

My Home is My Castle: Empowering Consumers' Data Literacy in the Digital Home

A Case Study on Voice Assistants

Dissertation

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Abstract

The well-known phrase in the title of this thesis is based on the idea of one's own home as a place of security, self-determination, sovereignty, and retreat. The proliferation of IoT (Internet of Things) devices in private households and the interconnectivity of internet-enabled devices with one another and the external environment give rise to the supposition that the concept of the home may undergo a transformation. This is due to the fact that the data collected and processed by IoT devices also exerts an influence on the home. However, permanent recording often takes place in the background and unnoticed by the residents.

The work for this thesis therefore was an examination of the extent to which consumers are aware of and can deal with the data collected in their households and what practices and solutions can help them overcome the uncertainties that sometimes exist. Consequently, the focus for this thesis, in particular, was on voice assistants (VAs), as on the one hand they serve as a platform in the smart home to control other devices and thus have corresponding usage data and, on the other hand, they can intentionally as well as unintentionally collect user data through their microphones as invisible and potentially "always-listening" sensors.

Methodologically, the work was based on a living lab with which a design case study was conducted. Moreover, qualitative approaches were used with a mix of methods to examine consumers in terms of their data literacy and working practices, using VAs as an example. To increase their data literacy, human-centered design approaches were used to implement a tool that would increase their awareness of data, empower them in data work practices and ultimately increase their data literacy. The end result was a prototype that allows users to request, view, and explore their interactions with their VA in order to identify saved interactions and recognize their own behavioral patterns.

Finally, the work done for this thesis is an important contribution to the research areas of Usable Privacy, Information Visualization, and ultimately Consumer Informatics:

First, and with regard to **Usable Privacy**, current data access and work practices were investigated, to identify and address the barriers in data work for increasing data awareness and literacy based on identified user needs and challenges. The results showed that existing provider solutions such as apps or data access processes (in accordance with the GDPR) are complicated and only provide limited or insufficient information about the stored personal data. The derived user experience journey and the prototype to support data requests for user data (using the example of VA systems) can ultimately help companies to make it easier for their users to access data. Moreover, they can be used to provide initial approaches to making formats that are usually only machine-readable also human-readable.

Furthermore, in order to promote human readability and data awareness, **Information Visualization** approaches were used to prepare the raw data in an understandable way. This was done to reduce the uncertainties and knowledge gaps on the part of consumers. The example of VAs was used to show that consumers were often unaware of the multitude of everyday interactions, but also of misactivations. In addition, further visualizations showed how strongly the devices of the VAs and the system as a whole are interwoven in the "home" ecosystem and everyday consumer life.

Finally, the work done for this thesis contributed to the field of **Consumer Informatics**, as the increased data literacy resulting in particular from the aforementioned points enables consumers to regain more control and awareness over their homes and their (digital) consumption practices. Precisely because the demarcation of privacy and personal information (such as preferences, settings, and usage data) in the domestic context is made more difficult by data-collecting products and services, the approaches and solutions investigated and developed in this thesis provide promising support options for consumers. The results of the work, therefore, make an important contribution to redressing the imbalance of information and power between consumers and companies.

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Related Publications

Some parts of this dissertation have already been published as conference or journal papers:

Section 5: Dominik Pins, Alexander Boden, Britta Essing, and Gunnar Stevens. 2020. "Miss understandable": a study on how users appropriate voice assistants and deal with misunderstandings. In *Proceedings of Mensch und Computer 2020 (MuC '20)*. Association for Computing Machinery, New York, NY, USA, 349–359. <https://doi.org/10.1145/3404983.3405511>

This publication has been translated into English for use in this thesis.

Section 6: Dominik Pins, Timo Jakobi, Gunnar Stevens, Fatemeh Alizadeh, and Jana Krüger. 2022. *Finding, Getting and Understanding: The User Journey for the GDPR'S Right to Access*. In *Behaviour & Information Technology*, 41, 10, 2174–2200, <https://doi.org/10.1080/0144929X.2022.2074894>

Section 8: Dominik Pins, Timo Jakobi, Alexander Boden, Fatemeh Alizadeh, and Volker Wulf. 2021. *Alexa, We Need to Talk: A Data Literacy Approach on Voice Assistants*. In *Proceedings of the 2021 ACM Designing Interactive Systems Conference (DIS '21)*. Association for Computing Machinery, New York, NY, USA, 495–507. <https://doi.org/10.1145/3461778.3462001>

Section 9: Dominik Pins and Fatemeh Alizadeh. 2021. "Im Wohnzimmer kriegt die schon alles mit" — Sprachassistentendaten im Alltag. In A. Boden, T. Jakobi, G. Stevens, C. Bala (eds.). *Verbraucherdatenschutz – Technik und Regulation zur Unterstützung des Individuums*. Schriften der Verbraucherinformatik. Hochschule Bonn-Rhein-Sieg, Vol. 1. https://doi.org/10.18418/978-3-96043-095-7_05

This publication has been translated into English for use in this thesis.

Section 10: Dominik Pins, Fatemeh Alizadeh, Alexander Boden, Gunnar Stevens and Sebastian Zilles. 2025. *Demystification of Technology - Empowering Consumers to Access and Visualize Voice Interaction Data*. In S. Habscheid, T.Hector, D.

Hoffmann, D. Waldecker (eds.). *Voice Assistants in Private Homes. Media, Data and Language in Interaction and Discourse*. Transcript, Bielefeld, Germany, 331–364. <https://doi.org/10.14361/9783839472002-013>

Moreover, these publications contribute to the presented topic. However, they are not included as sections of this thesis:

- Timo Jakobi, Gunnar Stevens, Maximilian von Grafenstein, Dominik Pins, and Alexander Boden. 2020. *User-friendly formulation of data processing purposes of voice assistants: a user perspective on the principle of purpose limitation*. In *Proceedings of Mensch und Computer 2020 (MuC '20)*. Association for Computing Machinery, New York, NY, USA, 361–372. <https://doi.org/10.1145/3404983.3405588>
- Dominik Pins and Fatemeh Alizadeh. 2021. *Without Being Asked: Identifying Use-Cases for Explanations in Interaction with Voice Assistants*. In *Conference on Human Factors in Computing Systems (CHI'21) Extended Abstracts*, Online Virtual Conference. <https://doi.org/10.13140/RG.2.2.18764.33923>.
- Fatemeh Alizadeh, Dominik Pins, Gunnar Stevens. 2023. *User-friendly Explanatory Dialogues*. In P. Fröhlich & V. Cobus (eds.). *Mensch und Computer 2023 -- Workshopband (MuC'23)*, Gesellschaft für Informatik e.V., Rapperswil (SG), Switzerland. <https://doi.org/10.18420/muc2023-ws16-120>
- Fatemeh Alizadeh, Peter Tolmie, Minha Lee, Philipp Wintersberger, Dominik Pins, and Gunnar Stevens. 2024. *Voice Assistants' Accountability through Explanatory Dialogues*. In *Proceedings of the 6th ACM Conference on Conversational User Interfaces (CUI '24)*. Association for Computing Machinery, New York, NY, USA, Article 29, 1–12. <https://doi.org/10.1145/3640794.3665557>

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Part I

Introduction and Overview

*It turns out 'Hey Alexa'
is short for 'Hey Keith Alexander'*
Edward Snowden, *Tweet on
former NSA chief's hiring at Amazon in 2020*

1 Introduction

1.1 Motivation

In 2019, it became known via media reports that voice assistant (VA) providers listen to their users' audio recordings and use them to improve their products as well as services, particularly for better speech recognition. As may be expected, Google, Apple, and Amazon not only use AI or other technologies for this, but also employ staff who listen to many audio recordings every day. The employees have reported how they could listen to users giving their account numbers and passwords [342], children calling Siri their best friend [222], or a man trying to order sex toys [57], among other things.

Even if these interactions seem to be rather the exception than the norm, the media reports have revealed what many consumers and, above all, VA users had previously only suspected or feared: VAs such as Amazon Alexa, Google Assistant or Apple Siri embedded in everyday life record and store countless statements and activities, and that is the case regardless of whether they were spoken to on purpose or not. It is not without reason that the devices are also referred to as "always-listening" [175, 328], which means they can also record potentially sensitive or intimate statements, conversations or situations that are not intended for everyone or should not fall into the wrong hands. Studies have shown that users are partially unaware that the (audio) data is stored [191] and, above all, that accidental recordings are stored and evaluated anyway [191, 287].

Similar to smartphones, VA systems can serve as a platform for data-based services (also known as 'skills' in the case of Amazon Alexa), which spread into households and can also connect to other internet-enabled devices there. The resulting networked ecosystem of devices and services develops into a ubiquitous member of the home and offers a state of constant accessibility. However, it also enables constant monitoring and control through the collection of data and information [56]. The resulting complex structure, lack of visibility, and traceability

of data processes and procedures within the digital home also quickly leads to consumers being concerned and overwhelmed by the "black box" [19, 186, 213]. This jeopardizes the home as a familiar and undisturbed place for free development and expression of personality and the epitome of privacy.

In this thesis, privacy, particularly informational privacy, is understood not only in terms of its spatial dimension but also as a domain or state in which individuals can shield and protect their personal information, as well as their identity, from the public sphere [272]. This understanding includes the ability to control who has access to this domain and, more specifically, to personal information [182]. Consequently, privacy must be regarded in a contextual manner, as individuals vary the extent to which they divulge personal information and aspects of their identity contingent on the circumstances, the individuals involved, their intentions and the setting [86, 233, 238]. In this regard, the behavior and decision-making of individuals are often shaped by their attitudes and assessments of the anticipated outcomes [83, 85]. However, behavioral patterns that appear contradictory can also emerge depending on the situation or over time [233]. These changes can be attributed to shifting contextual conditions or attitudes of a person [120]. In some instances, such alterations can result in a sense of powerlessness due to a lack of resources or perceived futility of the attempt to protect oneself [162, 367].

The protection and security of the home involves new challenges stemming from smart home technologies and VAs, as the amount of recorded and processed data is becoming more and more extensive, complex, and therefore no longer traceable for consumers [14, 370]. This manifests itself in the fact that smart devices in the home no longer solely rely on targeted input from the user for the collection and recording of information and data. Instead, their sensors, which are often invisible, can record and collect data and information unnoticed [311].

Both the lack of awareness and traceability ultimately create an imbalance of information between providers of VAs and consumers about how data is collected and processed [1, 369, 191, 193]. In addition,

like other IoT devices, or everyday artifacts in general, VAs quickly fade into the background in terms of the users' perception of them. Consequently, it quickly goes unnoticed whether data and audio recordings have been captured by this device – at least for their users as well as other persons present (family members, roommates, visitors, etc.). The latter are often even less informed than the primary user or administrator of the systems and are inevitably at the mercy of the devices or data collection [81, 175, 204].

To compensate for this imbalance of information, consumers need ways and tools to help them recognize, but also understand, the data collection and processing of the devices they use. Although both Amazon and Google offer dashboards of interaction or activity logs for viewing past interactions (see Figure 1), it is largely unexplored whether and how VA users integrate these into their everyday lives to help them overcome existing uncertainties and thus counterbalance the imbalance. The dashboard also does not offer the possibility of drawing cross-references, for example, between the users' shopping list and their fitness skills, whereas companies like Google, Amazon and all the connected third parties can use this data to create user or customer profiles for different areas of life [92]. Thus, not only is there an information imbalance, but also a power imbalance, since there is a lack of easily understandable tools for the viewing and interpretation of data on the user side [64, 106].

Both of the above mentioned imbalances undermine data awareness and data work, which are important factors in consumer data literacy. In this context, data awareness refers to a consumer's understanding of what data is collected by an IoT device and what data flows emanate from these devices [345, 343]. Data work is understood here as data legibility by human, as well as making sense and use of data, and turning this information into action [105, 335]. Both concepts reinforce each other and contribute positively to the empowerment of consumers in their data literacy – the ability to access, interpret, critically evaluate, manage (or control) and process data [165, 375]. At the same time, consumers should also be empowered to use their data the way they want and transform information into actionable knowledge. This

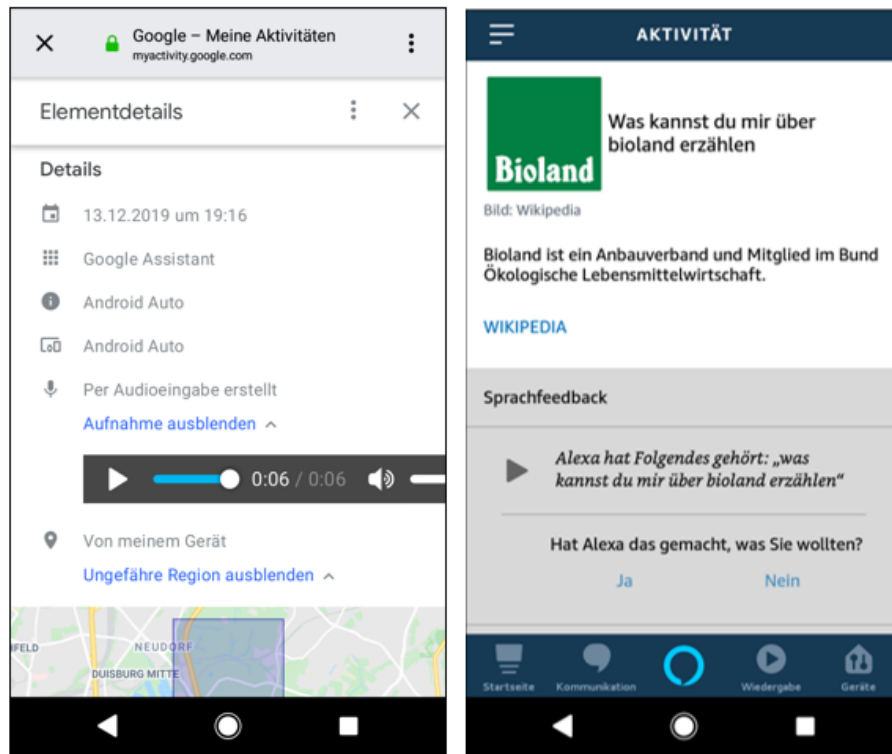


Figure 1

Examples of excerpts from the interaction / activity log provided by Google (left) and Amazon (right).

is why, data literacy should not only be a key skill for any individual, but also a prerequisite for informed privacy regulation. Finally, data literacy will contribute to a reduction of the imbalance of information and power between consumers and organizations, as the home in particular should remain an area in which consumers are empowered to have awareness and control over their data. Moreover, they should be able to handle it in a self-determined manner.

A promising method to achieve user empowerment is Information Visualization (InfoViz) [55, 160], which appears particularly useful when investigating ways to improve data understanding for consumers. For example, Fischer et al. [106] as well as Castelli et al. [59] have shown how a visualization of IoT data provided transparency and comprehension for users.

With a vision to raising data awareness and enabling data work practices, the right to data access in accordance with the General Data Protection Regulation (GDPR) Article 15 was a promising approach for the work reported in this thesis:

The data subject shall have the right to obtain from the controller confirmation as to whether or not personal data concerning him or her are being processed, and, where that is the case, access to the personal data [...]. (Article 15, GDPR)

Insight into the data via the GDPR should ensure that all data related to the user and its usage is transmitted, potentially providing a holistic picture of what a VA collects and what the provider knows. However, the data obtained in this way should not only serve as a means and purpose, but the way in which this data is obtained and the format in which it is available should be investigated more closely. This was done as part of this work.

Based on the studies done for this thesis and the associated findings, first, there was a contribution to the support of consumers with regard to an understanding of the entire data processing by providers (collection, visualization and interpretation), and second, there is a basis for further research and development of the design approaches for consumer empowerment [105]. In particular, the design approaches will enable consumers to gain more control, trust, and self-determination in the handling of their data in the context of VAs. This can ultimately reduce the asymmetrical relationship of information and power between consumers and companies that relates to the collection and utilization of data. This dissertation contains important insights into data literacy in VA systems but is also intended to serve as a starting point for further research in other areas (especially the smart home) where data processing affects consumer privacy.

1.2 Areas of Contribution

The starting point of this thesis is the field of Consumer Informatics (see Figure 2). In order to strengthen the literacy and autonomy of consumers with regard to their data, the work for this thesis drew on approaches and discourses from the fields of Usable Privacy and InfoViz. The findings and solution approaches obtained in the work for the thesis therefore provide important contributions to current research in those research areas and can ultimately be summarized as the overall result of this thesis, i.e., the empowerment of consumers in their data literacy.

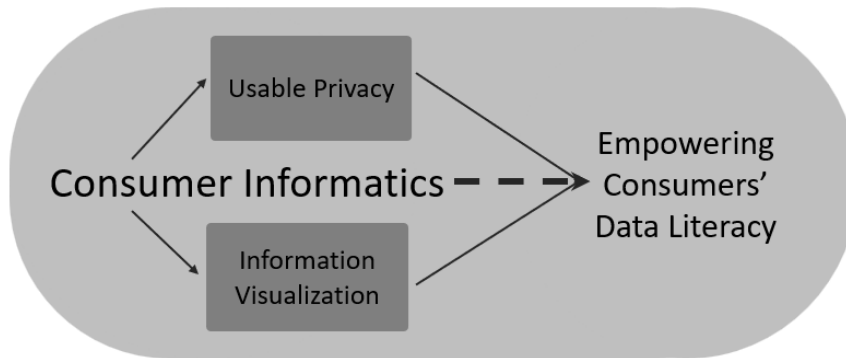


Figure 2

Areas of Contribution of the findings presented in this thesis

1.2.1 Consumer Informatics

The emerging field of *Consumer Informatics* deals with the "[...] systematic and methodologically guided investigation and design of information and communication technologies to support the household economies and everyday practices of consumers as well as their appropriation and social embedding."¹ [310]. It is thus located in the areas of digital consumption, digital markets and digital consumer protection and also involves consideration of ethical issues (e.g., fairness and sustainability) in these contexts [310]. In doing so, the field combines

¹Translated from the original German text.

approaches from both, (business) informatics and consumer sciences, and involves the aim of understanding how the use of digital products and services is practiced in everyday life [310]. This also includes how consumers make decisions and maintain control in order to preserve their informational self-determination. In doing so, researchers in the field aim to highlight the consequences of consumer behavior and consumption practices and investigate solutions to strengthen the (informational) self-determination of consumers.

As already outlined in Section 1.1 consumers are often in the weaker position, particularly due to the information and power imbalance between providers and consumers, which also leads to a lack of data literacy. However, there is evidence that consumers are increasingly demanding to be involved, so bottom-up participation can engage them more in the design and implementation process and thereby assert their interests [31]. The difficulty lies in capturing consumers as a single user group due to their heterogeneity in implementing various practices and decisions [310]. They also have diverse activity and information needs [31]. This thesis contains contributions through new insights into (data work) practices, especially in the use of VA systems in the digital home and their impact on consumers' privacy behavior.

1.2.2 Usable Privacy

Usable Privacy as a research field involves the pursuance of the approach of a user-centered and usable design of products and services that is especially focused on aspects related to privacy and (data) security [76, 7, 38]. Accordingly, in order to develop a usable solution for consumers, the following aspects must be fulfilled: privacy awareness [173], design of products and systems for security protection according to usability principles [354], and a simple, understandable and accessible design of privacy policies [283, 22]. Autonomy and data literacy are important skills for consumers in times of a data-driven economy and society, which require them to be able to transform information and, in particular, personal data into applicable knowledge [375, 278]. Communication and data transfer between devices and their manufacturers,

but also between devices and services within smart home systems or on platforms such as a VA system, also pose a challenge, as they make traceability more difficult [45, 67]. In this way, another contribution of the work for the thesis was an examination of solutions and ways of accessing and working with data in terms of their usability. Ultimately, needs and recommendations were derived as to how consumers can be supported in accessing their personal data and monitoring and managing their privacy (in the use case of VA systems). To this end, solutions for better data understanding were conceptualized and evaluated using the human-centered design approach. The findings derived from this are expected to help in the design of future solutions to support consumers in their data literacy.

1.2.3 InfoViz

The *InfoViz* field is concerned with enabling data work practices for consumers of IoT devices such as a VA. In recent studies it has been shown that existing solutions for data work are primarily suitable for developers and rarely for end users, since they need appropriate IT knowledge and experience to be able to use existing solutions and procedures for data processing [64, 106]. Especially with the proliferation of IoT devices, consumers ultimately interact with an ecosystem in which user data is collected via sensors. Accordingly, the new focus is on how users interact with this ecosystem and how they can influence the way data is collected and aggregated [32]. Since consumer knowledge about data collection and processing is often vague and abstract, both with regard to the ecosystem in general and the VA in particular, the work for this thesis involved a contribution to the reduction of data processing complexity through data visualization.

1.3 Structure of the Thesis

The thesis is structured in four parts, which are described in detail below.

Part I starts with a contextualization and the motivation of the topic in Section 1 and thus forms the framework of this thesis. In addition, the areas of contribution are introduced. The relevant state of research is explained in Section 2. Section 3 concludes the introductory part and contains a presentation of the defined research questions of the thesis as well as the research methods used. An overview is also provided of the associated research project "CheckMyVA", which used a living lab approach to investigate data awareness and data work practices with VAs in order to empower their users with regard to data sovereignty.

Part II is titled "Investigation of Consumers' Data Work Practices" and contains a presentation of two studies. In the first study in Section 5, usage practices of VA users were investigated with regard to understanding and appropriating interaction with VAs. Further, it was shown how data and information are used and reflected in the context of daily use to avoid misunderstandings. The second study presented in Section 6 involves how users evaluate the process of requesting their data from companies according to Article 15 of the GDPR, both to create data awareness and to be able to use it for further purposes. Both studies thus form the basis for Part III, which is concerned with the conceptualization and design of InfoViz solutions.

Part III is titled "Consumer Empowerment in Data Literacy: Design Approaches" and contains a presentation of the results of the design and evaluation studies conducted as part of the work, based on user feedback and experience gathered in previous sections. In particular, the studies included addressed consumers' lack of satisfaction regarding data access and work. The prototypical solutions developed here were intended to support consumers in data information and insight, as well as visual processing. In Section 8 the results are presented of a first prototype for the visualization of interaction data with VAs. In Section 9 an interim status is shown of the prototype development and an

important contribution is provided on how the placement of the device impacts the private sphere of its users. Section 10 is built on the findings from Section 8 and 9 and contains a presentation of the elaborated version of the prototype, which, in addition to data visualization, also supports the application process for requesting VA data from Amazon and Google.

Part IV is a summary of the findings of Part II and III, involving a discussion of the research questions and in particular how data awareness and possible existing data work practices can be improved through information visualization in order to empower consumers in their data literacy (when dealing with VAs). In this section, the considerations and approaches set out in the motivation and the current state of research are also referred to and discussed in order to summarize the overall contribution of this work. To conclude, limitations but also connecting questions are presented as an outlook for future research.

Finally, **Part V** includes the appendices, additional information on the associated project and studies, and the bibliography of references used.

2 Related Work

In this section the current state of research is presented in accordance with relevant areas of contribution (see Figure 2).

Section 2.1 contains a discussion of data literacy from the perspective of consumer informatics, thereby outlining current concepts and challenges related to data literacy in everyday consumer life and privacy behavior. The section begins with a definition of privacy in the context of digital consumption at home and contains a conceptual and historical classification of privacy. Subsequently, an examination is presented of the impact of the digital transformation on privacy, in particular in relation to the home as a place of retreat and the epitome of privacy. The digital transformation is being driven primarily by the advent of internet-enabled devices (IoT) and smart home systems, with VAs playing an important role in collecting and processing invisible data via their embedded 'always-on' microphones. The impact of this on consumer data awareness was explored in the work for the thesis.

In Section 2.2 the current state of research on data work and awareness is outlined, which are key elements of data literacy in the context of this thesis. It is also demonstrated how various stakeholders utilize, process, and work with data. In doing so, data working practices of companies, governments, and consumers are presented, which at the same time highlights the imbalance of information and power between the stakeholders. In addition, the GDPR is introduced as a valid legal remedy for consumers, which is seen as a promising approach in the context of this thesis to enable consumers more options for data work.

Section 2.3 introduces design and solution approaches as well as challenges for increasing data literacy through data visualization. The concepts and requirements for the design and development of products and services are presented according to the human-centered design approach. The focus is on both usability and ensuring the secure and privacy-preserving use of these products and services. A particular focus is on the methods of InfoViz, as these proved useful for the implementation of the prototype in the context of the studies in Part III.

Finally, in Section 2.4 the outlined streams and areas of research are combined under the term data literacy. In doing so, the key challenges and research gaps are considered that should be addressed by strengthening the data literacy of consumers (using the example of VAs).

2.1 Data Literacy in the Age of Digital Consumption

Consumers leave traces in almost all areas of life. In particular, the home is a place full of information and artifacts, with different contexts and meanings for the consumer (such as shopping lists or notes on the fridge, family pictures on the wall or books on the shelf) [214]. All of this information has been created and placed by the consumer him/herself or household community, so it is reasonable to assume that the consumer here has a sense of control over this information and artifacts.

Through the digitization of everyday life and the growing technological infrastructure in the home due to IoT devices multiple and sometimes more complex use cases and consequently problem spaces are opening up [306]. In particular, data-based services and devices, such as smart-phones, sensors or VAs are invading more and more private ("analog") areas such as the home. These pose risks that consumers are not always aware of due to their abstractness [114], e.g. the invisible albeit ubiquitous collection of data and its sharing with manufacturers, providers and the "external world" (third parties or other users). Accordingly, consumers can quickly lose the motivation and enthusiasm of being able to overview and manage this data or protect their privacy [114].

2.1.1 Concepts of Privacy

Privacy is generally related to a place or state where individuals can isolate themselves and their behavior from other actors (such as individuals, governments or companies). However, in work from the social sciences and law in particular, it is made clear that the term can have different meanings and perspectives. While the general understanding is

initially also found in many theoretical constructs [128, 272, 352, 353], these take different aspects into consideration upon closer examination.

From a sociological perspective, the concept of a private realm can be delineated as the counterpart of the concept of the public sphere or public space, thus defining those areas of life and activity, such as family life, leisure activities, and especially the home, as the commonly defined space of private life [128, 112]. In addition to a spatial perspective, there is also a decisional as well as informational understanding of privacy [272]. The former addresses the preservation of decision-making and action and the protection against external control, while the latter refers to the right to protection of personal data [272] and the possibility for individuals to control the time, type, and extent to which personal information is exchanged and used by others [182]. Informational privacy is nonetheless closely related to spatial (or even physical) privacy, as the pervasiveness of digital media and IoT devices means that a large amount of data is collected from consumers' personal environments [353].

In addition to the social sciences, privacy is also an important and established concept in the legal sciences. In Germany, the protection of privacy is regulated, in particular, by Article 2 (1) of the Basic Law (German "Grundgesetz", GG), as well as Article 13 of the GG "Inviolability of the home" and Article 10 of the GG "Privacy of correspondence, posts and telecommunications", which additionally define the scope of protection for privacy. Since 2018, with a view to informational privacy, the General Data Protection Regulation (GDPR) also regulates the protection of personal data and enables consumers a greater right to self-determination.

Up to now, a sphere model has been used primarily in the legal sciences to assess violations of personality rights [144, 357]. This model also distinguishes the different areas of privacy from one another very well and thus also illustrates the approaches to classifying privacy from the social sciences that have been presented so far. In its core, it consists of four spheres [144]:

- **Intimate Sphere** (Intimacy): This is the innermost and most protected sphere of the personality. This includes private thoughts, emotions, and personal life choices. The intimate sphere also covers highly personal information, such as health status or sexual life. Intimate privacy is the most protected, but it also has a small scope of application. This includes the innermost world of thoughts and feelings, as revealed in diary entries or soliloquies, for example. It also covers highly personal information, such as health status or sexual life. Intimate privacy is almost inviolable, since this area is directly linked to human dignity and is subject to a particularly high level of protection against encroachment.
- **Private Sphere:** The private sphere includes personal matters that do not directly concern the intimate sphere. It encompasses private life and the entire domestic and family sphere and should not be accessed without the person's consent. Furthermore, this sphere gives the person space to exercise the right to free development of the personality. However, privacy can also be located outside of one's own home, in public areas, for example, in a separated space in a restaurant. This sphere also includes certain information e.g., one's account balance, vacation destination or place of residence. However, an encroachment here is not necessarily unlawful, but it is weighed against relevant fundamental rights and affected interests. The more a person is a person of public interest (e.g., a politician), the more he or she must tolerate such things.
- **Social Sphere:** This is the outermost area of the personality and includes the area of a person that can be readily viewed by third parties, but it does not represent a conscious turning to the public. This includes activities and actions in public, e.g., social contacts, a visit to the cinema, sitting on a park bench or even activities in the work context. Due to the semi-public space, this sphere offers little protection in the case of encroachment on the individual's freedom.

- **Public Sphere:** In the case of deliberate public or social statements in the public sphere, such as the performance of an artist, participation in a demonstration or a public speech, interventions in and regulations on personal rights are the least restrictive. If these actions are of public interest, what is observed can also be reported in the media. This sphere therefore also represents the counterpart to the private sphere.

In the digital age, this spherical understanding is increasingly proving inadequate to describe the protection of private life and informational self-determination. While legally the core area of a private lifestyle is still covered by Articles 1 and 2 of the GG [353, 357], as is illustrated in Figure 3, the spheres appear to be increasingly intertwined due to the proliferation across everyday life of media and IoT. This interweaving of spheres makes it more difficult to protect the inner personality sphere from commercial interests and governments. For example, consumers are exchanging sensitive health issues with chatbots, uploading personal images and documents to social networks, seeking intimate relationships via apps, or connecting any area of the home internally and with the world with the help of VAs, smart devices and sensors (see Figure 3). This can ultimately lead to a context collapse if, for example, specific data is willingly disclosed in one area but should be protected in another area (e.g., private vs. professional context) [239, 344]. However, the interconnectivity of data across devices, providers and services makes it difficult for consumers to maintain separation. In the interdisciplinary field of privacy studies, the areas of social sciences, law, media studies, and computer science are concerned with this challenge [135, 310]. There is even talk of an end of privacy due to the pervasiveness of IoT and the sharing, processing, and disclosure of data in various areas [135, 310, 290].

2.1.2 Consumer Attitudes and Perception of Privacy

The reasons why consumers disclose and share information are generally difficult to grasp, as many factors come into play that determine or

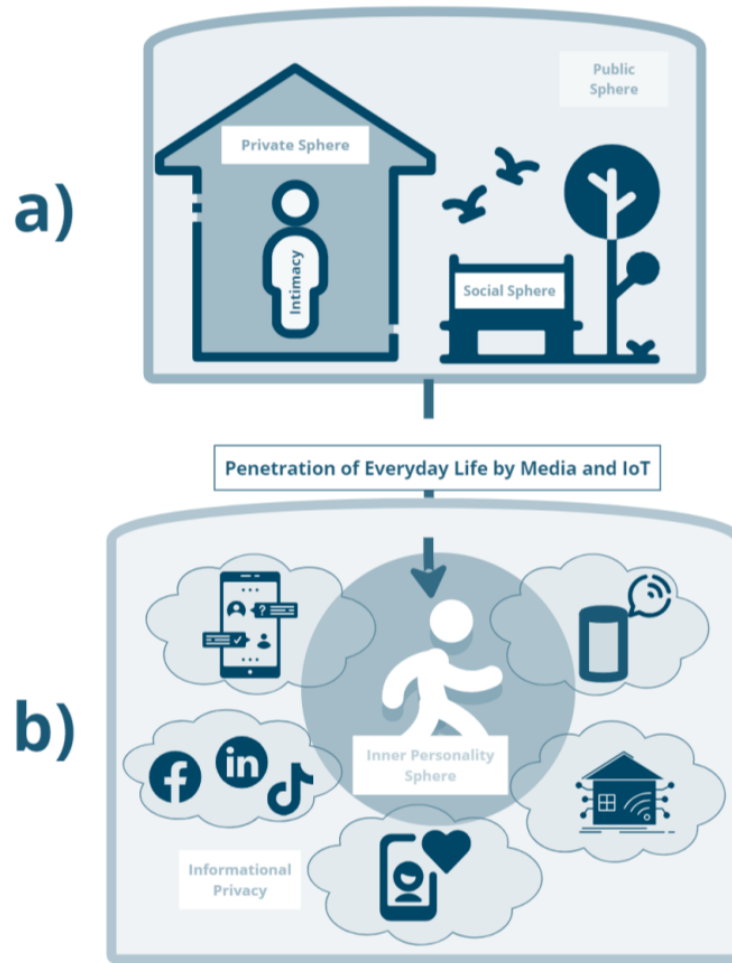


Figure 3

a) The spheres model of personal rights and b) the collapse of the spheres with varying degrees of penetration by media and IoT

at least influence perception and behavior [212, 86, 356, 33, 11]. The intentions and goals pursued are therefore highly complex, context-dependent and individual. Moreover, they pose a great challenge to research and development when it comes to identifying and measuring needs or designing and developing privacy-enhancing technologies and services [29, 121, 175, 70, 63].

Some concepts and approaches are presented in the following that can ultimately provide explanations for consumer attitudes and actions dur-

ing use, but above all that can be influenced by increased awareness and data literacy. They can also provide explanations as to why there is an imbalance of knowledge and power on the part of consumers.

The Need for Privacy

According to Westin [353], four functions of privacy can be identified that consumers work toward when protecting their informational privacy. In this regard, personal autonomy, emotional release, self-evaluation as well as limited and protected communication serve as tools to achieve individual goals for self-actualization [353]. Nevertheless, individuals show a need for disclosure, sharing and exchange, e.g., for social recognition, emotional relief or control and influence of the environment [353, 197].

Disclosure and exchange involve risks such as rejection, loss of control, loss of integrity, betrayal, but also exposure (of the other person) that must be weighed by the individual, as at the same time they are crucial for personality development [197]. Excessive privacy behavior and isolation may also cause these risks [197]. For this work and with regard to the invisible data collection of IoT devices, it is above all the loss of control over the (involuntarily) disclosed data that was counteracted with the help of data work practices and an increase in data literacy.

Privacy Behavior - A Contextual Issue

The familiar environment of the home leads consumers to behave differently than in public, in particular more freely and informally. This is illustrated by the media reports mentioned in the motivation in Section 1 about employees of respective providers listening to audio recordings [342, 222, 57]. In these, in addition to intimate moments and sensitive information, partly insults (both, to the VA and to other people) or arguments were recorded [222]. In this regard, the perception of whether a situation or behavior is private depends on various factors besides location that determine context.

The influence of context was already evident in the sphere model, where the presence of other people can play a role to varying degrees in whether and what information can be viewed and to what extent it

is protected (see Figure 3). In addition to the social presence of others, which is influenced by the feeling of observation and the relationship to the other [69, 259, 77, 225], it is also a matter of the sensitivity of the information involved such as the vocalizing of sensitive health related information [69].

Cho et al. have pointed out that voice interaction can enhance the perceived social presence of the VA in comparison to text-based conversations [69]. In this context, computers (and hence VAs) can also be perceived as "social actors" (according to the "Computers are Social Actors" (CASA) Paradigm [322]) even if users are aware that they are interacting with machines [23, 50, 69, 228, 322]. And it is voice and voice output, as in the case of VAs, that reinforce the perception, trustworthiness, and interaction behavior as well as a possible personification of VAs [93, 218, 69, 185, 256]. These aspects have less of a direct influence on data literacy, but they play a role in the use of VAs, the interaction, and the information that is disclosed and shared with the VA and thus determine the data that can be collected and available. The solution approaches that were researched in the work for this thesis can be influenced by this and, conversely, can also change usage behavior by raising awareness.

Privacy Calculus Theory

According to rational choice theory and in particular privacy calculus theory, humans tend to act rationally, and risks and costs are weighed against the benefits and expected results [83, 85]. This assumes that consumers will also be aware of possible risks when protecting their privacy and would take these into account in their actions, such as disclosing personal data on a website or the settings for data tracking in an app. A well-known counter example of this is the non-reading of terms and conditions or privacy policies, which are instead "blindly" accepted in order to be able to use a product or service as quickly as possible [121, 202, 14]. It has also been shown in studies that even if they are read, they provide little information or explanation about what actually happens to the data [14, 153], so that consumers are usually not exactly aware of what data is collected, or how it is processed,

which is relevant for the associated risks and disadvantages (see e.g. [153]).

This can lead to "heuristic shortcuts"[123] that make actions such as the disclosure of data appear often irrational or paradoxical.

Privacy Paradox

The privacy paradox refers to the user's intentions and attitudes about disclosing personal or confidential information and the actual behavior in a specific situation where such information is disclosed [233]. As previously described, self-disclosure through the publication of social media posts containing personal information is related to various motivations that promise, for example, social recognition or emotional relief, thus enabling at least short-term benefits and a positive outcome [197]. In the specific situation, these often outweigh the long-term effects – in both positive and negative respects – of an action, so that a further use of the disclosed information by the provider or readers is less strongly considered [120, 6].

Consumers are well aware that their data is linked, for example, in the context of profiling [327, 51]. Nevertheless, the procedure for this, as well as the concrete use of the user profile, is perceived as very abstract and complex [119, 158, 292], whereas the benefits of convenient use can be experienced directly. Moreover, from a consumer perspective, it is almost impossible to obtain and understand all the information in a usually limited amount of time in order to classify potential risks in terms of the likelihood of their occurrence [6]. This creates information asymmetry with respect to products and services where data should be disclosed. This can be explained in terms of decision making, in addition to incomplete information, also by the bounded rationality model, according to which decisions cannot be robustly decided due to a lack of availability of time and a calculation possibility [164].

The privacy paradox should also not be understood as constant, since the context in which intentions to protect one's own privacy are expressed or concrete actions are carried out changes over time [120]. This may be due to a change in lifestyle, shift in values, or new op-

portunities in the use of products and services, or the availability of additional information to assess and evaluate new information.

Accordingly, research results suggest that the actual actions or behaviors of consumers should be examined, as these promise to yield more insight than the often rather abstract attitudes and intentions toward privacy protection [164].

Rational Fatalism

The acceptance by consumers of the collection and storage of their own data can be explained in two ways. On the one hand, they feel safe because they feel anonymous and secure due to the large amount of data coming from a large number of similar users, which is also defined as the SIDE phenomena (Social Identity model of Deindividuation) [266]. On the other hand, a powerlessness can be observed due to the feeling of hopelessness, but also the lack of consideration for their own security that is described in the model of rational fatalism according to Kerwin [162]. In this model it is stated that risk assessments and decisions are made not primarily for self-protection, but because of resignation on the part of the consumer that he or she has no choice anyway or assumes to have no control over the consequences or outcome. In the case of privacy, this refers primarily to helplessness or a lack of ability to adequately protect one's privacy [367]. Consequently, an imbalance of power arises, since the control mentioned here as well as the corresponding possibilities are only determined and made possible by the provider. Risks and negative consequences are rationalized by accepting them, since the consequences are inevitable or the consumer also does not see any advantages for him/herself if she/he would reduce their willingness to take risks [367]. Xie et al. have identified fatalistic traits in this regard at three levels [367]:

- On a **legal level**, since consumers per se do not have ownership rights over their personal data and they partly assume that the current legal situation is not comprehensive enough to adequately protect privacy.

- On a **functional/technical level**, consumers hardly have a choice or the possibility to use or completely adapt products and/or services according to their (privacy) needs, such as completely anonymous internet use. As a result, they are effectively forced to use certain products and services.
- On a **corporate level**, because consumers know and assume that the companies behind the products and services are collecting, analyzing, and profiling their data, they feel helpless against the fact that the companies are using numerous available means to invade their privacy.

The higher the perceived level of fatalism and the presence of a power that determines actions and consequences, the more likely people are to give in to risks and attempts to protect their privacy. This can be seen in other areas as well, such as leading a healthy lifestyle [367].

2.1.3 The Media's and IoT's Impact on Privacy

In "The right to privacy" [352], Warren and Brandeis for the first time addressed the privacy of the individual and the need to protect personal rights due to media intervention through the innovation of photography. Therefore, it was possible in a short amount of time to take pictures of other people and partially without their awareness. Later innovations such as the telephone, the television, and the Internet also influenced the concept of privacy in a similar way and caused the boundaries between privacy and the public sphere to soften [128]. In conclusion, the media appeared to be driving the increasing dispersal and disclosure of private information [349]. For example, the death notices and obituaries in newspapers in the early/mid-20th century, the talk shows, and family series, as well as (docu-)soaps on radio and television since the second half of the 20th century.

The collection of data also increased in other areas, for example in the 1950s with the invention of the credit card and new technical possibilities that have become since then even simpler and compacter for storing data [353]. While Westin suspected in the 1970s that this would

lead to increasing surveillance by authorities and governments, which would threaten the individual and his or her privacy [353], it is now apparent that economic players are using the data for their business models [197, 311].

With the rise of the smartphone as a mobile IoT device and consumer's ubiquitous companion, the last few years have also seen a sharp rise of smart home devices and systems in private households [4]. Accordingly, it was suggested that global smart home market revenue could reach around €111.50 billion in 2022, with household penetration at 14.2% [305]. A smart home system in this context is understood to be a system or augmented environment of the home, consisting of multiple IoT devices and applications that can be connected together to share information and automate processes or procedures [245, 296]. Today, many IoT devices for the home are available on the free market [131] and can be either monitored, maintained, and controlled individually, e.g., via the provider's app, or connected together via platforms (such as io Broker, openHAB, Google Home, or Apple Home). In conclusion, smartphones and smart home systems are turning out to be an increasingly extensive source of user data thanks to their function as an ecosystem and the ability to link apps and services [4].

Finally, the challenge with regard to the smart home when thinking of privacy is, that IoT devices are equipped with digital sensors that have become smaller, cheaper, and more accurate within the last few years. This enables an ubiquitous observation of the consumer as well as the merging of user generated data stocks, also known as "Big Data" [311]. Whereas in the past consumers proactively turned to the media, and through them the public to disclose personal information, now with the rise of IoT devices and consequently their manufacturers and related organizations, they are also entering the consumer's private sphere: the home.

2.1.4 Voice Assistants – And the Home Begins to Listen

Smart home devices can be controlled in various ways by the user directly or automatically based on defined conditions. In a study conducted by Hoffmann et al. [137] they investigated users' preferred methods of interaction and compared control via voice, touch, and gestures in the air. The results highlighted that voice commands and a touch display are the most preferred ways for interaction. This already points to the increasing popularity of commercial VAs such as Siri (Apple), Alexa (Amazon), and Google Assistant (Google) in the domestic context [334].

The term "voice assistant" refers specifically to the voice interface, which a user can use as an input device and for interaction. A VA can be installed as an application on mobile devices, on the on-board computer of a car or as part of devices at home in the form of "smart speakers" [35, 138, 27, 39]. Other terms frequently used in this context with VAs are "intelligent personal assistant" [255, 108, 185], "digital (or virtual) personal assistant" [42, 161, 44], "conversational agent" [256, 186, 288, 282], "speech assistants" [74, 49], "voice user interfaces" [253] or "conversational interface" [215, 203], where the latter can also refer to chatbots, the text-based counterpart to VAs.

VA systems, on one hand, often fulfill the needs and desires of consumer for convenience and a higher quality of life [376, 370, 296, 253, 35], but on the other hand, without encryption or due to misconfiguration by its user, each single device represents a potential risk and attack vector [36, 224, 140]. Those security risks can also have an impact on physical security of the home but also on the personal and informational privacy of the consumer [140, 370]. As Möllers has pointed out, even commercially available systems are vulnerable to passive attacks like eaves dropping and traffic analysis due to cheap sensors and devices on the market [224]. In studies it has been shown that consumers have concerns about ubiquitous IoT devices at home, fearing in particular a loss of control and a lack of transparency [378, 370].

