Glitch Studies and Smart Speakers

A Spotlight on User Experiences of Unexpected Behaviors

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Abstract *Smart speakers have been widely adopted but come with substantial privacy risks, touching on different privacy types such as informational, social, and physical privacy. Scholars have increasingly studied the privacy implications of smart speakers, finding that users tend to have limited privacy concerns and engage infrequently in privacy protection behavior. Extant research also stresses the contextual and situated nature of privacy around smart speakers, pointing to relevant affordances of the technology. Despite these knowledge advancements, a glitch studies perspective on smart speaker interactions and privacy is notably missing. The glitch studies approach was developed by Rosa Menkman at the intersection of art, technology, and critical social research. It directs the attention to glitches as seemingly small and mundane but powerful moments of interruption that allow for reflection and have productive character. In this contribution, we introduce a glitch studies perspective to the investigation of smart speakers and privacy, showing its fruitfulness. We first discuss the literature on smart speakers and privacy, before providing a concise overview of the glitch studies approach. We then present our data and methodological approach. Based on open text responses from an online survey in the United Kingdom, we identify four types of smart speaker glitches: randomly starting to talk or carry out unexpected activities, misinterpreting the user, technical issues related to connectivity, and violating social and contextual norms. Each glitch type is described in turn, with quotes from the survey as illustrative examples. We conclude with a short summary, some implications for research and policy, as well as directions for future research.*

1. Introduction

Smart speakers are voice-controlled mobile devices that use artificial intelligence (AI) in the form of natural language processing to perform hedonic and functional tasks, such as playing music, setting reminders, and retrieving information (Lau, Zimmerman, and Schaub 2018). Normally located in the home and often embedded within a broad arrangement of smart devices, smart speakers have quickly become mainstream. In the United Kingdom, 42% of households had a smart speaker in the first quarter of 2023 (Ofcom 2023), while around 35% of adult United States residents owned at least one smart speaker in 2022 (Schwartz 2022). Amazon Alexa-enabled speakers, such as the Amazon Echo, are the clear market leaders, followed by Google Assistant-enabled speakers and Apple Siri-enabled speakers (Feldman 2018).

Starting around 2017, in line with the increasing adoption of smart speakers, there has been considerable academic interest in this emerging technology (e.g., Brause and Blank 2020, 2023; Hoy 2018; Kang and Oh 2023; Lutz and Newlands 2021; Mols, Wang, and Pridmore 2022; Pridmore and Mols 2020; Smith 2018; Waldecker, Hector, and Hoffmann 2024). However, the terminology used is diffuse, including terms such as voice assistants (Fetterolf and Hertog 2023; Gruber et al. 2021), smart speakers (Kang and Oh 2023; Lutz and Newlands 2021), smart speaker assistants (Brause and Blank 2020, 2023), mobile virtual assistants (Guzman 2019), digital personal assistants (Hurel and Couldry 2022), intelligent personal assistants (Mols, Wang, and Pridmore 2022), and conversational agents (Mariani, Hashemi, and Wirtz 2023). As Lutz and Newlands (2021, 149) note, "users frequently conflate the intelligent assistant and the device. Amazon Echo, the material smart speaker, is often thought of as being 'Alexa.'" Fetterolf and Hertog (2023) qualify that "Echo refers to the smart speaker (the device), while Alexa refers to the VA [voice assistant] within it" (14). In this chapter, we chose term "smart speaker" to refer to the assemblage of both the material device (e.g., the Amazon Echo) and the AI system embedded within in (e.g., Alexa). Neither the disembodied voice assistant without the device nor the embodied device without the voice assistant are sufficient to understand the technology at hand, given the entanglement of material, spatial, temporal, and discursive aspects.

