorithmic decision-making processes in voice assistants among participants. Respondents only rarely mentioned the term "algorithm" explicitly, but this does not necessarily mean that they are not aware of algorithmic processes at play. Their awareness of how algorithms influence what content they receive from voice assistants seemed to be the result of a basic awareness that information in digital devices and services is processed, selected, and used automatically for different purposes. Some of the participants drew on their experience with (algorithmic) processes in other digital services (e.g., Google Search or Amazon) to explain what happens in voice assistants.

Awareness of Voice Assistants as a Type of Service or Device

While most participants—whether they were regular users of voice assistants or not—had very individual sets of voice assistant skills, with some having a more advanced and broad awareness than others, there were a few participants who had almost no skills at all. For instance, a 61-year-old man from Germany stated the following when asked about voice assistants: “I don’t even know what that is, a voice assistant.” However, later he recalled having heard the term “Alexa” somewhere before. After asking his wife about it,² he remembered that some days ago, at a wedding, people had used an Alexa apparently as a baby monitor. However, he said that he did not know anything else about voice assistants and never had thought about them. Another example is a 22-year-old woman from Bosnia who understood voice assistants as transcription software mainly to help visually impaired people. She explained that based on certain keywords in a question, voice assistants bring up answers that are already stored inside the device.

These are examples of two participants who knew very little about voice assistants, as they basically never had encountered such devices before. Unlike other participants who had little experience with voice assistants, these participants could not apply experiences from using other digital devices and services (e.g., smartphones, Google Search, or Amazon) to voice assistants. In general, participants who had broader Internet skills due to their experiences with other, in some cases algorithm-based, digital devices and services seemed to find it easier to approach new or unfamiliar devices like voice assistants.

Understanding How Voice Assistants Work

Our results suggest large variation in understanding the various aspects of how voice assistants function. Moreover, most participants (75 of 83) showed signs of uncertainty in their comments. Both the participants who were experienced with voice assistants and those who were less experienced used words like “maybe,” “perhaps,” “I don’t know,” “I believe,” and “I assume.” The answers were diverse no matter what level of experience respondents had with voice assistants. Gender, age, and country of residence were mixed among both respondents who felt able to answer our questions and those who felt less able to do so. For instance, when asked about whether they believe that voice assistants always listen, some stated that voice assistants always listen just because it is technically possible. Others explained that such devices need to do so to hear when they are addressed with their respective wake words (e.g., “Hey Siri” or “Alexa”). A few participants mentioned that especially Alexa devices, unlike Siri devices, would always listen (“So, with Siri I don’t know, but with Alexa certainly in all situations. . . . So even when it’s off”; male, 24, DE). Some mentioned that voice assistants only listen when their voice function is activated. Others said that such devices only start listening when asked a question (“Probably just when I ask”; male, 21, RS). Participants also distinguished between “listening” and “recording,” indicating that voice assistants always listen, but that this does not necessarily mean that they record what they hear. Respondents also had various ideas about what specific information voice assistants collect. They mentioned a combination of traits such as

² According to our protocol, respondents were not supposed to engage with others during the session and the conversations were held in private. In this case, the participant deviated from the protocol by calling out to his wife during the interview.

demographics, information about people's language skills, interests, habits, social relations, online purchases, physical and mental health, and criminal record.

Participants' individual responses together with their uncertainty when answering our questions (i.e., saying "maybe" or "I don't know") indicate that respondents did not possess a common basis of reliable information about the functioning of voice assistants. Instead, they had many different theories and ideas based on various sources about how voice assistants work.

Information Sources About Voice Assistants

In addition to learning about participants' experiences with and awareness of algorithmic processes in voice assistants, respondents' remarks also included information about the sources for their ideas about these processes. Since this was not something we asked systematically from everyone, we do not have the information for everybody, but we received enough responses to warrant analysis. Participants referenced three types of sources: the media; social contacts; and their own experiences with voice assistants and other algorithm-based applications, online services, and devices.

The Media

When it comes to media as a source of information about voice assistants, some respondents mentioned the news, like this woman (30, DE): "I also hear more and more about what data are collected with Alexa, in a household when you use something like that. . . . I think this was on the news." Participants also talked about information from commercials as well as from books and movies ("Well, I think . . . after watching *Her*, the movie, I think it's a little crazy how the evolution of voice assistants in media could become [*sic*]"; male, 28, U.S.). Some did not give a concrete source for their information, but only said they had seen a video about voice assistants somewhere or read something about them online.