The lack of transparency relates to the use and processing of data by

providers and its consequences [119], as well as a lack of traceability as to where (and which) data is being sent [292]. In particular, lay persons seem to have little idea which organizations and entities are involved in data access and processing [158]. Furthermore, earlier studies showed that the user experience often suffered from poor experiences during interaction [35, 71, 159, 215] and with regard to voice recognition [186, 287, 175]. On the one hand, this leads to an adaptation of behavior to the VA's capabilities [243], on the other hand, the less than reliable voice recognition and activation (e.g., through similar-sounding triggers in conversations or by TV) creates uncertainty on the part of consumers as to whether audio recordings are taking place unnoticed and whether they may contain confidential or sensitive information [232, 237, 376].

2.1.5 Imbalance of Information towards Data Processing and Risks

A lack of knowledge and awareness leads to incomplete threat models [1, 369] as well as risks not being adequately perceived and assessed by consumers [1]. While there are already a variety of studies on risk perception and awareness on internet use like online shopping, surfing, and social media [24, 36, 130, 139, 184, 233, 238, 375], the effects on the private home, especially with VAs or smart speakers placed there, have not yet been examined that much. Microphones (as well as cameras) are considered to be one of the most intrusive sensors in the home environment, according to Oulasvirta et al. [237]. In this respect and with regard to VAs, users often see the potential that they could be permanently switched on as "always-listening" devices [175, 328, 193].

In various studies it has been found that there is a lack of understanding about how devices operate, even for tech-savvy users, which leads to rationalization or resignation in maintaining one's privacy [1, 138, 175, 327, 374, 376, 204]. Moreover, when it comes to saving of voice recordings, it was shown in some of the studies that users both are sometimes unaware that their data is stored and are particularly dissatisfied with the fact that this is done indefinitely [191, 193]. Manikonda et al. further stated that the concerns of users who had low privacy con-

cerns and did not know about the audio storage increased as it became known [193]. As countermeasures, this sometimes leads to users muting their VAs or disconnecting them from the power supply for sensitive conversations [175, 255]. Although these measures protect against the collection of data, consumers remain uncertain as to what data is collected and processed in other supposedly harmless situations.

Particularly with regard to communication and data transfer between devices and services in an ecosystem of platforms, traceability is difficult [45]. For example, Abdi et al. found that users have incomplete mental models, and therefore are often unaware, of what data is passed from the provider to the services involved in the VA ecosystem [1]. To shed light on this, Orr et al. [236] and Kwak et al. [172] analyzed numerous VAs' data sets. While Orr et al. [236] investigated what data can be found about Alexa and whether it possess data of evidentiary value in criminal investigations, authors Kwak et al. [172] analyzed the VA data of another VA service to be able to evaluate the accuracy of commands for voice presentation attack detection. Orr et al. used the Alex app and web-interface and identified timestamps, recorded speech (with different user voices), transcribed commands, the response from Alexa, and invoked skills as related data types. Kwak et al. [172] could identify other information based on a dataset stored by the company and six attributes: Device ID, utterance (speech-to-text converted format), time stamp, command type (e.g., open application or set alarm), matched application (for execution), and processed state (success of execution). This shows that a different degree of information content can be assumed depending on the provider. While these studies involved an examination of these data sets for research purposes, taking a more technical and content-oriented approach, the aim of the work for this thesis and related studies was to explore the data together with consumers and create approaches to make it more accessible to consumers for data work purposes.

In a recent survey on VA security, Yan et al. [369] pointed out that a balance of information can also have a positive influence on trust between consumers and VA systems (and the provider). However, trust also plays an important role between different users of a VA system,

which is influenced by perceived control over one's own data [167]. This also played a role in the context of the work for this thesis, as the home is often understood as a social place, so that the privacy of several users is affected when using VA systems, as is shown in the following section.

2.1.6 The Home as a Social Context

In a similar manner to the sphere model, the context of the home is also referred to as a domestic or family sphere, meaning that it is often not just a single person who is affected by data collection through IoT devices, but several household members. Furthermore, there are also visitors, neighbors, domestic workers, or even mail delivery people about whom (personal) data can be collected. Thus, they and also their privacy protection are affected, albeit indirectly [194], since IoT devices and VAs are often shared devices that are probably used by all of these groups [138, 175, 191, 194, 204]. Consequently, different kinds of users are exposed to the devices in an uninformed way [81, 118, 324]. In particular with regard to children, various studies have shown that their use of devices must be taken into account in the design and development of smart devices [324, 115, 276, 116], as they can also use the devices in unconventional ways, which can pose health risks (e.g., injuries), financial risks (such as accidentally placing orders), and psychological risks (such as viewing, reading, or listening to inappropriate content) [324, 115].

In various studies it has been found that not only children but also visitors and domestic workers should be considered and supported in their privacy awareness and protection [11, 372, 371, 194, 195, 333]. It was also shown in the studies that there is a high potential for conflicts to arise. This is due to an imbalance of power between household members and bystanders, but also is related to the data collected, which may lead to a multiparty privacy conflict [275, 321]. A conflict can arise in particular when a person possesses data about another person, such as voice recordings or a picture on which this person is (also) depicted, and passes this on or even publishes it. Moreover, there is

also a power imbalance between members within a household. In this regard, it has been shown in studies that there is usually one administrator or primary user in a household who sets up and manages the devices [118, 175, 195, 283]. Different studies have shown, that primary users are often less concerned about their own data, but more about the data of guests or children and would also like to be able to set role-based access options (for children or guests) or limitations on the commands available [204, 191, 175]. Despite this, secondary users also perceive themselves as owners, although they do not have direct access to the user account [175, 204].

2.2 Data Literacy by Data Work and Awareness

In the field of digital consumer behavior and market research, AI and data science methods such as deep learning, decision trees, Bayesian learning, text mining and others [102, 142] are increasingly used to identify relevant information in user data and to derive behavioral patterns [64]. While there are already a number of tools that provide functions for exploring heterogeneous data sets (e.g., Tableau, Qlik, MatLab, or R), these tools are aimed at companies or data analysts and developers, and not at consumers as end users themselves [106, 58]. This illustrates the imbalance of power in the utilization of personal data already mentioned in the introduction.

In the course of digitalization and the emergence of data-driven business models, the term "Big Data" was introduced to describe the associated processing of data on a large scale (variety, volume, velocity) [311, 199, 332]. Consequently, big data can be useful in a number of fields, such as in medical and transportation systems [199]. Nevertheless, it also poses unprecedented threats for user's privacy [332].

2.2.1 Data Work Practices of Companies

Companies, as well as other organizations with data-driven business models, hope to gain advantages for their products and services based

on the usage data. Stevens and Bossauer have identified three kinds of business models [311]:

1. **Quality Improvement:** Data stocks for internal use in order to improve the quality of what is already offered
2. **Product Extension:** For the generation of new data-driven services
3. **Marketing Purposes:** As a commodity to be sold to or shared with third parties.

However, this leads to an imbalance in terms of information [12] and power [134, 270] at the expense of consumers, since companies, but also governments as data collectors, are given a multitude of options for interpreting and analyzing consumers (as data givers). At the same time, however, they leave the user with uncertainty about the possibilities of an evaluation of their data and its utilization and meaningfulness. In the following, two major data work practices of companies are briefly outlined, which particularly illustrate the imbalance of power and information.

- By **Profiling**, anonymized data sets of different users are used and examined for their commonalities by systematic collecting, organizing and inferring the user profile information (user's interests, characteristics, behaviors, and preferences) [92, 299]. Companies then use this information to provide personalized advertising, information or offers for their users.
- **Scoring** is an advanced form of profiling [299]. For this, user data and characteristics are weighted by algorithms according to specified characteristics, which determines the user's score [268]. Two well-known examples here are the social credit system from China or the credit scoring company Schufa ("Schutzgemeinschaft für allgemeine Kreditsicherung") in Germany [338].

In profiling and scoring, decisions are based on probabilities for a certain future behavior, which in turn are based on statistical experience

with the assigned comparison group [329]. Credit agencies as well as companies therefore have a great interest in being able to access as much data as possible in order to best assess a person's behavior, interests, or even risks, e.g., with regard to creditworthiness [299]. Due to the increasingly better accessibility to general data, companies and credit agencies have good opportunities to do this [84]. However, profiling and scoring are risky if they promote the discrimination of groups and, for example, aspects such as age, family status, health, residence, and gender, but also sexual or political interests are included in the calculation [299]. However, both practices are not transparent for consumers. With regard to profiling, there is a danger of creating a filter bubble, where consumers fear that they will only receive one-sided content and information, or be only confronted with their own opinions or equivalent opinions [136, 226]. Furthermore, it is also known that companies may sell some of this data to 'infomediaries' that are specialized in merging personal data from different sources to generate even more detailed profiles [197, 311]. However, here too, consumers are not sufficiently informed about what these companies do or whether they are trustworthy.

2.2.2 Data Work Practices of Governments

As Westin predicted in the 70s, governments are also seeking to store their citizens' data [353]. In the course of fulfilling its state tasks of administration and protecting its citizens, governments collect and process a wide range of personal data, including information from civil registers, tax data, but also from monitoring locations and the collection of data to prevent crime and terrorism [355]. As mentioned in the previous section, the Chinese government also uses scoring to enable or deny its citizens certain options.

Due to experiences during the Nazi era and the GDR, people in Germany were sensitized early on to the danger of any abusive use of data by the government. In the digital age, at the latest since the NSA affair in 2013, the general public has been informed about the dangers of state surveillance: Triggered by the whistleblower Edward Snowden,

it became known that state authorities worldwide monitor electronic communications with the justification of protection against attacks and terror [198]. In liberal democracies, there has long been a debate about how the role of the state should be framed in the area of data protection and to what extent it should be allowed to intervene in different areas of society. This takes place against the backdrop of the view that privacy is literally considered a matter of individual privacy [198].

In Germany today, there are still ongoing attempt to enforce data retention, in which all telecommunication processes (telephone, cell phone, and Internet connections) are to be stored as a precaution, i.e., without any reason, in order to ensure general security and fight terrorism and crime. From the perspective of the European Court of Justice, the blanket storage of Internet and telephone communication data is not permissible [355]. Besides Germany, other countries also advocate the use of a "second key" for decrypting encrypted data in telecommunication processes. However, experts have been critical of this, as it would only provide another possible access point for criminals and terrorists and would have correspondingly and/or consequently worse results than simply the lack of a decryption option by the state [3]. Accordingly, consumer fears of government surveillance or espionage are not unfounded and may reinforce mistrust of smart technologies and the storage of data and, consequently, into whose hands it falls.

2.2.3 Consumer Rights (GDPR) as the Key to Consumer's Data Work

Irrespective of his role as a citizen, customer or user, a person has a right to freedom and privacy in accordance with fundamental or human rights (see in particular GG Article 2 or AEMR Article 12). Furthermore, at least in the European Union, data protection is based on fundamental principles, which can be derived primarily from the requirements set out in the GDPR. The GDPR came into force in 2018. Its main objective is to strengthen the informational self-determination of citizens of the European Union (EU) and to regulate when and how personal data may be collected, processed, and stored. The GDPR replaced Directive 95/46/EC on the protection of individuals with regard to the processing

of personal data and on the free movement of such data, which had existed in Germany since 1995.

The GDPR does not apply to all data, but specifically to personal data. Accordingly, personal data are

[...] any information relating to an identified or identifiable natural person ('data subject'); an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person.
(Article 4, GDPR)

Some data categories are generally excluded from processing if they are classified as sensitive and provide information about a person's ideological beliefs, genetic characteristics or sex life, as stated in Article 9. The GDPR also stipulates that data may only be used for "specified, explicit and legitimate" purposes (Article 5, GDPR). However, these purposes must be communicated in advance. In recent studies it has been shown that the wording, also with regard to purpose limitation, is often still vague or very complex [14, 153] and effective interpretation still needs to be researched [153].

Chapter 3 of the GDPR also includes the data protection regulation that should enable consumers to exercise control over data processing. This includes in particular the following consumer rights:

1. **Transparency and Modalities** (Art. 12): Article 12 provides that data subjects shall receive a concise, transparent, intelligible and easily accessible form of any communication and information related to the processing of their personal data in a clear and simple language.
2. **Information and Access to Personal Data** (Art. 13-15): The articles contained here grant the right to information about the

collection (or also origin) as well as access to personal data. In addition, consumers have the right to request the personal data collected by an organization in a precise, transparent, understandable and easily accessible form in a clear and simple language.

3. **Rectification and Deletion** (Art. 16-20): Section 3 empowers consumers to have their incomplete or unwanted personal data completed or deleted without unreasonable delay. Furthermore, in order to transfer their personal data to other organizations, they may request that it be provided in a structured and machine-readable format as far as possible.
4. **Right to Object and Automated Individual Decision-Making** (Art. 21 & 22): This section empowers consumers to object at any time to the processing of personal data concerning them, in particular where personal data are processed for direct marketing purposes, including profiling.

The rights of protection and defense of the GDPR are very generally formulated and give space for interpretation when it comes to implementation. In particular, the GDPR is caught in the interplay between, on the one hand, preserving or promoting the ability of organizations to innovate and thus keeping them as open as possible. On the other hand, this makes it more difficult to check whether rights are being observed (e.g., with regard to the completeness of information) [62] or how reporting procedures are to be designed that comply with both the GDPR and the consumers' demand for privacy protection (e.g., with regard to transparency) [14].

With regard to conversational agents (and VAs) Saglam et al. [282] have identified four open issues when it comes to their design and the consideration of GDPR:

- **Lack of Algorithmic Transparency:** In particular for sensitive topics such as finance and health, open and honest agents are essential so that users are explicitly informed about the way their data is processed and have the opportunity to access and rectify their data.

- **Managing Consent:** The design of consent practices for agents can be challenging, as the mere use of a chatbot does not constitute unambiguous consent within the meaning of the GDPR. For VAs that are used in the home environment, however, consent should be obtained at the start of the configuration process.
- **Right to Erasure:** The personalisation and accuracy of the agent in processing users' responses are in direct conflict with the targeted deletion of (sensitive) data by the user or their right to be forgotten.
- **Data Minimization:** Even sensitive inputs are inevitably processed in order to generate an appropriate response, even if they have been captured accidentally or unnecessarily. However, this makes full compliance with the GDPR more challenging, particularly in relation to sensitive data categories (e.g., ethnicity).

2.2.4 Current Data Work Practices of Consumers

Practices from the fields of self-tracking, self-documentation, and life-logging show that consumers can have an interest in working with (personal) data [358, 189, 302, 214, 289, 95, 330]. Although consumers have the opportunity to view their usage data via their user accounts with an organization, they are still dependent on what is offered and the resources provided by an organization in order to understand and make sense of their usage behavior and activities [307]. Furthermore, consumers often lack the necessary knowledge and tools to conduct analytics on their own, so they rely on the analytics offered by the data collectors. In addition, companies use different data storage methods, making it difficult to analyze (and link) different data across products [62, 293].

With regard to smart home use, the measurement and consumption data of a household are regularly tracked by consumers. Through smart metering systems, for example, energy or water consumption can be viewed and optimized [286, 59, 151, 335, 109]. Some users also occasionally look into the data for security reasons, e.g. to check their

network for unauthorized access, or to identify unusual activities or data flows [155, 240, 150, 370].

The data work practices outlined in this thesis show that consumers already use various ways to view data about themselves or their household. The ability to understand, reflect on (and optimize) one's own behavior or the use of resources is also in line with the previously mentioned reasons why consumers disclose or share their data (see Section 2.1.2). However, they are dependent on the tools and analyses offered by the manufacturers of the (IoT) devices. Furthermore, the users may not be aware of what data is being used for this purpose. The extent to which interaction data from the VA or the associated usage occasions is available or can possibly be used in a similar way is largely unexplored. Therefore, the work for this thesis involved an examination to what extent data work practices already exist or may be adopted with regard to VAs as a use case and how they can be reciprocally empowered with data literacy.

2.3 Data Literacy by Human-Centered Design & InfoViz

Based on the Human-Centered Design (HCD) of usable products and services, methods of usable privacy and security are intended not only to achieve tasks and goals effectively, efficiently, and satisfactorily (with regard to usability engineering) [145], but also to take security and privacy-related needs into account [76, 7, 38, 279, 354]. For this, the challenge is, that usability and data protection are often in conflict with each other in this context, since a higher level of privacy protection can usually only be achieved at the expense of the usability of a product or service [121, 175, 70, 63, 354]. In this regard, Garfinkel and Lipford [114] summarized four central aspect that should be considered when designing not only human-centered and usable but also secure applications:

- **Lack of Motivation:** Privacy and security are subordinate issues, as devices are primarily used for emailing, making requests, de-

vice control, or other everyday things. Moreover, consumers assume that they are already protected in all these activities.

- **Abstract Concept:** Digital privacy and security are abstract properties where many protection concepts are often perceived as unfamiliar and counterintuitive. They are also usually perceived as extra work.
- **Lack of Feedback:** To prevent dangerous mistakes, good feedback about the impact of an action is needed. "Good" feedback for safety and price management is a difficult problem and complex due to different needs.
- **Genie in the Bottle:** Once a secret is (accidentally) no longer protected (even for a short time), consumers can't be sure that it hasn't already been revealed. After that, it becomes extremely difficult, even almost impossible, to make sure that the genie is put back into the bottle.

The importance of simplicity and usability in terms of motivation for data protection and security is illustrated by the example of (not) reading terms and permissions granted for app or device use in detail before purchasing or installing IoT devices [121, 258]. Gerber et al. [121] were able to highlight three central issues as to why permissions are often not read:

- **Timing:** Reading of permissions conflicts with the desire for immediate use or is shown only while the app is already installed.
- **Labelling:** Naming and descriptions are technical and incomprehensible.
- **Overload:** There is often a demand for more permissions than strictly required.

Important elements and areas that are investigated and evaluated in the context of usable privacy and security are control [107, 21, 277, 303, 331], awareness about disclosure, collection and processing of

data [21, 114, 119, 284, 173], and improving privacy policies [267, 283]. In further studies consideration has been made of the usability of passwords [7, 26] or the support for data retrieval and sense-making of (raw) data [335, 59, 148, 375, 278].

With the growth of data-collecting technologies in the 1970s, the challenges regarding data protection also became greater [197, 353]. This ultimately led to the development of Privacy by design (PbD), which sees itself as a countermovement to "surveillance by design" [79]. The approach includes seven principles for proactive and effective data protection when dealing with data-processing technologies [271, 61].

To raise transparency to data collection and processing, and thus to track and create awareness of one's own data trails, different approaches have been researched. In this respect, however, transparency does not merely mean making data and processes visible, but also, in particular, understandable and traceable in order to be able to assess potential risks [19, 258].

One promising approach to increase data awareness and transparency is to notify the user about collected, processed or sent data. For this, Schaub et al. [283] referred to choice models (opt-in, opt-out) in which users must explicitly agree to a data practice. Furthermore, consumers should be able to allow or deny certain access without the consequence of no longer being able to use the app or device [283]. Notifications can also help bring awareness to collected data and potentially associated risks during use. For example, Seymour et al. [292] developed "Aretha", a speaking firewall that can provide information about which data has been sent to which services. Balebako et al. [28] also used just-in-time notifications to illustrate when data is shared using two smartphone apps as examples, which were also summarized as visualizations to raise awareness of data leaks.

While the above approaches are useful for making the exchange of data visible, the aim of the work for this thesis was to make the interaction data with VAs visible and usable. Pötzsch was already able to derive first basic requirements in order to support data and privacy awareness [258]:

- **Measure privacy attitude of people:** Privacy preferences of people, motivate them to configure and change preferences
- **No invasion to privacy itself:** Minimal disclosure of data to public and minimal interruptions
- **Understandable for target group:** Consider perception understanding and needs of the target group for the design of usable application
- **Consider cognitive boundaries:** Present data to people in a way that they are able to handle it cognitively
- **Tailored to the specific contexts:** Present information with regard to the current context, e.g. user, task, device or recipient
- **Offer support, no assumption of responsibility:** A tool should not convey the impression that they fully protect privacy

These requirements represent an initial basis for the prototype developed as part of the work for this thesis, which is intended to enable data work practices. Moreover, methods of information visualization were taken into account, which should be particularly useful for visualizing the interaction data in order to raise awareness. The InfoViz methods are therefore discussed in detail below.

2.3.1 Methods of Information Visualization

A well-known saying is that "pictures are worth a thousand words". Thus, it turns out that in many areas visual presentations, pictures or maps are often more memorable than a speech, a textual description or report [297]. Moreover, due to increasingly complex systems and the associated data and information available [366], the field of InfoViz is an useful approach for making information available for the recipient. In this regard, data and information should not merely be made "available" or transparent which may lead to an information overload [60], but should support the recipient or user in completing tasks by allowing the associated data and information to be visualized, explored,

and adapted [58, 160, 55, 5]. According to Keim [160], InfoViz is based on three pillars: the data type to be visualized, the visualization technique, and the way of interacting with the data (interaction and distortion technique).

The basic steps in InfoViz are captured in Shneiderman's Visual Information Seeking Mantra "Overview first, zoom and filter, then details-on-demand" [297]. He has also differentiated them again into a total of seven tasks to process the data [297]:

- **Overview:** Gain an overview of the entire collection.
- **Zoom :** Zoom in on items of interest.
- **Filter:** Filter out uninteresting items.
- **Details-on-demand:** Select an item or group and get details when needed.
- **Relate:** View relationships among items.
- **History:** Keep a history of actions to support undo, replay, and achieve progressive refinement.
- **Extract:** Allow extraction of sub-collections and query parameters.

InfoViz shows a strongly task- and especially human-centered approach in the implementation of visualization, where the user or recipient must be involved in the design and implementation at an early stage [183, 58]. Accordingly, previous approaches of "one size fits all" solutions are not fit for purpose, as information needs may differ between users, but may also change over time and due to the long-term use of systems [151, 58, 60, 361, 356]. Finally, the goal or purpose to be fulfilled is also important, from which motivation [201], knowledge crystallization [55], and competence by working with the information [5, 151] arises.

Solutions and tools for visualization must be adaptable as well as integrable into everyday life and (social) practices [151, 183, 5, 365, 58].

In this regard, Liebermann et al. [183] have made a distinction between end-user participation during the initial design phase and research on end-user modification during usage. This is supported by Jakobi et al. [151] because while at the beginning it is mostly about creating awareness and exploring the data, later consumers are more likely to want to know when deviations or anomalies occur.

When it comes to visualization design, one of the main challenges is to find the appropriate type of visualization for the data [160, 60]. Different Tool-kits have been developed, to design different kind of visualizations for analysis and exploration (e.g., [132, 101]). Castelli et al. [60] has collected typical forms of presentation based on a literature survey (used in the case of energy consumption):

- **Bar-& Line Graphs:** Giving historical feedback and party for comparing consumption of devices or households.
- **Gauge Charts:** Showing current consumption.
- **Spider:** Showing cyclic patterns e.g. to present high or low consumption.
- **Pie Chart:** Showing division of devices or of different users.
- **Textual/Numerical elements:** Providing exacts values (amount, average) but also rankings (as tables) or text elements for storytelling (seldom).
- **Symbols, Landscapes and abstract forms:** Rating the consumption, e.g. using Emojis.
- **Other:** Using boxes about the status (on or off) and the impact of the status.

It is the case that not only the type of display decisive, but also the device used and the available screen size [60, 68]. Nowadays, applications should be designed in accordance with the "mobile first" principle [68], because this way the feedback can be accessed more effectively and immediately at different locations and on different devices (compared to a "classic" stationary PC) [60, 68].

2.4 Consumer Empowerment for Data Literacy

In the previous three sections on data literacy in the context of digital consumption, data work and awareness, as well as human-centered design approaches, it was outlined how consumer behavior and data work practices in the context of the digital home were examined in this thesis. Moreover, possible solutions have also be considered to reduce uncertainties regarding data processing. In this respect, consumers have to deal with various challenges that can be overcome by increasing their data literacy through data visualization techniques. The biggest challenge seems to be that the fascination with smart devices for smart home use and their perceived or experienced benefits in everyday life is offset by the often abstract and trivialized or accepted consequences. Although consumers are generally aware that when they use IoT devices, data is collected and processed by their manufacturers, a lack of information or insight means that they have little opportunity to understand and make sense of the related complex structure [29, 114]. This also leads to abstract or misleading assumptions about what IoT devices collect, process, and store in the consumer's home. Moreover, it is unclear to what extent consumers are aware of existing solutions or legal steps, on the one hand, and how they provide clarification on the other.

VAs are IoT devices frequently used in the private sector, which are a special case as they are always listening or ready for use in the household, waiting for the trigger to start a recording. In studies it has already been shown that this often leads to incorrect activation, whether due to misunderstood words from the user or other noises in the background, e.g. coming from the TV [287, 186, 175]. While this data is used by providers to improve speech recognition, consumers are sometimes not even aware that this data is stored or can be viewed [191, 193].

In the drawing of boundaries for the protection of digital privacy, a constant interplay of power relationships between companies and consumers can be observed, in which there is often an asymmetry to the detriment of the user/consumer. On the one hand, consent is uni-

laterally prescribed as a central regulatory component for a contract that could potentially come into existence, which falsely suggests self-determination on the part of the individual and, on the other hand, obscures the power of the organization, because a consumer can rarely choose from alternative actions or negotiate the type of data use [270, 12].

By using InfoViz methods, new data work practices can be created that also offer consumers the opportunity to visualize activities of the VA system and thereby reduce the complexity of data processing in their home. This provides them with certainty about what data is being processed and a basis to make decisions regarding their use behavior and the processing of data.

As is shown in Figure 3 the use of IoT is blurring the boundaries between the different spheres of privacy [310, 290]. In addition to the randomly or accidentally stored recordings, the VA as a control system in the smart home has insights into various use cases and contexts through the related interactions. This can, in particular, lead to a context collapse [239, 344], because data could be shared with the VA provider that the consumer did not want to disclose. However, there are few solutions as to the extent to which these devices influence the blurring or intervene in the individual areas. In this respect, the frequent proneness to failure of VAs poses a particular risk, as snippets of conversations containing sensitive information can potentially be recorded. Therefore, the visibility and visualization possibilities of the interaction data were researched in the course of the work for the thesis in order to create opportunities for data work that raises consumers' awareness and strengthens their data literacy. This enables measures to be taken to maintain their privacy.

3 Study Outline and Questions

Based on the motivation, and strengthened by considerations and approaches from related work, the following research questions were derived for the work done for this thesis:

RQ1 How do consumers perform data work practices to explore and understand personal data in general and in particular with VAs?

RQ2 How to support the empowerment of consumers in their data literacy by information visualization, thereby counteracting the imbalance of information and power between organizations and consumers?

In the context of the thesis, **RQ1** is discussed in Part II and **RQ2** in Part III. Figure 4 further shows graphically how the questions are addressed.

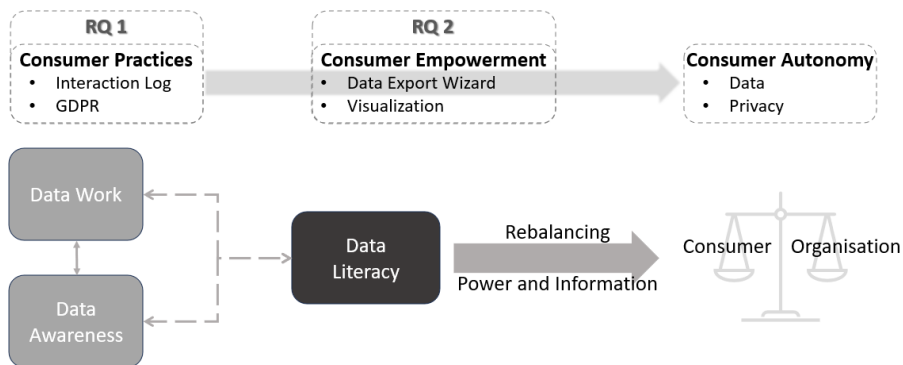


Figure 4

The interplay of data work and awareness contributes to the empowerment of data literacy, which in turn leads to a reciprocal enhancement. This creates a balance of power and information between consumers and organizations, increasing consumer autonomy.

Accordingly, Sections 5 and 6 deal with consumer practices for answering **RQ1**. Both studies contain the results of an investigation into how consumers use data in the appropriation process and everyday life. Moreover, there are insights into what needs they express with regard

to access to their personal data and understanding data processing processes in order to better understand the initial situation.

In Section 5 an examination is presented of how users of VAs integrate them into their everyday lives and how they appropriate voice interaction and commands in particular. One focus was on unsuccessful interactions and how these were resolved in the past. For this purpose, the interaction logs available from the providers (see Figure 1) were also viewed in order to reconstruct and evaluate the interaction and make aware of the interaction and data log.

In Section 6 "Finding, Getting and Understanding", a study was conducted to examine how the right to access data as a legally regulated means of access to personal data can be implemented for consumers, and to what extent the data received is understandable, creates awareness of the data processing by the companies (e.g., in terms of trustworthiness) and whether the data is "(re-)usable" for the user. For this, not only providers of VAs were considered, but also various companies and organizations in order to evaluate the solutions offered by the organizations.

RQ2 is addressed in the studies of Part III, and deals with consumer empowerment (see Figure 4), as human-centered design approaches were used to design and evaluate a prototype, which both resulted in the derivation of requirements and recommendations on how consumers can be strengthened in their data literacy and thus counteract the imbalance of knowledge and power.

In Section 8 an initial prototype design for data visualization is presented, which for the first time allowed VA users not only to view their data, but also to explore their usage behavior as a whole. As in Part II, this has contributed in particular to the creation of data awareness, but at the same time allowed the collection of initial user needs, which should serve for further data work practices.

Section 9 builds on this study and contains a mature version of the prototype, which offers further possibilities in addition to data visualization and supports the consumer in his data work by means of a data export wizard and a dashboard for data visualization. The section

also addresses the importance of the placement of a VA device at home and shows that voices and noises from adjacent rooms can be captured, even if this is possibly not intended.

Finally, in Section 10 the status of the prototype at the end of the project is presented. This includes an introduction to the implemented functions and visualizations and how these can support consumers in their data practices based on the identified user needs, thereby enhancing their data awareness and competence. Lastly, the chapter also provides initial insights into the potential of tools such as the prototype to counteract possible skepticism about data collection during the use of VAs by increasing data literacy.

3.1 Methodology

The work for this thesis used a mix of methods from predominantly qualitative approaches, although one of the studies also used quantitative methods (see Section 6). However, the approach and methods used in this study can be bundled under the methodology of the *Design Case Study* (DCS) according to Wulf et al. [363] and were applied mostly in the context of a living lab study conducted within households. In the following, the procedure of the DCS is first presented as an overarching framework, as well as the methodology of the living lab as the general setting of this work, and its implementation in the research project on which this work is largely based. This is followed by a presentation of further methodological approaches used in the work for this thesis.

3.1.1 Design Case Study

The methodology of DCS is a useful and practice-oriented problem-solving strategy when designing innovative information and communications technology (ICT) [364]. Based on the action research paradigm [313] DCS deals with (social) practices, institutional arrangements and technological infrastructures to understand design and appropriation of ICT artifacts [364]. According to Wulf et al. [363], there is an inter-

relation here, especially between social practices and IT artifacts, in which

- the design of the artifact is grounded by **ethnographic studies**,
- the **appropriation of the artifact** is empirically studied over a longer period of time,
- **designers work with practitioners** to explore the design of innovative IT artifacts in situ in a participatory manner and
- **design research** is reflected to and within **design practices**.

The long-term approach involves several challenges that should be considered during implementation. These include, in particular, that the setting will change with regard to existing practices as a result of the introduction and appropriation of innovative artifacts, technical problems or events over which the researcher has no control, but which may nevertheless threaten the time and cost schedule [363, 364]. For planning the research activities within a DCS and overcoming the aforementioned challenges, three phases (or activities) are defined [363, 315] to successfully investigate and implement design and appropriation of an ICT artifact over a longer period of time:

1. **Empirical Pre-Study:** The aim of the first phase is to understand and investigate the context and in particular the existing practices to establish a focus. For this purpose, different empirical methods can be used, which are determined depending on the already existing knowledge of the researcher and the circumstances of the context. The results of the pre-study provide the basis for the second phase, but do not determine its outcome.
2. **Technology Design:** The second phase in particular is characterized by close collaboration between researchers, designers and practitioners. It thereby combines the results from the first phase with appropriate approaches from design and current research. As far as possible, the aim should be to involve practitioners already involved in the pre-study.

3. **Evaluation study:** The third phase refers to the appropriation process when the artifact is rolled out to observe and evaluate its use empirically over a longer period of time. Ideally, this context represents the same setting as in the first phase in order to identify its impact on social practices. This phase provides insight into why certain design and appropriation achievements work or do not work under certain contextual conditions, which should validate the requirements set or show that further steps need to be added to it.

Even though the phases are described linearly here, except for a natural starting point in the overall process to define the case (through a pre-study) as well as within the individual phases, it is a reflective, overlapping, interleaving, and therefore iterative process [315].

3.1.2 Living Lab Studies

For the successful implementation of a DCS, as can be seen from its three phases, effort should be made to keep the practitioners and the setting as equal as possible [363]. For this purpose, living lab studies are a promising approach that can ensure this. According to the definition of Eriksson et al., a living lab is determined as

[...] a user-centric research methodology for sensing, prototyping, validating and refining complex solutions in multiple and evolving real life contexts. [96]

Similar to DCS, the living lab approach focuses on users as practitioners and how they accomplish tasks and practices in a certain context [96]. The aim, therefore, is to develop innovative artifacts by co-design involving designers, developers, and practitioners (and other stakeholders) [96, 363, 181].

Another key aspect of the approach is the setting. Instead of using laboratories or posed environments, the studies in a living lab are conducted under real-world conditions (e.g., at home or in the office) and usually

over a longer period of time [96]. This procedure allows researchers to gain knowledge and insights about the appropriation and use of new technologies in natural surroundings [113], which can both reduce laboratory effects (with regard to ecological validity or social desirability) [25, 180] and allow contextual factors to be directly incorporated into the study (such as a multi-person household, unexpected use or integration with other systems) [113].

Living labs further connect research with everyday life and society through application-oriented research and consumer involvement. It thereby enables people to actively participate and contribute to research, which can be an important driver for participation when it comes to recruiting participants [234]. In their section on lessons learned of a living lab study in the area of home entertainment, Ogonowski et al. [234] mentioned that it was even possible to work well with a heterogeneous sample and that both experienced and inexperienced users were able to contribute insightful input.

Finally, there are challenges that must be considered when conducting a living lab [234, 181]. For example, it takes sensitivity and empathy on the part of the researchers when they enter the setting, as well as a friendly and social attitude to establish trust with the participants in order to create a good relationship over the study period. This helps to motivate their participation till the end [234]. Another challenge that both researchers and participants have to cope with is the end of the project—usually due to time constraints—which often results in solutions being prototype-ready rather than market-ready, or that equipment made available must be returned, forcing new or adapted practices to be abandoned [234].

3.1.3 Investigating Data and VAs in a Living Lab

The approach and the studies conducted as part of the work for the thesis are closely related to the BMUV-funded project "CheckMyVA"²,

²Based on a decision of the Parliament of the Federal Republic of Germany via the Federal Office for Agriculture and Food (BLE) under the innovation support program.

which involved the investigation of approaches to better support consumers' data sovereignty and privacy protection when using.³

As part of the project, a living lab was used consisting of households to conduct research with them on their motivations, competencies and practices in the use of VAs, as well as for the accessing and viewing of the associated data. The primary goal was to design solutions together with consumers to support the process of requesting, viewing, and visualizing data and thus strengthen their data literacy. To this end, various methods were used such as interviews, design workshops, focus groups, and the completion of small monthly tasks by the participants. The latter were given to the participants at the beginning of each month and were used, among other things, to obtain initial ideas and assessments, which were then followed up with further workshops if necessary. The sample consisted of a total of 35 households, with three households dropping out of the project over time.

Within the project, contact occurred mainly with the administrator of the VA as the representative of the household. During recruitment, it was already apparent that this is often a male, adult person who also initiates the purchase of the VA system, sets it up, and administers it during use. However, in addition to 24 male contact persons, there was also 11 female contact persons. The average age of the contact person was 33 years. The sample included single households, partner households, family households, and shared flats. 19 households were also "newcomers" and did not yet have a voice assistant at home before the project. A detailed overview of all participating households can be found in Appendix A.

The project followed the universal design approach [244] to make the developed prototype as accessible as possible to all users (regardless of their age, abilities or other characteristics). This was necessary from the project perspective, as consumers are in themselves a very heterogeneous group. However, it was desired that the tool should not become a "one-size-fits-all" solution, but adaptable according to the "Flexibil-

³For further information on the project, please visit the project website at <https://checkmyva.de/>

ity in Use" principle of Universal Design [244]. This is also necessary because, as explained in Section 2, privacy needs and the possibilities for information visualization of data can be very different. The final version of the prototype developed is presented in Section 10.

3.2 Empirical Methods of the Thesis

The overall methodical framework of the work for this thesis is provided by the DCS with the integration of the living lab approach to define the setting. Within this framework, various methods were chosen for the investigation, which are described in more detail below according to the phases of the DCS. As already stated, the procedure for DCS is not necessarily linear but reflective, overlapping, interleaving, and therefore iterative. For this reason, methods from the evaluation phase were applied in the initial phase, for example, in order to examine and understand existing solutions and processes (and their appropriation) in the related context.

In Table 1 an overview is given about the applied methods for each of the publications that were used as section in this thesis.

Sct.	Publication (Short Title)	Used Methods	Sample
5	Miss Understandable	Semi-structured interviews, cognitive walkthrough	10
6	Finding, Getting and Understanding	Heuristic evaluation, questionnaire + SUS	59 (422)
8	Alexa, We Need To Talk	Cognitive walkthrough, user test + thinking aloud	11
9	'In the Living Room, She gets Everything'	Semi-structured interviews, user test + thinking aloud	11
10	Towards a 'Demystification of Technology'	User test + thinking aloud, Design Workshop	(35)

Table 1

Research activities according to section and publication in the thesis with information on sample size

The used methodology in Section 6 differs from other sections and was not a direct part of the living lab study. The approach used in the related study is based on the methodology of Grounded Design [269, 315], which is closely related to the DCS methodology [315]. However, it takes a more conceptual approach in order to make the experience and knowledge from design case studies relevant, shareable, and applicable beyond their specific setting [315]. Therefore, the study conducted in this section also maps well to the design case study phases and the framework of the work for this thesis.

3.2.1 Empirical Pre-Studies

The first phase is mainly for understanding and getting to know the context and practices in the real world. For this reason, open and explorative methods are particularly suitable, in which as many impressions and insights as possible can be extracted and conclusions drawn.

One common method used in this first phase are *Semi-structured Interviews* which help researchers to gain a fundamental as well as a holistic understanding of a specific context by means of open-ended questions by talking to relevant consumers, users or practitioners (as well as other stakeholders) [200]. Conducting interviews is thus a useful tool especially when researching a field that is still quite unknown (to the researcher potentially) in order to understand and investigate practices applied there [200]. As stated in Section 2, issues such as privacy are rarely the first priority for a consumer. For this reason, it was also important for this study not to directly address privacy behavior through open-ended questions, but to be able to draw conclusions about the importance of privacy and the resulting privacy behavior based on narratives of usage practices and experiences [200].

Another and quite more interactive method for eliciting context and related practices is related to *Focus Groups*. In contrast to conducting interviews, this allows a researcher to gather attitudes, experiences, and opinions of several people relatively quickly in a short period of time [176]. For this, one or more moderators provide questions or discussion

topics, which are then discussed in a small group, ideally consisting of five to seven (sometimes up to twelve) participants [200]. Through the exchange among participants, experience and opinion sharing can become a multiplier and fuel the flow of conversation which may lead to the disclosure of attitudes which, for example, are suppressed by psychological barriers in individual interviews [200]. However, the moderator must take care that the topic of the focus group is not lost and intervene accordingly at an early stage [200].

3.2.2 Technology Design

The work for this thesis was based on studies that can be located primarily in the first and third phases of a design case study. In the process, the insights, findings, and needs gained were harnessed for technical implementation in order to finally evaluate the result with the participants of the living lab. However, the associated project also employed *Design Workshops*, using a mix of participatory design methods to collaboratively develop creative solutions with the living lab, based on participants' expectations and needs. The goal of such a workshop was, for example, to use role play to generate explanatory dialogues, providing clarification by the VA itself when it behaved unexpectedly [17].

The publication presented in Section 10 of this thesis outlines the findings of another design workshop, which can be classified within the 'technology design' phase. During the workshop, the final iteration of the CheckMyVA prototype was first presented. In the subsequent phase of the workshop, additional widgets for data visualization were developed in collaboration with the participants using a digital collaboration tool.

3.2.3 Evaluation Studies

The Evaluation Phase is concerned with how (new) solutions integrate with existing practices and are adopted and evaluated by practitioners or consumers. In the context of the work for this thesis, this refers to

the effects that the developed, but also already available approaches for data insight and increasing data literacy, achieve and how usable they are.

Heuristic Evaluation is primarily used to examine tools or user interfaces for usability and UX problems by evaluators (usability specialists) [229, 231]. For this, several evaluators, but independently of each other, examine the tool or interface for violations of various heuristics and document the findings [231]. In the next step, the identified findings are discussed and evaluated with all evaluators. The resulting report consists of the findings with descriptions (or images) as well as recommendations for improvement and is forwarded to the development team. Heuristic evaluation is a fast and low-cost method, but it leaves the user out of the equation, so that only incidents based on the knowledge and experience of experts can be uncovered ("potential" usage problems). It is therefore recommended to use additional methods that also involve the user in order to uncover "real" usage problems of use [230].

In the context of this work, heuristic evaluation was used in particular to evaluate the process of data requests according to the GDPR and to derive the related user experience journey as an initial step. This was then proofed and evaluated by study participants (see Section 6).

A *Questionnaire* represents a standardized survey and is used in many different, disciplines, application areas, and forms [176]. In contrast to qualitative and explorative approaches, with usually only a few participants and an aim for an holistic understanding of an issue, a questionnaire and quantitative surveys are more concerned with the collection of attitudes, opinions or characteristics of groups and representative parts of the population (sample) [190], which are usually queried by closed questions with predefined answer options or scales (e.g., Likert-Scale) [190, 176]. They can be used to gather (user) characteristics (e.g., demographics). Quantitative methods like this makes it possible to make statements measurable by means of statistical procedures, for example, by determining frequencies, correlations, probabilities etc [190, 176]. In this regard, it is important to ensure that the questions

are clear, precise and unambiguous, otherwise the answers cannot be robustly compared and, especially in the case of online surveys, there is no possibility of intervention (e.g., by a moderator). In addition to closed questions, however, semi-open or open questions can be asked, which enable the participant, for example, to justify or elaborate on their answers [176].

There are today a large number of standardized and approved questionnaires in many areas, such as for measuring intelligence, personality, job satisfaction, product evaluations, privacy behavior, and also for measuring usability and user experience [176]. One example for measuring usability is the System Usability Scale (SUS)[46], which is described in more detail in the following as it was applied in the work for this thesis.

SUS is a questionnaire for measuring the usability of systems according to ISO norm 9241-11 [146]. SUS was created by John Brooke [46] in 1994 and has now become established over the years as the "de facto standard" [47]. The questionnaire contains ten questions or statements (see also Appendix B) to evaluate the usability of a system by its user by rating the statements on a 5-point Likert scale, ranging from "Strongly Disagree" to "Strongly Agree".