The research landscape on smart speakers is interdisciplinary, including contributions from the social sciences, the technical sciences, and business and management studies (Minder et al. 2023). While much of the literature is published in computer science and human-computer interaction (Feng,

Fawaz, and Shin 2017; Geeng and Roesner 2019; Lau, Zimmermann, and Schaub 2018; Luger and Sellen 2016; Malkin et al. 2019; Zheng et al. 2018), recent years have seen dynamic interest from the social sciences, including emerging empirical evidence from communication and media studies (Brause and Blank 2020, 2023; Lutz and Newlands 2021; Pridmore et al. 2019; Vitak et al. 2023; Waldecker, Hector, and Hoffmann 2024). In that area, human-machine communication (HMC) has advanced our understanding of communication modalities with smart speakers and related technologies such as social robots (Guzman 2017, 2019; Lutz and Tamó-Larrieux 2020). Privacy, in particular, presents a prominent angle to approach the topic (Lutz 2023), given the sensitive nature of the data collected and the use of smart speakers in domestic settings. We will accordingly frame this chapter strongly within privacy discourse on smart speakers. However, we will rely on an under-used theory in the space, namely *glitch studies* (Menkman 2011).

To our knowledge, this is the first contribution to apply glitch studies to smart speakers. Glitches, and any other unexpected behavior by the smart speaker, risk user confidence in the technology and may raise concerns over the privacy and security of user data. However, glitches may in some instances enhance the relationship between the user and smart speaker, such as by triggering anthropomorphizing scripts. Glitch studies offers a fruitful lens to study smart speakers because it acknowledges the fallibility and imperfection of technologies, centering on seemingly small and mundane instances of frailty rather than large breakdowns. Glitch studies is especially helpful for understanding privacy in the context of smart speakers, thus heeding the call by Newlands et al. (2020) for an increased attention to privacy violations as a result of mundane technical breakdowns, possibly stemming from rushed innovation pathways. Focusing on glitches also points to alternative trajectories of technical development, opening the scope for counter- and off-label uses as well as creative, artistic, and playful design (Kemper 2023).

Drawing on rich textual data from an online survey among 369 smart speaker users in the United Kingdom, we explore the user experience of glitches and overarching themes, connecting glitches to privacy perceptions. In the remainder of the chapter, we provide a short literature review on privacy and smart speakers as well as glitch studies. We then describe the survey and data, present the findings in the form of four key themes and accompanying quotes, and conclude with a synthesizing discussion as well as outlook.

2. Literature Review

Privacy and Smart Speakers

In a recent systematic literature review of voice assistants in private households, Minder et al. (2023) identified nine topical clusters and four overarching streams: conceptual foundations (stream 1), systemic challenges, enabling technologies and implementation (stream 2), efficiency (stream 3), and applications and use cases (stream 4). In this review, the authors show that computer science is the area with the highest number of relevant publications (197), followed by the social sciences (52), and business and management (20). Within the social sciences, the US takes the first place in terms of output (19 publications), followed by India and the UK (5 each), Germany and Japan (4 each), and Australia and the Netherlands (3 each). Across the four streams and nine clusters, there is an overarching "focus on users' perceived privacy risks and concerns and a focus on the impact of perceived risks or concerns on the adoption of VA technology" (9). The authors also note a lack of cross-disciplinary engagement.

Another recent systematic literature review, based on 89 publications, focuses on privacy and security in smart speakers exclusively (Maccario and Naldi 2023). The review highlights smart speaker research as a growing trend over the last four years, with most contributions emerging from the United States. The literature encompasses five themes: privacy concerns, factors influencing adoption, identification of vulnerabilities, development of countermeasures, and legal issues. Interestingly, and again in line with the broader review by Minder et al. (2023), most of the research centers on technical aspects (vulnerabilities and countermeasures), showing a strong focus on concrete privacy and security problems. While privacy concerns act as a pronounced deterrent in adopting smart speakers, the literature presents other factors such as platform-related variables, connectivity, technology optimism, and functional versatility. Despite fewer papers on legal issues, Maccario and Naldi (2023) anticipate an increase in this area. Together, the two reviews show the need for a multi-dimensional understanding of privacy in smart speakers that goes beyond security and considers contextual, social and legal elements.

Recent literature in media and communication studies and the interdisciplinary areas of critical data studies, science and technology studies and Internet studies have enhanced our understanding of privacy in the context of smart

speakers. Table 1 shows an overview of such studies with their methodological approach, main theories used, and key results.