Social Contacts

Participants repeatedly mentioned social contacts as a source of information about voice assistants. Many stated that family members, partners, friends, and acquaintances had shared their experiences with voice assistants with them. For instance, one woman (44, HU) said, "We have a friend . . . , so when he says, 'OK Google, turn on the light in the bathroom' then it turns it on for him." Another respondent (male, 23, DE) said, "My brother bought an Alexa and he looked into the program and said, okay, it will only record and save what I say after the keyword [i.e., 'Alexa']."

Experiences

Often participants referred to experiences when they talked about voice assistants. These experiences can be divided into three groups: (1) participants' own experiences with using a voice assistant; (2) experiences of seeing other people use voice assistants; and (3) experiences from using other applications and online services that participants related to voice assistants. For example, one man (50, U.S.) concluded from his experience with a voice assistant that they are very much preprogrammed:

They [voice assistants] are pre-programmed, as much as they can be. I mean, it's got to have some smarts to it, but I've asked it stuff before, and it's like, "The answer you're giving me does not help at all."

Many participants also described situations where they had experienced how relatives, partners, friends, and acquaintances had used voice assistants. One woman (39, U.S.) said, "My hairdresser has Alexa in her hairstyle place, and she asks Alexa to put different genres of music all the time. It's funny."

Furthermore, participants often drew on their experiences with other apps and online services, especially regarding questions about the functionality of voice assistants. For instance, respondents compared the way voice assistants come up with a response with the way Google Search works. One woman (21, RS) said, "Well, like a computer, like we type something on Google and it just has a voice." A few participants also referred to the technical functionality of Google Translate: "And there are a million kinds of words, and then, just like Google Translate, when you use that app for speech, it recognizes some words, and recognizes some of the answers" (female, 36, BA). Moreover, many respondents mentioned their knowledge of and experience with the data practices of Amazon, Apple, Facebook, and Google. For instance, one man (31, U.S.) said, "I'm thinking of like Facebook and how they make marketing profiles on you based on your activity." Another woman (30, HU) stated: "I guess, just like Google and YouTube."

Overall, participants' diverse understanding of voice assistants was also reflected in the variability of their information sources. They ranged from news, science fiction books and movies, experiences of relatives and friends, own experiences and rumors, to prior knowledge about the practices of corporations like Amazon, Apple, Facebook, and Google.

Discussion

Users of voice assistants depend on a variety of algorithms that perform different tasks in these systems: from speech recognition to the processing of commands and queries to developing the spoken answer. Building on literature on Internet skills, this article explored people's awareness of how algorithms influence what information they receive when using voice assistants, finding large variation in a multinational sample of adults of all ages. In general, participants had very individualized skill sets about voice assistants, varying not just in their overall level of understanding, but also which specific aspects of voice assistants they could address. There is no universally shared understanding of voice assistants. A few participants had almost no skills at all, while some appreciated several nuances of these systems, although not always articulating them through technical terms like "algorithms," per se.

When it came to participants' awareness of algorithms, only a few explicitly mentioned the terms "algorithms" and "artificial intelligence" (AI). Yet many seemed to be aware of some forms of automatic, decision-making processes inside of voice assistants. This awareness was not necessarily based on regular experiences with voice assistants. Instead, respondents often relied on experiences with other digital devices and services, such as Google Search, the Facebook newsfeed, Amazon, and smartphones, as well as information from social contacts and the media. This finding has methodological implications for studies that attempt to measure people's algorithm skills through the use of the terms "algorithm" or "AI" (Bucher,

2017; Gran et al., 2020; Rader & Gray, 2015), since it suggests that people may be aware of related processes without necessarily appreciating the technical terms associated with them.

Our findings revealed that experiences and use of voice assistants alone do not necessarily result in awareness of voice assistant algorithms. On the contrary, many users of voice assistants in our study seemed to have drawn primarily on experiences with other digital devices and services, as well as information from social contacts and the media for explaining how voice assistants work. This highlights the benefits for people who already have broad Internet experiences. Such people were able to profit from their experiences with other digital devices and services when using and thinking about voice assistants. The finding connects with existing scholarly work on voice assistants (Luger & Sellen, 2016; Manikonda et al., 2018) arguing that technologically knowledgeable users enjoy an advantage when it comes to understanding and using such services and devices. It also echoes earlier findings about how experiences with an algorithmic technology are linked to a better understanding of them more generally (Cotter & Reisdorf, 2020; Rader et al., 2018).