Based on the rating, a score is determined that reaches a value between 0 and 100. The higher this value, the higher the classified usability of a product. Based on several studies, the value 68 was identified as the average value, so that higher values indicate good usability of the tool or system [280]. Its generalizability of use is supported by the fact that SUS has already been used in numerous studies [46, 281]. Quantitative studies often require large samples in order to be able to make valid statements; SUS already allows small samples to suffice [280].

Another typical, but qualitative method for gathering feedback from users regarding usability and UX and for investigating their interaction with tools and solutions are *User Tests with Thinking Aloud* [176]. In this method, users evaluate a tool, system, or a prototype by completing typical tasks. Meanwhile, they are supposed to "think aloud", which means that they say aloud what they see, what they want to do, and

describe their activities during the completion [176]. The tasks can be determined in advance by the moderator, e.g. through a test guideline, or arise only through the narrative flow of the user. The primary goal is not a complete and correct completion of all tasks (especially if they were set beforehand), but the identification of weaknesses and deficiencies in order to record these findings so that they can be corrected or optimized afterwards. This method is helpful for testing new products and, in particular, for investigating their learnability. However, it can also be used with familiar tools or those already integrated into everyday consumer life to identify potential deficiencies or workarounds, as well as how consumers deal with them. Meanwhile the moderator notes down all statements and important findings as critical incidents. For this reason, it must be ensured that the moderator is independent and not directly involved in the development and that the participant feels comfortable and knows that it is not she/he but the system that is being tested [176]. In addition, she/he should be regularly reminded to speak out loud his/her thoughts and intentions in order to gather as many critical incidents as possible [176].

For the work done for this thesis, user tests were used as part of the design process to test and explore the visualization tool with the user's own VA interaction data to identify optimization potential and further ideas for data visualization.

3.2.4 Data Analysis

Accompanying the empirical research, recognized methods were used for data evaluation and analysis. The analysis of the qualitative data in the studies presented in this thesis are based on two different methods: *Grounded Theory* according to Glaser and Strauß [316] and *Thematic Analysis* according to Braun and Clarke [43]. Both methods support the exploratory and practice-oriented approach of the overall procedure, in which an understanding and assumptions about the practices can only be gained through the material of the empirical methods (inductive approach). Both methods are briefly illustrated below. Furthermore, requirements according to the HCD approach [146] were derived on

the basis of the results and findings from the qualitative studies on evaluation.

In the case of *Grounded Theory*, assumptions and theoretical models are made based on the data during the empiricism by open-coding sequences in the data in order to identify commonalities and recurring themes between different data sets (e.g., interviews or documents) [316]. However, differences are also noted. As the empirical phase continues, the resulting assumptions and theoretical models are tested and refined with new data. This procedure is thus also called an inductive approach, since it is only through the results that the theoretical model is formed [316]. The empiricism as well as the analysis of the material is usually continued until a saturation in the results becomes apparent. This procedure served in the work for this thesis, in particular, for the evaluation of the interview data (and screenshots) during the interviews and was used to make assumptions about the usage practices [316].

For the evaluation of collaborative methods such as the focus group, the inductive *Thematic Analysis* according to Braun and Clarke is suitable [43]. For this, the materials are examined for themes in order to identify patterns as well as ideas and concepts as themes, similar to grounded theory. These are first (openly) coded and then discussed along with the overarching research question in order to subsequently examine the material with a focus on the defined themes. In doing so, the themes are described in detail and ideally illustrated with examples from the data [43].

During the *Requirements Specification* according to HCD [146], requirements for use for the tool to be developed are defined, which are often derived from the process step of understanding the context of use. However, since it is also an iterative process, it is often the case that further requirements for use can also be derived from other steps, especially evaluation based on user feedback. In the course of the iterative process, it is also the case that requirements for use are validated, discarded or refined. A requirement is defined as a

[...] condition or capability that must be met or possessed by a system, system component, product, or service to satisfy an agreement, standard, specification, or other formally imposed documents. [147]

Requirements for use, in particular, provide the basis for the design and evaluation of interactive systems to meet user needs [146]. They are also part of the stakeholder requirements, which also includes functional, organizational or legal requirements and form the basis for system requirements.

Part II

Investigation of Consumers' Data Work Practices

*The real challenge may lie
in involving users in a sociological sense
that is to say, by taking into account
the micro-context of their everyday lives.*

ISTAG, *Involving Users in the Development
of Ambient Intelligence*

4 Introduction

In this part and in the following two sections the context and problem space is framed. In Section 5 findings of an interview study are presented in which appropriation and usage practices of VA users were examined and the extent to which data and information about the interactions are used or play a role in ensuring successful interaction with the VA. Furthermore, interaction logs were explored with the majority of participants in order to reflect on unsuccessful interactions in the past. It can be seen that the available data and information offer great potential not only to explore usage practices, but also to raise awareness of how the VAs are used by their user and to what extent the systems and providers of the VA process the corresponding data. Nevertheless, the interaction logs provided by the vendors, however, might be suitable for viewing the interactions that have recently taken place, but offer little support for an overall view or for exploring the data.

For this reason, in Section 6, it is shown how consumers can make use of the right to data access in order to view their data and thus become more data aware. Individual steps in the application process were evaluated in terms of their usability (using SUS) and, at the end, the data received was assessed in terms of completeness, usefulness and trustworthiness, among other things. In this study, however, not only were VA companies were considered, but organizations in general, which the participants as subjects were free to choose. Based on the findings, requirements were finally derived that contribute to an empowerment of data literacy with regard to data access (and use).

Both studies lead to assumptions and conclusions for RQ1 by providing an overview of how consumers embed VAs in their everyday lives and what role privacy and data processing plays in this regard. Further, it is shown how existing approaches for accessing and viewing (interaction) data are experienced and used by consumers. Taken together, the studies show that consumers are aware that data is being collected "somewhere", but for the most part they are not aware of existing ways or solutions for viewing or working with data.

5 "Miss Understandable" – A study on how users appropriate voice assistants and deal with misunderstandings

Abstract

This study examines the appropriation and usage of voice assistants like Google Assistant or Amazon Alexa in private households. Our research is based on 10 in-depth interviews with users of voice assistants and a follow-up evaluation of their interaction histories. Our results illustrate situations in which the voice assistants were used at home, what strategies the users adopted to interact with them, how the interactions were performed, and what difficulties users experienced. A focus of our study is on misunderstandings, situations where interactions failed partially or completely. Our study shows that the full potential of voice assistants is often not utilized, as complex interactions are often subject to failures and users revert to simple use cases. Our participants used their voice assistant mostly for simple commands, often not even trying new functions. An analysis of their appropriation strategies resulted in implications for the design of supportive tools as well as the further development and optimization of voice interfaces.

5.1 Introduction

Digital voice assistants such as Google Assistant or Amazon Alexa have been spreading rapidly in private households for several years. Such devices allow their users to perform and control certain tasks and activities by means of speech. From an HCI perspective, it is interesting to note that voice assistants not only accept commands but also respond by means of speech, thus giving interactions a humanized and emotional character [185, 220]. This is accompanied by increased expectations on the part of users regarding the intelligence and possibilities of interaction [186, 216]. However, in studies it has been shown that this assumption quickly leads to disillusionment in more complex interactions, and users must adapt to the voice assistant's capabilities [71, 216, 243]. This must be viewed critically, as the usability of subsequently installed voice apps in particular is often still in need of optimization in contrast to the basic functions [215], which is reflected, for example, in rather negative user ratings of the functions and capabilities. Such interaction issues furthermore influence the appropriation process of such technologies.

This study was an examination of human–voice-assistant–interaction by means of ten in-depth interviews with users and led to the highlighting of the strategies they have adopted in interacting with voice assistants. To begin with, the study involved an investigation of the occasions when the voice assistant is used in the home environment (in the long term), how an interaction proceeds and what difficulties have arisen when setting up and using the voice assistant. As another part of the study, the interaction log was examined with same users to analyze its usefulness, focusing on situations where the interaction fails or threatens to fail. An analysis of such misunderstandings as well as users' repair or workaround strategies provided insights for the design of related supporting tools. They also provided approaches for the further development of speech-based human-machine interfaces.

5.2 Related Work

The main focus of the study was on the appropriation and usability of voice assistants, with particular attention to appropriation strategies, perception, and the handling of misunderstandings. By appropriation, it is meant the study of the actual usage practices of voice assistant users, which are not always congruent with the forms of usage intended by the designers [88, 251]. In this context, anthropomorphous and social components also play a role in the interaction between humans and voice assistants [227]. These can lead to excessive user expectations in terms of appropriation [219] and were accordingly also considered in the study.

5.2.1 Appropriation and Usability of Voice Assistants

The appropriation and use of voice assistants have already been addressed in several studies. For example, Moore et al. [215], Reeves et al. [265], Pyae and Joelsson [257] and Pearl [241] with the usability and user experience of voice assistants being investigated. Moore et al. [215] have given design suggestions to improve the design of the voice interface, since interaction with voice assistants has so far often led to disappointment on the part of the user – which is justified by the fact that it is still too different from a natural conversation (between humans) due to a lack of conversational competence. Pyae and Joelsson [257] used an online survey to investigate the usability, UX, and usefulness of Google Home smart speakers. Here, comprehension difficulties in particular were identified as problems, and participants included people who did not own a voice assistant themselves but had used it elsewhere or planned to buy it in the future. In 2017, the company eresult conducted an ethnographic context analysis on "Digital voice assistants as intelligent helpers in everyday life" [40]. The results showed that the success of voice assistants is largely dependent on their usability.

Our study was an attempt to build on this research by looking at interaction processes, focusing on understandings and misunderstandings,

as well as the structure of the speech act to gain new insights. A similar approach has already been used by Bentley et al. [35] and Sciuto et al. [288]. In their study, Bentley et al. focused on the variability of commands across time and user groups and considered the typical times of day of use [35]. However, they did not consider the problems associated with the use, which arise in particular when appropriating usage. The focus of this study was on how users emerge conversational patterns and open up (new) contexts of use. In doing so, it was desired to uncover in particular situations in which problems and misunderstandings arise. Based on this, strategies were highlighted of how users deal with any misunderstandings and which solution approaches they develop in the process.

An interaction with technology is always characterized by trust. In addition to frequent concerns about privacy and data protection [210, 228] the question arises about how trust in functionality can be established, which is why a closer look was taken at the last aspect in particular. Just as in human-related interactions, misunderstandings can arise and lead to errors in interactions with computers: "Communicative understanding is therefore not abstinent from things, and it makes sense to relate the question of how it comes about, as well as the endless reasons for misunderstanding and miscommunication, also to things." ⁴ [157]. Following on from this, the results of the study highlights how trust is established and the methods users use to appropriate the technology, how they react to misunderstandings and what strategies are developed to avoid them in the future. Following Draxler et al. [89] and Dourish [87], elements of appropriation were also considered, which describe the process of how users become familiar with an interactive product and adapt it to make it suitable for their everyday use [87]. Since voice assistants in multifamily households are often used by multiple users who presumably share their strategies and solution approaches, collaborative elements were also considered.

⁴Translated from the original German text.

5.2.2 The Social Nature of Voice Interaction

The question of the social properties of computers as interaction partners has been the subject of scientific studies in the field of human-machine interaction for decades [23, 50, 97, 122, 288, 337]. In these studies it has been pointed out that while computers are ascribed an actor status, they are not permanently considered to be social counterparts. According to Suchman [322] interactions with computers remains almost exclusively instrumental. However, due to the use of speech to control voice assistants in everyday use, the question of whether or to what extent a social nature of the interaction with the voice assistant takes place, thereby increasing expectations of the capabilities, keeps coming up in the literature as it gets closer and closer to being like communicative action between humans [228].

Florian Muhle [220] has taken up this question and considers how social interaction with (conversational) robots can be investigated from a sociological point of view. He has considered different approaches of social theory that deal with a possible participation of robots in social processes. In doing so, he came to the conclusion that the communication-theoretical approach according to Luhmann [187] is the most suitable approach, since it focuses on communicative rather than actor-centered patterns of interpretation that lead to expected actions.

In other studies the distinction between social and non-social interaction with artificial intelligence have been considered. For example, the question has been addressed of what human artificial intelligence is ("Are you human?" [219]) and the expectations people have as actors in virtual worlds and interactions with artificial intelligence. In other work the perceived social nature and expectations were examined of a user when interacting with a voice assistant. For example, Seymour [291] offered initial thoughts on the design of a loyal and respectful voice assistant. Cho [71] in turn, addressed the nature of interactions and which mental model they follow. Purington [256] explored the degree of personification of voice assistants by analyzing user experience reports. She shed light on how users described and talked about Amazon Alexa. Porcheron [253, 254] was interested in how voice assistants

in multi-person/family households are integrated or how they behave during human interactions.

Against this background, the research done in this work raised the question of which social processes or mechanisms come to light during appropriation and interaction. In this respect, a social process is characterized, for example, by the consideration of norms and manners, while mechanisms are understood as the way in which the voice assistant is spoken to. Finally, the findings were used to derive approaches as to how interaction can be made more pleasant in terms of usability and UX.

5.3 Method

The results obtained in this study provide insights into the appropriation and use of voice assistants and an elaboration on users' experiences with the interaction. For this purpose, ten semi-structured in-depth interviews were conducted with households that use a voice assistant at home (see Table 2). At the time of the study, the VA purchase had taken place between one and a half months and four years previously. The households consisted of single households as well as couples and families, some of which had children of different ages. All households used at least one voice assistant device. Among them, five households used Google Assistant and six households used Amazon Alexa. (One household used both systems, but predominantly Amazon Alexa).

The interviews took place from September to November 2018 and lasted approximately one hour each. The interview guideline was semi-structured and covered the following topics: acquisition and appropriation, places of use and frequent occasions of use, voice apps that are no longer used – including the cause for this, interaction patterns, and ideas about future and conceivable usage occasions. Following the interviews, after the users had given their consent, the interaction log was jointly examined with the user, which can be viewed via the service providers' website or app. Seven households agreed to do this. The focus was on misunderstandings in the previous four weeks, in order

Table 2

Overview of the households and their use of the voice assistant

ID	Interview duration	Household members	Branch/ Profession	System	Devices	Location	Start of Use
H1	69 min	m, 31 years	IT	Google	1x Home 1x Mini	Kitchen / living room Bathroom	June 2017
H2	60 min	m, 32 years f, 30 years	IT Health	Amazon	1x Dot	Kitchen / living room	Dec 2017
H3	65 min	f, 52 years m, 33 years f, 16 years	HR IT Pupil	Amazon	3x Dot 1x Show 1x Echo	Living room, Bathroom, Bedroom Kitchen Bedroom (f,16)	July 2017
H4	48 min	m, 40 years f, 40 years m, 9 years m, 8 years	IT N/A Pupil Pupil	Amazon Google	1x Dot 1x Mini	Living room Bedroom	Sep 2017
H5	70 min	m, 39 years f, 38 years f, 3 years	IT Translator N/A	Google	1x Mini	Kitchen	July 2018
H6	68 min	m, 34 years f, 32 years m, 3 months	Merchant Merchant N/A	Amazon	2x Dot	Kitchen, Living room	Sep 2018
H7	73 min	m, 26 years, f, 20 years m, 32 years,	Student (IT) Student (IT) IT	Google	1x Home 1x Mini	Living room Bedroom Living room,	Oct 2016
H8	52 min	f, 31 years m, 2 years m, 3 months f, 51 years	Merchant N/A N/A N/A	Amazon	4x Dot	Kitchen, Hallway, Bathroom	Nov 2014 (beta phase)
H9	45 min	m, 47 years f, 17 years m, 13 years	IT Pupil Pupil	Amazon	1x Echo 1x Dot	Living room Bedroom	Nov 2016
H10	73 min	m, 26 years	Student (IT)	Google	1x Mini	Living room	Oct 2018

to trace individual situations discussed in the interview in detail on the basis of the interaction log and to discuss any misunderstandings. For the case of interesting problems, a screenshot of the interaction was taken for documentation and later evaluation.

The interview was evaluated by transcribing and analyzing the recordings and screenshots. In doing so, the procedure model was followed of grounded theory according to Glaser and Strauss [189]. Therefore, categories were iteratively formed based on the material and linked together until a saturation in the findings became apparent. Thus, through the aforementioned themes, it was first explored how the acquisition process and appropriation occurred and how everyday use of

the assistant emerged. For this paper, the main focus was on learning how to use the voice assistant correctly and, in particular, how to deal with misunderstandings. The presentation of the results is divided into "5.4.1 General Results" and "5.4.2 Strategies for Successful Interaction and Dealing with Error Interactions". The general results are related to the purchase and everyday use of an assistant, whereby the following paragraphs with their headings can be understood as categories which, from the authors' point of view, considerably influenced the use and handling of voice assistants. Thus, they also play a role in speech behavior and, in particular, the handling of misunderstandings, which will be considered in more detail in Section 5.4.2.

5.4 Results

5.4.1 General Results

Purchase and setup. For all participants, curiosity about the new technology and the possibility of controlling music and devices in the home by voice were the main reasons for the purchase. The decision for a system was mostly a result of the fact that the provider's services were already in use. Google Assistant, for example, was chosen primarily by those users who used an Android smartphone and other Google services and thus assumed better interoperability. In the case of Amazon Echo, in addition to existing subscriptions to Amazon Music Unlimited or Prime Video, the advertising viewed played an especially important role.

The choice for a certain type of device was primarily made based on the price in relation to the sound quality. Consequently, households often opted for a more compact version due to the price, provided the sound quality was sufficient. One of the participating households already owned an Echo Show, which was the only voice assistant device with an integrated screen available in Germany at the time of the interviews. For the majority of the participants, however, the device was too expensive or seemed unattractive in terms of its usage potential in

comparison to a laptop, tablet or smartphone (and the website or app used with it).

Concerns about data protection and privacy were low before and during acquisition or were put into perspective by the fact that, according to the users, a smartphone provides the opportunity "[...] that they can listen in all the time." (H10). Similar to the results obtained in social media surveys, participants also considered themselves to be too unimportant or that their data and recordings were relevant to anyone: "We have nothing to hide." (H9).

Overall, it was predominantly male household members who were enthusiastic about technology or worked in the IT sector and initiated the purchase and acquisition. Female household members sometimes had more concerns or did not see any specific need for their own use. However, they quickly agreed to the purchase because of the advantages mentioned. The setup worked without any problems for all participants, as this was done automatically by the device and the associated app. The setup of smart home devices and their connection with the voice assistant also was problem-free for most of them. However, one household was unable to set up or connect a smart lamp.

Places of use and associated occasions of use. In the cases studied, there were often several devices for controlling the voice assistant in a household. The main place of use was the living room or open-plan living area with kitchen. Due to this central positioning, voice assistants can be regarded as a component at the heart of the home. The smart home devices connected to and controllable by them were also frequently located there. Other rooms in which additional devices were used were the (separate) kitchen, the bedroom, and the bathroom. In these locations, they were mainly used to listen to music and to retrieve weather information or news.

In the kitchen, organizational tasks such as calendar functions and shopping lists were used more frequently in addition to the timer function. For example, one participant from the household surveyed who used an Amazon Echo Show in the kitchen reported, "While I'm waiting for coffee in the kitchen in the morning and I see the photos from the

last vacation on Alexa, that's always nice. Then I also always check for the appointments coming up today and the weather." (H3) However, its use for cooking seemed less interesting because the biggest barrier to this was the lack of visuals and users would prefer to have the recipe in a readable format in front of them or at least see what the finished dish should look like. Nevertheless, even the household with an Echo Show (H3) did not use it for this purpose, since cooking by recipe was less common here.

Some Alexa users reported that Google or Siri on the smartphone or tablet provided better answers to questions, and Alexa was often unable to answer questions, at least at the beginning. One user attributed this to the search engine "Bing" used with Alexa, which would deliver fewer good results than a Google search (H2). This subsequently influenced the use of the devices, so that devices other than the voice assistant were used to retrieve information. One household owned both voice assistants, as the Google Home Assistant was purchased at an additional discount as part of a special offer. This offered them the opportunity to try out both systems. At the time of the interview, however, Alexa was used almost exclusively, as it was connected to more devices at the household and, in his opinion, the setup and connection with other devices worked more easily.

Interestingly, another planned purchase of a voice assistant was frequently mentioned for the bathroom, as here too is a purely verbal control of the voice assistants advantageous, particularly for playing music or reading out messages while showering. Two households had also already taken their voice assistant with them on vacation to use it for music, weather information, and to find out the opening hours of nearby stores and sights.

Satisfaction with the interaction. Overall, the participants indicated that they were satisfied with the interaction. However, they also reported that the commands used were often very short and self-contained, in which the assistant responds to a command and then the interaction is already finished. The interaction was more fluid after an initial familiarization period, so that the pauses after the activation word "Ok,

Google" or "Hey Alexa" became shorter and eye contact with the device was no longer necessary. According to the interviewees, the more concise and precise the command, the better the voice assistant understood. Due to this short duration and the character as an 'action-reaction' interaction, only a low anthropomorphism was recognizable among the users with regard to the voice assistant. Thus, during the interviews, paraphrases such as "die Tante" ("that broad") (H8), "Dörte" (H2), or more often the personal pronoun 'she' were used, but this was more likely due to an avoidance of the command words (so that the assistants would not be "woken up"). However, some users also wished that manners such as "please" and "thank you" were used by the voice assistant, as they feared that their own speech behavior would be curtailed as a result or that the short, command-like statements could have a negative influence on the way children express themselves and speak.

Viewing the interaction log. In the second part of the interview, the interaction log of the previous four to six weeks was viewed with seven of the interviewed households. Although the participants were largely aware of the possibility of viewing it, it was rarely used before the interviews. Thus, some were surprised at the type and amount of data that was generated and stored, even for a period of four to six weeks. It thus also made them aware of the frequent use of the assistants. Frequently, the interactions seen here were limited to simple commands (such as play music, set timer), which then usually succeeded due to the routine. The visual representation of the interactions as a chronological list in the app and on the PC, however, was perceived as very confusing, so that it was difficult to get an overview and identify misunderstandings in the mass of entries.

5.4.2 Strategies for Successful Interaction and Dealing with Misunderstandings

Appropriation of voice commands. After the initial phase, which was characterized by trying out and testing many functions and apps, routine crept in during use. For example, some participants reported that although some applications were still installed, they were no longer

used because they could not assert themselves against the usual way of doing things, such as writing a shopping list by hand or switching on the light using an analog switch. It was also pointed out that their use was sometimes too cumbersome and time-consuming, for example, when all channels with their planned content were recited when asked about the TV program. This was perceived as taking up too much time for participants. The functions used on a daily basis, such as playing music, controlling lights, setting a timer or asking about the weather, caused fewer problems. Overall, the interaction worked well from the participants' point of view. They reported that they had become accustomed to speaking as clearly, distinctly and precisely as possible during the interaction in order to avoid misunderstandings. Failed interactions usually led to the users repeating their statement at first and speaking slower and louder with each further repetition required and turning more towards the voice assistant, for example by making eye contact: "Sometimes I talk to it like a toddler and stand right in front of it." (H3). Or: "I then talk in a different tone of voice, somehow more like a drill sergeant." (H5).

In another household (H3), a list of possible and working commands represented a guide to use and, at the same time, a strategy to avoid misunderstandings. It was created by the main user for the rest of the family members to learn the correct commands (see Figure 5).

In this figure are shown possible commands divided by places of use. The second column lists the possible activities, followed by the wake-up word (column 3) and the required command (in column 4). A fifth column contains additional information, e.g. what happens when the command is spoken (light on/off or dimming) or information about subsequent possible actions, such as reaching for the remote control after switching on the TV. The commands were often chosen very individually (e.g., „Schicht im Schacht“ ("That's it") or „fahre Esszimmer hoch / runter“ ("shut up the dining room")), but also illustrate the necessary short and clear formulation of the commands.

In order to start music playlists with special names or to play special song titles, there were also comprehension difficulties if these were

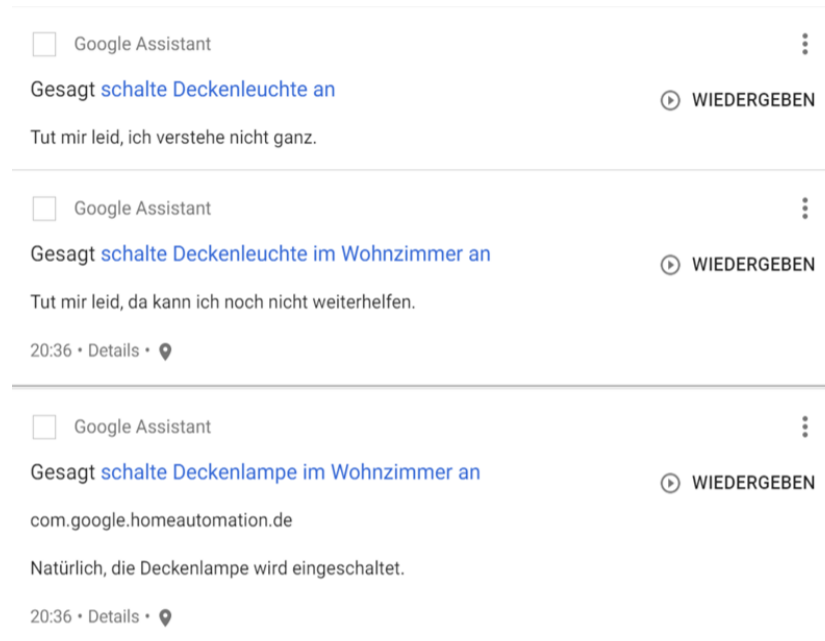
SmartHome			
Raum	Aktion	Befehl	Info
Wohnzimmer	TV einschalten	Alexa, TV/Fernseher einschalten	Dann mit Fernbedienung
	Musik Einschalten.	es ist Zeit für Musik	Gerät einschalten
	DVD, amazon netflix	starte Filmabend.	Dann mit Fernbedienung
	Stehlampe an	schalte Stehlampe an	
	Buntes licht	schalte Blaueslicht ein.	
	Wohnzimmer Ecke aus	Schicht im Schacht.	
	Geräte beim TV bedienen	"multimedia bedienung" mit Harmony	Bedienung TV, Analge, STB
	Licht Wohnzimmer aus	aus die Maus.	Steckdosenlichter aus
Esszimmer	Licht	schalte Kronleuchter/Esszimmerlicht ein/aus	ein und ausschalten
		Kronleuchter/Esszimmerlicht auf 60%	dimmen
	Rollladen	fahre Esszimmer hoch / runter	Rolladen hoch/runter fahren
		stelle Esszimmer auf 60%	auf bestimmte Höhe stellen
Allgemein	Rolläden Sonne	die Sonne scheint.	Fährt die Rolläden auf 50%
	Haus in den Nachtmodus	Gute Nacht	
	Morgens	es ist Frühstückzeit	

Figure 5

A self-made overview shows household members possible commands (Excerpt). (H3)

in English or less well-known "[...] because I speak German and the bands usually have English names or English titles, [...]." (H1). When controlling lights, shutters or technical devices, it was more frequently criticized that only those terms can be used that are also given as commands in the settings, which affected the natural flow of conversation and led to slightly altered repetitions in the choice of words until the correct word was found (see Figure 6). The participant commented on this, "You can only use the stored words, so if you accidentally say light instead of lamp, it won't understand." (H1) Another participant reported that long or compound words are often not understood: "The words aren't supposed to be too long. She often didn't understand 'living room ceiling light', so we changed the command and now say 'switch on the light in the living room'." (H3) As a consequence, the terms were changed to simpler or clearer terms. One user described that it happened that several appliances reacted when she was not specific enough: "Sometimes both devices react, so kitchen and living room, and then all the lights are turned off." (H9) These examples highlight the overall lack of freedom in interacting with voice assistants, making it clear that the user must adapt to the its capabilities.

Complex interactions. Longer or open conversations rarely took place. For example, users reported that Alexa more often does not know the answer to questions and that the participants therefore must resort to

**Figure 6**

During the interaction, the user is strongly bound to the command words. (H1)

textual input on the smartphone or tablet in such cases, since questions and possible queries cannot be answered via voice interaction. Typically asked questions related, for example, to the capitals of different countries, the meanings of names or information on famous people. Individual attempts to cook a dish according to a recipe failed due to the lack of flexibility in asking for the information needed in the situation.

As an example, a more complex interaction is shown and described in Figure 7 between a user and the voice assistant. The user tried to bake muffins with the help of Chefkoch and Google Assistant. First, she tried to get a recipe directly via Google Assistant but was unsuccessful. She then started the third-party service "Chefkoch" and received three suggestions when she asked for a quick muffin recipe. During the joint review of the interaction log, the user remarked that she would have liked to know what criteria were used to select the recipes, as there were over 800 muffin recipes on the Chefkoch website, for example. She chose the first recipe from the suggestions, whereupon she was given user ratings and information on preparation time. She was also

asked whether the ingredients should be read out or whether she would like to start preparing them.

The user asked for the ingredients, whereupon the assistant asked her for the number of servings. This is where the misunderstandings in the interaction began, since her answer "12 muffins" was not understood by the voice assistant several times despite inquiries and repetitions. However, until the portions were specified, the interaction was successful. And although the quantity was correctly understood, it ultimately failed because of the word "muffins" and the variants "Daumen" ("thumbs") and "Metaphern" ("metaphors"), which were understood by the voice assistant, but were only recognized as understood terms by viewing the interaction log during the interviews. After the failed attempts, the voice assistant finally closed without any feedback. As the user reported in the interview, in this situation she also did not know what exactly was meant by a portion, because for her it could refer to the number of baking tins, muffins or people.

Misbehavior due to incorrect activation. In some cases, users reported that the voice assistant occasionally "went off by itself" (H6) when the TV or music was on, or they were having a conversation with bystanders. For example, if a character in a series was named Alex, the Alexa voice assistant often recognized it as a waking word. In most cases, the voice assistant responded that it did not understand anything. In some cases, however, the assistant also gave answers to what it had understood, as is shown in Figure 8. In this case, Alexa had understood and processed the command "Hallo also gib skills jetzt Noch" "Hello so give skills now Noch" after the waking word, whereupon information about Noch GmbH & Co KG in Wangen was played back, although the user (H3) had not addressed the voice assistant directly.

**Figure 7**

Interaction log of a user with Google Assistant and the skill 'Chefkoch' while attempting to baking muffins. (H5)

**Figure 8**

The voice assistant (here Alexa) partially responds to spoken words that were not addressed to it. (H3)

5.5 Discussion

The interviews showed that the decision for the purchase of a VA system was often based on people's awareness of it (especially with Amazon Alexa). However, the existing ecosystem of services and hardware in the user environment, into which the voice assistant system can be better integrated, also played an important role [89, 207]. In this context, the living room and (connected) kitchen offer a lot of potential for use, since these usually also represent the heart of the home. The greatest benefit – as already shown in previous studies by Bodendörfer [40] and Pearl [241] and also according to the interviewed users, is that control and information acquisition is purely by speech, so that no further physical actions are necessary (e.g., the use of hands). Thus, one original consideration was that the voice assistant could effectively

assist with cooking. However, in the sample in this study, kitchen use focused almost exclusively on setting a timer and listening to music. In some cases, people in a household used the voice assistant for a shared shopping list. The biggest barrier to its use for cooking or open interactions in general is the lack of visualization. However, the only screen voice assistant available at the time of the interviews (Echo Show from Amazon) turned out to be too expensive and did not seem worthwhile compared to other devices already available, such as a tablet or smartphone.

The research confirmed previous studies in that there is often disillusionment with the capabilities of the voice assistant, as the high expectations regarding capabilities and understanding were mostly disappointed [35, 71, 215]. To this end, it was possible to highlight that interaction often reduced to short, closed sequences – mainly because users failed at more complex interactions and limited their expectations according to the capabilities. As examples of this, more complex tasks were identified such as cooking according to a recipe or the problem of making precise inquiries about a TV program of certain channels. For these, it was shown that controllability and flexibility in conversation were missing or insufficient, as the voice assistant quickly reached the limits of its conversational skills [215, 265]. This could be seen across different interactions. The examples listed illustrate that the fundamentally broad usage potential of voice assistants is slowed down by the fact that speech recognition is in great need of optimization and there is a lack of openness regarding the interaction, which means that there is still a need for further research and development.

Despite the identified problems, the surveyed users were found to be satisfied with the interaction overall once they understood the voice control and the possible commands and expressions. In line with previous studies [243], users adapted to the capabilities of the voice assistants. In this study, further insights were provided, especially regarding the handling of misunderstandings. Since questions and instructions need to be spoken precisely, and in a specific way as possible, trying new interactions is often unsuccessful and users quickly fall back to fa-

miliar interactions. This behavior indicates a low tolerance level for new functions on the user side due to anticipated misunderstandings.

Problems also seem to exist with English-language terms, which the German-speaking assistant does not always understand correctly. Thus, misunderstandings occurred especially with unfamiliar music titles or bands, and also for the cooking example from Figure 7, where it can be assumed that the voice assistant misunderstood the word muffins and interpreted it as a German term (such as thumbs or metaphors). Nonetheless, the participants reported improved understanding of commands by the voice assistant over time, which can be attributed to their growing experience with the technology in addition to technical updates. Users learnt over time which commands led to desired results and how to use them to avoid problems (such as using the right vocabulary). However, updates can cause occasional problems, such as when the vocabulary or interaction forms of voice apps change without appropriate communication to the user. The learning cycle would then sometimes have to start all over again. This can be seen as a clear indication that there is a need for appropriation support for voice assistants, for which a deeper analysis of usability problems can provide further information.

A common reason for usability problems is that the support and guidance provided by the voice assistant often do not follow the user's logic. At the same time, the user often does not know what the voice assistant has not understood or what information is still missing. Instead, the voice assistant ends the interaction – sometimes without comment. Such problems occur primarily with voice apps from third-party providers, as these have to be accessed in a more complicated way by additionally mentioning their name and require different interaction strategies in each case. The lack of freedom in choice of words (e.g., variation between light, lamp, and luminaire) also poses problems for users. Based on the examples presented, it has been shown that communicative understanding plays an important role in the interaction with voice assistants [157] and users can build trust in the technology through tools such as an overview (see Figure 5) of possible commands. Misunderstandings in this context are often non-transparent and com-

municated with an "I didn't understand that", with no suggested solutions mentioned. Various approaches to prevent misunderstandings or incorrect interactions could be investigated, in which the voice assistant asks questions, asks to repeat, visually displays the misunderstood statement on another device, or plays it back to the user in order to reveal the error. [14]. In a similar way, Google Assistant already sends search queries to the device connected to the voice assistant, for example, when it searches for nearby restaurants.

The assumption that the user views the voice assistant primarily as a tool [322] was confirmed in this study. Nevertheless, there were indications on the part of the user of a perceived social situation when interacting, whether through the high expectations set in advance for the intelligence of the voice assistant or through the manner of speech and expression [227] or the desire for certain modes of expression on its part. Due to speech as an everyday practice, it also happens again and again that users tended to move into natural, open, and flexible interaction despite the limited and predetermined possibilities if they did not express themselves correctly enough, which is illustrated by the misunderstandings and misbehaviors pointed out.

5.6 Conclusion and Outlook

The study shows that voice assistants are embedded as an integral part of everyday life among users due to their central placement in the living environment (especially living room + kitchen) and the high level of satisfaction despite limitations in any interaction. The locations of use and the structures of the households studied were quite homogeneous. Users trust the functionality of the voice assistant mainly because they have adapted to its capabilities and mainly use simple commands, as more complex instructions often still lead to misbehavior [243]. Expectations of interaction are based on natural inter-human interaction, and disillusionment with the capabilities of the technology often occurred quickly. At the beginning of the appropriation process, users were often rather unclear about the functions and capabilities of the voice assistant.

The grounded theory approach followed in this study does not strive for generalizability, but exploratively uncovers strategies that users use to address and avoid misunderstandings. In addition to the experience reports, the reflection of the interaction log played an important role. Future work should, for example, be focused more on a specific context of use, such as watching television, cooking, or controlling smart home devices, so that these can be examined in greater depth and thus enable quantifiable statements to be made, also with recourse to usability scales (e.g., AttrakDiff, System Usability Scale), or the anchoring of usability problems in the dialog principles of DIN EN ISO 9241-110).

Dealing with misunderstandings. Through the study, it was possible to show examples of which strategies are used in households to deal with and prevent misunderstandings. This involves, on the one hand, how users deal with misbehavior and misunderstandings and, on the other hand, how they establish a successful interaction with the voice assistant. Currently, there is a lack of support options that show in which way users can interact with the voice assistant with the shortest possible commands. Furthermore, it could be observed that the user often lacks additional support or display media during the interaction (e.g., in the kitchen) that visualize further information, for example. In this way, the user could better understand content or receive solution or feedback options (e.g., by asking questions) in the case of incorrect interactions, as would happen in a natural, human interaction. For this, it would make sense to transfer solutions from the area of appropriation support to voice assistants. This could include showing users which voice apps and usage strategies other users are successfully using, thus supporting serendipity and shared learning around the use of the assistant [89]. For this, the artifacts that were analyzed provided interesting starting points for design, such as the list of commands created by users themselves, which could be automated based on interaction log and presented to users appropriately.

Orientation to natural interaction. Furthermore, it was also shown that social and anthropomorphic aspects also play a role in the interaction with voice assistants. These should therefore be taken into account when designing usable speech interfaces [253]. Also according

to Luhmann's communication theory approach, personification of people and things leads to a reduction of complexity and thus makes action predictable [187]. Users also need more flexibility in interaction. Currently, for example, synonyms still have to be entered manually for a command, such as "light" or "lamp" for "light", in order to be understood. Here, it would be helpful if common synonyms for terms are linked or can be stored so that the interaction works more smoothly and is less error-prone. Currently, the user has to adapt to the assistant, which should not be the case in terms of user-centered design.

Interaction history as an informative analysis tool. Due to the often short, routine interactions as well as the self-restraint of the users, misunderstandings and failed interactions occur relatively rarely in everyday life. Therefore, especially the approach used in this work of analyzing interaction histories in combination with in-depth interviews offers interesting insights into usage problems and improvement opportunities. The heart of the participants' homes – the living room (in some cases with a connected kitchen) – turned out to be the most frequent location for the voice assistant. This offers many possible applications for requesting information and other potential uses. It was shown in this work, for example, that pure voice interaction in the kitchen quickly reaches its limits and that it may therefore be necessary to combine the voice assistant with other modalities such as a screen or a smartphone [75].

Finally, the examination of the interaction log showed that the display is very confusing and also not easily accessible. For example, searching for specific situations mentioned in the interview proved difficult, as these could not be specifically searched for or displayed. For further studies, it could be helpful to prepare the data accordingly and focus on specific interactions such as misunderstood commands or topics (e.g., kitchen context). This would not only provide users with an easier way to view their data but would also create more transparency in the collection of user data. So far, with the interaction log, users can mainly view their interactions, delete them, or provide feedback on whether they were successful. Further evaluation should be carried out on how this data can be better utilized for both users and research.

6 Finding, Getting and Understanding – The User Journey for the GDPR's Right to Access

Abstract

In both data protection law and research of usable privacy, awareness and control over the collection and use of personal data are understood to be cornerstones of digital sovereignty. For example, the European General Data Protection Regulation (GDPR) provides data subjects with the right to access data collected by organizations but remains unclear on the concrete process design. However, the design of data subject rights is crucial when it comes to the ability of customers to exercise their right and fulfil regulatory aims such as transparency. To learn more about user needs in implementing the right to access as per GDPR, we conducted a two-step study. First, we defined a five-phase user experience journey regarding the right to access: finding, authentication, request, access, and data use. Second, and based on this model, 59 participants exercised their right to access and evaluated the usability of each phase. Drawing on 422 datasets spanning 139 organizations, our results show several interdependencies of process design and user satisfaction. Thereby, our insights inform the community of usable privacy and especially the design of the right to access with a first, yet robust, empirical body.

6.1 Introduction

The collection and processing of personal data for commercial purposes is an increasingly widespread phenomenon that is becoming more important for companies associated with both digital and non-digital products across all sectors. New, connected “smart” products that collect and exchange detailed personal data—such as smart fitness trackers [208], smart home systems [59], or connected cars [152] — contribute to this trend.

In both data protection law and research of usable privacy, the awareness of [21, 261, 99, 119, 258, 284, 301] and control over [53, 107, 166, 277, 303, 304, 331, 343] the collection and use of personal data are understood to be cornerstones of digital sovereignty. For example, the European General Data Protection Regulation (GDPR) provides data subjects with the right to access data collected by organizations. In this vein, GDPR provides general guidelines for implementing the right to access, such as adequate levels of authentication, pieces of information to provide, and more generally the provision in “concise, transparent, intelligible and easily accessible form, using clear and plain language” in Art. 12 (1) GDPR. Regarding the design of the process of exercising data subject rights such as the right to access, Art. 12 (2) GDPR highlights that the respective data “controller shall facilitate the exercise.” Lawmakers thus generally see controllers as responsible for helping their users exercise their right to access.

However, for companies and organizations in general, this new framework raises uncertainty regarding requirements for compliance with the regulation. For the case of the right to access data, organizations need to implement a process for users to claim their data, but it is still unclear how such a subject access request (SAR) process should be designed, how authentication should work, how data should be requested, provided, presented, and explained to customers in a compliant and customer-friendly way.

Usability studies reflect that process design is crucial for users being able to complete an interaction [20, 143]. However, little is known

about the factors facilitating or hindering SARs in terms of process design. Insights about factors such as user needs and capabilities are highly useful not only from a research perspective, but also for organizations to use data protection as a competitive advantage by optimizing their customer experience [124, 154, 156]. While there is some research on usability of dashboard solutions for addressing data subject rights, the market adoption of such generally desirable solutions has been low. Vitale et al. designed a prototypical data dashboard that helps support people in organizing their data from different platforms and devices but is focused more on data curation than on aspects of usability due to its prototypic appearance [346]. Raschke et al. also designed, implemented, and evaluated a privacy dashboard intended to enable and ease the execution of data protection rights [264]. Similarly, Pins et al. found that existing dashboards through which companies allow their customers to look into their interaction data with voice assistants are difficult to use [248]. Regarding manual SARs, Alizadeh et al. looked at user satisfaction with SAR data from loyalty card providers; the sample, however, was rather small, which did not allow for a structured analysis in terms of usability [14]. There is even less research that adopts a processual view for assessing handling SARs. The findings from these studies often highlight that many companies are non-responsive or fail to comply with other legal provisions. For example, Urban et al. looked at the responsive behavior of online ad companies and the data they provide [339]. Kröger et al. [168] ran a longitudinal study on app vendors, looking at response behavior, data sharing practices, authentication, and transmission security.

Our work contributes to the design science research [169, 269, 341] on the implementation of the GDPR. We carry out an empirical study in two-step to analyse in the third step the implications for design. Our goal is to inform designers about process design decisions that facilitate or hinder usable access as well as transparency about data collection and use in light of user needs and capabilities.

6.2 Design Science Methodology

Design is a learning process in which user research is used to derive empirical grounded design guidelines and recommendation. The major difference between commercial design and academic design research is the former aims to solve a specific problem, whereas the latter aims to provide actionable design knowledge [125, 269] and summarizing insights and lessons learned in the form of design guidelines at the end of the paper.