Table 1: Summary of User-Centered Research on Privacy and Smart Speakers

Publication	Methodology	Key Theories and Results
Brause and Blank 2020	12 semi-structured interviews with smart speaker users (qualitative)	Domestication theory; Identified six smart speaker use genres (companionship, self-control and productivity, sleep aid, health care, peace of mind, increased accessibility) and spatially distributed uses based on users' perception.
Brause and Blank 2023	12 semi-structured interviews with smart speaker users (qualitative)	Privacy work and privacy as contextual integrity theory; Revealed new types of privacy work and rationales, suggesting an expansion of the model of contextual integrity to understand privacy perceptions with smart speakers.
Fetterolf and Hertog 2023	16 semi-structured interviews with young adult Alexa users (qualitative)	Privacy and trust literature (e.g., digital resignation); Three strategies to manage distrust in smart speaker company: anthropomorphism, digital resignation, and occasionally taking protective action.
Gruber et al. 2021	83 semi-structured interviews conducted in 5 countries (qualitative)	Found awareness of automatic decision-making in voice assistants, influenced by experiences with other digital devices and services.
Hurel and Couldry 2022	Thematic analysis of documents from Amazon and Google, news coverage and academic research (qualitative)	Data colonialism and dataveillance literature: Examines different aspects of data extraction of the home in the vein of data colonization: territorializing the home for data extraction, redirecting the user to specific actions, justifying data accumulation
Kang and Oh 2023	Survey of 474 smart speaker users in the US (quantitative)	Privacy literature and theories (privacy calculus, privacy management theory, protection motivation theory); Examined three privacy management strategies in smart speaker use: privacy disclosure, boundary linkage, and boundary control.

Publication	Methodology	Key Theories and Results
Lutz and Newlands 2021	Survey of 367 smart speaker users in the UK (quantitative)	Contextual integrity theory, privacy cynicism; Privacy concerns about third parties are most pronounced, with privacy protection behaviors being uncommon, but affected by privacy concerns and motives.
Mols, Wang, and Pridmore 2022	Combination of survey with 291 university employees and focus groups with 35 participants, both in the Netherlands (mixed methods)	Affordances; Develops a multidimensional understanding of privacy concerns around household smart speakers, differentiating between surveillance, security, and platform concerns.
Pridmore and Mols 2020	9 semi-structured interviews, 6 focus groups with 35 university personnel and 5 focus groups with 22 young adults in the Netherlands (qualitative)	Surveillance capitalism, technology adoption; Highlights the complexity of data production at a household level and how smart speakers produce myopic views of users for platforms.
Vitak et al. 2023	11 focus groups with 65 US adult users and non-users (qualitative)	Communication privacy management theory; Investigates differences in attitudes and concerns toward voice assistants and how attitudes are influenced by device features.
Waldecker, Hector, and Hoffmann 2024	Eight German households: conversation analysis of audio and video material (actual smart speaker use) and interviews (qualitative)	STS literature (e.g., boundary objects), and surveillance capitalism; Examines the agencies of users and device/service providers, discussing how these are intertwined and distributed.
Xu, Chan-Olmsted, and Liu 2022	Survey of 991 participants' attitudes and behavior patterns related to smart speaker use (quantitative)	Uses and gratifications theory and privacy management literature; Explores the gratifications that users seek and identifies main strategies for privacy management, highlighting two routes: protective and precautionary.

As the table demonstrates, there is a plurality of both methods and theories used in smart speaker research. Most of the discussed studies used qualitative methods, potentially due to the relative nascency of the technology or the focus

on media and communication, critical data studies and STS. Overall, the evidence painted is varied and deep. The following three trends in the literature can be synthesized

a) *Varied use and privacy concerns*: Users employ smart speakers for diverse purposes, from entertainment to healthcare, with prevalent privacy concerns related to data collection and potential misuse.
b) *Awareness and complex privacy management*: There is a growing awareness of the algorithmic functioning of these devices, with some users adapting to privacy concerns through strategies like device manipulation and digital resignation. Research highlights the complexity of privacy management, involving multifaceted strategies that balance perceived risks and benefits, and are influenced by users' privacy self-efficacy. Overall, however, privacy protection seems infrequent and superficial.
c) *Data security and surveillance challenges*: Users exhibit mixed reactions to surveillance and security, with concerns about third-party access and the implications of continuous listening prompting discussions on legal and ethical frameworks in smart speaker technology.