Like all research projects, this one also has limitations. While we took great care in achieving diversity on several important variables such as gender, age, and national background, the majority of our respondents were highly educated, with more than half having a college degree, and several others in the midst of studying for their college degree. Because much research across countries has shown that education is positively related to Internet skills (Hargittai & Micheli, 2019; Litt, 2013, offer reviews of this literature), including more less-educated respondents would likely offer even more diversity in perspectives.

It is also important to acknowledge that not all participants had equal opportunity to gain experiences with voice assistants due to the limited language support of these services in various countries. Leading manufacturers such as Amazon, Google, and Apple initially produced their voice assistants for the domestic American market and only gradually began to optimize their products for other national markets (Holt, 2018). For example, at the time of our data collection, it was not yet possible to speak Bosnian or Serbian with Alexa, understandably limiting the voice-assistant experiences of people in Bosnia and Serbia (Amazon, 2019). The interviewees thus had different chances of getting to know voice assistants, depending on their place of residence and foreign-language skills (i.e., whether they could speak English or not). When work in the future decides to do cross-national comparative analysis, it will be important to keep such different local factors in mind.

An important aspect of algorithm awareness that we do not touch on in this article concerns associated privacy and security issues. While a significant domain, it is beyond the scope of this article to address it in part precisely because it is of considerable importance and analyzing related interview material in addition to what we already do would require more space than we have in one article. Certainly, it is a critical component of Internet skills that Hargittai and Micheli (2019) also highlight as an important skills dimension.

Conclusion

Following prior scholarly work on Internet skills, we studied people's skills with voice assistants focusing on participants' awareness and understanding of how algorithms influence what information users

receive from such services and devices. Given the growing diffusion of algorithmic decision-making in digital services and devices, we were especially interested in voice assistants for two reasons. First, voice assistants are advertised as devices demanding almost no other skills than being able to talk. Second, the entire interaction with voice assistants is based on algorithms selecting and filtering information thus comprising a helpful case study for the study of algorithm skills. Participants in our study profited from broader Internet skills based on their experiences with other algorithm-based digital devices and services when it came to voice assistants.

Experience with voice assistants alone did not seem to be the decisive factor in explaining why some people had a broader awareness and understanding of algorithmic processes in voice assistants. There seemed to be no common source of reliable information about the functioning of voice assistants leaving people to mix personal experiences with information from social contacts and the media. People's understanding of how voice assistants collect and process data can influence their willingness to use them (Lau et al., 2018; Liao et al., 2019; Pridmore et al., 2019). This could serve as an incentive for manufacturers of voice assistants to reflect on the benefits they might reap from providing existing and potential customers with basic information on how their devices work. Instead of relying on various rumors, theories, and bits of information, people could then make an informed decision (i.e., about the benefits and the downsides) regarding their use of voice assistants.

Accordingly, a fruitful direction for future research is to focus on investigating how important skills—such as the awareness of algorithmic processes—can be taught, supported, and learned. Especially with devices like voice assistants that are designed to require almost no skills to use, how people learn about their behind-the-scenes functionality is an important question. Given that they resemble black boxes (Pasquale, 2015) offering little insight into their functioning and the role of algorithmic decision-making in particular, it is important to study what people understand about them and how they acquire that knowledge. To have even some form of awareness of algorithmic processes—without knowing all the details—in itself can be seen as a helpful skill. Only when people are aware of algorithmic processes can they begin to evaluate them, question them, and understand in more detail how algorithms influence the information they receive from voice assistants.

One approach to help people develop an awareness of how algorithms influence the information they receive from devices such as voice assistants would require lawmakers to push manufacturers to some minimum level of transparency, journalists to provide algorithm accountability reporting about the limits and downsides of algorithms (Diakopoulos, 2015), and schools to incorporate the teaching of different skill dimensions in their curricula. This article guides such approaches by showing what level of skills people possess before such initiatives are realized.

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