In our study, we adopt the Grounded Design (GD) approach [269, 315, 364] as a specific variant of Design Science Research (DSR) methodology [169, 269, 341]. The GD Approach comprises three parts: (1) problem diagnosis to understand the design and use context, (2) action taking to design and using artefacts in an iterative way, and (3) evaluation to understand the appropriation of the design artefact.

The problem diagnosis phase present an essential part of the design research where the design context, the problem, its causes, and consequences will be analyzed [169, 341]. The design of digital systems poses a challenge that must be equally technically feasible, economically viable, as well as desirable and usable to the users [221]. These characteristics are not necessarily congruent. Hence, an essential part of the design process is to understand the design context from the user's perspective. For this reason, in this phase the GD approach [269] suggest using explorative user research methods, to understand the user's practices covering user's perception but also her actual observable behavior as well as the socio-material context that shapes this behavior. The problem diagnosis provides insight into what the problem is, but not what the solution should be.

To bridge the gap between descriptive and prescriptive knowledge, the second essential part of DSR involves exploring potential solutions of the problems identified in the diagnosis phase [169, 341]. Design concepts and guidelines can be developed in various ways. For instance, in a top-down manner they can be deduced from proven kernel theories [126]. GD provide an alternative way [308, 315]. Standing in the

tradition of grounded theory, GD argues to develop design theories in a button-up manner, abduct them from the explorative user research. In general, the scope of validity and applicability of such design concept and guidelines are typically smaller than the one of behavioral theories such as the theory of planned behavior [10]. For this reason, Gregor und Hevner [126] describe design guidelines as mid-range, nascent design theory.

In this paper we are focusing on the diagnosis phase. Following the recommendations of the GD approach, we carry out an explorative user research. This user research was operationalized by a two-step study about user needs in the implementation of the right to access as per the GDPR. In the first step (see Section 6.3) we define from the GDPR, the literature, and heuristic evaluation, an SAR user experience journey which includes five touchpoints. In a second step (see Section 6.4), we asked 60 undergraduates to carry out and document their SAR experience, where each touchpoint was evaluated by a modified system usability scale (SUS). After data cleaning, the sample of our study includes 422 SAR evaluation sheets of 59 undergraduates. The findings shed light on the role that the right to access has for privacy control as perceived by users, report user expectations regarding the design of a usable process of SAR and explore potentials for supporting intelligible and transparent design of the data archives provided.

To bridge the gap between what is and what should be, we discuss these findings regarding the implications for design and abduct design guideline that should give design researcher and practitioners an orientation (see Section 6.6). These guidelines highlight the need for connecting HCI research with legislation to assess the effectiveness of measures as demanded in Art.12 GDPR and also Art. 25 (1) GDPR.

6.3 State of the Art on Usable Privacy and the Right to Access

In this section we outline the concepts and protective aims of the right to access as per the EU GDPR. Second, we survey the research on con-

trol and awareness in the realm of usable privacy and how our study contributes to research in the field of GDPR data subject rights.

6.3.1 Data Subject Rights in the European General Data Privacy Regulation

The GDPR introduces new consumer rights. For example, Art. 20 GDPR introduces a new right to request data for transfer to other organizations — the right to portability. This right is intended to increase — but not exclusively — data protection competition among organizations. It obliges data controllers to make personally identifiable information available to the new service provider in a structured, common, machine-readable format as much possible [347]. Overall, Chapter 3 of the GDPR introduces four rights for data subjects:

1. The right for transparent information provides the data subjects with a concise, transparent, intelligible, and easily accessible form of any communication and information related to processing their personal data using clear and plain language.
2. The right to correction and deletion enables the data subjects to have their incomplete or unwanted personal data completed or erased without undue delay.
3. The right to object to automated decision making allows the data subjects to object at any time to the processing of personal data concerning him or her, especially where personal data are processed for direct marketing purposes, including profiling.
4. The right to access personal data grants data subjects the right to claim personally identifiable information collected by an organization in a precise, transparent, understandable, and easily accessible form in clear and simple language.

For each case, many terms are open for interpretation when it comes to implementation. Currently, there is still much to be done to reduce uncertainty about which measures will be judged as sufficiently compliant

with concepts such as “understandable”, “transparent”, and “accessible” in court — all the more so as these terms partly overlap, depending on the content [347]. While legislation has been in place for some time, it remains unclear how to design SAR processes that comply with both the GDPR and users’ demand for privacy, for example, in terms of facilitation by the controller and transparency of data collection and use. According to Article 12 of the GDPR, the controller shall provide information about actions taken regarding the SAR without undue delay and within one month of receipt of the request. Moreover, Article 15 of the GDPR requires that the process of claiming data will result in information being provided “in a concise, transparent, intelligible and easily accessible form”.

Criteria for easy access could largely be subsumed under usability criteria and the way to design the process of claiming data. Previous studies show that consumers often do not fully know what data is collected about them, and this in turn may lead to anxiety and concern [217]. Accordingly, consumer trust may be increased by designing products and services with transparency in mind [217]. Creating transparency and intelligibility, however, imposes rather complex and abstract requirements [34, 151], especially given that non-programming users often struggle to understand information flow on the internet in general [158].

6.3.2 Control, Awareness, and the Right to Access in Usable Privacy

Concerning usable privacy research within the HCI community, control [53, 107, 166, 277, 303, 304, 331, 343] and awareness [21, 261, 99, 119, 258, 284, 301] about data collection and use are cornerstones of its research; this research often takes a user-centered perspective to design usable solutions.

Traditional fields of research include improving privacy policies [267, 283] and password usability [7, 26, 295]. Particularly with increasing amounts of data being collected and used, studies have also started to investigate the design of supporting users in their struggle to make

sense of data [335] by means of adequate and flexible visualizations [148, 264]. For example, Angulo et al. built a data tracking tool that displayed an overview of a user's data disclosures to different online service providers and provided them with the collected data about them [21]. Similarly, awareness and control of data disclosure on the mobile phone interface is a widely explored context [28, 103, 94]. In this regard, Bentzing et al. compared application designs to investigate how increasing transparency can influence users' privacy-related behavior on mobile phones [37]. Felt et al. [103] conducted an extensive survey of the diverse strengths and weaknesses of design alternatives. Similar studies targeting the support of data and privacy awareness have been conducted in the area of smart home data [151, 335] and smart metering [150].

However, relatively few studies so far have explicitly targeted the implementation of provisions and data subject rights provided by the GDPR. These are especially interesting, as the GDPR itself provides that its own implementation should be designed in an "effective" manner [98], which arguably the community of usable privacy researchers is predestined to investigate, given that well-researched yet abstract concepts of awareness and control are also deeply enshrined in GDPR. For example, a usable implementation of the principle of purpose limitation has been investigated using the example of data processing of voice assistants [153]. Moreover, the data subject rights in GDPR are currently being researched, such as the right to data portability [359, 80]. Closely related to the right to access data, transparency-enhancing tools have been proposed — mostly following a dashboard approach. For example, similar to the usable privacy dashboard by Raschke et al. [264] mentioned above, Olausson developed a dashboard specifically targeting nurses' work [235]. Tolsdorf et al. [336] qualitatively compared ten implementations of dashboards, comparing their levels of compliance. Still, dashboard implementations are scarce in practice and are often only adopted by big players on the market. Looking at manual SARs, Alizadeh et al. interviewed customers of German loyalty card systems, who were asked to make use of their right to access [14]. The scope of the study, however, is limited to a single organization, focusing on

how data is provided and the potential to help users with their privacy practices. With a similar perspective on supporting sense-making and data literacy, Pins et al. [249] designed and tested a prototype that visualizes the interaction with voice assistants based on data of SARs from Amazon Alexa and Google Assistant.

6.3.3 Research Gap: Effectiveness of the Right to Access from a User Perspective

In general, investigations into the provisions of the GDPR from a consumer perspective in the field of usable privacy are scarce. Existing studies that adopt a consumer perspective on the right to access largely ignore the challenge of getting data in the first place. Instead, studies focus either on the compatibility of the data provided as a result of the SAR with user demands in terms of supporting privacy practices and data literacy [14, 249] – or they take the provision of data for granted by building dashboards on top of the data [264]. The study closest to our approach, Urban et al. [339], contacted 39 companies to check for several SAR parameters such as response time, reaction to questions, and the disclosed information in the context of online advertisement. Similar work has been done by Kröger et al. [168] for app vendors who conducted a longitudinal study on several SAR items such as response time, data provided, and security mechanisms. However, these studies do not apply a processual lens, nor do they evaluate the phases they identify in a user-centered way; instead, these studies merely check against legal provisions. To the best of our knowledge, there are no large-scale studies on usability assessments of the implementation of SAR processes. Moreover, there is currently no structured approach for evaluating the design factors that drive or hinder users when conducting SARs. This information, however, is relevant both from the standpoint of research on usable privacy as well as for assessing the controller's role in facilitating the user in this process, as demanded in the GDPR.

6.4 Getting the Data: The User Experience Journey

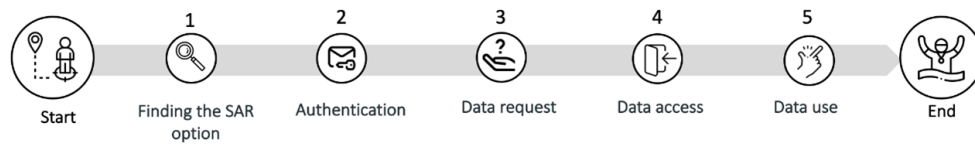
6.4.1 Procedure

To learn more about user needs in the implementation of processes for SARs, we started with a problem diagnosis according to the DSR by analyzing the implicit and explicit provisions of the GDPR. For instance, the GDPR defines the right to request an electronic copy of data by users, the need for authentication, as well as the expectation that the data should be provided within 30 days. While such specifications shape the user experience, they do not guide the implementation of an SAR process. For these reasons, three researchers individually carried out 10 SARs from various organizations to understand the procedure and current design practices so as to facilitate the problem diagnosis [341]. During the process each researcher documents his/her insight and creates a protocol of the most important steps. In a second step, we conducted a group discussion in which we compared the results. During this discussion, consensus was reached on what would be the major touchpoints that constitute the SAR User Experience Journey (see Appendix C). In sum, the identified touchpoints were experienced and documented in a similar way, deviations and inconsistencies in the procedure and naming of the touchpoints could be cleared up within the discussion. The only open point related to when the user should authenticate because there are several possible options in this regard. As this definition is based on the expert opinion of the researchers, our definition of the User Experience Journey is related epistemologically to the heuristic evaluation methodology, which involves a small set of evaluators to examine the user experience [231].

6.4.2 The User Experience Journey

As a result of our study, we identified five major touchpoints in the process of conducting an SAR as illustrated in Figure 9:

Finding the SAR option: One key challenge to kick off the process is finding the entry point to conduct an SAR. Arguably, this challenge is

**Figure 9**

The five major touchpoints in the user experience journey of a subject access request process

strongly influenced by where the user finds the needed information and what communication channels must be used to get that information, e.g., a website, phone, or e-mail. In addition to the challenge of finding the right place, the user experience can suffer if the information is not prominently presented, if it is described in a complex way, or if it uses terms unknown to the user such as “data controller” or “data subject.”

Authentication: Users need to provide authorization for the SAR to avoid misuse. This phase is directly informed by the GDPR. Often this task can be managed via an existing account with the service in question. In cases in which, for example, name-password combinations do not pre-exist, other methods must be used such as two-factor authentication; moreover, in non-digital environments (e.g., doctor or authorities), the authentication can be inconvenient, for example, requiring one’s passport or other documents for identification.

Data Request: For completing the SAR, the user must express her demand. At first glance, this seems trivial. Yet, this touchpoint will be more complex in practice. Therefore, this touchpoint focuses on the different steps to complete the SAR such as how it is implemented and supported by the organization. Further, user experience will be influenced by the provided feedback such as whether the request was received or what further steps will follow.

Data Access: Providing users with access to the data includes several aspects to consider. For example, once collected and set up, there is the question of how organizations inform users about the availability of the data (post, e-mail, app message, etc.). Moreover, there are different ways of providing data. For example, compressed folders can be

downloaded or are directly sent via mail or e-mail. These variations come with different challenges such as requesting large files or managing access control to the files. Additionally, there is no prescribed file format on the part of the GDPR in Art. 15 specifying what this copy of data should look like.

Data Use: Finally, after having received the data, utility of data for users must be subject to special scrutiny because it addresses the regulatory aim of providing users with transparency regarding data collection and use by data controllers. It is this phase that ultimately decides the process's main goal: informing users about potentially complex data.

The touchpoints have some logical order; for example, a data request must be carried out before the data can be provided and accessed. However, the steps do not fully determine the chronological order of the process, but alternative paths are possible. Authentication, for example, may have been completed by logging into a services homepage before finding the option to exercise the right to access.

6.5 Implementation of the User Experience Journey Study

In a second step, we conducted a user study, in which we asked the participants to exercise SARs and document their experience regarding the identified user experience journey touchpoints. This step further completed our problem diagnosis by exploring and uncovering usage and design issues in current data request solutions to better understand the problem space and identify user needs. In the following, we provide details about our participants, the adaption of the SUS to measure and document the user experience, the procedure, and ethical considerations in the process.

6.5.1 Method

Participants

Our participants were HCI and Information Systems master students in a course in Germany that presents lectures about the basics of usable

privacy using the organizational implementation GDPR as a case study. The course was conducted between October 2020 and January 2021. We asked the students to exercise their right to access with up to 10 organizations and assess the user experience of the whole process. We give this task quite early (in the second session of the course) to make sure participants would be able to complete the SAR process and thus their documentation. Because organizations have up to three months to fulfill data subject requests, we asked the students to fill out the touchpoints-related SUS and questions as soon as they completed it. Beyond that, students had two more months (end of March) to submit their fulfilled questionnaires. We did not impose any restrictions on the selection of organizations (see the following ethical considerations), but we did ask them to identify organizations that were potentially interesting to them personally.

Overall, we collected a total of 454 SAR evaluations by 60 participants (min = 1, max = 11, avg. contributed = 7.55). After data cleaning and data preparation, we included 422 evaluations by 59 participants in the analysis.

Ethical Considerations

Working with the right to access may bring researchers into contact with sensitive information. We took several steps to safeguard the privacy of the participants. Since we were only interested in the process design and its user experience, we refrained for privacy reasons from looking into the data. Instead, we asked for file types and information categories provided, such as “name” and “address” in a “yes/no” manner. To further strengthen the privacy of our participants, we let them freely choose which organizations to contact and exclude any services they were uncomfortable disclosing their relationship with.

While there was a guideline of aiming for 10 SAR evaluations, we did not treat this as a criterion for course completion and it did not have any influence on the grades if less (or more) than 10 documentation sheets were provided. Since the documentary sheet was also important for their overall coursework, it was in the students’ best interest to have

these sheets filled in order to serve as a basis for the creation phase when improving the SAR process user experience.

An ethics application was submitted to the Ethics Board of the University of Siegen. From their point of view, no vote is required for this study.

Measuring the User Experience

For measuring the user experience of the user journey, we provided an Excel sheet that featured a modified SUS questionnaire for each for the first four phases and one for evaluating the overall experience. SUS is a “de facto standard” [47] for measuring the usability of systems according to ISO norm 9241-11 [145] and was created by John Brooke [46]. The result of the questionnaire is a score between 0 and 100, where a score of 68 is commonly seen as average and, consequently, values above 68 represent good usability [280]. Its generalizability of use is supported by the fact that SUS has already been used in numerous studies [46, 281]. We further decided to use the SUS as it allows comparison of different products and services due to the generic wording of the statements — even with small sample sizes [280]. This was important as it was not clear what different kinds of solutions or ways of requesting the data exist, how many different organizations were contacted, and by how many participants.

For our study – and to evaluate the process of requesting – we made some modifications of the questionnaire statements, as can be seen in Appendix B. For instance, we excluded the question about the potential frequency of use as the GDPR’s data subject rights are limited by law against unreasonably frequent use with organizations being allowed to reject or charge a reasonable fee for requests (Article 15 (3) GDPR).

Questionnaire Design

For an initial overview, we asked the participants to document some basic information about the organization (e.g., the name and type), the data provided (such as the volume), the time needed to conduct the SAR, the purposes stated for use of data, and the provided file formats.

We used SUS to rate the overall user experience as well as the touch-

points “finding”, “authentication”, “request”, and “access”. To allow comparison, the questions were presented as a 5-point Likert scale, with answers ranging from “strongly disagree” to “strongly agree”. For each touchpoint, we ask four additional open questions to document details about shortcomings, personal perception, feelings, and ideas for improvements.

To reflect the regulatory goal of transparency, we also include the post-SAR activities defined as the “data use” touchpoint. Our aim was to evaluate the extent to which getting and using the data would contribute to users’ privacy practices and might ease potentially existing concerns about the data use of organizations. While privacy is a complex and multifaceted issue, for practical reasons we limit this section to the following three topics:

1. The first topic was about the contribution of the SAR process to the perceived data protection compliance of the organization. We see it as a minimum requirement that users perceive the overall process to at least pose a contribution to organizational compliance with the legal GDPR requirements.
2. The second topic was about the data provided contributing to improve the data literacy of the user. With the help of the SAR, the user should be able to examine whether the data collected match her expectations or lead to new insights.
3. Finally, the third topic covered behavioral changes. To find out if SAR could be a tool for privacy awareness and making potentially extensive data collection by organizations more transparent, we asked if the data provided had an impact on the users’ attitudes and privacy behavior.

Data Cleaning and Preparation

In total, we collected 454 SAR evaluations by 60 participants (min = 1, max = 11, avg. contributed = 7.55). Of these evaluations, 363 provided by 29 participants (min = 1, max = 10, avg. = 7.62 contributed) were fully complete. For most incomplete sheets, the comment section

revealed that data never was received. In other cases, participants left out sections where they were unable to rate the process step in question because they did not go through a process (e.g., when they were identified in person and not via a digital touchpoint or interaction). Given the exploratory character of our study, where such reasoning was provided, we included partially complete sheets for analysis in the sample, resulting overall in 422 SAR evaluations, conducted by a total of 59 students.

6.5.2 Findings

In the following, we provide an overview of our adjusted sample and insights into the evaluation of the different touchpoints, focusing on the SUS score.

Sample Characteristics

Our sample includes 422 SARs from 139 organizations. For a better overview, we clustered these into 11 organization types based on the participants' responses. Table 3 provides an overview about what organizations belong to what category. For reasons of space, further individual cases are partly indicated by "...".

Reflecting the special position of Google, Amazon, and Apple as providers of multiple and different services and products, we placed them in their own category of "Multi Service Providers."⁵ Although Facebook, Instagram, and WhatsApp, are part of the same organization, each of these services implements an independent SAR process, so we have treated them independently.

Most of the SARs targeted social media and messenger organizations, with Facebook as the most frequently contacted organization. Although we gave participants the freedom to choose the organizations for the SAR themselves, the table shows that primarily organizations for online services such as Amazon, eBay, PayPal, Duolingo, or Yahoo were selected. Nevertheless, there also were local organizations in our sam-

⁵Interestingly, no one requested his/her data from another international multi service provider, Microsoft.

Table 3

Overview about the sample

Category	SAR	Organizations	Volume [MB]	
	n	n name (SAR count)	Mdn	M
Total	422	139	1.0	1178.9
Social Media / Messenger	153	16 Facebook (41), LinkedIn (28), Instagram (23), WhatsApp (16), XING (8), Snapchat (7), Skype (6), Telegram (5), Pinterest (4), Dribbble (4), Slack (3), Twitter (3), Steam (2), Discord (1), ...	1.0	227.1
Multi Service Provider	74	3 Amazon (39), Google (29), Apple (6)	28.0	4708.1
E-Commerce	41	20 eBay (11), Zalando (9), Lieferando (2), Etsy (2), Rebuy (2), About you (1), Adidas (1), Alles Rahmen (1), Daraz.pk (1), dm drugstore (1), DefShop (1), Goodreads (1), ...	0.2	1.1
Finance / Payment	35	20 PayPal (12), Sparkasse (5), Access Bank PLC (1), Allied Bank Limited (1), BBVA Bancomer (1), Binance (1), FBNQuest (1), Deutsche Kreditbank Berlin (1), ...	0.7	2.4
Streaming / Entertainment	21	4 Spotify (11), Netflix (8), Blizzard Entertainment (1), Electronic Arts (1)	6.8	646.7
Travel / Tourism	20	13 DB (4), Booking.com (3), Airbnb (3), ADAC (1), Deutsche Lufthansa AG (1), Flixbus (1), MVV GmbH (1), Nextbike (1), Primera Plus (1), TIER (1), Uber (1), Waze (1)	0.2	0.2
Health / Insurance	17	16 Autoscout24 (1), Techniker Krankenkasse (2), AOK Bayern (1), AXA (1), Clue (1), DRK (NORD) (1), Gesetzliche Krankenkasse (1), Family Doctor (1), mhplus (1), Nürnberger (1), ...	0.3	1.1
Education / Learning	17	12 Duolingo (4), University (3), Coursera (1), CodeCademy (1), DataCamp (1), FH Aachen (1), Gymnasium Waldkraiburg (1), Wilhelm von Oranien Schule (1) Italki (1), ...	0.2	0.4
Cloud / Mobile Provider	15	11 Yahoo (4), Samsung (2), 1&1 (1), idrive (1), Dropbox (1), Lidl Connect (1), Mega (1), Personal Paraguay (1), Tigo Paraguay (1), Unitymedia (1), Vultr (1)	2.5	55.7
Job / Work	12	7 GitHub (4), Trello (3), Amila (1), Fiverr (1), Indeed (1), Miro (1), OCC Mundial (1)	0.3	33.8
Miscellaneous	17	17 Deutscher Evangelischer Kirchentag (1), Landessportbund NRW (1), McFit (1), openPetition (1), Philippine Embassy (1), Städtische Bühnen (1), Stadtverwaltung (1), ...	0.9	0.9

ple, such as family doctors, universities, banks, or sport and fitness clubs.

Our sample reflects the so-called data-opolies [320] as the data volume provided via the SAR is rather small and there are only a few exceptions with large file size. To quantify this phenomenon, we calculate

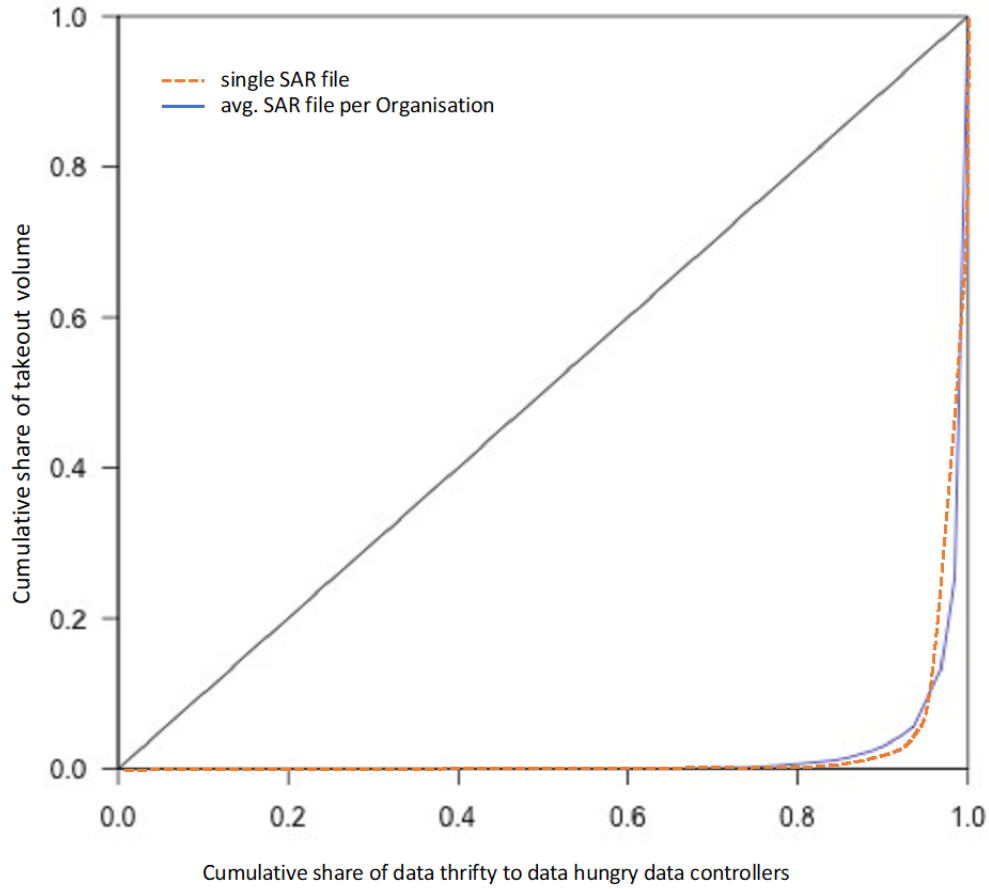


Figure 10

Lorenz Curve showing the high irregular data volume distribution of the sample

the Lorenz curve and the Gini index [211] as a measure for the concentration of the data-driven economy. Figure 10 shows that the Lorenz curves calculated by the single SAR files and by the average SAR file per organization are quite similar. The same holds for the corresponding Data Gini index (DGI), which is 0.95 in the case of the single SAR files and 0.96 in the case of the average SAR file for the organizations. As this value is near 1.0, it expresses the high irregular distribution of the data volume. For this reason, in Table 1 we provide both statistical average values, the mean, and the more robust median. The mean data volume in our sample was $M = 1.178$ GB; however, the median is just $Mdn = 1$ MB. This means that in 50% of the cases, the data provided was 1 MB or less in size.

Table 4

SUS evaluation for the individual touchpoints presented for the different organizational categories

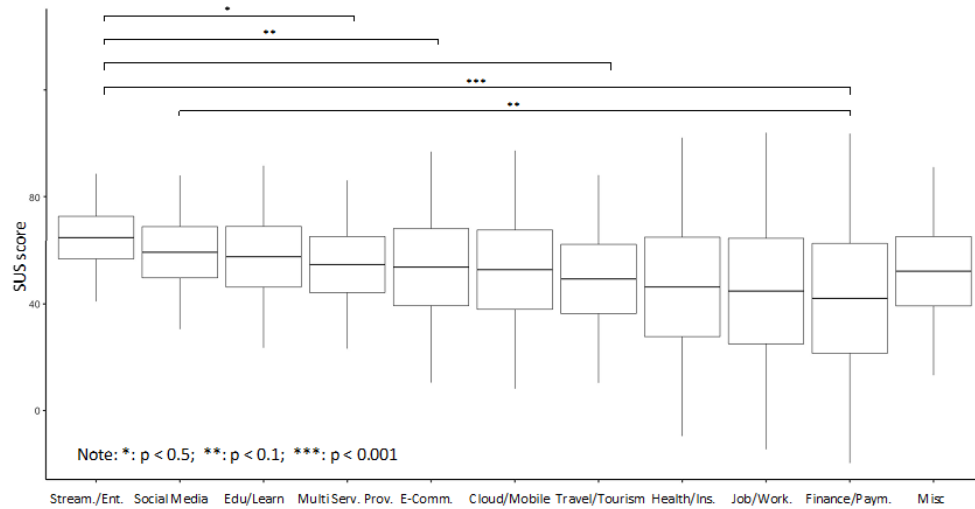
Category	Overall grade			Finding		Authentic.		Request		Access	
	M	SD		M	SD	M	SD	M	SD	M	SD
Total	F	55	14	45	12	56	11	53	12	51	11
Streaming / Entertainment	D	65	8	49	8	59	6	56	5	49	6
Social Media/ Messenger	F	59	10	50	10	57	8	56	8	51	11
Education / Learning	F	58	11	46	10	54	9	49	9	53	12
Multi Service Provider	F	55	11	44	11	56	10	54	10	47	11
E-Commerce	F	54	14	45	12	56	13	54	12	55	11
Cloud / Mobile Provider	F	53	15	45	9	57	10	53	10	55	10
Travel / Tourism	F	49	13	38	12	52	12	48	11	48	15
Health / Insurance	F	46	19	39	18	53	13	47	16	45	16
Job / Work	F	45	20	40	16	48	18	41	17	49	12
Finance / Payment	F	42	21	38	15	53	14	45	18	52	10
Miscellaneous	F	52	13	38	11	51	17	48	18	56	9

Note: We applied Bangor et al.'s grading scheme [30], ranging from A to F, where F is the lowest category with an SUS score below 60.

Overall Experience

The rating of the overall experience is low across all categories (see Table 4). Applying the grading scheme of Bangor et al. [30], all categories are graded F, which equals “not acceptable”. Only Streaming / Entertainment makes it to a D with a scoring of 65. Notably, “finding” the option to start the SAR scores lowest in all sections and has also been rated unacceptable for the best scoring categories. Surprisingly, the overall rating is higher than every single touchpoint except for authentication, which is higher.

The two top-rated categories are providing digital services only (Streaming / Entertainment, Social Media / Messenger), while the lowest-scoring categories are likely to contain highly sensitive data, as defined by GDPR (Health / Insurance, Job / Work, Finance / Payment). The one-way analysis of variance ($F(10, 390) = 8.42$; $p < .001$) showed that the organizational category has a significant impact on the SUS rating. The additional conducted Kruskal-Wallis rank sum test (Chi square = 940.13, $p < .001$, $df = 2$) showed the same result. As illustrated in Figure 11, Two-sided t-test (Bonferroni adjusted) showed a significant difference between the SUS score of the Streaming / Entertainment sector and the E-Commerce sector ($t(54.9) = 3.73$; $p < .001$; p_{adjusted}

**Figure 11**

The overall experience SUS scores for the different organizational categories

= .025), the Multi Service Provider sector ($t(41.8) = 4.74$; $p < .001$; $p.\text{adjusted} = .001$), the Travel / Tourism sector ($t(27.3) = 4.41$; $p < .001$; $p.\text{adjusted} = .008$), and the Finance / Payment sector ($t(41.7) = 5.57$; $p < .001$; $p.\text{adjusted} < .001$). There is also a significant difference between the SUS score of the Social Media / Messenger and the Finance / Payment sector pair ($t(32.7) = 4.56$, $p < .001$; $p.\text{adjusted} = .004$).

To add to the understanding of the overall rating, we explored the comment section. Comments stemming from negative SUS ratings were mostly highlighting the negative experience of a specific touchpoint. For instance, the participant of SAR 313 comments that in the case of Amazon, it was the most complicated task of all to find out how to initiate the SAR. Other participants noted that they liked to have more control and that more options should be available to tailor the SAR according to individual needs. Others offered surprising insights into the SAR data and mentioned specific design decisions they liked throughout the SAR process, such as that the process was easy and informative because the touchpoint could be found in the settings. Other participants were torn; on the one hand, they praised the little time needed to get through the SAR process while, on the other hand, they missed

information on their GDPR rights or the purpose of extensive data collection.

Finding

Of all touchpoints, the finding touchpoint scored lowest with a SUS of 45 in average ($sd = 12$; Table 4). The organizations of Finance / Payment had the worst SUS value ($avg = 38$, $sd = 15$), while Social Media / Messenger services performed best. But even here, the SUS value of $avg = 50$ ($sd = 10$) is still poor and falls into the lowest SUS category F.

A major reason for the SUS score seems to be that it takes a long time to find the place to apply for the SAR. On average, the finding process took between a couple of minutes up to several hours ($Mdn = 5$ min, $M = 3$ h 09 min). We perform a linear regression ($F(1, 352) = 53.03$, $p < .0001$, $R^2 = .131$, Adjusted $R^2 = .0128$).⁶ The results (see Table 6) show that the SUS score is significantly related to the logarithmized time needed to search and find the touchpoint, which itself essentially shows a standard distribution. The regression analysis can be interpreted in such a way that when search time doubles, the SUS score deteriorates by about 3 points. However, the low R^2 indicates that the search time

Table 5

Time needed for the overall experience and at each touchpoint

Touchpoint	n	Mdn	M	min	max
Overall Experience	344	7 min	42h 16 min	<1 min	5 weeks
Finding	354	5 min	3h 09 min	<1 min	5 weeks
Authentication	237	1 min	1h 28 min	<1 min	2 weeks
Data Request	303	2 min	2h 43 min	<1 min	3 weeks
Data Access	257	3 min	18h 59 min	<1 min	4 weeks

Note: Some participants gave up during the process or never received the data. We excluded these cases from the calculation

⁶The visual analysis (Appendix D, Table 33) shows that the distribution is roughly “bell-shaped.” As the Shapiro-Wilk test for the residuals of regression ($W = 0.974$, $p < .0001$) indicates a deviation from normality, we also perform an additional linear regression with bootstrapping (with $R = 5000$ replications). This leads to similar results (Intercept-95% CI [LL, UL] = [34.632, 41.002]; Finding Duration (log scaled)-95% CI [LL, UL] = [-4.189, -2.054])

explains only a small part of the variance, such that other factors also come into play for a good user experience.

Table 6

Regression results using the finding duration as the criterion of the SUS score

Predictor	b	b 95% CI [LL, UL]	beta	beta 95% CI [LL, UL]	sr ²	sr ² 95% CI [LL, UL]	r	Fit
(Intercept)	37.81**	[35.34, 40.28]						
Finding Duration (log scaled)	-3.14**	[-3.99, -2.30]	-0.36	[-0.46, -0.26]	.13	[.07, .20]	-.36**	
								R ² = .131** 95% CI [.07, .20] Adjusted R ² = .128

Note. A significant b-weight indicates the beta-weight and semi-partial correlation are also significant. b represents unstandardized regression weights. beta indicates the standardized regression weights. sr² represents the semi-partial correlation squared. r represents the zero-order correlation. LL and UL indicate the lower and upper limits of a confidence interval, respectively.

* indicates $p < .05$, ** indicates $p < .01$

The challenge of identifying the entrance point is also well reflected in the comments, revealing general search patterns. For example, participants reported searching in their account settings or the privacy policy page on both the website and app of the respective organization. Moreover, participants used search engines both right away and as a secondary option when they were unsuccessful in browsing the website and app. Sometimes, participants even ended up contacting customer service, such as chat or hotline. Across all types of organizations, participants missed clear instructions and/or contact persons for their issue. While personal support is costly for organizations, participants often expected to be able to request their data online automatically to avoid time consuming support cues like simple download options or a self-explanatory navigation. Unfortunately, some organizations offered the opposite and were even inconsistent within their own architecture – for example, by linking to non – helpful support pages.

Overall, both positive and negative comments reveal the search strategies adopted and show that the variety of solutions across organizations resulted in inconsistencies and a lack of guidance for users. Where placement of the SAR initialization was similar to previously experienced cases, participants memorized the position and found it easier. SAR 259 therefore highlights the potential benefits of standardization for the finding touchpoint:

“The layout for designing this process was perfectly allied with social media platforms, and I didn’t need to think a lot to reach the result I was looking for.” – SAR 259 Google

Authentication

Authentication is necessary to ensure that only legitimate users can request data. On average, the authentication process took between a minute up to an hour (Mdn = 1 min, M = 1h 28 min). The evaluation sheets show that various means for authentication are used (see Table 7): Most frequently the participants authenticated themselves via their user login (63.4%), their e-mail (15.6%) or other digital verification such as Google or Facebook ID (5.4%). In only 3.8% of the cases, users needed physical proof of identification (e.g., showing a passport, doing a Postident verification, or scanning and sending authentication documents via mail). The evaluation sheets show that in 11.8% of cases, other means for authentication are requested by the organizations, which the participants did not specify.

Table 7

The different means of Authentication and their SUS score

Authentication Means	Count		SUS score	
	n	%	M	SD
Total	391	100	56	11
User login	248	63.4	58	8
E-mail	61	15.6	53	13
Google ID, Facebook ID or similar	21	5.4	57	8
Passport, Postident or similar	15	3.8	44	10
Other	46	11.8	54	17

The authentication touchpoint has the best SUS score of all touchpoints (see Table 4). The total score of 56 (sd = 11), however, still places it in the lowest category F. Table 7 and Figure 12 shows that authentication via user login or another digital proof of identity reached the highest scores (score = 57, score = 58, respectively), followed by e-mail (score = 53). “Passport, Postident or similar” performed worst (score = 44).

The one-way analysis of variance ($F(4, 361) = 8.58$; $p < .001$) showed that the means of authentication has a significant impact on the SUS rating. The additional conducted Kruskal-Wallis rank sum test (Chi

square = 1248.1, $p < .0001$, $df = 3$) showed the same result.⁷ Two-sided T-test (Bonferroni adjusted) showed a significant difference between the Passport, Postident or similar, and User login pair ($t(13) = -5.26$; $p < .001$; $p.adjusted = .002$), as well as using Google ID, Facebook ID or similar ($t(22) = -4.29$; $p < .001$; $p.adjusted = .003$), but not between the other pairs. This indicates that digital authentication channels are preferred, while the kind of digital channel that will be used is less important.

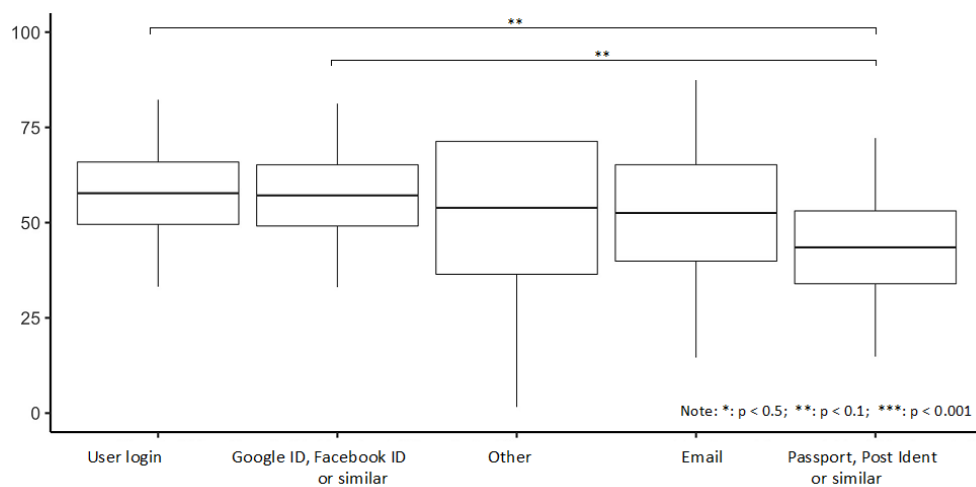


Figure 12

The SUS scores of the authentication touchpoint for the different authentication means

The comment section provides additional insights. In general, the comments either criticized the fact that there was no additional authentication in place or that too much was asked to provide. While authentication by passport was perceived to be secure, having to jump back and forth between devices to scan and provide the ID card produced difficulties, was time consuming, and was thus unsatisfactory. In other cases, such as with market platforms like eBay, the low level of authentication needed, however, raised concerns.

⁷We perform an additional Kruskal-Wallis test because the Shapiro-Wilk test indicates that the ANOVA residuals departed significantly from normality ($W = 0.951$, $p < .0001$). See also: Appendix E, Table 37

In their comments, participants pointed out that they felt more secure when the authentication procedure includes different modes or devices. A suggestion was to make two-factor authentication mandatory for the process. Finally, participants mentioned that they lacked proper information altogether about what ways of authentication existed in advance. On the contrary, most comments that conveyed positive feelings described a functional download process that used only a simple log-in without any further devices.

Notably, participants were positive when the authentication could be made online via means already known to users such as the user login. However, this expectation was somewhat taken for granted, which means it resulted in neutral (not positive) ratings.

Data Request

The data request touchpoint describes the activities of the user to complete the request for the SAR. With a SUS score of 53, the data request receives the grade F and is at the midpoint of the different touchpoints (see Table 4).

On average, the data request touchpoint took between a few minutes up to several hours ($Mdn = 2 \text{ min}$, $M = 2\text{h } 43$). We perform a linear regression ($F(1, 299) = 45.28$, $p < .0001$, $R^2 = .131$, Adjusted $R^2 = .0128$).⁸ The results indicate that there is a significant impact of the needed time on the SUS rating (see Table 8). However, the low R^2 indicates that the duration explains only a small part of the variance. This means that other factors besides time also play a role for a good user experience.

Besides the largely automated procedures, writing an e-mail for SAR was perceived as a simple way for a data request; however, some participants also expressed concerns about making an SAR request via e-mail

⁸The visual analysis (Appendix D, Figure 34) shows that the distribution is roughly “bell-shaped.” Because the Shapiro-Wilk test for the residuals of regression ($W = 0.957$, $p < .0001$) indicates a deviation from normality, we also performed an additional linear regression with bootstrapping ($R = 5000$ replications). This leads to similar results (Intercept-95% CI [LL, UL] = [59.034, 63.548]; Data Request Duration (log scaled)-95% CI [LL, UL] = [-3.476, -1.871])

Table 8

Regression results using the data request duration (log scaled) as the criterion of the SUS score

Predictor	b	b 95% CI [LL, UL]	beta	beta 95% CI [LL, UL]	sR ²	sr ² 95% CI [LL, UL]	r	Fit
(Intercept)	61.41**	[58.94, 63.89]						
Data request Duration (log scaled)	-2.67**	[-3.45, -1.89]	-0.36	[-0.47, -0.26]	.13	[.07, .20]	-.36**	
								R ² = .131** 95% CI [.07, .20] Adjusted R ² = .128

Note. A significant b-weight indicates the beta-weight and semi-partial correlation are also significant. b represents unstandardized regression weights. beta indicates the standardized regression weights. sr² represents the semi-partial correlation squared. r represents the zero-order correlation. LL and UL indicate the lower and upper limits of a confidence interval, respectively.

* indicates $p < .05$. ** indicates $p < .01$

for various reasons. In the case of PayPal, for instance, the participant's comment made in SAR 330 identifies security concerns because PayPal, as a financial service, holds sensitive data. Another problem when making an informal request via e-mail is that the participant receives no guidance about how to formulate the e-mail and what the next steps will be after sending them. These unguided processes led to confusion. Especially in this step, there were some comments about not receiving answers or data from organizations.

Data Access

The data access touchpoint is when the user waits for the data to be provided by the organization and the subsequent access to that data. On average, the access process took between a couple of minutes up to several hours (Mdn = 3 min, M = 18h 59 min). The access touchpoint SUS score of 51 places it in the lower midfield of all touchpoint scores.

Our study reveals that various data formats exist in practice (see Table 9). Most frequently, machine-readable data formats are used, such as JSON/XML (26.3%) or CSV/XLS (14.3%). Less common are human-readable data formats such as PDF or HTML. However, about one third (33.1%) of the SARs still used none of these formats. To our surprise, 5.1% of all SAR were answered with paper printouts. On average, in the case of human-readable SAR data formats, the SUS score is higher (score = 55) compared to the machine-readable ones (score = 40.3). The one-way analysis of variance ($F(3, 353) = 6.45$; $p < 0.001$)

Table 9

SAR data formats used by organizations

Data Format	Count		Data Volume [MB]		SUS score	
	n	%	Mdn	M	M	SD
Total	372	100	1.0	1178.9	51	11
Human-Readable	79	21.2	0.8	333.3	55	10
PDF	7	1.9	0.4	0.5	66	6
HTML	72	19.4	1.0	369.7	54	10
Machine-Readable	150	40.3	1	535.2	49	10
CSV/XLS	52	14.0	0.2	279.7	51	10
JSON/XML	98	26.3	1.3	670.0	49	10
Paper slips	20	5.4	7 (Pages)	20 (Pages)	54	12
Other	123	33.1	3.0	2883.9	49	12

showed that the data format has a significant impact on the SUS rating. The additional conducted Kruskal-Wallis rank sum test (Chi square = 543.11, $p < .0001$, $df = 1$) showed the same result.⁹ As illustrated in Figure 13, two-sided T-test (Bonferroni adjusted) showed a significant difference between the human-readable versus machine-readable pair ($t(157) = 4.01$; $p < .001$, $p.adjusted < 0.001$) as well human-readable versus other ($t(185) = 3.85$; $p < .001$, $p.adjusted < .001$), but not between the other pairs.