The review so far shows how privacy in the context of smart speakers is not a singular, one-dimensional concept but a multi-faceted phenomenon that requires contextual awareness. Nissenbaum's (2010) theory of contextual integrity is therefore particularly relevant (as applied in Lutz and Newlands 2021). The theory argues that privacy is not about the mere secrecy of information but about the appropriate flow of information depending on social norms and contexts (Apthorpe et al. 2018). Smart speakers, which are often placed in private settings like homes, challenge traditional boundaries and norms associated with information flow. The devices' ability to passively listen and record conversations, even unintentionally, can breach the contextual integrity of a home setting, where certain conversations are presumed to be private and confined within the space.

Glitch Studies

Glitches, often occurring as technical anomalies, can show critical privacy vulnerabilities (Kemper 2023; Menkman 2011). The unintended experiences of glitches offer a richer understanding of the interactions and challenges posed by smart speakers.

A glitch is typically defined as a "short-lived fault in a system, such as a transient fault that corrects itself, making it difficult to troubleshoot" (Wikipedia 2023). Peña and James (2016) describe glitches as "unforeseen behaviors within a system", especially computer systems, but also in related areas such as art and video gaming. In software development and maintenance, a glitch differs from a bug, where the former is more transient and less critical, but still noticeable, whereas the latter presents a more fundamental rupture. In glitch studies, these anomalies are not merely errors to be fixed but opportunities to gain insights into the design, use, and impact of technology. Menkman (2011) coined the term glitch studies and contributed a concise manifesto that is based on extensive artistic engagement. The manifesto challenges the perpetual pursuit of flawless technology, arguing that every new medium will inherently possess its own unique imperfections, so-called "noise artifacts". Glitches are not just errors or failures; instead, they are opportunities for creative exploration and critical examination of technology, including opportunities for serendipity and learning (Peña and James 2016). Menkman (2011) also contextualizes glitch studies within discussions on noise (as in signal transmission and complexity theory) and differentiates hot and cool glitches.

The manifesto ends with eight propositions, which show the academic and artistic scope of glitch studies. The first proposition claims that "[t]he dominant, continuing search for a noiseless channel has been – and will always be – no more than a regrettable, ill-fated dogma." Several of the other propositions call for artistic experimentation and challenge the status quo (e.g., proposition 3: "Get away from the established action scripts and join the avant-garde of the unknown. Become a nomad of noise artifacts!"). At the same time, the manifesto has pragmatic elements and emphasizes temporal aspects of glitches (last part of proposition 5: "Be aware of easily reproducible glitch effects, automated by softwares and plug-ins. What is now a glitch will become a fashion."). In the final two sentences, the approach is synthesized: "Flow cannot be understood without interruption or function without glitching. This is why glitch studies is necessary." Thus, glitch studies is not only an analytic or scholarly program but very much action-oriented. Glitches serve as means to dispute the conventional templates of creative practice, bringing to light hidden dynamics of technology. In the end, glitch studies offer a more critical and reflective engagement with digital media.

While still an under-represented approach in the academic literature, glitch studies has been taken up in pedagogy (James and Peña 2023; Peña and James 2016; Preece and Whittaker 2023), showing its potential for enhanced

learning. Peña and James (2016, 123), for example, specify that "[g]litch pedagogy not only instigates the game-sense of learning but celebrates mistakes and processing errors as central to creativity, inquiry, invention, and discovery of processes underlying knowledge construction and mobilization in the twenty-first century". Beyond pedagogy, glitch studies has also been taken up in gender and queer studies (e.g., Linghede 2018), human-computer interaction (Kim, Van Dierendonck, and Poslad 2019), geography and urban studies (Leszczynski 2020) as well as cultural studies (Kemper 2023; Rutten and De Vos 2023). Kemper and Kolkman (2017, 8) apply glitch studies to algorithms, locating within interruptions of expected use "an entryway into the hidden or taken-for-granted logic according to which they operate".

This perspective of creativity, inquiry and invention within glitch studies is also relevant in the context of smart speakers, where glitches can expose the complexities of human-technology interactions and the broader implications of AI-driven devices in private spaces, making users reflect on the technology in a different light. Glitches can range from simple misunderstandings of voice commands to unintended activations and inappropriate or strange responses. Each of these occurrences offers a window into the operational logic of these devices and the user interactions they engender, breaking down the ordinary flow of conversation. Glitches bring to light the intricacies of voice recognition technology, the assumptions embedded within AI algorithms, and the challenges of designing technology that seamlessly integrates into daily life, thus potentially increasing transparency and explainability (Felzmann et al. 2019, 2020). Studying glitches in smart speakers thus provides a highly relevant approach to understanding user experiences.

Glitches in smart speakers can also have broader societal implications. For example, a glitch that inadvertently records a private conversation not only raises privacy concerns but also prompts questions about surveillance, data security, and the ethical responsibilities of technology companies that might prompt media stories and thus public attention (Estes 2018). By examining these glitches, researchers can uncover the often invisible power dynamics and ethical considerations inherent in the deployment of smart speaker technologies. A close reading of glitches also allows to deepen the contextual integrity norms at play around smart speakers (Apthorpe et al. 2018; Lutz and Newlands 2021).

Methodologically, glitch studies require an interdisciplinary approach, combining insights from computer science, sociology, media studies, and design. However, a particular focus is not only on the technology itself but also

its understanding among users and what it does to the human-technology relationship. Interactive interviews where users are encouraged to describe their technology use in situ can be employed to study the multifaceted nature and consequences of glitches, such as through the think-aloud protocol (Nielsen, Clemmensen, and Yssing 2002) or algorithm audits (Diakopoulos, Bandy, and Dambanemuya 2023).

3. Methods

We use an in-depth online survey to assess privacy perceptions and glitches around smart speakers. Prolific was the platform of choice for recruiting survey respondents due its flexible screening options, including a question for smart speaker ownership. Moreover, Prolific has comparatively good data quality and makes sure to reward participants ethically (Douglas et al. 2023; Palan and Schitter 2018; Peer et al. 2017, 2021). The survey was launched in October 2019 with a sample size of 369 UK-based respondents. It had a series of closed-ended questions about privacy concerns, privacy protection behavior, motives for using smart speakers and use modalities, which are not used in this chapter, as well as an open-ended question that forms the basis for the analyses here. A more detailed description of the methodological procedure and an overview of the closed-ended questions is available in Lutz and Newlands (2021). Regarding the open-ended question, an open text box queried respondents about incidents where the smart speaker exhibited erratic or unexpected behavior. The exact wording of the question was: "*Please describe below any incidents where the smart speaker exhibited erratic or unexpected behaviour.*" The answers to this question provide the main body of evidence for this study. We analyzed the open text answers through inductive thematic analysis, reading the responses several times and then grouping them based on what emerged as the salient glitch category.

4. Results

Table 2: Common glitches encountered by Amazon Echo users (Note: data Collected in October 2019)

Type of Glitch	Example Quotes[1]
1. Randomly starting to talk or carry out unexpected activities	*"my alexa has randomly talked in the middle of the night."* *"Out of the blue, Alexa has started speaking about something completely random. A couple of times, she has just started playing a radio station."* *"randomly speaks sometimes. It was bought by another member of the household. I don't like it, don't trust it, and don't use it."* *"Sometimes starts talking when no one is in the room or it's deadly silent."*
2. Misinterpreting the user	*"Just one time when I asked for it to play Elton John rocket man and it played your song instead."* *"many when asking for music it plays something random."* *"I tried to use the shopping list function and was misheard on most items with some very amusing results."*
3. Technical issues related to connectivity	*"Only on Christmas day. We were setting up the echo and so were thousands of others, which effected the echo to work properly."* *"She usually behaves erratically when the Internet connection is suboptimal."* *"Sometimes it just loses connection unexpectedly."* *"The only time this happened was when an update was incoming,so I have to wait a while for update to take effect."* *"When we moved houses Alexa refused to connect to Internet, kept getting error on the app and she wouldn't say anything more besides she can't connect."*
4. Violation of social and contextual norms	*"I once asked Alexa to turn the lights off and she made a comment about manners and refused to turn the lights off until I said please."* *"When asking to play music, the speaker sometimes tries to make me purchase Amazon Music, even though I regularly and only use Spotify."* *"When chatting in general, someone joked 'be careful Alexa's in this room she'll hear you' and Alexa responded. It was a bit creepy."* *"Wouldn't stop farting even after being told to stop after my daughter asked her to fart."*