In their comments, participants expressed their negative impressions, describing the implementation as “catastrophic” and the access possibilities as cumbersome (e.g., “Simplifying the workflow of data request and receiving the data”). Readability, representation, and data structure was also an issue: “Even as a ‘non-layman’ it was hardly possible to understand the data”. In general, answers referring to a neutral SUS contained neutral descriptions but also positive reactions to the access points. Participants were satisfied with the access to the data because the representation of the data was simple and reasonable.

⁹We perform an additional Kruskal-Wallis test because the Shapiro-Wilk test indicates that the ANOVA residuals departed significantly from normality ($W = 0.973$, $p < .0001$). See also: Appendix E, Table 38.

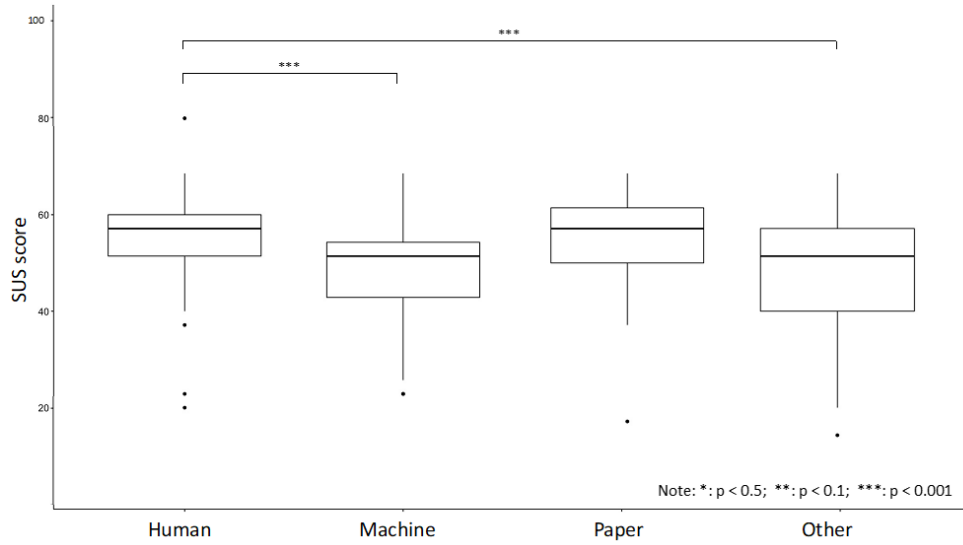


Figure 13

The SUS score for the human-readable data formats (PDF, HTML) is higher than machine-readable one (CSV/XLS, JSON/XML)

Data Use

The data use touchpoint covers the post-SAR activities that include anything the data subject found the data provided to be useful for. We were especially interested in evaluating the perceived contribution of the provided data to the perceived transparency of data collection and use, GDPR compliance, data literacy, and impact on users' privacy behavior.

Perceived contribution to organizational GDPR compliance

The GDPR provides that users of a service collecting personal data shall have a right to access collected data. Hence, we would expect that the overall SAR process contributes to perceived organizational compliance with the legal GDPR requirements. Table 10 shows that, on average, participants agree with this statement ($M = 0.68$).

To a large extent, the SAR process also contributes to a perceived compliance with other data subject rights. The highest contribution is provided to the Right to Object ($M = 0.51$), while for the Right to Rectification, the impact is lowest ($M = 0.33$). According to participants, the

Table 10

Contribution of the SAR to the perceived compliance

The SAR contributes to ...	n	M	SD
... the GDPR compliance	366	0.68	0.75
... the right to object	358	0.51	0.76
... the right of access and data transparency	364	0.42	0.99
... the right to data portability	362	0.36	0.89
... the right to rectification	356	0.33	0.93
... the right against automated decision	348	-0.14	0.90

Note: strongly disagree = -2, disagree = -1, neutral = 0, agree = +1, strongly agree = +2

SAR process does not contribute to the right against automated decision making ($M = 0.14$). One explanation in this regard could be that while the SAR process does make data collection and processing more transparent, the use of data and its impact on personal life might not be explained sufficiently.

We perform a linear regression ($F(1, 363) = 28.04$, $p < .0001$, $R^2 = .072$, Adjusted $R^2 = .069$).¹⁰ The results (see Table 11) indicate that the extent of the contribution to perceived GDPR compliance seems to depend on the overall User Experience of the SAR process in question. Nevertheless, the R^2 is quite low, such that the influence seems to be relatively low.

Table 11

Regression results using the SUS score as the criterion of the perceived GDPR compliance

Predictor	b	b 95% CI [LL, UL]	beta	beta 95% CI [LL, UL]	sr ²	sr ² 95% CI [LL, UL]	r	Fit
(Intercept)	-0.15	[-0.46, 0.17]						
SUS score	0.01**	[0.01, 0.02]	0.27	[0.17, 0.37]	.07	[.03, .13]	.27**	
								$R^2 = .072^{**}$
								95% CI [.03, .13]
								Adjusted $R^2 = .069$

Note: A significant b-weight indicates the beta-weight and semi-partial correlation are also significant. b represents unstandardized regression weights. beta indicates the standardized regression weights. sr² represents the semi-partial correlation squared. r represents the zero-order correlation. LL and UL indicate the lower and upper limits of a confidence interval, respectively.

* indicates $p < .05$. ** indicates $p < .01$

¹⁰The visual analysis (see Appendix D, Figure 35.) shows that the distribution is roughly “bell-shaped.” Because the Shapiro-Wilk test for the residuals of regression ($W = 0.863$, $p < .0001$) indicate a deviation from normality, we also performed an additional linear regression with bootstrapping with ($R = 5000$ replications). This leads to similar results (Intercept-95% CI [LL, UL] = [-.507, .209]; SUS score-95% CI [LL, UL] = [.009, .021])

Perceived Transparency of organizational Data Processing

Regarding transparency, we found two major aspects having an impact. The first concerns the design and presentation of the data. Comments showed that participants were sometimes left in doubt about the organization actually sharing all data stored about them. Such doubt was especially present when users thought that they would have contributed a considerable amount of data but did not receive much. In this sense, data protection-friendly policies of organizations could even backfire, if the takeout was not designed accordingly – for example, by providing transparency about what kinds of data might have been deleted or anonymized – and thus would not be present in the SAR. SAR 83 is a vivid example of such doubts:

“I guess they only provided that data to give the impression they are GDPR compliant, but I feel they are hiding data because I have used the platform plenty of time to hire teacher services, but the document they provided me has no info about that” – SAR 83 Italki.

The second issue that emerged concerning transparency involves the principle of purpose limitation – one of the key principles of the GDPR in ensuring that users have means to understand the ins and outs of what may be done with their data. These purposes must be provided as part of an answer to an SAR. In our sheet, we provided an arbitrary list of commonly used purpose statements (see Table 12). First, the rather low mentioning of “Other” purposes points to the fact that the few purposes we chose do seem to apply to a large number and variety of organizations in our sample. On the one hand, this “standardization” tendency may be interpreted as something good for consumers, to provide resemblance and comparability. On the other hand, from the perspective of transparency for users, it seems unlikely given the variety of organizations that types of processing can be subsumed under merely nine different purposes while at the same time helping users understand the extent of the data use practices of the 139 different organizations in our sample.

Table 12

Data processing purposes provided

Purpose	Count		Answers [in %]		
	n	%	Unclear	Yes	No
Transfer to Third Parties	406	96.2	31.0	42.6	26.4
Pricing	403	95.5	22.1	23.1	54.8
Fraud Prevention	405	96.0	22.0	44.2	33.8
Legal Obligations	408	96.7	19.9	52.9	27.2
Contract Execution	410	97.2	18.8	41.2	40.0
Client Communication	400	94.8	16.2	60.8	23.0
Provision	407	96.4	15.7	52.6	31.7
Marketing	403	95.5	14.4	57.3	28.3
Personalization	402	95.3	13.4	62.9	23.6
Other	216	51.2	30.6	35.6	33.8

The purposes that participants were able to exclude most often were those of individual pricing (No = 54.8%) and contract execution (No = 40.0%). At the same time, these purposes also were among the least popular (Pricing: 23.1%, Contract: 41.2%). Given the variety of organizations, this finding is not surprising as participants did not have a customer relationship with many organizations or did not have a contract. On the other side, the purposes of personalization (Yes = 62.9%), client communication (Yes = 60.8%), and marketing (Yes = 57.3%) were most commonly identified.

Furthermore, even though organizations must inform their users or clients regarding the purposes of collecting data via the SAR, there was nevertheless a notable absence of transparency regarding the processing purposes. In terms of a lack of clarity, personalization (unclear = 13.4%) and marketing (unclear = 14.4%) achieve the best values. Overall, however, these values show that participants were unable to consistently rule out the existence of any of the purposes we asked for. For about one out of three SAR, it remained unclear if data was transferred to third parties. Almost every fourth SAR sheet (unclear = 22.1%) reported lack of clarity about the existence of individual pricing.

Perceived Benefits and Data Insights

Data awareness and data literacy are important prerequisites to make informed privacy decisions. It is not yet clear to what extent SARs can

have a positive effect on this; the answers in our sample show mixed results (see Table 13). Participants agree that received data contributes to data awareness by helping them to understand what an organization knows about them ($M = 0.64$). In addition, participants on average perceive the data to be easy to understand ($M = 0.47$). The contribution to data literacy, in contrast, is far lower ($M = 0.11$). One reason for this discrepancy may stem from the fact that although participants were able to browse their data, they were hardly supported in using them. As a result, participants had a hard time figuring out what to do with it ($M = -0.55$). One factor in this regard may also be the fact that participants found the data format difficult to use ($M = -0.19$).

Table 13

The perceived value of data received

The received data ...	n	M	SD
... helps me to know what they know about me	360	0.64	0.91
... was easy to understand	363	0.47	1.07
... had improved my data literacy	360	0.11	0.96
... includes information which I did not expected	358	0.07	1.14
... does not provide a benefit for me	358	-0.03	1.07
I learn a lot from the received data	360	0.01	1.05
The data format makes it easy to use it	357	-0.19	1.01
I know what I can do with the data	363	-0.55	1.01

Note: strongly disagree = -2, disagree = -1, neutral = 0, agree = +1, strongly agree = +2

Attitude Behavioral Change

In principle, the SAR can change the user's attitude toward the organization in both directions. On the one hand, by creating transparency and making the data available, trustworthiness can be created, and privacy fears can be reduced. On the other hand, however, trustworthiness can also be eroded and privacy concerns fostered if (a) the SAR is poorly implemented or (b) users find out about a surprising extent of data collecting and use.

Table 14 shows, however, that the SAR has almost no impact on attitudes of trust toward the organization. One reason could be that the SAR is not yet well implemented, as indicated by the SUS, but it is not so bad that trust is lost as a result. In addition, the SAR does not include unexpected data ($M = -0.03$), which neither increases nor lowers pri-

Table 14

The impact of the SAR on the attitude toward the organization

The SAR ...	n	M	SD
... changes my feeling of being valued as customer	363	0.07	0.86
... increases my privacy concerns	358	0.01	0.90
... lowers my privacy concerns	358	-0.54	0.66
... changes my attitude towards the organization	362	-0.05	0.91
... improves my trust in the organization	363	-0.22	0.95
... decreases my trust in the organization	363	-0.33	0.82

Note: strongly disagree = -2, disagree = -1, neutral = 0, agree = +1, strongly agree = +2

vacy concerns. In addition, both effects could balance each other out, such that overall trust is neither increased nor decrease on average.

The low impact of the SAR on attitudes toward the organization, trust, and privacy concerns are also reflected at the level of behavioral change (see Table 15). As there is no change in attitudes, it seems that participants do not see a need to change their behavior in terms of privacy settings ($M = -0.43$), information disclosure ($M = -0.54$), or data deletion practices ($M = -0.55$).

Table 15

The impact of the SAR on privacy behavior

The SAR motivates me ...	n	M	SD
... to take some action	365	-0.22	0.96
... to change my privacy settings	359	-0.43	1.04
... to change my information disclosure behavior	350	-0.54	0.81
... to change my approach towards using the right of rectification	354	-0.55	0.91

Note: strongly disagree = -2, disagree = -1, neutral = 0, agree = +1, strongly agree = +2

6.6 Discussion

Our study demonstrates the large variety of ways to implement an SAR process. Following the DSR [169, 269, 341], we now continue with exploring and highlighting major challenges and potential solutions according to the user experience journey and design of the SAR procedure. We close our discussion with a summary of our insight in the form of a set of design guidelines to provide actionable design knowledge in accordance to DSR [125, 269].

6.6.1 The User Experience Journey as Guiding Map for Implementation

Our initial step was to understand the procedure of conducting an SAR and current design practices to identify different touchpoints the user has to go through. We already assumed that our five identified touchpoints follow a logical order; for example, a data request must be carried out before the data can be provided and accessed. However, the steps do not fully determine the chronological order of the process. The touchpoint of authentication, in particular, may occur in other or even multiple positions. For example, users who are permanently logged in (e.g., Facebook or Google) may skip the authentication or login step right at the beginning. In connection with the touchpoint data access, authentication might be necessary to ensure that only a legitimate person can request and access or open the file. With our study, however, we were able to validate the five touchpoints as coherent steps within the user journey, which may have to be adjusted in sequence for individual cases.

6.6.2 Finding instead of Searching

An important challenge for any user journey is to offer users a good start. Our findings show how this holds true for the SAR process, where the finding touchpoint had the lowest SUS score with 45. Notably, participants started searching in many cases via search engines immediately – even before turning to the website or organizational app. The importance of search engines for finding the entrance point is also highlighted by participants as a “last resort,” in case they could not find anything on the website or in the app.

As noted by participants, organizations should provide a prominent place on their website to make it easier to find the SAR option. From a usability perspective, the SAR option should be located close to the account or privacy settings or as a separate contact option, especially when there is no automated procedure. Additional access points could be provided as part of the privacy policy. This way, the mere existence of the SAR and the right to access could be presented as part of reg-

ular use of a service. Most importantly, the finding touchpoint would perhaps benefit from standardization in terms of positioning. However, organizations must clearly take care that such a prominent option will not disrupt everyday use. Regarding this design tension, we need further studies into when and why users might want to initiate an SAR by themselves.

6.6.3 Authentication: Dealing with Tension between Usability and Security

Users must authenticate before they can get their data. Our study shows that there is a tension in authentication between usability and security. Depending on what kind of data the organization collects, participants expected stronger security measures (e.g., for market platforms or financial service providers), while in other cases participants expected more convenient measures. Our study indicates that authenticating via the normal login procedure based on one's existing username and password was the most comfortable option. However, this practice also represents a security risk, as when user accounts get hacked. Without additional authentication, attackers could easily get hold of all data about a user. For more security, two-factor authentication (e.g., for financial service providers) might be the better option.

Another practice was that people authenticated via phone or via e-mail. For security reasons, this practice is problematic, as this could also easily be misused by hackers. Organizations should at least implement some additional authentication (e.g., date of birth or place of residence).

In contrast to such lax security measures, our study also demonstrates that some organizations asked for physical proof of identification and/or requested scans of ID via e-mail. These designs were criticized for being time consuming, complicated, and for having to provide even more data to an organization.

One option to deal with the tension between usability and security would be the introduction of a trusted third party to whom the user

identifies himself once and who then identifies himself to other data controllers on behalf of the user. Further research, however, is needed to specify and regulate such a distributed authentication in detail.

6.6.4 Guiding the Data Request Process

The major design challenge implementing the data request touchpoint is helping users to formulate the SAR request. Our study reveals that participants desire more guidance through the procedure, particularly in the case of making an SAR request via e-mail. At first glance, writing an informal e-mail requesting one's data seems easy. However, our study shows that participants were unsure about what information to include and how to explain to organizations that they are referring to the right to access, which requires organizations to answer. Moreover, there was a lack of feedback on the status of the SAR—for example, whether the e-mail had arrived and was being processed and whether the SAR was even acknowledged.

Organizations should provide more guidance to users throughout the process, informing them how they can request their data and letting them choose what data they want to request and in what format they want to receive it. In addition, the availability of data and general changes in the state of the SAR process should be actively communicated.

The comments also show that the “data request” experience was often affected by the experience of the previous touchpoints. This insight highlights that it is not enough to optimize the user experience of each individual touchpoint, but that a good user journey must take care of a coherent process design.

6.6.5 Making Data Accessible – Both for Human and Machines

Setting up all data for answering the SAR appropriately often takes time. While little waiting time was preferred, delays are understandable, especially in non-automated processes. The design challenge here

is to ensure that users are informed about the data becoming available and providing the data via easily accessible channels. Moreover, data should be usable by humans and machines for further processing. The SUS score of 51 shows that these challenges are often not yet being met in practice.

As with the request touchpoint, the comments suggest that there is a negative impact on the user experience when users lack feedback, for example, on data having become available or delays with the respective reasons. Hence, organizations should specify an approximate time when the data will be made available or show a status in the settings where a user can check for updates.

Our study also raises awareness about the tension between human-readable and machine-readable data format. While machine-readable data format offers more possibilities for further processing, in terms of user experience the human-readable format was preferred. For instance, the SUS score was highest when data was provided in PDF (score = 66) or HTML format (score = 54). The data formats received make it likely that many organizations will respond to the SAR as well as a request in the form of the right to portability. While not illegal per se, from a UX perspective, the design for different use cases cannot avoid making compromises. We call, however, for providing the data in the machine-readable json-format together with an additional HTML-viewer to allow for human exploration (see touchpoint data use). In addition, when zip files with a complex structure are provided, the SARs should provide guidance and explanation of the directory and a clear labelling of the files to ensure comprehensibility.

6.6.6 From Data Provisioning to Data Literacy Support

Our study shows that in general, based on the data received, users perceived organizations to be compliant with GDPR regarding the right to access. In addition, the SAR did help participants see what data had been collected by organizations. Nevertheless, participants reported that most of the data was in line with their expectations without any

bad surprises or greater impact on their privacy behavior. In fact, they tend to feel safer.

Our study further indicates that the SAR currently is a necessary, but not sufficient, condition for privacy awareness and data literacy. Concerns about data completeness repeatedly emerged. Additionally, participants complained that it was unclear what they can do with the data and were not motivated to take action. As a result, they did not feel empowered but were disenchanted as they often received raw data instead of graphics and statistics.

This shows that we need more than the right to get our data; we also need support to make sense out of it. As noted, for example, by Pins et al. [249], what is needed is a data storytelling, so that users can gain added value from it, allowing them to take actions like deleting or correcting the data. A promising approach is data visualizations which increase user understanding, promote transparency, enable risk assessment, and foster personal data literacy.

6.6.7 Towards a Usable Process Design for SARs

As a conclusion drawn from the previous sections, we derive a set of guidelines for designing the SARs User Experience Journey that covers five touchpoints. Table 16 summarizes these guidelines. These guidelines should serve as an orientation for practitioners who must adapt them to the specific context of their organization. These guidelines, however, cannot replace a rigorous evaluation of the usability of the specific organizational implementation of the SAR process.

6.6.8 Limitations and Future Research

In the following, we outline several key limitations of our research and suggest some open questions to address in follow-up research. First, the participants of our study largely were HCI students in a graduate course on Usable Security and the GDPR, thus forming a rather homogenous group (e.g., potentially being more tech-savvy than average

Table 16

Lessons Learned and the Resulting Design Guidelines for the SAR User Experience Journey

Touchpoint	Lessons Learned	Guidelines
Overall Journey	Guiding the process and giving feedback	- Design the SAR as a multi-step user experience journey with finding, authentication, data request, data access, and data use as the key touchpoints. - Provide the user feedback concerning where s/he is in the SAR process and the next steps that need to be taken
Finding	Support finding instead of Searching	- Do not hide behind complex menu items or use misleading terms. - Place the SAR option prominently in the account or privacy area of your website or app. - Make it clear how to initiate an SAR.
Authentication	Dealing with tension between usability and security	- Ensure that authentication is done in a detour. - Protect the user by asking for more than just username and password.
Data Request	Guiding the data request process	- Disclose what you need from the user and how s/he should proceed. - Inform the user about the format in which they will receive the SAR and, at best, let them choose the right one among different formats.
Data Access	Making data accessible – both for human and machines	- Keep the user in the loop about the request status and when the SAR is available. - Provide data in machine-readable format (e.g., json) for portability and processing and additionally in a user-friendly format (e.g., HTML) for explaining and exploring the data immediately.
Data Use	From data provisioning to data literacy support	- Give support and explanations on the provided data for transparency about processing and sense-making. - Point out which data might be missing because they have been anonymized or pseudomized. - Highlight potentially risky data and explicitly show why this data is stored and how the user can make changes for permissions and collections

users). Further, we did not address whether the course content taught may have had an impact on response behavior and scoring with regard to the SUS evaluation. Consequently, our sample is biased toward corresponding organizations selected, as shown in the large “Educa-

tion / Learning.” The selection of organizations by the participants may further impact the results; for example, the Gini index should be considered as an estimation. These biases should be kept in mind when seeking to generalize findings. Additionally, participants had to document a process which sometimes took several weeks, which may result in inconsistencies and inaccuracy in remembering the duration of the activities. For this reason, the time specifications given here should only be understood as rough, subjective estimates. Despite these limitations, our study is the first to be able to paint a broader picture of user-centered usability assessments of the right to access. Regarding future research, our work provides a first orientation about how to structure the user experience journey. As a general guideline, users would benefit when being able to reidentify patterns used in other SAR processes. The touchpoints identified should be investigated in more detail in future studies to gain more insight into critical incidents and design patterns to improve the user experience. This is especially true for the finding touchpoint, where the low SUS score indicates a substantial need for action.

Future research should also study what people do — and want to do — with their data. Our study shows that the data received can promote users’ data awareness, but it left many questions open and was perceived as not improving data literacy. This raises the question of how we can support users in understanding and making sense of their data. In addition, we should study how users in daily life can be motivated to make use of their rights to access their data.

6.7 Conclusion

Data awareness and control over personal data and its use are cornerstones for usable privacy protection. Likewise, the right to access as per the GDPR is one of the key mechanisms for consumers to be able to control data collection and use by organizations. For implementing this right, Article 12 of the GDPR provides general guidelines, such as adequate levels of authentication, which information to provide, and more generally the provision is to be made in “concise, transparent,

intelligible and easily accessible form, using clear and plain language” [98]. However, there is no clear guidance about how an SAR process should be designed in terms of a user journey.

In this paper, we adopt the Grounded Design approach [269, 315] to provide an empirically grounded problem diagnosis [341, 364] about the implementation of the SAR process today. Doing so, we first introduced a user journey for the right to access and, secondly, conducted an evaluation of different design decisions. We discovered that the whole procedure lacks structure and guidance. Difficulties were already arising at the beginning, when users experienced difficulties finding the SAR option, and there were difficulties at the end with a lack of support in making use of the requested data. Addressing the problems identified, we discuss design opportunities. Intending to make this design knowledge actionable, we provide a set of guidelines for practitioners. As mid-range theory propositions, guidelines present a nascent design theory [126], which are of practical relevance in giving organizations an orientation about how to implement the GDPR in a manner that is faithful to the idea of strengthening user rights. It also informs consumer organizations about the current state of the GDPR implementation and where the consumer needs help to pursue their rights in an effective way. Future work should test our nascent design theory, providing instantiation validity [188] by evaluating how practitioners adopt our guidelines and whether this would improve the usability of the SAR process compared to current implementations.

Beyond the legal discourse on the GDPR, our study shows that this discourse would benefit from a serious incorporation of human factors. Research on usable privacy can play a major role in informing practical solutions and providing data protection authorities with a user-oriented view. We show that user needs, mental models, and capabilities can play an important role in both the process of drafting legislation and in supporting data protection authorities to evaluate the facilitating role of data controllers when implementing the right to access.

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Part III

Consumer Empowerment in Data Literacy: Design Approaches

*Overview first,
zoom and filter,
then details-on-demand.*

Ben Shneiderman, *Visual Information Seeking Mantra*

7 Introduction

Based on the user experiences, everyday life and data work practices from the previous part, Part III presents design approaches that were developed and evaluated to support consumers in gaining data insights and processing visual information, addressing the lack of satisfaction with current data insights.

For the study reported in Section 8 an initial prototype was created for visualizing the interaction data and helped the study participants to apply for a data takeout in order to obtain immediate and more detailed feedback on difficulties in the request process (which were lacking in the study of Section 6). Subsequently, the data visualization of the received data enabled an initial solution approach for data work, in which the users received a general overview and were able to structure the data according to individual categories.

Section 9 and 10 are built on the findings from Section 8 and (interim) results of the iterative design process of the prototype are presented. Based on the needs and incidents identified with regard to the request process, a data export wizard is implemented that supports its users in finding the option for requesting data and selecting the appropriate format for the subsequent visualization of the data, thereby guiding them through the entire process. As soon as the data can be downloaded, the tool also transfers the data directly to the dashboard for data visualization. In addition to the access to the data request, the tool also offers a direct link to the provider's privacy settings, which can be used to change the data storage settings, for example. In Section 10 the final status of the prototype at the end of the project is presented.

8 Alexa, We Need to Talk: A Data Literacy Approach on Voice Assistants

Abstract

Voice assistants (VA) collect data about users' daily life including interactions with other connected devices, musical preferences, and unintended interactions. While users appreciate the convenience of VAs, their understanding and expectations of data collection by vendors are often vague and incomplete. By making the collected data explorable for consumers, our research-through-design approach seeks to unveil design resources for fostering data literacy and help users in making better informed decisions regarding their use of VAs. In this paper, we present the design of an interactive prototype that visualizes the conversations with VAs on a timeline and provides end users with basic means to engage with data, for instance allowing for filtering and categorization. Based on an evaluation with eleven households, our paper provides insights on how users reflect upon their data trails and presents design guidelines for supporting data literacy of consumers in the context of VAs.

8.1 Introduction

Imagine the keyboard of your computer would log every word or sentence you enter in a file. What would this data reveal about you? Fortunately, a common keyboard does not store this data (at least not until now). Voice assistants (VA), however, are perceived by users only as simple input devices to ask for information and control smart home devices without any greater importance [248, 348]. Unlike keyboards, VAs do log every interaction by default. Combined with the fact that VAs are prone to cause unintended interactions [287] and are an integral part of daily life as they are often being positioned in social places such as kitchens, bed- or living rooms [288], they are potentially very privacy-sensitive technologies. Yet, users are often not fully aware about the kind of data being collected about them and their homes by a VA. Consequently, they do not know how the data are processed and what they reveal about them. This further makes it hard to make informed decisions. Hence, trust in the vendors instead of informed privacy consent has been identified as the central factor affecting the use of VAs [111, 360].

As data is increasingly collected and processed by almost all kinds of digital services – ranging from surrounding embedded sensors to broadly established cloud services [57, 311, 325] – consumers tend to feel both vulnerable and unable to trace their data or to protect themselves [158]. This is especially important in the case of VAs, which are placed in users' private spaces and collect data about them (e.g., recordings, preferences, and location), revealing their daily routines and the (usage) behavior in their homes. Right now, VA vendors only provide abstract information about the collected data in their privacy policies or allow users to see simple lists of interactions with their VA devices hidden somewhere deep in their account settings. By empowering users in their data literacy on voice interaction data, we want to make the operations and processes of VAs more transparent, thereby helping users to make better informed decisions regarding data and privacy protection. Adopting a research-through-design approach [377], the prototype we present aims at making VA data accessible to end users and unveil de-

sign elements suited to support sense-making of privacy implications relevant to users. For gaining data of VAs, we made use of the right to access articulated in Art. 15 GDPR, granting users the opportunity to request all personal data collected by a device in a machine-readable form. These takeouts are non-standardized and typically consist of compressed folder structures with a combination of audio, json, html, and other file types. At that time, the prototype was able to process the conversation related data from Google Assistant and Amazon Alexa. These interaction data were visualized on a timeline, accompanied by basic functions for interacting with data, such as categorization and filtering for terms from the commands.

We evaluated our prototype with 11 users of VAs (8 Amazons' Alexa and 3 Google Assistant users) using a combination of interviews and observation as proposed, e.g., by Tolmie et al. [335]. The interviews focused on users' expectations, awareness, and concerns about data collection by VAs. Following up, we used a research-through-design approach [377] and let users explore their data freely. We observed their interaction with our prototype based on tasks and questions we have set and by thinking aloud to analyze their sense-making of the data.

Beyond drawing attention to VAs as an important field for research on supporting data literacy, we contribute with insights and guidelines for HCI practitioners to support consumers in their data work and sense-making of sensitive data in general and particularly audio/transcribed data to reduce the existing imbalance of power and knowledge between consumers and vendors:

- Through providing transparency on the variety of collected data and information to participants, we investigate users' data collection awareness regarding their VAs,
- By providing visualizations and means of interaction with the data, we analyze how consumers make sense of data collection and processing as well as how it affects their perceptions, and

- Based on these insights, we propose and demonstrate design approaches for visualizing VA data to support data work to ultimately strengthen consumers in their data literacy.

8.2 Related Work

With VAs becoming common in private households, recent work has shown that users often only have superficial awareness of how a VA works [186] and how the collected data is being used [175]. That is why we take up recent work about the adoption and use of VAs, illustrate why it is important to foster user awareness of the extent of data collection in users' private spaces, and report how recent research explores ways to make the use of VAs more privacy-friendly. We further address how users understand data collection as they often do not know or even do not care about that [175, 328]. According to current research, the latter is mainly due to the lack of transparency and complexity of terms and conditions as well as privacy policies [52, 153]. This may lead to feeling overwhelmed or disappointed and cause users' distrust. As presented in 8.2.3, we contribute to the ongoing research in HCI by providing insights about the sense-making of data.

8.2.1 Adopting VAs in Daily Life and Private Spaces

As previous work depicts, VAs are often perceived as simple input devices. For example, Porcheron et al. [253] investigated voice interfaces in everyday life and claimed that interactions with VAs are not of conversational but rather of rational nature. Nevertheless, when adopting a VA, users often face high expectations regarding their functionalities [76, 248, 348]. In some cases, VAs were even anthropomorphized [185, 256].

As recent work has shown [35, 72, 253, 288, 348], users need to learn how to integrate the VA into their daily and social life at home. By studying long-term use of VAs, Bentley et al. [35] found that after a longer period of time, routines of functions and usage times can be

identified. Sciuto [288] supported this insight and concluded that intensity of use is strongly dependent on the daily routines of the users as well as the devices' locations. This leads to the assumption that VA data allows for comprehensively picturing users and their activities. Moreover, VAs suffer from unintended activations as Schönherr et al. [287] found. However, VAs do not treat these interactions differently and collect every word followed by the misinterpreted activation word. Combined with the fact that users tend to forget that a voice assistant is present [72], the awareness about the actual extent of data collection may be reduced even further.

The use of these so-called "always-listening" [175, 328] devices and the potential for using the collected data has not only been a sensitive topic in general society for some time now [326, 327]. It has also been of interest among the HCI community regarding privacy preserving technologies [1, 73, 82, 175]. In addition, the collection and use of VA data is also of importance from a legal perspective as it may be of evidential value for law enforcement [236, 246].

In the HCI community, this aspect motivated the exploration of possible measures to avoid data collection, e.g., by using wearable microphone jammers [66], implementing solutions for data protection like a detector for security-critical commands [172], and improving activation-word detection by taking the gaze direction and voice volume level into account [209].

8.2.2 Consumer Understanding of Data Collection and Processing

In their study on data collection practices of VAs, Malkin et al. [191] found that about half of their participants (51,7% of 116) were unaware of or unsure about companies' keeping their recordings for an indefinite time. Additionally, users only vaguely understand the extent of data collection and their processing by the system or vendors [1, 327]. This opaqueness is a known phenomenon which also exists for other services and is attributed to the fact that terms of use and privacy policies, which include information about just these practices,

are commonly not read or understood [158], fostering misconceptions on the customer side [267, 327]. In this vein, many customers were surprised when it came to public attention that subcontractors of VA vendors listened to actual user-input audios to train VAs [57].

Previous studies have shown how existing measures for transparency in VAs seem to fail consumer needs [14, 153, 206]. For example, Jakobi et al. [153] revealed that consumers did not perceive the purpose limitations provided by VA data protection policies to be informative with regard to the extent and consequences of data processing.

Vendors already provide a dashboard that offers tracing data and the system status of ongoing interactions with a VA. Another way to interact with data was made possible with the adoption of the GDPR that gives consumers the right to access, manage, and transfer their data. Recent work on feeding back data to consumers based on the right to access shows how mismatches between data collection and users' expectations can have a variety of consequences: For example, Alizadeh et al. [14] reported that consumers mistrust loyalty card companies, assuming that they were hiding something from their takeouts. A similar conclusion was also reached by Merrill et al. [206] who investigated the perceived capabilities of biosensors (e.g., face expressions or GPS and accelerometer) and pointed out that on the one hand, devices may seem creepier than they are, whereas on the other hand, in fact, seemingly harmless devices may be used to infer intimate details such as emotions or mental health. They further concluded that users' perceived capabilities about technology often rely on the physical shape or interface of the device, which will become an important issue when designing and implementing tools gadgets with ubiquitous sensors.

VAs and other smart home devices are also described as black boxes to their users – especially if they are not tech-savvy. While these interconnected devices blend into consumers' daily life, lack of control and accountability of their inner workings lead to various concerns, for instance about remote access control or reliance on services or vendors [48]. With the home being the epitome of privacy [128, 352], consumers should be able to see and control what actually happens there

[59, 335]. For example, throughout the phases of technology appropriation [298] smart home technology acceptance hinges on appropriate ways of providing insights in the system status [151].

Jakobi et al. [151] already identified design resources for fostering controllability and accountability of do-it-yourself smart home systems that increase data literacy, eventually helping users to learn about system behavior and processes such as data disclosure. Arguably, similar principles may be applicable to the use of VAs in the home but have not been getting as much attention. That is why we want to pick up this thread on accountability of connected devices and focus on the conversation data of VAs in this paper. By doing so, we increase both visibility and accessibility of the collected and stored data and draw attention to executed actions and hidden processes (especially unaware activations) [34, 287].

8.2.3 Designing for Sense-Making of Data

The lack of transparency of data collected by sensors at home and fostering consumers' data literacy is a common topic in research [360]. For example, users of smart home systems need solutions to maintain their systems to understand how it works and behaves, especially to get informed about unexpected events [151]. However, users need support in exploring and making sense of their data collection and use [335] beyond receiving notifications. Whereas companies are able to employ data scientists, households lack both skills and tools (e.g., for natural language processing) to identify and judge sensitivity of data [59, 106, 335]. Hence, designing tools that support users in their data work and its challenges are still a matter of ongoing research [67, 114]. This clearly illustrates the imbalance of knowledge and power over user data between users and companies.

One noticeable example is the study of Castelli et al. [59] that shows how flexibility and compatibility to routines and practices are crucial for a visualization of connected device data for smart home systems. Another important study was conducted by Kurze et al. [170], who

developed a method called "Guess the data". In their work they observed the individual but also collective sense-making of live data of people's homes. Other approaches address privacy precautions specific to the smart home like storing and processing the collected data in the devices locally [370] or the minimization of data collection [221]. Furthermore, there are already tools existing that notify consumers when a device shares data [292] or that summarize the shared information [28].

Initial studies on data work with dashboards developed by VA vendors themselves show – while raising awareness in general – how provided information in the form of chronological lists was not well suited for users to explore data and build an understanding of their VA data footprint [248]. Moreover, VA data may introduce a different challenge: Since VAs can operate as a connective platform of smart home devices, apps, and services that bundles a variety of sources and information, interaction data of such devices may hold a rich database about activities at home. Vitale et al. [346], for example, already investigated a centralization of different information on a data dashboard to support users to curate their data from across platforms and devices due to the mix of devices and cloud platforms used by customers.

The field of usable privacy [7, 114, 45] is, from an HCI perspective, about enabling consumers to be more aware of their personal data disclosure and providing usable controls for privacy management [7, 76, 354]. This includes both usable tools for accessing and managing personal data as well as support in understanding how and for what purposes the data are processed [114, 340]. Research often focuses on sensor data like energy consumption, system status, stability of smart home systems or the presence of people in a room as there already are tools supporting sense making of smart home data [59, 106, 170].

With regard to VAs, there is already some research on designing natural language processing tools to help consumers find hidden patterns and meanings of their (potentially sensitive) data at home [292]. However, to best of our knowledge, there are no tools that support sense-making of voice interaction data specifically.

We argue that data of voice assistants is a non-trivial task and sensitive issue: In fact, there exist many design resources for smart home data analysis that can be reapplied for designing sense-making tools for VAs. For example, as it is the case for many data collecting devices, users only have a vague understanding of the type of collected data as well as timing, storage format, and intended use by the service provider [1]. However, VAs need to be treated different due to the natural language interaction via voice, the accidental activations, and the thereby collected data that arguably make VAs different. Combined with the known problems of opaqueness and lack of usable control of embedded devices, VAs, at least in their current form, are suited to further weaken consumers' informational autonomy over insights into activities at home and the data collected about these activities and routines. Therefore, much like with other smart home devices, a promising approach in this respect is researching usable tools for supporting consumers in analyzing their voice interaction data to foster awareness and sensitivity for privacy implications of conversation data with VAs.

8.3 Data Visualization Prototype

In previous work, we investigated the use and appropriation of voice assistants in private homes [248]. In this context, we presented users their interaction histories on the dashboards provided by the vendors. This led to some interesting insights for the users but turned out to be too limited for deeper reflections in the sense of fostering data literacy or awareness. Based on this work and the Visual Information-Seeking Mantra by Shneiderman [297], we developed a prototype (see Figure 14) which is able to visualize, browse, cluster, and filter conversation data. It accepts data takeouts as input as provided by Google and Amazon via the right to access as postulated in GDPR.

For the implementation, we compared both datasets – especially the interaction data transcriptions – to identify visualization possibilities and decided to focus on time stamp and transcribed commands in our initial prototype since both variables were consistently present. Takeouts from Google further contained the answers of the VA which were

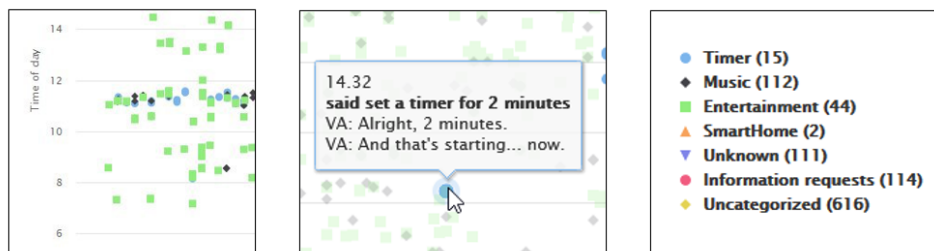


Figure 14

Screenshots of our prototype for supporting consumers in understanding their VA data. Left: Graph with interaction events, sorted by day and time of day. Middle: Information of an individual event. Right: User-defined categorizations to structure data.

missing from the Amazon takeout. However, by now, Amazon also provides such information for some commands. Based on those conditions, we decided to show the interactions as points on a graph, sorted by time with the possibility of categorization by terms extracted from the transcribed commands to identify patterns. Other studies support this decision as they have already shown that time series data and the visualization of patterns and actions are usable cues for supporting people in reasoning about data. Further, many automated actions that were programmed were mostly triggered by the time of day [78, 151, 205].

The tool visualizes every interaction on a timeline, where the x-axis shows the date and the y-axis shows the time of day of the interaction. Hence, each column in the graph represents a day from 0:00 at the bottom line to 23:59 on the top line. The user can zoom into the graph and move the view to look at clusters of interactions in detail (see Figure 14, left). If a single interaction marker is selected, a tooltip shows the user's command as recorded by the device in combination with the VA's response (see Figure 14, middle).

To further support sense-making, the tool allows users to sort their data into categories based on terms from the users' commands, for instance "timer" would include all user commands that contain this expression. These categories are then coded with individual colors and symbols (see Figure 14, right). Users can toggle visibility of each category to

focus on single events or categories. For supporting the classification of interactions, the tool implements a simple natural language processing algorithm which tokenizes the user commands and presents the terms as a list ordered by frequency. By doing this, users can see which terms appeared frequently in their voice interactions and might be interesting to use as selectors for categories, such as "music", "play", "start", etc., as illustrated in Figure 15.

We supplemented a video as a visual demonstration of our working prototype to this paper.

8.4 Research Methodology

Between June and August 2020, we conducted a remote study with 11 participants to observe how our prototype affects consumers in their sense-making process. The study took place remotely via a video-conferencing tool because of the COVID-19-situation and was led by two interviewers: one moderator and one note taker.

Prior to the data exploration session, we supported the participants in requesting their data and interviewed them about their expectations regarding the provided data takeout. In case of Alexa, the data takeout can take up to several weeks until it is made available. We therefore continued with the second part of the study after the data takeouts could be accessed. Although this was an important and interesting step towards the conduct of the exploration, this paper focuses on the data exploration in order to keep the scope and focus narrow.

During the data exploration, we asked participants to share their screen to be able to trace their activities and provide support if needed. The shared screen was recorded with their consent. Both interviewers wrote down their observations about critical incidents, interests, and needs expressed by the participants regarding data visualization and usability. We asked them to verbally reflect on their data and freely express any questions. Each exploration took about 60 to 90 minutes. Our analysis was based on an open-coding approach in the sense of Grounded theory

Takeout Data

Limit # of events:

Categories

Name	Keywords	
Timer	timer	Delete
Music	musik,spotify,radio,spiel,lied	Delete
SmartHome	Licht,Heizung	Delete
Entertainment	Netflix,Witz	Delete
Questions (weather, information)	Wer,was,wann,wie	Delete
Unknown interactions	Unbekannter Sprachbefehl	Delete

Word Count

Term	#	
gesagt	717	Use as Category
google	112	Use as Category
unbekannter	111	Use as Category

Figure 15

Settings and functionalities of the prototype for visualizing the data.

[317] which helped us to analyze users' behavior and needs regarding data work and sense-making.

The data exploration session started with a 10-to-15-minute exploration of the data takeout where we discussed the clarity of the data and files they received. We also asked about the relation of the information regarding the users' expectation recorded in the first round of interviews. After that, we gave them access to the prototype to explore the data. The procedure was structured openly so that our participants could freely explore the prototype and their data. Nevertheless, we prepared a guideline with four tasks to guide the users through the exploration. The observation started with task 1 by copy-pasting the conversation

data into a respective form field on the prototype (see Figure 15, number 1). After clicking on "Start" (number 2), a first visualization appeared with "Music" and "Timer" as two pre-defined categories. We gave the participants some time to freely explore the prototype and data visualization while thinking aloud. The second task was to create own categories (number 3) by considering the graph, the containing interactions, and the word list (number 4). Finally, the last task was to create another category for all data that relate to unassignable interactions (number 5) which are declared in the data takeout as "data not available" for Alexa users and "unknown voice command" for Google Assistant. This was planned as a separate task as we assumed that the participants were not aware of the existence of that data. Furthermore, we wanted to investigate if they understood the meaning of this tag and thereby wanted to ensure that they became aware of these data with potentially sensitive content.