1 Quotes are reported unedited for spelling and grammar.

Of the 369 respondents, 264 reported to use an Amazon Echo (71.5%), 74 a Google Home (20.1%), 12 an Apple HomePod (3.3%), 3 (0.8%) another speaker (all of which indicated to use a Sonos), and the remaining 16 respondents (4.3%) were ex-users. In the following, we focus on the Amazon Echo users. Of the 264 Amazon Echo users, 181 respondents (68.6%) had some type of glitch experience, 74 (28.0%) reported no glitch experience, and the remaining nine respondents (3.4%) did not fill out the text box (the question was requested response, with a reminder to those who did not put anything in the text box, but not forced response). Subsequently, we analyzed the comments of Amazon Echo users, identifying four main glitch types.

Table 2 shows four types of common glitches with corresponding quotes. A first common glitch type was about the Amazon Echo randomly starting to talk or initiate activities without any user prompt. The unpredictability of this behavior can be unsettling, especially when it happens in quiet environments or during unconventional hours, like in the middle of the night. Such occurrences can lead users to questions around the reliability and privacy of their device, as they may worry about being listened to or recorded without their consent. The spontaneous activation of the device raises concerns about its autonomous functions and the potential for privacy breaches. The connotations with this glitch are primarily negative, expressed best by quote 3 (*"I don't like it, don't trust it, and don't use it."*)

A second glitch type was with delivering wrong, misleading or unusable results to queries. Here, the glitch is about the Echo misinterpreting user commands, resulting in unexpected or incorrect responses. This can range from playing the wrong song to mishearing items on a shopping list, with both amusing or frustrating outcomes. While these instances may seem trivial, they highlight the limitations of the device's natural language processing capabilities and can erode user trust. Misinterpretations also touch upon privacy concerns, as they imply that the device may not always understand the context or intention behind user interactions, potentially leading to inappropriate or sensitive information being recorded or acted upon incorrectly. Compared to the first glitch type, the connotations seem slightly more mixed and benign (e.g., the relatively narrow glitch experience from quote 1: *"Just one time when I asked for it to play Elton John rocket man and it played your song instead.*[2]*"*).

A third glitch type had to do with technical connectivity and time-outs. In some instances, the connectivity issues resulted in other glitches, for example

2 Reference to songs 'Rocket Man' and 'Your Song' by Elton John.

seemingly incorrect interpretations (see second quote in this category). This type of glitch also occurred with situational changes, for example, when new updates had to be installed or when a person moved house. These technical glitches can affect the usability of the device and may lead to concerns about the stability and reliability of the technology, impacting user trust. Furthermore, connectivity issues can exacerbate privacy concerns if they lead to unanticipated device behavior or failures in executing privacy controls. Compared to the previous glitch types, this glitch seems more situational, with several respondents using modifiers such as "only".

A fourth and final glitch type has to do with violating social norms or communication norms in certain situations. While instances of this type of glitch were rare, they are most interesting in terms of privacy (maybe together with glitch type 1), contextual integrity and social expectations. An interesting instance occurs when commercial aspects seem to cloud the interaction with the user (see second quote of the last category). Other examples include the device making inappropriate comments, refusing to follow commands without polite phrasing, or responding unexpectedly to conversations it overhears. Such behaviors can be perceived as intrusive or creepy, undermining the social acceptability of the device. On the other hand, this glitch type also offers potential for reflection and contextualization among the users, prompting them to question the technology and see the bigger picture.

Taken together, our findings offer an indication of what glitches smart speaker users commonly encounter. In the future development of the research, we aim to connect the qualitative findings with the quantitative data, exploring whether certain types of glitches correlate with privacy concerns. The research contributes to the emerging field of HMC and privacy (Lutz 2023) by adopting the relatively new perspective of glitch studies to smart speakers. This perspective shows the generative nature and quality of unexpected and seemingly erratic technology behavior. According to glitch studies, such glitches and imperfections open up avenues for user reflexivity that transcends dominant and pre-programmed notions of sociality.

5. Discussion and Conclusion

The exploration of user experiences with smart speakers, particularly focusing on glitches and unexpected behaviors, sheds new light on the complex dynamics of human-technology interaction. The survey results show that the oc-

currence of glitches is something many users experience. The different types are varied and range from misinterpretations of commands to unsolicited responses. These glitches, although often minor in nature, resonate deeply with user concerns, especially regarding privacy and trust. The findings underscore a critical aspect of smart speaker technology: the delicate balance between utility and user apprehension.

Drawing on glitch studies (Kemper 2023; Menkman 2011) proved fruitful to expand our repertoire of making sense of smart speaker-user interactions. Glitches, in this context, are not just technological anomalies but are instrumental in shaping user perceptions and interactions with smart speakers. They serve as a lens through which the complexities of AI-driven communication can be understood. Each glitch experience contributes to a user's ongoing narrative with their device and their domestication (Brause and Blank 2020; Waldecker, Hector, and Hoffmann 2024). These narratives often reflect broader concerns about the role and reliability of AI in everyday life, highlighting the need for a deeper understanding of the socio-technical systems we engage with.

The connection between glitches and privacy concerns is particularly striking. Instances where smart speakers activate without a wake word or respond inappropriately reveal the underlying continuous listening capabilities of these devices. Such occurrences raise critical questions by researchers about the handling and potential misuse of personal data (Lutz and Newlands 2021). The findings emphasize the need for more transparent and user-centered privacy practices in the development of smart speakers, to rebuild and maintain user trust.

In terms of theoretical implications, the emphasis on glitches offers a unique contribution. While previous research has extensively covered user experiences and privacy concerns (see Table 1 and the Literature Review), the specific focus on glitches adds a new dimension. It aligns with existing literature on the imperfections of algorithms and AI (Kolkman and Kemper 2017) but goes further to delineate types of imperfection with specific empirical data.

The insights gained from this study have *practical implications* for both smart speaker developers and policymakers. Manufacturers should prioritize user-centric design, particularly in addressing glitches and enhancing privacy features. Transparent communication about how data is processed and used, along with user-friendly privacy controls, may enhance user acceptance (Felzmann et al. 2020). For policymakers, the findings highlight the importance

of robust privacy regulations and standards specifically tailored to AI-driven devices in private spaces. The AI Act, a landmark legislation for AI systems in Europe, was recently adopted and is currently being implemented (Tamò-Larrieux et al. 2024). Given the voice-modality of interaction between users and smart speakers, provisions in this Act about biometrics should apply also to smart speakers (cf. Horn in this volume). It remains to be seen if these systems will classify as high-risk AI and thus face strict scrutiny and more stringent regulation.

The study opens several *avenues for future research*. Foremost, the research field needs to examine how glitches actually impact user attitudes and behavior, both through qualitative and quantitative methodologies.Longitudinal studies could provide insights into how user perceptions and experiences evolve over time, especially as users become more accustomed to the quirks of their devices. Additionally, investigating diverse user demographics could reveal variations in experiences and expectations, contributing to more inclusive and adaptable smart speaker technologies. Another promising area is the exploration of user experiences across different technological setups and ecosystems, providing a more comprehensive view of the smart speaker landscape.

In conclusion, this chapter enriches our understanding of smart speakers, not just as technological artifacts but as integral components of our daily lives that continuously interact and learn from us. By focusing on glitches, we gain a deeper appreciation of the challenges and opportunities presented by these devices.

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