8.4.1 Sample

The 11 participants of our study (see Table 17) were 9 male and 2 female German native speakers with a mean age of 37. All of them were VA users. They either lived in single households or shared their homes with their family, partners, or flatmates. Participants were recruited via social environments of the authors or via snowball sampling. The most important criterion here was a general interest in the data that is or might be collected by a VA, regardless of their level of concern regarding privacy. Furthermore, qualified participants needed to have access to the collected data. Therefore, an additional precondition for participation was being the account holder and qualified of requesting a takeout via the right to access [58]. We informed our participants about a post-study 15 € voucher only after they had agreed to participate in our study. This approach ensured that our interviewees were taking part in our research primarily because they were interested in the data and not motivated by financial incentive. The account holders who we talked to turned out to be mostly the male household member. This is, as we also reflected in the analysis, in line with the general user

#	Age	Sex	Household	VA System
P1	35	male	3 people, Family	Amazon
P2	27	male	3 people, Partnership / Shared flat	Google
P3	48	male	4 people, Family	Amazon
P4	26	female	1 person, Single	Amazon
P5	35	male	4 people, Family	Amazon
P6	24	male	1 person, Single	Amazon
P7	34	male	3 people, Family	Amazon
P8	56	male	3 people, Shared flat	Google
P9	34	male	2 people, Partnership	Amazon
P10	58	female	2 people, Partnership	Amazon
P11	31	male	5 people, Shared flat	Google

Table 17

Participant information of our study

group composition of smart home devices [296]. The participants had used either Amazon Alexa or Google Assistant for one up to four years. Our sample includes 8 users of Alexa and 3 of Google Assistant, which reflects the fact that Alexa is more popular in Germany [273]. However, we also included Google users to contrast different data trails. The main use cases turned out to be rather similar in all households and included mainly smart home control, especially lights and TV, listening to music or radio, and asking for information like news, weather, or knowledge inquiries. Some used it for playing interactive games, especially quizzes, others for entertainment like watching series or telling jokes. Two households connected their VAs with their calendar to regularly ask about upcoming events. Another household used the VA to maintain a shared shopping list.

8.5 Results

In this section, we present the results of the data exploration. We first give a short overview about the process of receiving the data and its exploration to explain users' expectations regarding the data. After

that, we continue with the visualization and sense-making with the help of the prototype.

8.5.1 Expectations on the Takeout Format

After participants had received their data takeout, we started with a 10-to-15-minute exploration of the raw data. In contrast to Amazon Alexa users, Google Assistant users had the option to choose their data takeout format, for instance, json or html, and could therefore already develop an idea of how the data will be presented. However, our interviewees who used Alexa expected to receive a more accessible and well-formatted takeout since they obtained no information about the potential content, format, or structure prior to the download. As high-level expectations, some thought of receiving a link to a website where the data would be prepared and fed back: These data were imagined to be statements about recommendations of songs they listened to, or information about who had access to this data. However, the expectations regarding the scope and depth of detail were different: With respect to the data format, five participants mentioned they expect a single extensive pdf document or excel sheets with tables. Overall, participants were afraid that the data might be aggregated or otherwise incomprehensible:

“I think I get them in the simplest possible form. I would be surprised if they were complete or even meaningful. I am really curious what I get.” (P5)

There was consensus that, similar to the interaction history provided by vendors through their proprietary dashboards, the file would include information about the timestamp, the command, and the answer. Moreover, most of the participants thought of an option to listen to the record as it can be done in the vendors delivered interaction history. Two participants also imagined that information about the devices used would also be provided, for example how long the TV was on or whether and what data exchange had taken place with the devices.

8.5.2 Exploring the Data via the Takeout

The dispersed structure of the directory in the data takeout made it harder to gain an overview and understanding of the provided data as the labelling of folders and files were not self-descriptive. Html files, if available, were easier to understand than csv or json files. As expected, three of our participants who reported previous experiences with programming and / or worked in the IT sector had less problems to go through the takeout or open and read the files. All other participants, however, described the content as very technical, difficult to read, and hard or impossible to understand – especially because the labels and terms were provided in English.

Next to the format of the presentation, some participants were also surprised by the contents of the data takeout; for example, becoming aware of the mere amount of data in the takeout from Google (and all its services):

“[There are] 9,427 files. [...] That means 30 files per day over a year, that’s quite a lot.” (P8)

Another participant was especially surprised about the audio files of the commands that were ever spoken to the VA which were a part of the takeout:

“I’m just unzipping the directory and that’s a lot [...] There are alone 3,170 mp3 files [of 6,979 in total] in the folder of Google Assistant, that’s totally crazy. [...] And this means, there have to be a lot of other interesting files in the directory.” (P11)

After the open exploration of the directory, we asked our participants to identify the interaction related data, especially the recordings and transcriptions to use the latter for further processing with our prototype. Again, the participants had problems to identify the correct files or were unsure about where to look for them. The files of the Google

Assistant, for example, were located within the folder “My activities” whereas the participants expected to find them on a directory level similar to other Google services like Gmail or Maps. Alexa users were unsure if they had found the correct files since they were confused by the missing structure of the provided csv file – it was presented as a single string containing all information.

The raw data format provided by the vendors underlined our assumed need for implementing a tool that visualizes and supports in sense-making of the data.

8.5.3 Exploring the Data via the Prototype

Within the prototype, the participants were able to visualize their interaction data in a graph with the date noted on the x-axis and the time of the day shown on the y-axis. This already helped participants to get a birds'-eyes overview of their spoken commands since the beginning of use:

“The graph and the categories are pretty cool. I thought of pie charts about general use. But this allows me to see what I said and when [. . .] As you can see here ‘turn that [light] off’ and as here is shown, you can see when I went to bed at these times.” (P2)

The participants quickly understood the graph and identified their typical usage times by noticing accumulations of events in the morning and the later afternoon or evening with empty areas in between.

We further implemented a word list that shows regularly used terms based on users' commands ordered by frequency of use (see Figure 16). The word list together with looking at the graph was always considered to be helpful for building new categories. They also followed their mentioned use cases such as "Control" (of lights or volume), "Weather", "TV", "News" or "Shopping" (for shopping list). Their reactions to the visualizations were always positive:

Found terms

Term	#	
alexa	884	use as category
stop	374	use as category
data	130	use as category
not	130	use as category
available	130	use as category

Figure 16

List with identified terms out from the interactions with the terms 'data', 'not' and 'available' that refer to unknown voice commands (own example)

“I have now actively searched for "shopping" and the tool now shows me when I added tissues and toilet paper to the list. I like it, I really like it.” (P5)

Four of our participants expressed the wish to have a list of complete commands for building categories but were also concerned that commands for the same task can vary regarding wording or syntax. None of our participants felt the need to apply the category for unknown voice commands by themselves since their categorization reflected their actual use. Therefore, we created a specific task consisting of assigning all interactions caused by unintended processing of the VA to the respective unknown voice commands category because we also wanted to discuss this in our interviews. Some Alexa users were already confused about the English terms in the word list (see Figure 16) even before we directed their attention in our dedicated task:

“I don’t know now what this means. I don’t think we have spoken in English to her, but maybe Alexa said that when something happened. But I can’t explain it to myself.” (P1)

The participants quickly came to conclusion that these commands might have occurred due to technical problems like internet or connection issues or that these might have been incomplete or unintended interactions:

“Either they are the ones where my flat mates were saying something or those are commands where it [the VA] was unable to assign it to a command.” (P8)

Nevertheless, these interactions attracted their interest and made some participants reconsider their views about the collected data. For example, one participant asked about the necessity of storing especially the data on unknown commands:

“I wonder why the data is stored for such a long time, especially those unknown voice commands.” (P3)

When Alexa users listened to a few audio files connected to these unknown commands, they sometimes only recognized the activation word or TV noises from the background. On the one hand, this calmed them down. On the other hand, however, it also made them realize that there could be more sensitive information recorded. As a direct reaction to this encounter, four participants stated they might be more careful about what they say with a VA present in the future to avoid its unintended activation:

“When I give a command in the future, I would try to make sure that I am in a neutral environment or that I am paying attention to what is being said in the background.” (P6)

Google Assistant did not attach any recordings to their unknown voice commands, and users were therefore wondering why the information was appearing in the data at all without further clarification.

The visualization of the data was appreciated by the participants and allowed them to reflect on their current use of the VA. It also supported them to better understand what data was collected about them but they rarely saw the need to use a tool like our prototype on a regular basis:

“I don’t know why I would use it again in a couple of weeks, after I had a look at the tool today, because then I won’t see any difference. [...] At the moment the tool is still rather good as something ‘Nice-To-See’.” (P11)

This might be because the prototype did not allow further interpretation and analysis of the data. Therefore, we asked participants about their interests and needs in the next step as reported in the following section.

8.5.4 Supporting Sense-Making

During the thinking aloud part of the exploration, we got meaningful insights into how the visualizations inspired people to reflect on the use of their VA. Furthermore, the visualization motivated them to ask further questions, for example about what other things Google or Amazon might know about them. We identified four different areas of envisioned use of a VA data awareness tool:

For maintaining an overview. The prototype helped participants to get aware of their usage behavior and times by categorizing the commands. The different colors and forms for each category further helped to trace the interactions. By hovering an interaction point in the graph, the participants could also see every single interaction with its date and the conversation in a little tooltip next to the event (see Figure 14, in the middle). This visualization was evaluated as helpful although Alexa users were missing the answers of the VA since this feature was not yet available during the implementation of the prototype.

The participants expressed further needs to get information about the person voicing the command, the used device, and its location. Besides VA interaction data, participants were especially interested in data disclosure to involved devices (e.g., smart home devices like lights or TV) or third parties (e.g., when using skills / actions like Spotify):

“It would still be interesting to see who the [addressed] app provider is or who is behind it. But more I cannot do with it

yet. I think it would be really exciting to see if there is another interaction list between the devices.” (P6)

P6 envisioned the mentioned list to contain information about the data that were transferred between the devices and also show if the information was only a signal or the whole command. It would also be helpful to see if an interaction was executed successfully.

For looking back at past activities. The graph and the timeline further enabled participants to look back to see all interactions, even those that happened when the user was not at home. As a result, the data takeout revealed some information about what other household members were doing during the absence of the account holder:

“As a user [account holder], I can see data from periods of time even when I was not at home. In terms of privacy, this is already precarious and like a small eavesdropping attack. If I were to suspect that my wife was receiving male visitors, then I could practically start looking for them now. You know: ‘At this and that time I wasn’t at home, and there is an audio file where I can hear a male voice in the background!’ or something like that.” (P3)

While perceived critically from a privacy perspective and the existing advantage of knowledge about other household members, it was also perceived helpful for specific issues like rediscovering information that had been looked up with the VAs previously:

“For example, if I want to find a song I heard in the past. The category ‘music’ and the date could help me find the song again.” (P10)

For learning about interactions. As mentioned in the results, the word list was helpful to identify frequently used terms, and it supported participants in building categories. Some participants asked for a list of all used commands, which then could be used for categorization or

clarification about potential differences in interpreting the voice command and the intended interaction from a technical point of view:

“It currently shows me the identified expressions as single words. It would be interesting if you could say as an alternative option ‘show me this as it was understood’, as a whole command.”
(P9)

The participants were interested in getting to know about differences or changes like if the way of talking is becoming more human-like or not, for example, by analyzing the duration of the commands as another participant concluded:

“The length of the commands is also saved in the data. [...] a hypothesis might be that people talk more complexly with it over time, what I actually do not believe. But then you could show how the number of seconds per command has changed over time.” (P11)

P11 also proposed a better presorting of the terms or commands by topics for a clearer structure of the list and the data:

“It would be good if data were as much as possible pre-categorized. These single terms are actually not that relevant. Rather, they are more relevant [as categories like] smart home control, alarm clock, everyday organization, or multimedia [...].”
(P11)

For re-balancing power and knowledge. Our participants were interested in the visualization of the data, but also expressed a need to know what the data tells about the users and how the vendors might analyze their behavior – in other words, how others use the data and what they learn about the users:

“First of all, I would like to know what they are doing with the information they have gathered. That would be interesting,

and it would also be interesting to know what they do with terms like ‘television’, if they use it in any way.” (P9)

Here, a need can be observed to understand which patterns can be identified and even how single terms or commands affect their analysis. For example, participants expressed the need to get further analyses about the music they listened to, based on recommendations of their music app:

“The VA also knows for every song which similar songs exist or what I would like to hear next.” (P7).

Besides the analysis of the content and the way of talking to the VA, two participants also assumed that the audio file could be used to analyze the speaker or the situation s/he was in:

“The audio file probably tells if I am alone, if there are other voices in the background, if there is a party going on or an exuberant mood. [...] The vendor can already generate a good profile about me.” (P6)

Only one participant noted that it is less a question of the type and manner of the analysis than of the conclusions that can be drawn from them:

“I can imagine they store other, more profound data too. For example, analytics about the voice [...] as well as other basic things such as the algorithms that I as a layperson might not be able to use [...].” (P4)

As a concluding example for a users’ visualization, Figure 17 depicts a graphical representation of the data from P11 who used his Google Assistant for about two years in his room in a shared flat. Therefore, he was the only user besides his girlfriend who would sometimes use it. P11 mainly controlled smart home devices, specifically lights and power consumption of other devices (category "power").

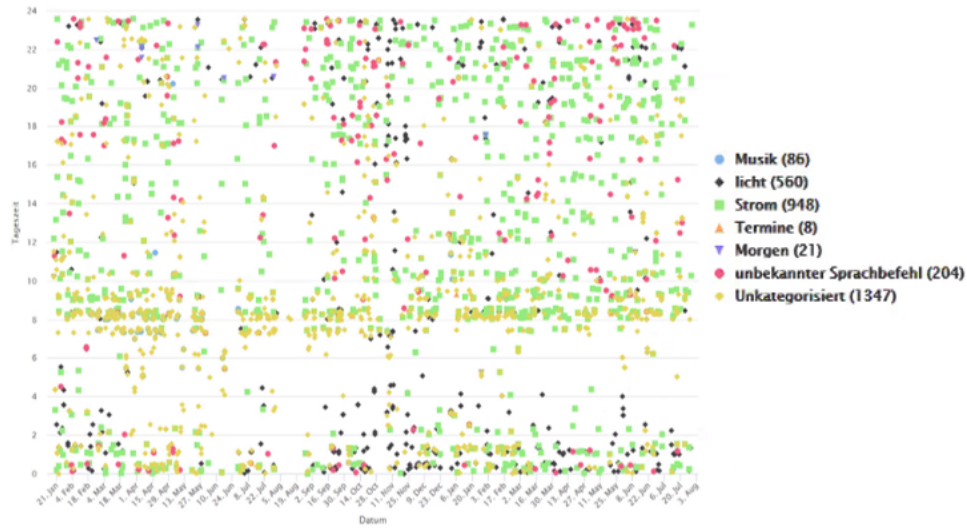


Figure 17

A visualization of VA data from P11 with 3,172 interaction points in total since his first use in January 2019. The categories on the right with number of events in brackets are as follow: Music (86), Light (560), Power (948), Events (8), Morning (implemented routine of actions) (21), Unknown Voice Commands (204), Uncategorized (1,347)

8.6 Discussion

The results show that, much like for other embedded devices, also for VAs, user expectations about data collection often differ from the data which is actually being collected [206]. In the following, we therefore show the participants' learning process and discuss how a tool like the prototype used in our study supports users in increasing their data literacy if it is enhanced further.

8.6.1 Awareness Creates Data Literacy

Throughout the study, our participants underwent a learning process as we supported them in reflecting about their personal VA data. This information was previously described as difficult to grasp. Their expectations regarding what data might be collected were based on the vendors' interaction log and their mental models about common usage

situations. Our tool partially acknowledged these views as the general categories fit the use cases that had been expected, but also made our participants aware of both the amount of use and especially the unintended interactions.

Bringing attention to recordings. However, the users were surprised to find information such as full audio recordings including, e.g., background noises, which allow for drawing conclusions about the situation in their home. In this regard, some participants highlighted additional privacy implications for themselves as well as for bystanders [298]. Besides the awareness of the interactions with the VA – intended or unintended – we asked our participants about concerns regarding privacy when they had a look at their data. As other studies have demonstrated, our users felt generally aware of the privacy implications of voice recordings [67, 110, 287], especially of those that contain sensitive content [67, 82].

Revealing unintended interactions. Another issue evolved around the existence of unknown voice commands and their meaning and privacy implications: Being able to look through and listen to these recordings turned out to pose a trigger for participants to wonder about the sensitivity of VA recordings from a new perspective. It also confirms our initial assumption that VA data is not as trivial as suggested in other research [170]. We therefore argue that these data sources are of high relevance for further development of awareness tools for VAs.

Addressing user needs for sense-making. As our previous work had shown [248], the list of commands in the vendors' dashboards offers few practical functionalities to navigate through interactions. Furthermore, despite our sample consisting partly of tech-savvy users, the raw data format posed a serious challenge in terms of intelligibility. There is a need for more tools like the prototype presented in this work to help users making sense of their data and raise awareness about what IoT devices detect, save, and process. Here, our study pinpoints the fact that consumers seem to be less interested in how the data is processed [327, 374]. However, they do care about what is revealed about them or what additional data layers are created through the processing

[110]. Usable tools for providing awareness and transparency in terms of privacy implications will have to find a balance between showing detailed (e.g., raw) data or technical detail and high-level visualizations.

An interesting question in this regard is to what extent such tools interfere with or match the algorithms that companies use to interpret data. On the one hand, our findings indicate that business secrets are not affected because they are anyway exempt from the regulation and do not have to be revealed [98]. On the other hand, it is unclear how we can provide adequate analyses of companies' data for users with the limited possibilities of working with individual takeouts in contrast to the possibilities of vendors who have access to data of all users. One approach could be to focus more on shared analysis such as building a database of keywords and categories that help users analyze their data collectively other than performing individual analysis on single data sources.

8.6.2 Data Literacy as a Skill that Concerns Everyone

Based on the Privacy Personas by Dupree et al. [91], we could identify mostly personas ranging from "lazy experts" and "amateurs" in our study as they trust or rely on the security of the services they use and often mentioned they have nothing to hide or there are other devices or services that already collect their data [374]. One participant in our study (P10) was more concerned about the always-listening device and therefore stored it in the drawer when it was not in use. This indicates that P10 showed a higher motivation to protect her privacy and security than our remaining participants by choosing security over convenience. A closer look into the interview data in follow-up research will give more insights about the attitudes of our sample.

Although awareness about data safety and security issues including the potential of profiling people is gaining popularity, affected users often do not have the means to track and understand data collected about them via smart home devices such as VAs. Additionally, data takeouts which are requestable from the devices' vendor require a certain techni-

cal understanding for users to make sense of them. It is therefore necessary to provide helpful and easy tools to regularly check data transfers for users at home [59, 78, 151, 205] – just like it should be done with ones’ financial tracks. That is why, based on the Design-for-All principle [244], we intended to create a tool which enables interested VA users to investigate what the voice assistant is picking up at home.

As our results show and what can be confirmed by other related work, the needs and interests regarding data can be different among users and may change over time [151, 346]. For instance, some participants were only interested in unexpected events whereas others directly started to ask further questions about how the speech behavior might change over time and how this adaption could be represented. This further implies that not the full set of available information will be necessary for every use of the prototype and for each user. For example, users may just need a notification telling them that everything works as expected [151] but sometimes they want to investigate further or explore more detailed questions about their data. This change in needs and type of data investigation should be considered for the implementation of future functionalities, for example by adding exploration tools for more advanced users or by offering personalization options.

8.6.3 Guidelines for VA Data Literacy

The prototype turned out to be a useful first step towards helping users to better understand their data from conversations with VAs as well as the information within the data collected. Therefore, it can support strengthening data literacy. The prototype enabled our participants to interact with the otherwise rather unintelligible raw data more intuitively and raised awareness about unintended recordings. By conducting the observation of data exploration, we were able to show the tool’s utility and gather further needs and ideas from our participants to improve the prototype:

Support right from the start. The dispersed structure of the takeout made it hard to understand the data and complicated the navigation

within the directory. Therefore, supporting users in exploring and understanding their data should start with explaining the content of the various files and folders and offer follow-up actions a user can take, such as importing the required file from the original data takeout file structure into the visualization tool. On the one hand, this would be more comfortable for the users; on the other hand, it means that the tool should be precise about how the imported data is further processed to inform users about privacy implications. Finally, privacy settings and preferences are often only prompted when a user encounters an unknown product or service for the first time and are likely to be forgotten and never shown or informed about during long-term use. Awareness about the existence of collected data including relevant policies should be evoked from time to time to prohibit unwanted surprises.

Share categories and support to structure the data. The prototype offered categories and a word list to structure the data. During the user test, we detected categories which were relevant to at least the majority of our participants. Our users also directly asked for more pre-defined categories to speed up the process of structuring the data. Requested categories were, for example "Smart Home control", "Lights", "Unknown commands", "TV", "Shopping" or "Weather". Implementing more robust automated detection and improved algorithms for suggesting categories may be one viable option. Additionally, allowing users to exchange categories with each other might be a privacy-friendly way to cooperatively support them with sense-making. In general, improving the way categories are built with smarter support functions like usage times, voice recognition or categories based on tasks and their related commands would help users considerably in making sense of their data.

Reconstruct the context. The visualization of voice interaction data in a graph supports consumers to have an overview and to understand their data in contrast to a chronological list as offered in the vendors' apps. Besides the information about the time, the content, and the answer of the VA for each voice command, participants were interested in additional information such as an identification of the person voicing the command. This would help to reconstruct situations by showing who used which of the devices. Furthermore, it would enable users to

identify unknown voices or unusual locations as potential threats. In addition, participants found the location or the used device to be interesting since VAs can also be used in mobile devices. Moreover, some devices can also be used in different rooms at home. If audio recordings are available, it would be useful to make them easily accessible and link them to the interactions to enable users, for instance, to immediately listen to unintended interactions or failed automatic transcriptions.

Draw attention to unintended interactions. Events and interactions that deviate from normal use or were recorded unintentionally were the most concerning data for our participants. These events should be highlighted so that consumers can reflect on these and maybe initiate further steps. Current labels like "data not available" as offered by Amazon Alexa provide no information and force users to listen to every file manually. The transcribed voice recognition of these data would be a good starting point to further support consumers in quickly grasping these data.

Tell the consumer how the vendors (might) see them. Participants also asked what the data tells vendors and third parties about their use and elicited profiles. Our participants were aware of the fact that companies use VA data, for improving voice recognition and personalized advertising. In this vein, they wanted to understand how their data affects the analysis and what can be concluded about the consumer [263]. This can be an analysis of preferences in music based on the users' playlists or even a personalized profile that can be drawn from the use of the VA.

Disclose the communication between devices and services. As a platform, a VA offers access to a variety of third-party services and an application ecosystem. Hereby, our participants were interested in exploring their own data traces beyond the boundaries of single services. A VA command including a skill or third-party device is likely to share data with these third parties and can consequently not be accessed by requesting a data takeout from Amazon or Google.

8.6.4 Limitations

Our study was focused on the impressions of account holders as they were the ones with access to the VA data. However, VAs collect voice data from all household members disregarding who has activated the device or who can be heard in the background. Future research should also consider other household members during the design process since VAs also collect data about them. This would be an important direction to broaden the scope of our study [118]. It must also be emphasized that we used only the conversation data and left out other content and data from the takeout. Furthermore, it would be interesting to test our findings with a bigger and more diverse set of users. Especially in the case of more vulnerable groups of users, collaborative aspects might play a bigger role in the context of computing, controlling, and managing the smart home in general [110, 262] as well as VAs in particular [138].

8.7 Conclusion

The aim of our study was to learn more about what users of VAs know and understand about data collection and their use by the vendor. We therefore developed a prototype to explore the conversation data with eleven users and gained three major insights: First, the exploration revealed that users were not or hardly aware of the data collection of unintended interactions. Second, users were surprised about the storage of the recordings and what other data or sounds might be associated with it. And third, resulting from the previous points and the other insights, we determine the need for a tool to strengthen data literacy making conversations with VA systems and its context more transparent. This should lead to reducing the imbalance of knowledge and power to access and understanding users' data footprints at home. As related work had already shown the relevance of providing transparency about the amount and use of smart home data in general, this paper provides further insights with special regard to VAs. Furthermore, by confronting users with their data, we challenged their

assumptions and supported their learning processes in understanding their usage behavior by showing them what kind of data VAs store.

For future research, we want to identify more needs regarding the unintended events and further allow analytics about topics and patterns users are interested in and of which they require more information [175]. As research on mobility [151] as well as energy data [59] highlights, it is less necessary to present all data, but more important to alert consumers when unexpected events have occurred, specific kinds of information need to be requested or even to tell if everything works as expected. Hence, we plan to implement a dashboard based on the prototype with additional functions from which the users can choose the ones they need. This will go beyond the previous options of the prototype (visualization and categorization) to support further sense-making and management of other types of user data like audio recordings.

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9 'In the Living Room, She gets Everything' – Voice Assistant Data in Everyday Life

Abstract

Voice assistants such as Alexa or Google Assistant have become an integral part of many consumers' everyday lives. They are particularly appealing due to their voice-based and therefore hands-free control and sometimes also their entertaining character. The living room and kitchen are the most common location for these in the home, as this is where household members spend most of their time and where everyday life takes place. However, this also means that a lot of data that is not intended for the voice assistant can potentially be captured and collected in these locations. As a result, it cannot be ruled out that the voice assistant is activated - albeit inadvertently - by conversations or noises and saves recordings, even if it is activated unintentionally by people present, by other devices (e.g., televisions) or from other rooms. As part of a research project, users were asked about their usage and placement practices of the voice assistants and a prototype was tested that visualizes the stored interactions with the voice assistant. Based on the findings from the interviews and the guidelines derived from the subsequent usability tests of the prototype, an application is presented in this paper for requesting and visualizing the interaction data with the voice assistant. This makes it possible to display interactions and the associated situation by displaying the time, the device used, and the command for each interaction. Additionally, unexpected behavior such as accidental or incorrect activation was also made visible. In this way, it was desired to sensitize consumers to the susceptibility of these devices to errors and enable more self-determined and safer use.

This publication has been translated into English for use in this thesis.

9.1 Introduction

Voice assistants such as Siri, Google Assistant and Alexa have been established as voice-controlled companions for many consumers, as they support and simplify user's everyday lives. According to Postbank's annual digital study, almost one in three Germans used a voice assistant in 2019 [179] – and the prevalence is increasing; in 2020, 45% already stated that they use a voice assistant on their smartphone or at home [285]. While every smartphone now has a voice assistant pre-installed and users consciously use it or may have already activated it once by mistake, the purchase of voice assistant devices for use at home is usually a conscious decision. However, more and more household appliances also offer built-in microphones or cameras or the possibility of being connected to the smart home, which sometimes means that consumers no longer have an overview of where artificial intelligence (AI) (such as a voice assistant) is implemented [16] or in which situations they are already using AI [18].

Google Assistant and Alexa (Amazon) are popular voice assistants used at home and are most frequently placed in the kitchen, living room and/or bedroom by users [288, 248]. However, some devices are also used in the bathroom. All these places represent social and central (retreat) places in the home, in which private and intimate situations also occur, which are demarcated accordingly and should remain out of the public eye [352, 128]. This often makes voice assistants a controversial topic, as they are potentially always ready to record and – in the case of devices with a camera – can also capture images or videos from these areas. In addition, there is the uncertainty as to which company or person is listening or watching [133]. In this regard, non-users in particular, but also users, often have concerns, as the voice assistant stores data even if it is accidentally activated. These concerns are usually due to a lack of trust in the use of the data and a fear of losing control over data sovereignty [360] which is why the invasion of privacy or the collection and storage of data by the voice assistant is often viewed critically.

As part of a project to increase the data sovereignty of consumers with voice assistants, it is desired to counteract this uncertainty and show users what data is collected by a voice assistant, especially in the home environment.¹¹ The approach used in this work was to use the data take-out that consumers can access in accordance with GDPR Art. 15 "Right of access by the data subject" or Art. 20 "Right to data portability", which obliges companies to hand over all personal data in a machine-readable format. With the help of a data visualization application developed within the project, the raw data of the machine-readable format, which is usually incomprehensible to laypersons, can be prepared and presented in an understandable way and made interpretable. In doing so, the approach was followed of the human-centered design process in order to develop a suitable tool based on real user needs and requirements, which included as many consumers as possible in terms of use in accordance with the "design-for-all" principle [244].

9.2 Related Work

The use of voice assistants represents an interesting area of research from the perspective of various scientific disciplines. In addition to the investigation of various use cases [288, 35, 248] and user satisfaction [186, 296] guidelines for the design of voice assistants have also been developed [223, 323]. The extent to which voice assistant data can be relevant as evidence for criminal prosecution has also been investigated from a legal perspective [246, 236].

From a consumer perspective and with a view to the protection of privacy and informational self-determination, research results have already been published that lead to user-centered and usable support in dealing with one's own privacy and other data protection-relevant topics in accordance with usable privacy [7]. Furthermore, and in times of big data and the proliferation of the IoT, it is also important to strengthen or empower consumers' data literacy. With the help of these approaches, it is possible to derive concepts and solutions to restore the

¹¹For more information on the project: <http://checkmyva.de>

balance of information and power between consumers and companies regarding the collection and use of personal user data. Related work in these areas is presented below. In doing so, focus was placed on the use of voice assistants in the home environment, with a particular focus on the relevance of and expectations for privacy and data protection. Furthermore, we present contributions on the understanding and perception of data-collecting AI devices and provide insights into related work on the visualization of data for user-centered sense-making and interpretation of this data.

9.2.1 Use of Voice Assistants in (Multi-Person) Households

Voice assistants such as Google Assistant, Alexa or Siri often arouse fascination and high expectations of their capabilities among users in the initial phase. Many users assume that they will be able to have ongoing interactions (conversations) [71]. However, it has been shown that more complex applications cause problems in which communication that builds on one another is necessary, such as voice support when preparing a meal [248]. Voit et al. [348] have also stated how, during the appropriation of voice assistants at home, usage patterns become established while expectations are also unfulfilled. Similarly, Luger & Sellen [186] showed that the use of voice assistants is often accompanied by tendencies towards anthropomorphism, which is often due to a lack of knowledge about how the system works among consumers that do not have special IT knowledge [186]. This lack of knowledge and the common characterization of the systems as "always-listening" in the international HCI community [175, 328], however, also lead to skepticism, as it is often unclear what data the voice assistant stores or what impact this has on users' privacy [73, 175, 1].

Voice assistants can be controlled by anyone who is within earshot of the devices. Although both Amazon and Google already offer voice as-

sistants that can be trained to respond to the user's voice,¹² this only serves to provide users with a more individual or personalized user experience and results. This means that commands made by other household members and visitors who do not have their own profile or user account linked to the voice assistant can still appear in the main user's data, whether they are spoken on purpose or not. In a study by Geeng and Roesner [118], the authors investigated how access to the use and settings of the device is regulated among members in various households, revealing that often only the administrator of the smart home devices, who most likely also initiated the installation of the devices at home, has access to the collected data. In another study interviews were used to investigate the privacy risks in multi-person households that use voice assistants [138]. Here, too, it was found that other household members often lack the opportunity to gain insight into the collected data in order to see what is stored about them, while at the same time they can access can also access personal data such as contacts, the administrator's calendar or even make purchases. As a result, there is a need for solutions that provide more transparency about how the voice assistant works on the one hand and enables users to better protect themselves and their data and personalize access on the other.

9.2.2 Consumer Understanding of AI and its Data Collection

In previous studies it has been shown that consumer awareness of AI-powered technologies and the data they process is insufficient [16]. The results of a study by HubSpot of more than 1400 consumers worldwide found that 63% of those who reported not using AI tools were using them without realizing it [18]. Pega Systems confirmed these findings with a study of 5000 consumers, in which only 34% of respondents said they had ever used AI technology [242]. However, 84% of them had actually used these technologies [242]. Some studies have

¹²VoiceMatch (Google): https://support.google.com/assistant/answer/9071681#vm_pr&zipy=%2Cvoice-match-und-pers%C3%B6nliche-ergebnisse,
 Alexa voice profiles (Amazon): <https://www.amazon.de/gp/help/customer/display.html?nodeId=GYCXY2AB2QWZT2X>

involved an investigation of the perception and understanding of the intelligence attributed to voice assistants [90, 177, 117, 171, 368]. Xu and Warschauer [368], for example, have shown that children tend to assign voice assistants to a continuum between humans and artifacts rather than to a specific category. When children attributed more intelligence to the devices than to themselves [117, 368] they were more likely to trust and believe the information, which contributed to improved learning. By examining the state of intelligence or awareness of users, Druga et al. [90] showed that while younger children asked the voice assistant personal questions such as "What is your favorite color?", older children asked the device to perform actions they knew humans were capable of. It was also found that users with prior technology experience or technical backgrounds were more likely to make more concrete assessments. Moreover, the system's output allows consumers to draw conclusions about the device's behavior and actual intelligence [117].

In addition to the general understanding of AI-supported technologies and voice assistants, consumers' understanding of the data they collect has already been investigated. It has been shown that consumers are more likely to think of theories about how data can be used than about where the data comes from and how it is collected in the first place [260, 177]. Rader and Slaker [260] have shown in their study that users explain their activities based on their perception of the activities they perform and the processed data provided by the interface. Although users entered the data (e.g., age and weight) themselves, so that distance and calories were calculated based on steps or locations, they did not have a complete understanding of their raw data. As a result, users were unable to make informed decisions about the collection of their personal data and were unaware of further data processing and the underlying operating principles of the device. Misconceptions can lead to a lack of awareness of privacy risks. This is especially true when information is collected without consent, as in the case of Bluetooth beacon systems [373]. The beacons were part of an invisible IoT infrastructure in which no direct user interactions were required to enter personal data (e.g., location). In their study, Yao et al. [373]

used drawings as a method to determine consumers' understanding of how beacon-based systems work. The most common misconception was that these sensors collect and store user data, which in reality is not the case. They also assumed that they had to actively consent to receive location-based information. Finally, most users thought that the location, e.g. the store or shopping center that collects the data, also owns the data. As a result, the users who consciously or unconsciously chose to be part of the sensor-based system had little awareness of the actual mechanisms of raw data collection and processing. Therefore, to enable consumers to interact meaningfully and make informed choices, decisions made about the factors that influence consumers' understanding should aim to meet their expectations, and the design should transparently convey the actual capabilities of voice assistants and the data they collect.

9.3 Data Visualization for Sense-Making and Interpretation

Due to the often imprecise or lack of understanding of what data is collected by the voice assistant, as in other areas where a lot of data is collected, there is a call for solutions to present the personal data of users in a comprehensible form and thus provide an overview of what companies know about their users and thus also gain more control over the data collected about them. As demonstrated by the example of the voice assistant and in a previous study [249] unexpected events are of particular interest, which is also supported by other studies on smart home devices in general [360, 151]. Although the data insight options already offered by Google and Amazon make it possible to gain insights into the data, they showed potential for optimization with regard to the "exploration" of the interaction data, especially if they were already further from back in time [248]. Tolmie et al. [335] also concluded that a better understanding of what is collected by smart home devices and how this data is processed requires more than a simple notification or listing of activities so that users understand what is happening in their home, which can give them more confidence in the technology they use.

The aim of Usable Privacy [7] is to sensitize users to the process of data consumption by data-collecting services and devices and, in particular, to draw attention to what data is disclosed, in order to give users more control over data sharing and protection. This will enable further transparency and traceability of the data processed [114, 340]. There is already research and solutions for the presentation of smart home data [106, 59]. However, while collected sensor data is often "expected" as it has been deliberately installed for a specific purpose, voice assistants carry the risk of inadvertently recording data that is transcribed and stored during processing and may also contain sensitive data that the user is not aware of [249].

Furthermore, voice assistants can be seen as platforms that, like smartphones, bundle many different services that can be controlled by voice. This means that the assistance system also receives third-party service-related data, allowing it to present an even more comprehensive profile of the user or household. This was observed in a study on cloud platforms, in which a dashboard was used to organize data from a cloud platform and visualize it in an understandable way for users to view and maintain [346].

Based on the results and approaches of the current research mentioned above, it was desired to assert the right according to Article 15 GDPR together with consumers and gain a better understanding of the data collected and processed during an interaction with voice assistants based on the data takeout. According to the design-for-all principle, the tool to be developed should allow consumers to view the often difficult to understand and interpret machine-readable format to give them more control and understanding of the data collected.

9.4 Designing a Dashboard for Data Visualization

The aim of our project is to give consumers the opportunity to present their personal data collected by companies in an understandable and interpretable way. As it turns out, the data takeout in particular, often a zip folder with files in a machine-readable format, is usually difficult to

understand for less tech-savvy people without programming experience due to the technical or English-language presentation.

In this regard, the voice assistant is an interesting use case in two respects, as it fascinates many people with its intelligent and human-like capabilities and is therefore being used more and more frequently. However, at the same time – like many other AI systems – it is often perceived as a "black box" that is difficult to understand, which can lead to skepticism and mistrust of the device and the company behind it [360]. By developing a suitable tool, we would therefore like to balance out the imbalance of information and power between users and companies based on the data collected.

9.4.1 Previous Work

In 2020, a prototype was developed for the visualization of interaction data with the voice assistants Alexa and Google Assistant. This was developed as a web application based on the existing usable data from the .csv (Alexa) or .json (Google Assistant) file of the data takeout received and following the "Visual Information-Seeking Mantra" according to Shneiderman [297]. The prototype makes it possible to visualize the data and further allows its users to search, categorize, and filter their own data. In Figure 18 it is shown how data can be categorized and visualized as data points (see Figure 18, left). As is shown the middle image in Figure 18, it was possible to use the raw data to assign the date and time, the command given by the user and the response given by the voice assistant (only available for Google Assistant at the time of development process).

In addition to the graph for displaying the data, users are also able to create categories via a side menu, which can then be distinguished from each other in the graph by an assigned color, as shown in Figure 18 on the right. For the creation of categories, users can enter terms from the commands / statements used by the users so that corresponding commands and statements are assigned to the category. To support this,



Figure 18

Screenshots of the prototype for data visualization. Left: Graph with interaction points; Center: Detailed information on an interaction; Right: User categories for structuring the data.

a list of terms has been implemented that sorts the recognized terms by frequency and also allows categories to be formed (Figure 19).

As part of a small user study, the prototype was tested with users and their own data [249]. For this purpose, eleven participants were interviewed from the living lab, consisting of a total of 37 households (see Appendix A), were asked about their use of the voice assistant in a preliminary interview and jointly requested the voice assistant data. As soon as they received their data takeout, the prototype was tested in a second session.

From the findings, it was possible to derive guidelines on how interaction data with voice assistants should be visualized in order to make the use of the voice assistant more comprehensible, and thus safer, for users [249]. Based on these insights and guidelines, the prototype was developed into a browser extension that helps users access and visualize data for better understanding and interpretation.

9.4.2 Support Right from the Start: Data Request

The created dashboard was designed to be as intuitive to use as possible. For this reason, the interface was limited to central functions that can be accessed quickly (see Figure 20).

Since the data request itself was already causing difficulties, one aim was to support users in requesting their data using the browser exten-

Checkout Daten

```

{
  "time": "2018-09-13T18:17:44.456Z",
  "products": ["Google Assistant"],
  "locationinfos": [{"

```

So viele Datenpunkte maximal auswerten:

1000

Start

Kategorien

Name	Begriffe	
Timer	timer	Löschen
Musik	musik,spotify,spiel,lied	Löschen
Wetter	Wetter	Löschen
Radio	Radio,wdr	Löschen
Entertainment	Witz,Netflix	Löschen
Fragen	wer,wann,was,wo	Löschen
Smart Home	Licht,Lampe,Heizung	Löschen
AndroidAuto	rufe,schreibe,Route	Löschen

Kategorie hinzufügen

Gefundene Begriffe

Begriff	#	
gesagt	814	als Kategorie verwenden
spiel	266	als Kategorie verwenden

Figure 19

Sidebar of the prototype with option to create categories and list of terms used

sion, in particular to find a way of requesting and later selecting the data needed. In Figure 21 it is shown how the user is guided through the data request by red frames and texts in a further iteration. Since the browser extension is focused in particular on visualizing the voice assistant data, the user is supported by the provided instructions with regard to how to select the necessary data in the right format in order to visualize the interaction data using the dashboard. However, users also have the option to request all data collected by the company in this way.

9.4.3 Visualization and Structuring of Data

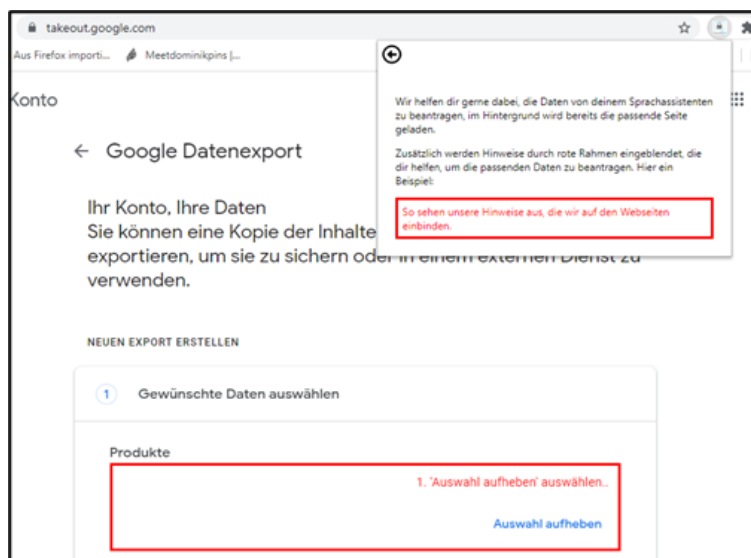
With regard to data visualization, little change was made to the prototype and further elements were added to it. Accordingly, the graph on which the interactions are displayed on the timeline, remains the core

**Figure 20**

Start menu of the browser extension

element of the visualization, as this type of display was also reported as being very helpful by the users.

According to the derived guidelines, users can thus create categories based on the terms used or choose from predefined categories to better structure their data (see Figure 22, left). For this, predefined categories were compiled based on the categories that the test subjects had formed from the first user study.

**Figure 21**

Guidance for the data request by red frames and texts on the provider's website (Google)

In addition to categorizing the data, users also expressed interest in how often they use different interactions. For this purpose, a pie chart was implemented that shows how often the categories occur in relation to the other categories based on the categories formed (see Figure 22, right).

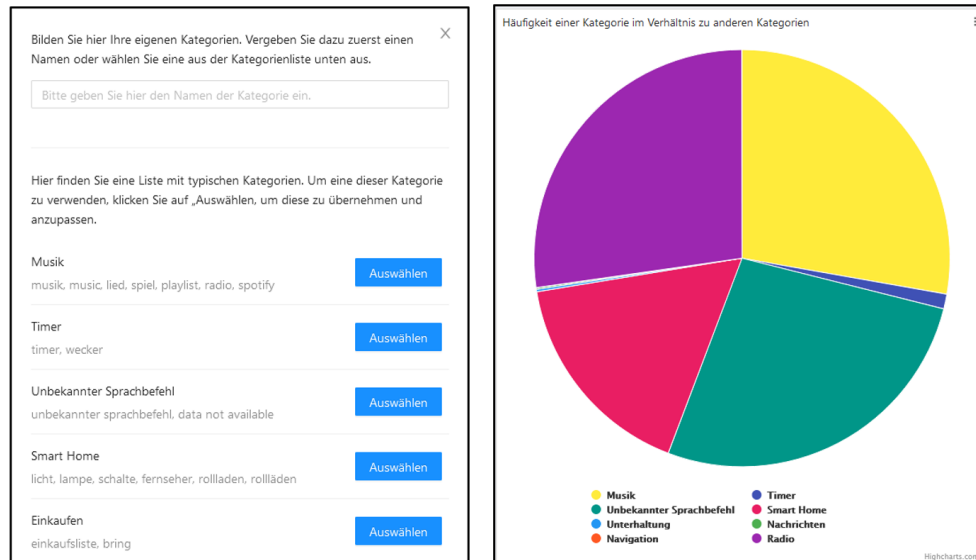


Figure 22

Left: Menu for creating categories with selection option from predefined categories
Right: Pie chart with relational frequency of the categories formed. (The frequencies are displayed in absolute values when moving over the pie slices)

9.4.4 Highlighting Unknown Voice Commands

As unexpected events are of particular interest to the participants, an extra category was predefined that highlights unknown voice commands for both Alexa and Google Assistant, which are stored in the data as "Unknown voice command" (Google Assistant) or "Data not available" (Alexa). In this way, users can now track which device was activated for unknown commands, when or how often the voice assistant was incorrectly activated, and the data stored in this regard. The storage of audio data can be switched on and off for both assistants, but while Google Assistant no longer stores audio recordings by default, this must be switched off by the Alexa users themselves so that the audios can be

also provided when data is requested. This allows users to listen to them in order to check what led to the unknown voice command. Unfortunately, direct access to the audio file in the data received (zip file) has not yet been possible in the developed our dashboard.

In addition to the list of identified words, another list was added to the dashboard that lists the whole commands. This means that users can not only track which terms, but also which commands they used frequently (see Figure 23).

Wort Anzahl			Befehl Anzahl		
Begriff	Häufigkeit	Zugewiesene Kategorie	Befehl	Häufigkeit	Zugewiesene Kategorie
w.	420		spiel w. d. r. zwei	368	
d.	419		wiedergabe stopp	245	
zwei	418		wiedergabe stoppen	119	
unbekannter	418		spiele w. d. r. zwei	23	
sprachbefehl	418		spiel w. d. r. zwei	13	
r.	417		stopp	10	
spiel	416		wie spät ist es	9	
wiedergabe	374		ja	7	

Figure 23

Lists of terms and commands with information of frequency

9.4.5 Context of Use: Placement and Embedding in Everyday Life

In order to better protect the home – which is considered the epitome of privacy – it was desired to give consumers a better overview and control over the rooms and devices in which data is collected and recorded. In the study it was shown that the participants see the voice assistant primarily as added value for the living room:

So in the living room, she [Alexa] actually gets everything. I wouldn't see her in any other room. (H35)

[...] We don't want it in the bedroom and children's rooms, and most of our family life takes place in the living room and kitchen. (H10)

This supports the findings of previous studies that the living room (often with an adjoining kitchen) is the most common location for voice

assistants, primarily due to the frequent presence of household members and the occasions of use for music, TV and smart home control [360, 248]. The statements indicate that the users interviewed did not see any added value in placing a voice assistant in the bathroom or bedroom, for example, and expressed fewer concerns about their privacy being restricted by the location. Nevertheless, devices that are not in the same room as the person speaking still react, as the following statements illustrate:

Sometimes you think to yourself: 'Why is she saying something upstairs in the bedroom when you're sitting downstairs in the living room and haven't talked to her?' (H2)

We often want to listen to music in the living room, but instead she plays it in the bedroom, even though I'm standing right next to her [in the living room]. (H18)

After saying "Ok, Google" in the hallway, the next Assistant doesn't react. Instead, a Google Assistant that is much further away is activated. (H11)

This shows that consumers are not protected from the fact that data can be collected about them even in areas where they do not want a voice assistant installed – whether due to a lack of added value or concerns about protecting their privacy. For this reason, information was added that shows the user which device recognized the command to an interaction. As the devices are usually named after the room in which they were set up, or users can quickly identify them by name, they can determine which device (in which room) has been activated. Following on from this, it is desired to present further device-specific information, for example how often a command was called via this device, or how often there were incorrect interactions or accidental activations with this device (so-called "unknown voice commands"). It is also possible to show when several devices have been activated for a command and which one has finally accepted the command, for which visualization solutions are to be developed.

9.5 Further Steps

The developed dashboard will be iteratively evaluated and further developed through the ongoing involvement of participants from the living lab. In addition, based on the results and to better protect consumers when using voice assistants (some with cameras), practices for personal protection within their own home will be discussed and developed. Third parties (visitors, other household members) who do not have access to the collected data are to be taken into account in order to raise their awareness of the issue so that they too can protect themselves better and, if necessary, needs should be identified in order to better understand the collection and processing of the data.

9.6 Conclusion

Smart devices such as voice assistants offer their users many possibilities and benefits in terms of handling. However, this ease of use, which is often perceived as convenient and simple, usually comes at the expense of transparency and traceability of the functionality. This is because companies do not disclose exactly how the underlying algorithms work, even though consumers show an interest in this and want to understand why, for example, a voice assistant was activated, how the data collected by the voice assistant is processed or which user profile may (or mistakenly) result from the usage behavior. According to user statements, data protection declarations are often not very informative, if they are read at all [153]. With our developed tool for data visualization, we would therefore like to bring the interaction data, which contains a variety of information (e.g., usage time, typical usage situations, the voice of the speaker, services used), closer to the users through their direct integration into the development process and as a result allow the generation of further interpretations. Based on their needs and the feedback from the usage test of a prototype as well as defined guidelines for the visualization of interaction data, a prototype was further developed into an application that supports users in requesting data and visualizes the interaction data with voice assistants

via a dashboard. Through further exchange with participants of a living lab and users of voice assistants, further possibilities for data visualization and interpretation are to be developed.

Acknowledgments

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10 Demystification of Technology - Empowering Consumers to Access and Visualize Voice Interaction Data

Abstract

Voice assistants (VAs) in households are becoming increasingly commonplace, with many users expressing their appreciation of the devices' convenience. Nonetheless, a notable number of users have raised concerns that the devices are "always listening", and that there is a lack of clear information from providers about the data collected and processed through their microphones. Adopting a socio-informatics research perspective, we used the living lab approach to work with users over three years to investigate their uncertainties regarding the data collected by VAs in everyday usage. Based on our findings from interviews, fieldwork, and participatory design workshops with 35 households, we developed the web tool "CheckMyVA" to support users to access and visualize their own VA data. This chapter presents the observations and findings of the three-year study by outlining the implemented features of the tool and reflecting on how its design can help improve data literacy and enable users to reflect on their long-term interactions with VAs, ultimately serving to "demystify" the technology.

10.1 Introduction and Background

Since their launch in 2015, voice assistants (VAs) for home use such as Google Assistant or Amazon's Alexa have been steadily gaining prevalence [41], with the global market estimated to exceed 200 million devices in 2023 [174]. While users appreciate the usefulness and convenience of VAs, the ability to control these devices by voice also serves as a gateway to a growing ecosystem of data-based services [318]. Initial studies have shown that users are often unaware of what data these devices capture and whether or how their data is stored [1, 13, 153, 248]. One reason for this is the lack of opportunities provided to users to learn about, understand, or manage the data collected by companies [153, 248, 249].

When it comes to tracking what VAs have captured or processed, providers do offer options such as interaction logs, which can be accessed in users' account settings (see an analysis of the log data by Habscheid et al. [129]), or, in the case of Amazon, users can ask Alexa directly why it performed in a certain way [15]. However, studies have shown that while these options make it quite easy to access recent interactions, they do not offer an overall view of interactions over longer periods, nor are they suitable for conducting in-depth data work [248]. For this reason, we leveraged the right to access data guaranteed by the General Data Protection Regulation (GDPR) in order to obtain raw interaction data from a longer period of time with which we could explore different visualization methods. Figure 24 shows how the interactions were presented in the data takeouts supplied by Google and Amazon respectively. The interaction data for Google Assistant (shown in JSON format in Figure 24) exhibit a uniform structure for each interaction. However, the individual labels at the beginning of each line are not self-descriptive: laypersons would not necessarily find them helpful to understand the subsequent information. Amazon provides the transcription of Alexa interactions as a CVS file, which includes the timestamp, the user command, the name of the audio file, and the response from Alexa for each interaction, listed line by line. As can be seen, both of



Figure 25
Dashboard for data visualization – (exemplary view)

10.2 State of the Art

10.2.1 Privacy Concerns about the Use of VAs

VAs are valued highly for their convenience and for the captivating way they enable users to operate music, connected devices, and entire home systems by means of voice commands [256, 1, 49]. However, for many people, their usage is also associated with opacity, concern, and mistrust [175]. Additionally, users have expressed disappointment that VAs do not always react and respond reliably, and more complex tasks are not always completed successfully [35, 186, 248].

The reasons for these negative sentiments often lie in users' uncertainty about what exactly VAs "understand" or record and how they process data [186, 191]. Recent research has shown that most privacy concerns are associated with accidental activations [287, 191, 108] along with anxiety about the presence of a device that is "always listening" [13, 175]. However, disappointment and frustration were also expressed about providers' failure to provide appropriate support to deal with problems, such as by suggesting repair strategies to clarify why a VA acted in a certain way or to successfully resolve misleading interactions [163, 248, 247]. Studies have shown that users are often unaware that they can view interaction-related data and review or delete them [191, 249, 288].

As a result of these operational difficulties and privacy concerns, users tend to adapt their use behavior by trying to make their voice commands as trivial, uninteresting, or short as possible [175, 191, 248]. This behavior can also be explained by rational fatalism [162] or resignation as an attempt to protect one's data from companies [249, 367].

10.2.2 Usable Privacy for Greater Data Literacy

Advocates of "usable privacy" argue for the need to design secure systems from the user's perspective [76] and to support consumers to manage their own data privacy [7]. This includes aspects such as improving

privacy awareness [173], making security tools usable [354], and making privacy notices understandable [22, 283].

Against the backdrop of increasingly comprehensive and complex data collection, current research in usable privacy focuses on adapting the data literacy concept [375]. This concept, which originated in the educational sciences, has been defined in various ways (see Koltay [165] for an overview). In summary, data literacy involves the ability to access, interpret, critically evaluate, manage, and process data, so that it can be transformed into actionable knowledge to make informed decisions [54, 165, 192].

In our contemporary data-driven economy and society, data literacy is not only a key skill for individuals, but also a prerequisite for informed data protection regulation. The GDPR right to access data has created an important technical basis for promoting data literacy by enabling individuals to access information stored about them. However, there is a lack of complementary measures to ensure that accessed data can be understood and effectively managed. To address this gap and promote data literacy among consumers, it is expedient to draw on methods such as information visualization (InfoViz) [297], data citizen science [196] and data work [335], and combine them with playful data exploration techniques [149].

In the research field of digital consumer behavior, artificial intelligence and data science methods such as deep learning [64, 102, 142] are increasingly used alongside classical statistical methods to identify relevant information in user data and to derive behavioral patterns. However, such methods are typically available only to companies and data scientists; there is a lack of usable solutions for consumers that enable automated analysis for different fields of application [106].

InfoViz methods facilitate the visualization of time series, networks, and hierarchical data [9, 351], which can reflect users' behaviors back to them [59, 149, 312].

Initially, we were aware of just three further studies that had explicitly used log files of interactions to investigate the use of VAs [191, 288, 35]. During our study, additional research examined interaction data to

draw conclusions about human–VA interaction within the smart home ecosystem [129] and to assess privacy sensitivity and intimacy using data sharing scenarios [127].

While these studies primarily analyzed data for research purposes, our aim was to design a tool that could directly help consumers themselves to explore and understand their data, ultimately empowering them by improving their data literacy relating to VA use. The findings presented in this chapter build on a previous study that tested the process for requesting interaction data and evaluated an initial prototype for data visualization [249]. Since then, we have completed the research project and are able to present the results of the iterative design process here.

10.3 Methodology

In this study, we adopted the ‘living lab’ approach to investigate ways to promote data sovereignty in the use of VAs. A living lab can be understood as a user-centered research methodology for sensing, prototyping, validating, and refining complex solutions in evolving real-life contexts [96]. Our procedure also incorporated the practice-orientated problem-solving strategy deployed in design case studies [364]. This approach takes into consideration the user, their (social) practices, institutional arrangements, and technological infrastructures, thereby exploring the design of innovative IT artifacts in situ [365].

Our aim was thus to study participants and their behavior in real-world settings, gaining insights into their use and understandings of voice interaction data. For the living lab study, we used mixed methods including interviews, fieldwork, and (design) workshops, in order to identify and validate users’ needs and requirements. This iterative process enabled us to design, develop, and optimize a prototypical web tool (see Figure 26 for an overview of the research phases).

Parallel to the living lab study, we used several data donations from our participants to test the efficacy of various machine learning (ML) models to draw conclusions about users based on their data (digital consumer analytics), for example, to identify characteristics of users

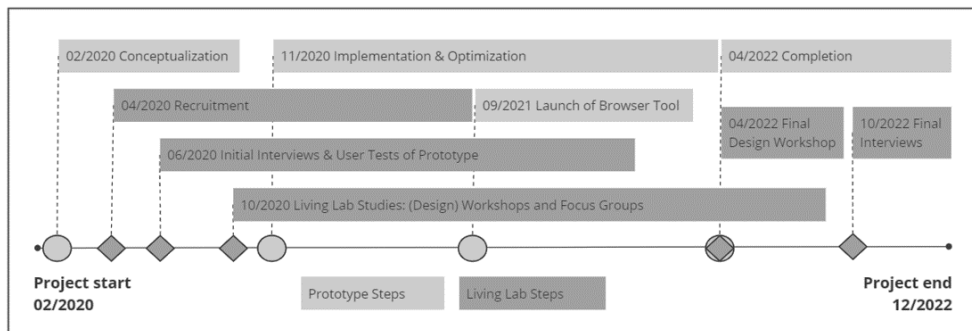


Figure 26
Project Timeline

or their households. Unfortunately, the data set proved too small for the models to be trained precisely enough to be of practical use in the prototype.

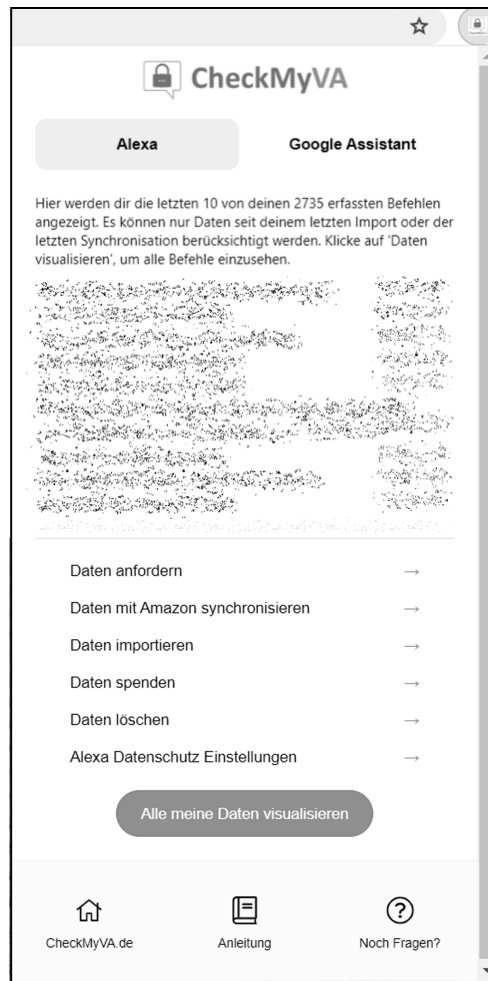
Shortly after project launch in February 2020, we recruited households for the living lab via digital and social media.¹³ By summer 2020, we were able to begin an initial needs assessment and evaluation of our first prototype with a sample of 12 households.

Over the course of the project, we worked with a total of 35 households. With each household we were in contact with a main participant who was the administrator of the VA and had access to the interaction data. These participants ranged in age from 18 to 56, with a mean age of 33. The sample included 24 males and 11 females, who lived in single and partner households, family households, and shared apartments. Sixteen households were "beginners" who had never used a VA at home before joining the research project (for greater detail, see Appendix A).

10.4 Findings and Implementation

The living lab study led us to design and produce CheckMyVA, a web tool that offers consumers two services: a data export wizard and a dashboard for data visualization, which can be accessed from a main menu (shown in Figure 27). The data export wizard directs users to

¹³Due to the contact restrictions imposed by the simultaneous outbreak of the Covid-19 pandemic, no other recruitment strategies were practicable.

**Figure 27**

Main Menu of the CheckMyVA tool

VA providers' export websites and guides them with helpful dialogues through the often laborious and obscure export process. The dashboard enables consumers to display various data visualizations of the interaction data once they have accessed it. The tool is freely available as a browser extension for Google Chrome and Mozilla Firefox and can process data from Alexa and Google Assistant.¹⁴

¹⁴For Google Chrome: <https://chrome.google.com/webstore/detail/checkmyva-browser-erweite/kpllpbalbkdcoklbnjlbbbeapfhoodp> (18.05.2024)

For Mozilla Firefox: <https://addons.mozilla.org/de/firefox/addon/checkmyva/> (18.05.2024)

10.4.1 Data Export Wizard

In our previous study, users had reported experiencing difficulties in finding user data, and that the process of retrieving it was very cumbersome and user-unfriendly [249]. Hence, we created the data export wizard with the aim of supporting users through the process of exporting data from Google and Amazon. With a single click, users are directed to the appropriate export web pages and are guided by help dialogues in boxes highlighted in red (see Figure 28), making it easy for them to request data exports from their VAs.

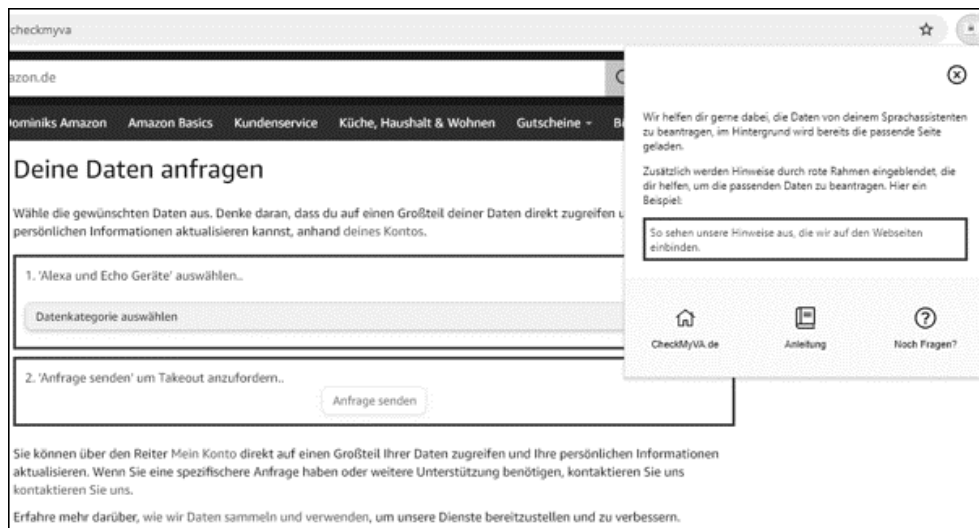


Figure 28

Guidelines for requesting a data takeout from Amazon

Once the user has received the data takeout, the wizard processes and reads the data locally in the background. The stored data is then made available through an interface between the web tool and the dashboard. This ensures that data remain secure in the browser without needing to be uploaded to other services. Users do not have to unpack data archives or search for and open the relevant files themselves.

Obtaining a data takeout from Alexa can take from several days to several weeks, and to obtain the latest interaction data, a new takeout request must be made each time. To address this issue, we explored alternative methods to make the latest interaction data available to participants more quickly. We successfully implemented a system that en-

ables interactions to be synchronized with our dashboard in real time. This real-time approach was well-received by participants. To make the process even simpler, we implemented another function that synchronizes data each time the browser is started.¹⁵ In addition to data request and synchronization, we added the following features to the wizard (see also Figure 27):

- **Import data:** Users can import locally-stored interaction data.
- **Delete data:** Users can delete the data stored in the browser and the prototype.
- **Privacy settings:** After viewing the data, some users wanted to check their settings. For this reason, we added a link that directs users to the privacy settings in their Google or Amazon accounts so that they can make quick adjustments.
- **Data donation:** This feature allows users to transmit their data stored in the prototype (transcribed voice commands, responses, timestamps, devices, etc.)¹⁶ to an internal server for further research within our research project, including user evaluation and training of ML models. Users must explicitly opt in to this procedure.

10.4.2 Data Visualization Dashboard

The initial prototype for data visualization featured a timeline that helped participants gain an overview of their interactions over a longer period of time [249]. This visualization was evaluated by participants as very useful and informative. Furthermore, the categorization of interactions according to specific terms enables the data points to be structured along the timeline in relevant ways, helping users to identify

¹⁵For Google Assistant data, this took a few minutes to a few hours, which participants considered acceptable. However, we have not found a way to synchronize the data in a similar way to Amazon.

¹⁶Due to the large size of audio files, and because the dashboard could not process audio data anyway, we limited the data donation to textual data only.

frequent or typical usage times and situations. Step-by-step categorization also facilitates the identification of further interaction patterns and of unusual or unexpected interactions or recordings. For instance, participants often expressed their surprise at discovering unexpected activities at night, or mentioned that they became aware that in viewing the visualization they were surveilling the interactions of other household members at times during which they themselves had been absent, e.g., when they had been at work [249].

Based on the results of the ongoing iterative process, we continued to optimize and extend the initial prototype. Like the data export wizard, the dashboard is implemented as a web application. It can access the user's data via the data export wizard automatically and offline, performing like a native desktop application. A screenshot of the final version of the visualization dashboard is shown in Figure 25.

In the process of preparing data for visualization, transcription errors (such as miscoded umlauts or punctuation marks) and VA command words (“Google”, “Alexa” or “said”) are removed to facilitate the visualization. Once the preparation is complete, users can create categories based upon individual command words using the Boolean operations (AND or OR). Each category can be assigned a color and a theme (see Figure 29). Additionally, we created a catalog of predefined categories that users can select from and customize.

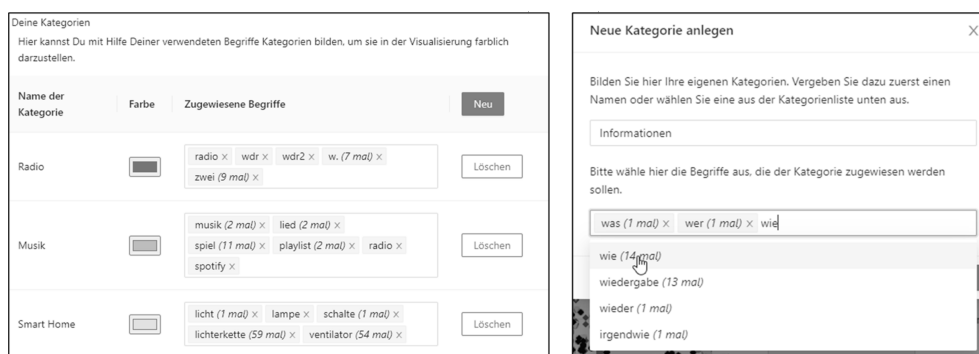


Figure 29

Widget for creating new categories based on terms

The categorized data thus forms the starting point for different visualizations and analyses. A scatter chart (timeline) displays each command as a dot in the color of the defined category (see Figure 25; bottom left of screen). This visualization shows the frequency of commands per category and thus helps users identify behavioral patterns associated with frequently-used categories. Users can zoom in on specific areas by dragging a frame over them with the mouse. Finally, by clicking on a category in the legend, all the corresponding dots on the timeline can be shown or hidden.

Over the course of the project, we added various widgets based on users' needs and interests. Widgets are tiles with data visualizations that can be freely arranged on the dashboard, allowing users to customize their views and prioritize the information most important to them. Each widget also offers the option to display data from an individually-defined time period. The following widgets were implemented:

- **Word list:** Following evaluation of the initial prototype, we modified the sorting options for the list of words spoken so that they could be presented either in order of frequency or alphabetically. The list also shows which categories a term has been assigned to.
- **Command list:** To meet participants' requests for a list of spoken commands, we added another list with the same presentation options as the word list. It helps users to identify speech patterns.
- **Usage occasions and their frequency:** A pie chart and bar chart showing the relative distribution of categories (s. Figure 30, top left).
- **Device usage:** A pie chart showing the relative distribution of devices used (s. Figure 30, right). This enables users to check the frequency of device use and draw conclusions about the associated rooms in the home.
- **Occasions of use per day and time:** A heat map that shows the number of commands in a given category aggregated into hours

per week. Each field is displayed in varying intensity of the category color depending on the frequency of use (s. Figure 30, left bottom). This helps users identify typical usage times per category.

We also conceptualized some additional widget designs in participatory design workshops in which participants expressed their needs and interests. The limited project timeframe prevented these widgets from being implemented into the tool, but participants' request for them nonetheless constitutes a significant research outcome. The following three design concepts for widgets would help users to gain a better understanding of VAs' data processing procedures:

- **Speech analysis:** A widget for categorizing and detailing commands in order to correct interaction/pronunciation differences and recognize changes in interaction behavior.
- **Data flows:** A widget to show how (and with whom) data is shared, identifying critical or personal data and providing user action options.

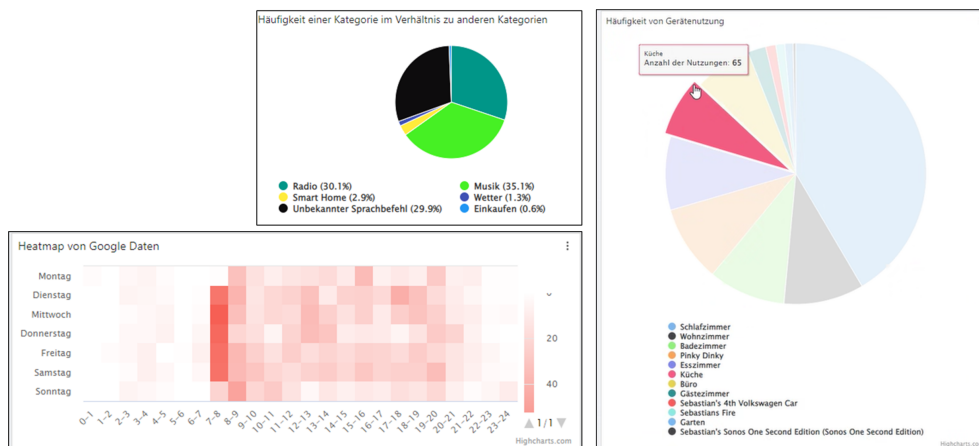


Figure 30

Widgets for data visualization: Relative frequency of each category within the total data set (top left), heatmap with clusters of interactions of a selected category (bottom left), and relative frequency of device usage by (assigned) device name (right).

- **Memories:** A widget for saving interaction data as material that can evoke memories of appointments, special occasions, or situations; supported by images or sound if these are available or linked to the data.

Finally, we conducted internal tests with ML models to explore how the data could be used in digital consumer analytics. The main goal was to identify profiles of users or their households. The users as well as our research team were interested whether the data could convey information about household size, age, gender, or a speaker's mood when interacting with the VA. We asked participants for data donations to test various ML models.

Due to the small size of the donated data set we were unable to train the models precisely enough to achieve conclusive results. Nevertheless, to give users a sense of what information could potentially be extrapolated from the data, we generated mock-ups based on the available data. These mock-ups present insights in the following widgets:

- **Household widget:** A list of all VA users, distinguishing individual voices and creating profiles that record their age, gender, and frequency of use of the VA (see Figure 31, left).
- **Sentiment widget:** A pie chart showing how often a particular command is executed with a positive, neutral, or negative intonation (see Figure 31, right).
- **Politeness widget:** Emojis indicating how politely users speak to the VA.
- **Health widget:** A scatter chart showing how often a user is sick, based upon audible symptoms like coughing, sneezing, hoarseness, or fatigue.
- **Background noise widget:** A scatter chart showing the frequency of certain background sounds and any incorrect activations they may have caused. For example, it indicates how often media (TV, radio, music), other conversations, or other sounds are present in the background.

- **Advertising widget:** A word cloud visualization of the brand names mentioned in voice commands.
- **Profiling widget:** A spider chart ranking inferred personality traits (see Figure 31, center).

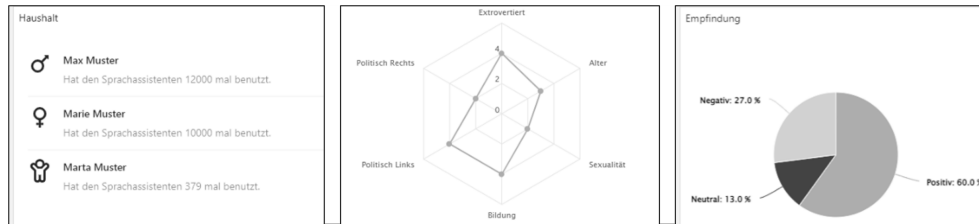


Figure 31

Widgets for the household/user profile: Amount of use per household member (left), inferred personality traits of a user (center), and inferred positive, neutral, or negative mood when articulating a voice command (right).

10.5 Discussion

In our living lab study, participants expressed great interest to try out the CheckMyVA tool for the first time, and reported that using it made them feel reassured [249]. Over the course of the study, however, only a small number of participants continued to use the tool regularly on their own initiative. In final interviews, the following reasons for using the tool were mentioned:

- Curiosity about what new interactions had been detected or stored by the VA.
- Coming across the tool icon by chance while using the browser.
- Checking for funny answers given by the VA.
- Checking for interactions including insults by others (and deleting them).

While the first two reasons indicate curiosity or the "accidental rediscovery" of the tool, the last two are motivated by the desire to review

unusual situations and interactions. This might explain why the majority of participants did not use the tool again; they may not have expected any new insights or unusual interactions, and therefore felt no subsequent need to explore the data. When asked in which situations they thought the tool might be helpful, several participants mentioned reviewing unexpected or incorrect responses. This suggests that after an initial "awareness" check, users' interest in the data shifts over time, with the most attention concerning deviant activities. Such a shift has also been identified in other studies with different data work contexts [60, 151].

10.5.1 Towards Better Support in Requesting Data (According to Article 15 of the GDPR)

The study has shown that the procedures of requesting data collected by VAs are neither simple nor easily comprehensible from the user's perspective [249]. Tools like our prototype that can guide users through the data request process thus make a valuable contribution to increasing data literacy and users' knowledge. Easily locatable and accessible guidance on how to view or request data from each provider can help users overcome barriers to addressing the issue of data collection, thereby increasing their competence to use products, services, and systems, as well as to manage their collected data.

It also became apparent that different corporations deal with the volume and format of users' data in very different ways [62, 293, 250]. Even between the two VA systems considered in this project, approaches vary significantly. Initially, we had planned to include interaction data from Siri (Apple), but that proved to not be possible due to their pseudonymization process, which prevents access to usable interaction data. Additionally, the ongoing development of these systems appears very inconstant. For instance, in response to public criticism, Google suspended the automatic storage of audio recordings for a while. Since then, it changed its policy so that Google Assistant users can currently

opt in to anonymized data storage to improve speech and audio recognition, which may involve human review.¹⁷

While such pseudonymization (or anonymization) practices are to be welcomed from a data protection perspective, their effectiveness remains questionable if conclusions can still be drawn from the content of audio or transcript data, even when it has been separated from user profile data. Amazon also allows Alexa users the option to disallow the storage of interaction data, but this requires deliberate deactivation by the user – if the default settings are not adjusted, users implicitly consent to data storage.

Policy makers should work to generate more guidelines for the storage of user data and should make corporations accountable for providing easily-accessible, relevant information about the collection and processing of users' data, especially regarding the companies' evaluation and analysis processes for consumer analytics purposes. For example, information should be provided on how sensitive information is handled when recordings are subject to human review.

10.5.2 Towards Demystification: Visualization and Sense-Making of Data

In accordance with Article 15 of the GDPR, companies are obliged to provide consumers with information about their personal data collected by the company, and to transmit it upon request in a machine-readable format for the purpose of data portability in accordance with Article 20 [98]. The personal data of our participants that we requested for this project was raw data, which consumers without technical knowledge would barely understand (see Figure 24). Previous studies have shown that users expect a more human-readable format [14, 249]. This highlights the need for solutions like our visualization dashboard, which enables users to make sense of their data and to better understand what it can show about their usage behavior [59, 148, 311]. While some information from the raw data takeout was clear and actionable, a major

¹⁷<https://www.cnet.com/home/smart-home/googles-privacy-controls-on-recordings-changes-what-that-means-for-your-google-home/>

challenge for us was to identify significant insights that could potentially be derived from the data in order to draw conclusions about users and their behavior. These relevancies are not clearly evident within the raw data sets, which makes it difficult for users to understand the profiles created about them, and there are no end-user options that would enable them to create their own analyses.

In order to meet our aim to empower VA users to understand and interpret the data that companies collect from them, we needed a sample data set with which we could demonstrate in an exemplary way to users the potential analytical capabilities of companies. Our ability to do this was limited by the small size of the data set that we were able to obtain voluntarily from the few households that were willing to donate their data. We believe that companies should make it more transparent how a user's profile is compiled and what criteria are used to generate such profiles, so that users can understand and adjust settings accordingly if they so wish. This transparency could balance the information and power disparity between the user and provider, without requiring corporations to disclose their algorithms, but nonetheless helping to clarify or 'demystify' the opacity of technologies like VAs. Indeed, the few households in our study that agreed to donate us their data only did so once they understood what it included, suggesting that transparency might influence users' decisions about sharing data, especially when they feel uncertain about how the data could be analyzed and interpreted.

During the study and data analysis, certain inconsistencies in the data takeouts became apparent. For example, Amazon provides information about the device used for each interaction in the accounts' interaction log, which can be found in the account settings. However, we could not find corresponding information in the data takeouts. This suggests that some data correlations are not included in the takeouts, even though some connections between transcripts and recordings are traceable. Similarly, with Apple, it cannot be ruled out that personal data may still be found in the data records that are stored pseudonymously. Previous studies [191, 249], found that consumers were surprised to learn that voice commands were stored long-term. Figure 32

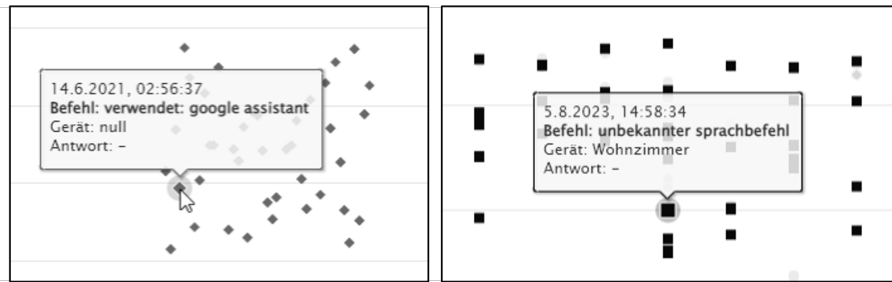


Figure 32

Unusual activities of the VA without intelligible clarification.

illustrates two activities of the VA shown on the dashboard that were included in the data set that users were surprised to discover had been stored, especially as such activities had an unclear purpose or occurred at unusual times.

Providers should therefore be held to account to make their data storage "transparent" in the sense that users should be able to understand which elements of the data are interlinked for companies' analytical purposes (without firms having to disclose their algorithms or methods used). Companies should also be required to delete data that no longer serves a purpose.

10.5.3 Raising Awareness of the Technological Infrastructure in which the VA is Embedded

For most participants, our study provided their first ever chance to view and engage with the data collected by their VAs. On the one hand, they said they felt reassured, because they had gained more clarity about what data the VA was collecting and how they could exert control over its transmission. In particular, it became clear that the majority of the data and usage situations (e.g., setting timers or playing music) that the participants learned about were not considered risky, concerning, or sensitive. This enabled them to act more self-determinedly when talking or acting near to a smart speaker at home. But on the other hand, viewing the data raised new questions, as they had expected to be able to obtain more information directly from the (raw) data received about the extent to which data was exchanged between vari-

ous services. Instead, they initially found themselves confronted with a folder directory comprising incomprehensible data records that first had to be "decoded" [249].

Research on VA systems should never consider them in isolation, but always in the context of the environment and linked services within which they are embedded [318]. Consumers express particular uncertainty regarding the extent of corporations' access to and exchange of data [138, 186, 191]. Recent research and our study indicate the importance of viewing the home holistically, as a network of different players, in order to understand various links and activities in context [319, 141]. For example, further research could distinguish between smart home products and services used (or their manufacturers) to provide more differentiated information about their general usage or integration in everyday practices.

A holistic view of the infrastructures or platform systems [252] would also help consumers to create transparent and trustworthy environments for themselves, which is particularly important for private and intimate areas like the home. Recent studies have furthered understanding of the basic intentions behind data collection/processing [274, 318, 319]. Our approach also focuses on showing users what the storage of interaction data can mean for them, their household, and their usage behavior. Further research should link these aspects more closely to help users better understand how their data is affected by corporations' intentions. To conduct such research effectively would require a larger data set than was available to us for this study.

Current data work practices offered by companies usually only address the account owner/administrator [204]. Therefore, a more holistic view of the home (technology) ecosystem is needed to achieve a multi-user-centric design, creating more productive, convenient, and inclusive IoT environments for other household members, visitors, etc. [319]. This approach would allow more people to gain insights into the interaction data and learn what the VA has captured about them and their households [204, 319, 350].

10.5.4 Limitations and Reflections

The scope of this study was limited by the sample. First, we engaged primarily with the administrators of the devices who had direct access to the interaction data via their user accounts; hence we focused mainly on their needs. As our study showed, and as other studies have demonstrated in greater depth [333, 324], other residents in a household are also affected by a VA's data collection – but they were not included in the study. These individuals should also be able to view the interaction data to see what the VA provider or account holder can see about them. Our tool provides an initial indication of how this could be achieved by making the dashboard accessible to other household members, for example, via a shared device (e.g., a tablet or PC) with the tool's browser application installed.

Second, by only working with administrators, our sample could have been affected by a demographic imbalance in terms of age and gender. Previous studies [118, 248, 249, 296] suggest that administrators tend to be male and tech-savvy, which may influence their interest in using VAs. However, this study did not aim to be representative but rather to support consumers who use a VA. Nonetheless, other user groups might express different needs and interests relating to data access from that we were not able to take into account in our study.

Another limitation arises from the dynamic nature of data usage and the services available to consumers at any specific time, which is constantly changing in response to ongoing developments, public criticism, and policy changes. Hence, replicating this study at a later time might yield different results.

10.6 Conclusion

In this chapter, we presented the features of a web tool created with the aim to empower VA users by increasing their data literacy, and reflected on the tool's development. This involved conducting a three-year living lab study to investigate VA use and data work practices, identifying

what users need in order to better understand how VAs collect and process interaction data. The tool includes a data export wizard that guides users through the process of requesting interaction data as well as assisting them in viewing and managing privacy settings. It also offers a dashboard that allows the data to be structured and visualized in different ways (e.g., according to user-defined categories) to help users better understand and reflect on their usage.

Previous studies have shown that users often express uncertainty and skepticism about what their VA is listening to and storing; similar sentiments were voiced by our participants. Our tool addresses this by demystifying VA systems for users, enabling them to explore their own behavioral patterns through visualizations and to recognize unconscious or accidental activations. Ultimately, the tool helped participants to assess what data the VA collects and what it can reveal about a person or household.

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Part IV

Research Outcome and Discussion

A human-centered focus is crucial for achieving the goals of providing natural, convenient, comfortable, friendly, and safe user experiences in the smart home.

Yuan Yao et al., *Human-Centered Smart Home Research*

11 Summary of Findings

The aim of the work for this thesis was to strengthen the data literacy of consumers in the context of the digital home using the example of VAs. With this goal in mind, the aspects of data work and data awareness as well as their interplay were examined by means of various studies. The resulting findings are expected to ultimately contribute to strengthening consumers' data literacy so that information and power imbalances between consumers and providers in data processing can be counteracted. To this end, the following research questions were defined, which are discussed in this section based on the findings.

RQ1 How do consumers perform data work practices to explore and understand personal data in general and in particular with VAs?

RQ2 How to support the empowerment of consumers in their data literacy by information visualization, thereby counteracting the imbalance of information and power between organizations and consumers?

In response to **RQ1**, from the studies detailed in Part II it was described that although consumers are aware that data is stored by providers, they do not have a concrete idea of how VA systems collect and process data. This showed that data processing or even offers/solutions for consumers to view these are unknown or quite abstract and they have not or only rarely thought about them (see Section 5). Instead, consumers rely on safe handling of the data and focus on the benefits of use. This already shows the rational as well as irrational consumer behavior with regard to privacy [6, 14, 153, 164, 233], as the devices are used in a private environment despite incomplete knowledge of potentially critical data processing. As part of the studies conducted, consumer practices were investigated to better understand their everyday life practices and interactions with their VA. Furthermore, existing solutions for data access and viewing were examined and how they adopt and evaluate them. For this it turned out that the provider's

interaction log (see Section 5) or the very differently implemented application process of organizations for requesting personal data in accordance with Article 15 of the GDPR (see Section 6), are seldom used or unknown. Furthermore, the presentation of the information proved to be unwieldy for detailed viewing, e.g., for a comprehensible overview of the data. It was also clear that users lack knowledge about how or for which purposes their data is processed or according to which criteria the data is used, for example, for profiling by an organization (see Section 6). The needs and findings identified in this part served as the basis for answering RQ2.

For answering **RQ2** concepts and design approaches were developed on how to empower consumers in their data literacy in order to reduce the imbalance of information and power between consumers and organizations. Part III of this thesis contained presentations of three development statuses of a prototype (initial version: Section 8, updated version: Section 9 and final version: Section 10) that is able to guide the consumer through the request process to obtain his/her (VA) data (see Figure 28) and further contains a dashboard with different visualization options (see Figure 25). The dashboard provides data overview and enables users to explore and understand his/her usage behavior. In this way, consumers were provided with a tool that enables them to work with data (in terms of requests, exploration and visualization) and thus balances out the unequal distribution of power. At the same time, the dashboard transforms the abstract mental model of consumers about the VA's data processing into comprehensible and user-related knowledge, thus also counteracting the information imbalance. The tool, an effective data work practice for consumers, therefore, promotes data awareness and strengthens data literacy by addressing both aspects. Through the iterative process including various phases of evaluation, user feedback was positive and showed potential for further extension possibilities of the data visualization.

In the following, the key findings regarding both questions are discussed and elaborated in detail. Further discussion will include what impact the results of this thesis can have on everyday consumer life and the digital home — focusing on VAs.

12 Towards Consumer Data Literacy with VA Systems

12.1 Enabling Data Work with Consumer Data

As has been shown in this thesis, consumers are often not aware of the possibilities for viewing their personal data or have not yet taken the initiative to view it, since they lacked a starting point (see Section 6), among other things. In this regard, privacy is often a subordinate topic and is viewed rather unpleasantly, as it is associated with additional work [114] and therefore data access is avoided without a specific reason. Through the studies presented in this thesis, however, it was possible to investigate how consumers perform data practices in terms of request, insight, and sense-making by confronting them with different ways to view and access data in order to raise data and privacy awareness.

With regard to the currently offered solutions by VA providers for viewing and managing past interactions in the app by means of an interaction log (see Figure 1) the presented studies pointed out that some of the participants heard about the interaction log for the first time and were also surprised by the amount of data and the range (such as listening to past recordings). Even though in the study reported in Section 5 interactions of the last six weeks were considered in order to look for interactions with misunderstandings and misperformances, the list proved to be unwieldy and difficult to keep track of. In conclusion, this way of data insight might be useful for viewing interactions that happened recently, but it is less suitable for a general overview and for data work, especially with regard to a holistic view of possible (usage) contexts.

The lack of clarity has led to the exploration of other ways and methods of accessing and supporting data with consumers. However, in recent studies the Google Dashboard (including activities of the VA) has been examined more intensively [294, 100] and it was shown that the data amount quickly led to cognitive overload [294] and no change in be-

havior seemed to occur with regard to privacy aspects, since according to their information, there were no recommendations for action or a risk assessment [294, 100].

Another approach we examined was the right to data access according to GDPR, which not only allows consumers to view their personal data, but also to store it locally and perform data work. Advantage was taken of this in the example of VAs in order to request data related to interactions with VAs and in a quantitative study to request personal data from organizations (see Section 6). Due to the relatively recent validity of the GDPR (since 2018), it was possible to show that the practices for data collection and storage as well as for processing for consumers on the part of the organizations are still in a state of flux and very different.

As outlined in the related work in Section 2, the individual rights of citizens leave room for interpretation, and that is why the broad and vague formulation of GDPR is in favor of the companies [14, 153]. According to this, consumers have a right to data information, but it is not specified how and in what form the (personal) data must be transmitted, which ultimately leads to many different solutions in terms of the data formats provided (see Section 6). While Article 15 of the GDPR, for example, leaves the method of data disclosure open, Article 20 only requires a "commonly used and machine-readable format" for data portability, but only if the processing is carried out by automated means. With regard to the GDPR, the challenge for data access arises that it will be difficult to check compliance with the GDPR, as the GDPR nevertheless involves an attempt to promote the innovation ability of organizations (e.g., with regard to the completeness of information) [62, 282, 14].

The results of the study for this thesis on requesting a GDPR nevertheless involves an attempt to promote the innovation ability of organizations (e.g., with regard to the completeness of information) data export for VAs (see in particular Section 8) showed that consumers had expectations that the data would be structured or prepared in a structured way, even if in a simple form. The complex folder structure (as a zip file) they received instead surprised them and quickly led to cog-

nitive overload and loss of orientation. For example, the data related to interaction with the VA (audio and transcription files) were hidden in the structure, and a table of contents was missing. Moreover, during further exploration of the data and folders, text files were encountered with technical language (see Figure 24) that was not understandable to participants, and even more tech-savvy study participants had difficulty reading and understanding the data (and possible correlations between them).

During the course of the associated research project, it became apparent, using Amazon as an example, that there are differences in the raw data through the data information and the offered interaction log of the provider. For example, in the raw data there was no connection between the device used and the interaction, while it was visible via the interaction log (see Section 10). Google also provides information about this in its data export (see json file in Figure 24). This circumstance makes the completeness of the data from Amazon data request questionable. In addition, there are also differences in the formats between the Alexa and Google systems examined (see Figure 24), which makes a comparison difficult and also calls into question the possible transferability of the data between both systems under Article 20 of GDPR.

As an initial step to support consumers in their data work, the defined user experience journey in Section 6 contains five touch points that consumers go through when requesting their data under Article 15 of GDPR. It was shown in the studies for this thesis that each of these five touch points were implemented differently depending on the organization and showed different weaknesses. As a first step, a basic standardization and automation of the procedure for all organizations is recommended in order to make the process more predictable for consumers, especially in order to find a way to start. Furthermore, there should still be different measures depending on the sensitivity of the data, in particular with regard to authentication by the user, since, for example, health data or banking/financial data are considered to be very sensitive. Finally, the format of the data should also be more standardized and be both human- and machine-readable, as it was funda-

mentally difficult to read and therefore not easy to understand. This would also make it easier to use the data set for further processing and data work, depending on information needs and the technical expertise of the consumer.

In terms of data preparation, for example, pdf and html documents received a better SUS rating as "human-readable" formats due to faster comprehension (see Section 6). Overall, however, only around one fifth (21.2%) of all SARs received were in this format, while around 40% were in a machine-readable format (CSV/XLS/JSON/XML) and one third had other formats that were not specified further. This highlights the difficulty of enabling data work practices and strengthening data literacy.

During the course of the studies, there were also some particularities and changes on the part of the providers, which once again illustrate the dynamics of data storage. For example, Apple and its VA system Siri store the related audio and transcription data pseudonymously. Therefore, Apple cannot release any related data to the user. This is very positive with regard to data protection at first glance; nevertheless, data is still being stored and processed. Despite pseudonymization, recordings and data are used by the companies to improve speech recognition [57] and can allow conclusions to be drawn about the user via the voice or sensitive and personal content in the recordings. However, this information can also be interesting for consumers, since it represents unconscious or accidental activations of the VA and the user could thus check whether sensitive information was recorded. Moreover, Google ceased the automatic storage of audio data (and its transcription) by default in the summer of 2020, requiring users to reactivate this feature manually [300]. This can now also be done for data storage with Alexa, but here the user must deactivate this on his own.

The topic of data storage and protection, therefore, continues to face challenges, which were previously categorized by Saglam using three of the six principles of the GDPR [282] and which can be underpinned by the findings obtained in the work for this thesis:

1. Information and access to personal data turns out to be possible, but as has been shown in Part II, it is not very intuitive, usable or practicable. As the results in Section 6 made clear, there is a need for greater support for consumers in finding, getting, and understanding their personal data, which should be taken into account in accordance with the steps in the user experience journey presented there. Existing solutions for viewing the interaction in the case of the work on VA also showed clear potential for optimization in the usability evaluation (see Section 5).
2. With regard to the principle of transparency, there is a need for optimization in data processing, especially about which data are linked with each other and how. Among other things, there should be uniformity between different data view options of a provider, since information that is available in one view but not in the other (such as the devices used for an interaction as pointed out in Section 10) can arouse distrust.
3. Closely related to the second aspect is the long and permanent storage of data with potentially sensitive content (such as accidental activation of a VA) by default. This should be deleted as quickly as possible in accordance with the principle of purpose limitation and data economy, or its purpose of storage and processing method should be made more transparent to the user. In this regard, study participants were wondering why unknown voice commands are stored permanently anyway, since they could view all of them since the first use of their own device.

In the studies in the thesis it was shown that the data set regarding VA systems can be very extensive. While consumers already have opportunities to claim their usage and personal data, they lack support and/or solutions to also manage and use them according to their information needs. In contrast to the companies and providers of data processing systems which can aggregate the data of their users, it was highlighted in Section 10 that data sets of a single user are very small and thus make it difficult to analyze them in order to draw conclusions

about usage behavior in line with any requirements. This leads to the aforementioned power imbalance [65, 106].

The implemented prototype enabled VA users to request the data and, at the same time, offered a dashboard for data visualization. By implementing this a privacy-preserving approach was included where the data would remain with the user on the device. This ensures consumers' data sovereignty by not having to share their data with third parties (e.g., us as researchers). Moreover, since the use of VAs at home usually involves more than one user, the solution could potentially be used by all dwellers once it is installed on a PC or browser that is accessible to all residents of the house. For the prototype, it was not possible to implement an immediate deletion function for certain interactions (as the data was stored locally and there was no direct connection to the user account). However, a link was provided that takes consumers directly to the privacy settings of the VA system, where they also have the option to delete individual interactions or the entire data set (see Section 10). The results from the user experience journey (see Section 6) also suggested that, after viewing the data, guidance should be provided on what possible or necessary steps or actions could be taken to manage personal data.

12.2 Raising Consumer's Data Awareness

The related work has indicated that consumers generally have a very abstract understanding of how companies process their data [114]. In the studies for this thesis (particularly in Section 5 and 8) it was possible to demonstrate this specifically in the use case of VAs and show that there is an unspecific assumption that VA devices are "always-listening" and storing data. However, the reactions from our participants in the studies highlighted that the amount of data often exceeded the amount assumed at the beginning of the studies and that the data contained unexpected activities e.g., at night. In addition, due to the difficult-to-understand raw data, it was also assumed in some cases that the provided data request was incomplete and that the companies were withholding data (see Section 6 and 10).

As was shown in Section 2, methods of InfoViz are a useful approach to support consumers in data work by complementing existing practices or enabling the appropriation of new practices. InfoViz aims to do more than just make data visible, as the corresponding solutions should also help users to complete information-related tasks [5, 58, 160]. Thus, the primary goal of the work for this thesis was not only to raise awareness but was also to reduce uncertainty as a key concern about what is captured and processed. A further aim was to identify approaches for how users can harness the interaction data according to their own needs in order to better understand their consumer behavior, particularly with regard to interaction with their VA. In this regard, it was shown in the thesis that visual artifacts can be useful to make the patterns of VA use and interaction visible by means of the data and thus enable concrete and understandable knowledge.

During the qualitative studies to examine the interaction data with the participants, either with the help of the provider solution (see Section 5) or as part of the evaluations for the implementation of the prototype (see Part III), all participants were very interested and surprised when they first looked at the data. In particular, they learned, how far back data collection (and use) had already gone (to the first interaction) and how many interactions they had. This for the first time gave the majority of the study participants a feeling for what data is processed when using an IoT device – in particular the VA – as they had not looked previously into it in such detail or did not know that or where this option was available.

As mentioned in Section 12.1, the use of the providers' interaction log was very unwieldy due to the necessary scrolling. In contrast, the prototype designed as part of the project offers a diagram as a timeline on which all interactions are displayed and structured as dots for a better overview. This made it possible to reduce the complexity of the abstract concept of "digital privacy" [114] and the associated unspecific knowledge of the "always-listening" devices that capture "any" data [119, 158, 327]. Furthermore, it gave consumers the opportunity to work with their data in order to understand (meaningful) connections. After the users were able to gain an initial overview in this way,

they were initially relieved, as the data shown mainly concerned the interactions carried out on purpose and no serious worrying activities could be detected at first.

Nevertheless, in Section 8 it was further highlighted that study participants themselves or through a task given within the user study became aware that there were also interactions shown that could not be directly assigned, which referred in particular to unknown voice commands. As the related audio data was also saved, the participants listened to it and finally understood that these must be accidental or incomplete activations. As stated in Section 8, this reassured the participants on the one hand, but on the other hand, some participants questioned why this data was stored permanently, as it had been available since the first use. Due to the often large number of interactions, it was only possible to randomly check individual interactions with the participants as part of the user tests. In their study, Malkin et al. [191] examined in more detail how individual recordings are evaluated by participants with regard to the sensitivity of the content. Nevertheless, in the study for this thesis participants stated that they will check these more closely afterwards to see whether critical situations were recorded, which they would then delete. Others stated that they would pay more attention in future to when the VA is activated in their presence without reason. This also showed that data work practices can create and raise awareness of data and that consumers themselves can derive actions from this.

At the end of the living lab study, it was checked once again whether and why people used the prototype on their own initiative (see Section 10), and it turned out that only a few of the participants did. Self-initiative purposes were mainly due to curiosity about what had happened since the last use, sometimes when they discovered the tool icon in the browser by chance. However, the more frequent non-use can in turn be attributed to the perceived lack of new insights, which is why the tool was sometimes forgotten.

The insight and traceability of data through InfoViz methods can also help consumers build acceptance and trust towards the technology and

the providers. Even if consumers often already "bring along" trust in the providers, because they have known them for a long time and use them in other areas, this should not be exploited on the part of the companies. Statements from participants in the studies for this thesis (see Section 5 or 8) as well as from other studies [175, 191] such as "They already know everything anyway" indicate a dependency relationship through resignation as well as behavior according to rational fatalism [162]. In doing so, it has been shown in the studies for this thesis that preparing data not only creates awareness among users, but also an interest as well as enjoyment in exploring the data. Although the awareness created in this way rarely leads to a change in behavior on the part of the users, (false) concerns can nevertheless be eliminated. Finally, as Feng et al. already mentioned in this context, that besides visualization, tools for data work should also be able to carry out actions and choices based on it [104]. The link to the privacy settings implemented in the tested prototype is a first step in this direction.

However, solutions and approaches in the future should, however, not be to create additional workarounds and allow users to access settings and data via other tools (such as the one developed as part of this study) in order to adjust requests or view them. Media disruptions such as these usually lead to additional work, which in turn motivates users less to deal with the data and potential risks. The use of the developed prototype has already shown that access via an additional application (via browser) appears to be too cumbersome in some cases after the first insight was given within the studies and evaluation. Further developments should therefore be oriented more closely to everyday practices, e.g. directly via app or user account.

During the studies and by the use of the prototype it was possible to identify a learning process that the participants went through when exploring and making sense of their data for the first time. This kind of data work increased their awareness of the data collected in the context of using VAs. This also reflects the three core steps of Schneiderman's mantra:

- The first look at the data **Overview first** initially triggered mostly surprise but also concern or was overwhelming, as the participants were struck by the amount of data available. Particularly in the raw form, it seemed that the first step was to identify points of interest that could contribute to understanding or sense-making. Nevertheless, this step in particular can help to estimate the amount and complexity of data and to understand the complexity of the system.
- By categorizing the data **Zoom and Filter**, for example, according to reasons for use or, if possible, according to users, devices or times, the data can be structured and the process of understanding can be triggered so that initial usage practices can be explored and understood. However, in the case considered in the work, the graph itself also offered a zoom function in order to take a closer look at a specific time period.
- As soon as the data is structured, further solutions should be offered for **Details on Demand** that link the data and allow further statements or analyses to be made. The third step also makes it clear that an initial awareness-raising phase will soon be followed by a phase in which users only require information in the event of deviations from the normal state.

12.3 Digital Home: Data Literacy in Everyday Life

The clear boundaries of privacy seem to be fading away due to the digitalization of everyday life, especially due to the advent of (social) media and IoT devices [310, 135, 290]. The reason for this can be traced back to the collection and sharing of everyday data, which is done either directly and on purpose by the consumer or in the background and ongoing by sensors. The latter primarily concerns the use of smart home devices, which once placed in the home can permanently and ubiquitously collect data and thus create a digital portrait of consumers' everyday lives [312, 376, 296, 370]. The VA is a popular device that not only provides consumers with information and enter-

tainment, but also enables them to control other devices embedded in the smart home in the form of an ecosystem of devices and services. Although the most used location is the living room as the center of the home, it is also used in other areas such as the bathroom or bedroom, which implies potentially all activities can be captured here (see Section 5). In some cases, participants deliberately excluded certain rooms for placement (e.g., bath- or bedroom). Nevertheless, also it was observed that participants reported that devices responded even when the person was not in the same room as the device (see Section 9). The detection of noises and voices from neighboring rooms such as the bedroom or bathroom, shows that consumers are not protected from having data collected about them even in areas where they do not wish to have a VA installed - whether due to a lack of added value or privacy concerns. They also lack the power and the ability to draw clear boundaries, so that despite deliberate placement of the devices or exclusion of certain rooms, a context collapse still occurs [239, 344] and potentially private data is collected and processed by the VA providers. These aspects further illustrate the merging of the different spheres of privacy (see Figure 3), which the user may overlook, but which s/he should at least be made aware of so that s/he can realign his/her privacy behavior if necessary. In this regard, consumers should be supported by educational services to better understand and track the activities and developments of technologies. For this purpose the prototype and the information about an interaction also raises awareness about which device was used. As the devices are usually named after the room in which they are set up, or users can quickly identify them by name, they can determine which device (in which room) has been activated.

In earlier studies, as well in the work for this thesis, it was shown that consumers, despite deciding to adopt a VA in their home, expressed slight concerns that the providers of the "always-listening" devices or third parties may be able to listen in. Here, indications for activation or recording (such as LEDs) only help to a limited extent [209, 108, 8], as these are not always noticed by users and therefore the concerns remain. Therefore, despite the concerns and awareness of the risks, the use and user behavior seems paradoxical, especially with regard to the

protection of privacy [120]. However, as was illustrated in Section 5, nowadays, the devices are quick and easy to purchase and uncomplicated to install, and therefore usually fade quickly into everyday life afterwards. This is often followed by a ubiquity of the devices that seems to lead to a habituation effect that overcomes the initial concerns – albeit slight and mostly abstract [114, 164]. However, even if there are already opportunities, be it by viewing the interaction log in the app or exercising the right to data disclosure, it was shown in Part II of the thesis that consumers do not seem to have much interest in using them on their own initiative. Instead, it was shown in the work for this thesis using the example of VAs that there is usually a feeling of powerlessness vis-à-vis the providers, according to which consumers can no longer resist "surveillance" by smartphones and IoT devices anyway [162, 367] or the thought prevails that they have nothing to hide. This showed that rational fatalism is not only found in social network services or online in general [367], but also in the use of VAs. Ultimately, however, privacy is not threatened or at an end [135, 310], as users still have the ability to turn off their devices and trust that VA providers do not have malicious intentions when processing data.

The benefits of using the devices, which appear more concrete and tangible due to the successful execution of the VA, consequently, outweigh the concerns. Through the prototype developed in this study and the support in data literacy, consumers can now look up which situations have been recognized or recorded. Although the provider's log also offers an initial remedy for recently occurring situations, the prototype in addition offers the option of selecting a specific time period in order to explore certain interactions or incidents. However, the challenge here also seems to be to motivate consumers in using solutions such as the prototype in the long term, which could be achieved by making it easy or more accessible [60, 68], among other things.

Consumers, who have decided to use a VA are primarily fascinated and curious rather than apprehensive when it comes to demystifying the black box and being aware of how the system and the provider collect and process the data and according to which criteria their own usage profile is created, as shown in Section 10. In conclusion, it should be

emphasized that consumers explain their data protection behavior, in particular their willingness to disclose their private data, by the fact that they "have nothing to hide". One could therefore ask companies the follow-up question "Do you?" as to why they are not willing to complicate and (as is often perceived) hide the reasons for data collection and use. Therefore, companies should follow up with easier data accessibility and work to balance the imbalance of information and power. For example, providing solutions to enable data working practices can help to increase trustworthiness in companies by demonstrating accountability through the provision of concrete information and making transparent how they process data.

By considering the VA less as an independent product and more as a tool, platform or "means to an end" via which commands or information are entered (similar to a computer or, more specifically, a keyboard), the interaction data could be used more comprehensively to improve the quality of use. For example, in Section 8 it was apparent that some study participants were interested in how speech patterns may change over time and what characteristics can be derived from the data. To this end, it was possible to design initial solutions that can, for example, provide information about gender, mood or attitudes and beliefs when interacting with the VA (see Figure 31). However, more meaningful analysis would require larger data sets, which could be achieved by merging the data of individual users or households with the data of other users, which in turn would mean sharing it with another entity (see Section 10).

In the work for this thesis as well as in other studies it has been shown that the integration of IoT devices into the home is usually initiated by male household members [296, 118]. These persons are often characterized by an affinity for technology and are more open to new technologies and "gadgets", and thus usually also take over the administration of the system ("primary user"). Nevertheless, the devices can be used by anyone within earshot of the device ("secondary users"). Even children or adolescents sometimes have their own VA device in their room. Accordingly, all residents see themselves as "owners" of the system, even if they rarely have the same access as the administrator,

e.g., to view or change user settings [81, 175, 204]. Moreover, it was highlighted in the research that secondary users are often more skeptical about the benefits or added value and the data collection during the acquisition process and were only convinced by the initiator (see Section 5). Guests and domestic workers could also be affected by data collection and are at the mercy of the devices [178, 204].

In the studies conducted for this thesis, it was possible to accompany primary users by exploring the interaction data and thus it was found that they are also in a special position of power when seeing how or when others used the device (actively or passively) (see Section 8). At the same time, they also saw it as their duty to handle it responsibly and to respect the privacy of secondary users. However, this power imbalance can also lead to abuse, for example, when serious conflicts arise, at the end of a relationship or simply by observing children or domestic workers [178, 204].

During the studies, it was possible to observe that the users perceived themselves as self-determined and that they repeatedly questioned their use critically. Furthermore, they reported and it was observed at the same time during the studies that with long-term use the interaction itself (and the awareness of the constant presence of the VA) recedes into the background. In most cases, successful and simple interactions also prevail and interactions (or activation) occur without any initial eye contact or the setting of pauses to wait for "waking-up" (see Section 5). In the studies for this thesis it was also shown that the VA penetrates the individual spheres, because over time, additional devices were purchased (or provided by the study), which were then placed stepwise in the home (and sometimes in a sneaky process). In addition, IoT technologies seem to be developing, changing or expanding at an ever faster pace.

In conclusion, in addition to individual self-determination, a collective form of informational self-determination should also be taken into account in the access options, in which data subjects are able to co-determine who is allowed to use this data and for what purposes [309].

In the study for this thesis on appropriation (see Section 5) it was shown that unsuccessful attempts at interaction, especially in the initial phase, quickly lead to the fact that occasions for use do not become established and, in this context, a lack of (visual) feedback for clarification or comprehensibility of a failed interaction was also mentioned due to incorrect information. By means of data work practices as a kind of consumption feedback [5, 151], the insight of the data can also reflect the way of speaking, which in conclusion can help to derive usable repair strategies, instead of simple repetition or trial-and-error approaches. At the time of the study described in Section 5, this still seems to work the other way around, with users adapting to the capabilities and behavior of the VA (see Figure 6), which leads to usage occasions with unsuccessful interaction being quickly abandoned.

In the work for this thesis and the implemented prototype it has been shown that interaction data, especially with a VA, can make usage behavior visible in a similar way to measured values on energy and water consumption in smart metering [59, 286]. This can also help to reflect interaction behavior. However, the challenge here seems to be to trigger consumers to look at the data more regularly and to engage with it (data work) in order to maintain awareness and data literacy, and keep it up to date (see Section 10). Studies in the field of smart metering (energy and water consumption) have also already established that long-term effects through insight into the data are less common and that it often remains a matter of catchy curiosity [151].

Using VA systems as an example, in Section 10 it was shown that, that information needs will change over time and that, after the first glance, no further insight seems to be required [151]. Instead, insight is needed when special situations or deviant behavior have occurred. This is presumably also due to the fact that the VA itself and the interaction become part of everyday life as consumers are more careless with time about usage, and the interaction becomes a subordinate task. In particular, the increased awareness of data at first glance leads to a different / new need for data practices. In the studies for this thesis it was shown that at the beginning and during appropriation, consumers are primarily interested in what the VA can do (its capabilities), what it recognizes

and why it did not understand something. As use proceeds, usable data practices could help to enhance the user experience and also increase trustworthiness by providers providing insight into the processing of interaction data. In this way, the existing information imbalance with regard to data processing between consumers and companies could be balanced out [2, 369, 191, 193].

Better analysis capabilities through the use of a larger data set will also allow more reliable conclusions to be drawn from the data. By knowing what data is available to them and that it is likely to be harmless, users may be more willing to share it (with other users) in order to create a better data basis for their own analyses, as was shown in Section 10. This information can also provide the basis for formulating recommendations for action to help consumers better assess the consequences of their actions and how they can better protect themselves, for example. Some of the study participants were open to sharing their data with the researchers. However, in order to avoid consumers having to share data with other or additional entities, one approach would be to create opportunities for trusted users (family members or friends) to bundle their user data in order to potentially generate a more valid data set.

13 Conclusion

13.1 Contribution

The work for this thesis was motivated by the fact, that IoT devices such as the VA collect and process data about the user, which happens permanently, but the user is often only aware of it in an abstract way. This results in an imbalance of information and power between consumers and companies, as the latter have more opportunities to process the data and can also obtain and generate more information due to the availability of large amounts of data from their users.

With this work, it was possible to address this imbalance by first looking at current practices in everyday consumer life, whether or how data work is carried out in the context of VAs. Due to the limited to missing knowledge about data processing (data awareness) and possibilities to gain access to it or to use the data for oneself (data work), a prototype was developed based on user needs in order to strengthen consumers (or in the context of this work: VA users) in their data literacy.

Starting with the contributions to the discourses in research on the consideration of *Usable Privacy* in times of IoT and GDPR as well as the approaches in *InfoViz* to user-centered data preparation and the promotion of data awareness for large data sets, these and other findings ultimately enrich the research discourses in *Consumer Informatics* and the self-determination of consumers by increasing their data literacy.

13.1.1 Usable Privacy

As part of the work for the thesis, data work was made easier for many in particular by using easy-to-use tools and less steps to understand privacy-critical devices such as a VA system. Furthermore, it was done to motivate consumers to deal with data protection issues and settings. This was achieved:

- by defining a user journey to reveal the complex and opaque application process for data information in accordance with Article

15 of the GDPR for the first time. This will help to make the process more transparent and standardized;

- by highlighting that consumers lack a space or starting point from which they can initiate access to or insight into their data;
- by identifying deficiencies in existing provider solutions and data exports (obtained via the right to data access) as supposed enablers for data work and proposing corresponding design recommendations;
- by using simple and understandable visualization methods to establish certainty and a sense of control quickly about VA data, even though privacy is often just a subordinate issue;

13.1.2 InfoViz

Through the studies presented in Part III, the identified effects can be confirmed by visualizing data already highlighted by previous research to strengthen data awareness among consumers, especially when using IoT devices in the digital home. Nevertheless, the work for this thesis provided new and important insights into the visualization of personal and usage-related data (based on the data export by Article 15 GDPR), especially with regard to the interaction data of the VA. When visualizing VA data, it must therefore be taken into account:

- that a large amount of data will be generated due to the daily and often extensive use of the VA, which is why lists such as those in the provider application can quickly lead to cognitive overload;
- that every interaction must often be considered in context and therefore, in addition to command and reaction, information on the device name, speaker, and time should also be listed in the detailed view;
- that it should not only refer to the content and use of the VA, but also the way it is used (and potential changes) such as speaking behavior which can be interesting for the user;

- that comprehensive data insight and transparency through Info-Viz methods increase acceptance and willingness to use data by making the often-abstract consumer knowledge about data use and protection more tangible. This therefore do not lead to abandonment.

13.1.3 Consumer Informatics

The aspects mentioned in the previous sections also essentially contribute to current research in consumer informatics and the greater involvement and support of consumers in the digitalization of their living areas such as the home. The results of this work are primarily related to VA systems, which are a source of both fascination and skepticism for consumers, as they are able to respond to voice commands on the one hand, but consumers themselves are unable to directly see and understand data collection and processing on the other. The work done for this thesis was able to counteract the lack of data literacy in digital homes identified here:

- by making the interaction data with a VA fully visible for the first time in accordance with the GDPR data information, so that data awareness could be strengthened on the one hand and data work for better understanding was made possible on the other;
- by identifying requirements regarding patterns of action and practices in the use of VAs, on how interaction-related data and information can support the interaction during the appropriation phase or for the purpose of repair strategies;
- by drawing attention to and clarifying the fact that not only everyday, and thus expected situations are permanently stored, but also accidental and otherwise triggered activations (e.g., by TV);
- by emphasizing the need for reliance and trustworthiness on the part of providers, as these play a central role in weighing up and revising uncertainties.

13.2 Limitations

The aim of the work for this thesis was to provide important insights into how data work practices contribute to data awareness and how both strengthen data literacy among consumers. To this end, a living lab was used to investigate various approaches of data practices using VAs as an example. Nevertheless, the approach presented here has limitations, although these will be explored in more detail in future research.

The aim of using the practice-oriented methodological approach was to explore consumer practices by means of a living lab consisting of households in order to primarily present information needs with regard to the interaction with VAs. The results thus obtained are not generally representative, as they relate primarily to the VA as one of many devices in the digital home. Representativeness, however, was not a claim from the beginning of the work, but rather the exploration and understanding of data work practices in the mentioned use case. The qualitative sample consisted of a relatively heterogeneous group of households, all of which are German-speaking and predominantly male as well as tech-savvy which also makes it difficult to generalize the results at this point; instead, the statements mentioned here require further research for validation, as practices and insights gained from the studies could be different in other countries. However, even within the household, different information needs may prevail depending on the role of the user. For this reason different user groups and household members could have been involved in order to balance the imbalance of information and power not only between companies and (primary) users, but also between household members (and visitors and domestic staff).

In addition, the work was limited to the interaction data included (especially in transcribed form), which a user obtains from the company with reference to Article 15 of the GDPR. It was assumed that this would provide consumers with a wealth of information that discloses a lot about their usage and interaction behavior. However, as the Amazon example showed, this data seemed to be incomplete because, among

other things, it was not linked to the device used. Consequently, in the future, the (quite complex) raw data as well as the directory of the data takeout would have to be examined in more detail in order to identify coherent and linkable data. Thereafter, it maybe would be possible to draw further information from the data. The machine-readability of the data also made it easier for to design the prototype.

With the end of the related research project, the research and development regarding the prototype for data request and visualization also ended. Even if the prototype is still available and usable, the question arises as to how data collection and processing or the availability of the data will change and how this will affect the usability of the tool. Based on the findings of the work for this thesis, however it seems to make more sense to consider the VA more in the context of the digital home and consumer's everyday life by taking into account data from other devices in future work.

In addition, it turned out that the initial viewing of the data is helpful, but also due to the lack of mobility of the solution (by the stationary PC) it is not always at hand to use it flexibly and immediately, for example, directly after an interaction / activity. This would allow the consumer to receive immediate situational feedback with the help of the prototype. For this case, it is indicated in current research that the choice of device for which an application is developed is decisive for the frequency of use and its success [60, 68]. The mobile-first movement also shows that flexibility and on-time are becoming increasingly important. However, smartphones may be less suitable in this context, as they are personal devices rather than shared ones. Furthermore, smaller screens also cannot display visualizations in accordance with the requirements and accessibility (such as the timeline developed in our prototype). In this regard, tablets could offer a promising intermediate solution, especially in the smart home area, as households already use a tablet for smart home administration and monitoring at central locations (e.g., in the entrance area), which is accessible to all household members.

13.3 Outlook

In conclusion, the findings have led to the following challenges that need to be addressed by future research.

With a view to the empowerment of data literacy, in further research VA systems should be considered more as a tool and means that is primarily used to control other devices and services in the digital home. As was shown in the studies of this thesis, the VA fades into the background of everyday life over the duration of use and is therefore considered to be of little concern, at least by the study participants, with regard to the data collected. This could lead to the VA moving into new areas of the user's private life through new applications that were not originally intended, but which creep in thanks to new voice control options. For this reason, future research with regard to VA data should also take greater account of the context, as the VA system itself is difficult to classify in terms of data protection and privacy. Furthermore, as has been shown in previous research, privacy can have different meanings depending on the context [86, 238, 356].

In addition, and in order to maintain data awareness, the existing and expected data should be used in a different way so that uncommon data (e.g., unintended activations) comes to the fore due to its different nature. Possible approaches here could be analyses and data processing from the areas of tracking or documentation of the self or lifelogging, e.g., by evoking memories, storytelling or the exchange with other users, as consumers are curious and interested in working with (personal) data.

As the log data regarding the interaction with VA systems has shown, VAs as a control element of smart home devices can also provide a comprehensive picture of the usage behavior of a consumer or their household. Recent studies have already highlighted the central role that VA systems play in the networked smart home and how they sometimes orchestrate it in terms of technical requirements [318, 319]. Solutions such as the developed tool presented in Part III have shown that data work and, above all, an initial prepared overview can considerably in-

crease the awareness of processed data. This also shows great potential for meaningful and informative data visualization of other data sets that can be requested. In this way and with the use of GDPR and Article 15 it will help consumers to keep track of their home and consumer life based on the data provided, as well as activities or simple contact points with a provider or organization (see Section 6). Solutions such as the prototype could serve as an interface between consumers and organizations, acting independently and enabling consumer-centered data visualization using InfoViz methods.

Future work should also draw more attention to unintended activations and the identification of potential risks by analyzing the relevant data and context to give shape to consumers' often abstract concerns. This would enable them to make better risk assessments. In the work for the thesis it has been shown, which can be confirmed by other studies, that consumers see less of a risk in profiling itself, but in the incorrect calculation of data and a resulting potential discrimination [299]. In addition, when drawing attention, no attempt should be made to spread fears, as this could lead to reactance. Instead, appropriate visualization methods could be used to draw attention to this in a simple and appealing way.

Finally, shared devices within a household, such as VAs that are used by other household members, visitors or even domestic workers, should also take into account their right to privacy and allow, at least for other household members, them to view the relevant data and allow data work practices. Standardizing the data of different smart home devices could further help to better link the digital home as a complex system of different actors (humans as well as technologies) and daily practices through InfoViz methods. Contextual visualizations and analytics can therefore be used to create certainty awareness and traceability can be created about the data-processed home and ensure a self-determined, informed, and equal (co-)living.

Part V

Appendix

A Living Lab Sample

Appendix A contains detailed information about the living lab sample.

#	Gender	Age	Job (Branch)	Level	Residents	VA system	Devices	Interest in the following topics				
								VAs	AI	Privacy	Smart Home	IT Security
H1	m	31	Software Developer / Consulting	Starter	2	Amazon, Apple	2	high	high	very high	very high	very high
H2	m	35	Service technician / Electrical	User	3	Amazon	8	very high	very high	medium	very high	high
H3	<i>Participation prematurely canceled</i>											
H4	m	31	Public sector, employee	User	5	Google	2	high	high	high	medium	high
H5	w	32	Specialist for market and social research	Starter	3	Amazon, Apple	2	high	high	high	medium	high
H6	m	24	Trainee Forester Senior Forest Service	User	2	Amazon	2	medium	medium	high	high	very high
H7	m	28	Electrical engineering	User	3	Google	5	high	high	very high	high	very high
H8	w	26	Research Associate (HCI)	User	1	Amazon	1	little	medium	medium	little	medium
H9	m	56	Office sale	User	2	Google	5	very high	very high	very high	very high	very high
H10	m	35	Industrial salesman, real estate industry	User	4	Amazon	4	high	medium	high	medium	high
H11	m	27	PhD student, physics	User	1	Google	3	high	very high	medium	high	medium
H12	m	18	Student	Starter	4	Google	2	N/A	N/A	N/A	N/A	N/A
H13	m	45	IT	Starter	4	Amazon	1	very high	very high	very high	high	very high
H14	w	32	N/A	Starter	1	Amazon	1	N/A	N/A	N/A	N/A	N/A
H15	w	27	Architect-Residential	Starter	2	Amazon	1	medium	very high	high	very high	medium
H16	w	40	Project Manager Market Research	Starter	1	Amazon	1	medium	medium	medium	medium	medium
H17	<i>Participation prematurely canceled</i>											
H18	m	34	N/A	User	3	Amazon	4	medium	high	little	medium	little
H19	m	23	IT Consultant	User	2	Amazon	3	medium	high	little	very high	little
H20	w	40	Research associate	Starter	2	Google	1	medium	high	high	medium	N/A
H21	m	29	Mechanical engineering packaging industry	Starter	3	Amazon	1	medium	high	very high	very high	very high
H22	m	27	N/A	User	2	Amazon	2	N/A	N/A	N/A	N/A	N/A
H23	<i>Participation prematurely canceled</i>											
H24	w	30	N/A	Starter	1	Google	2	N/A	N/A	N/A	N/A	N/A
H25	m	32	Scientific staff	User	2	Amazon	2	high	high	little	very high	high
H26	m	48	Scientific staff	User	2	Google	2	high	high	medium	high	medium
H27	m	21	Servicenow-developer ITSM	Starter	1	Amazon	2	high	very high	medium	very high	high
H28	m	34	Research Associate (Computer Science)	User	1	Amazon, Google	2	high	high	medium	high	medium
H29	w		Assistance, Research	Starter	1	Amazon	2	medium	medium	high	medium	high
H30	w	27	Research Associate, Digital Health	Starter	1	Google	1	medium	medium	high	little	medium
H31	m	21	Student, B.A. Speech Therapy	Starter	2	Google, Amazon	2	medium	medium	high	medium	medium
H32	m	34	Student (media informatics)	User	2	Google	2	high	high	high	high	medium
H33	m	34	Software developer	Starter	1	Google	1	little	high	high	No interest	high
H34	m	42	Sales for control technology	User	2	Google, Amazon, Siri	4	high	very high	high	high	high
H35	w	48	Freelancer Digital Media and Design	Starter	1	Google, Amazon	2	very high	very high	high	very high	very high

The strength of interest in the topics in the last five columns could be indicated on a 5-point scale with possible answers: very high, high, medium, little, none, "no answer" (N/A).

B Modification of the SUS Questionnaire

Appendix B contains the modification of the SUS Questionnaire exemplified by the step "Finding the SAR option".

SUS Questionnaire [46]	Modified questions for Step "Finding the SAR option"
I think that I would like to use this system frequently.	–
I found the system unnecessarily complex.	I found finding the SAR option unnecessarily complex.
I thought the system was easy to use.	I thought finding of the SAR option was easy.
I think that I would need the support of a technical person to be able to use this system.	I think that I would need the support of a technical person to find this SAR option.
I found the various functions in this system were well integrated.	–
I thought there was too much inconsistency in this system.	I thought there was too much inconsistency in making this SAR option accessible.
I would imagine that most people would learn to use this system very quickly.	I would imagine that most people would learn finding this SAR option very quickly.
I found the system very cumbersome to use.	I found finding of this SAR option very cumbersome to use.
I felt very confident using the system.	I felt very confident finding this SAR option.
I needed to learn a lot of things before I could get going with this system.	I needed to learn a lot of things before I could find this SAR option.

C Heuristic Evaluation for SAR User Journey Definition

Appendix C contains the results of the heuristic evaluation for defining an SAR user journey.

Table 18

The consulted organizations for the heuristic evaluation and the amount of conducted SAR by the involved authors, see column on the left. On the right is shown the identified and discussed key touchpoints, labelled by the final touchpoints.

Organizations	Identified Key Touchpoints and final labels
AMAZON (2)	1. Finding the SAR option 2. Authentication 3. Data Request 4. Data Access 5. Data Use
Google (3)	1. Finding the SAR option 2. Authentication 3. Data Request 4. Data Access 5. Data Use
Facebook (2)	1. Finding the SAR option 2. Authentication 3. Data Request 4. Data Access 5. Data Use
Telekom (1)	1. Finding the SAR option 2. Data Request 3. Authentication 4. Data Access 5. Data Use
Apple (2)	1. Authentication 2. Finding the SAR option 3. Data Request 4. Data Access 5. Data Use

D Regression Analysis

Appendix D contains the visualization of the data used in the conducted regression analysis.

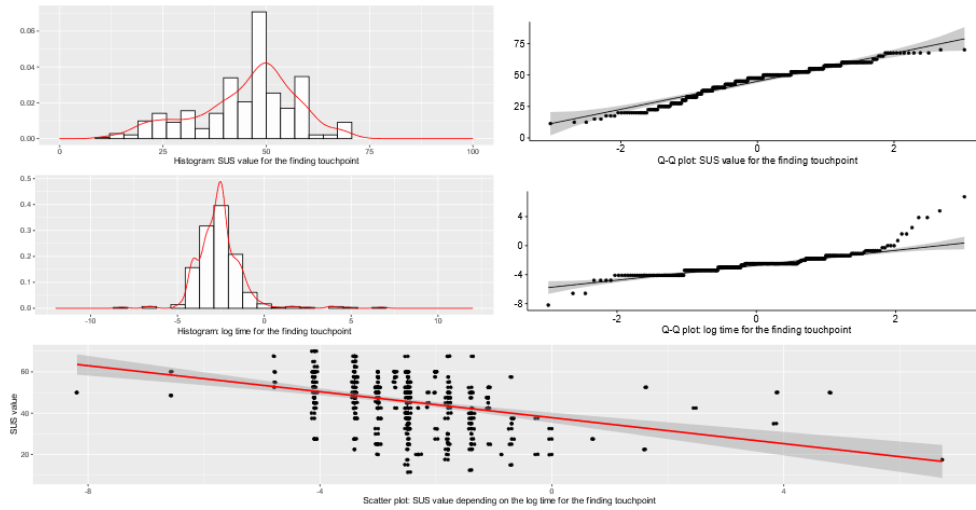


Figure 33

Plots of the SUS values of the finding touchpoint (top), the log time for the finding touchpoint (center), and the relation between both (bottom).

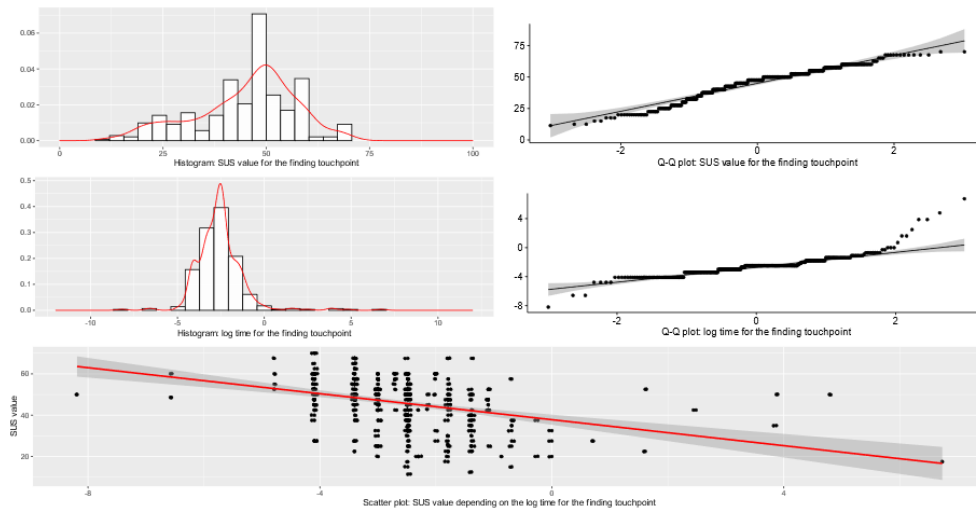
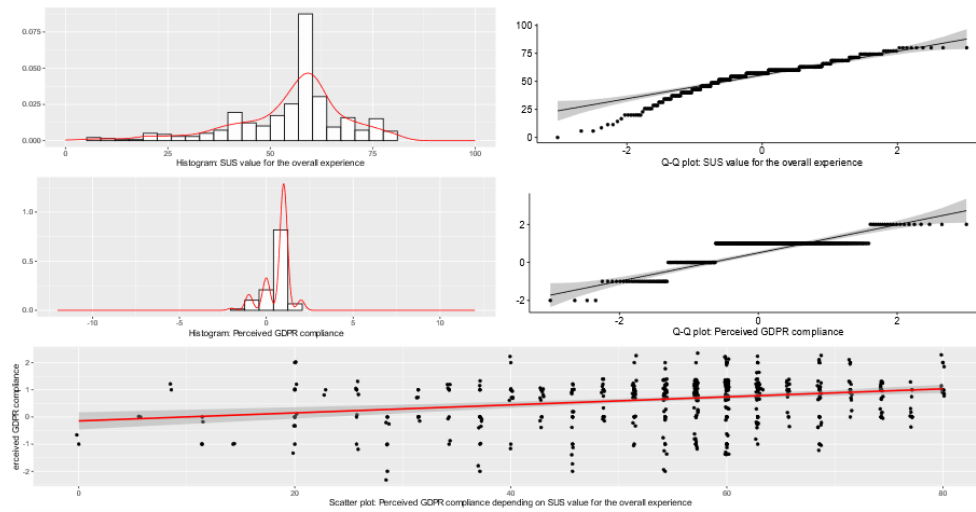


Figure 34

Plots of the SUS values of the data request touchpoint (top), the log time for the data request touchpoint (center), and the relation between both (bottom).

**Figure 35**

Plots of the SUS values of the overall SAR experience (top), the perceived GDPR compliance (center), and the relation between both (bottom).

E ANOVA

Appendix E contains the visualization of the data used in the conducted ANOVA.

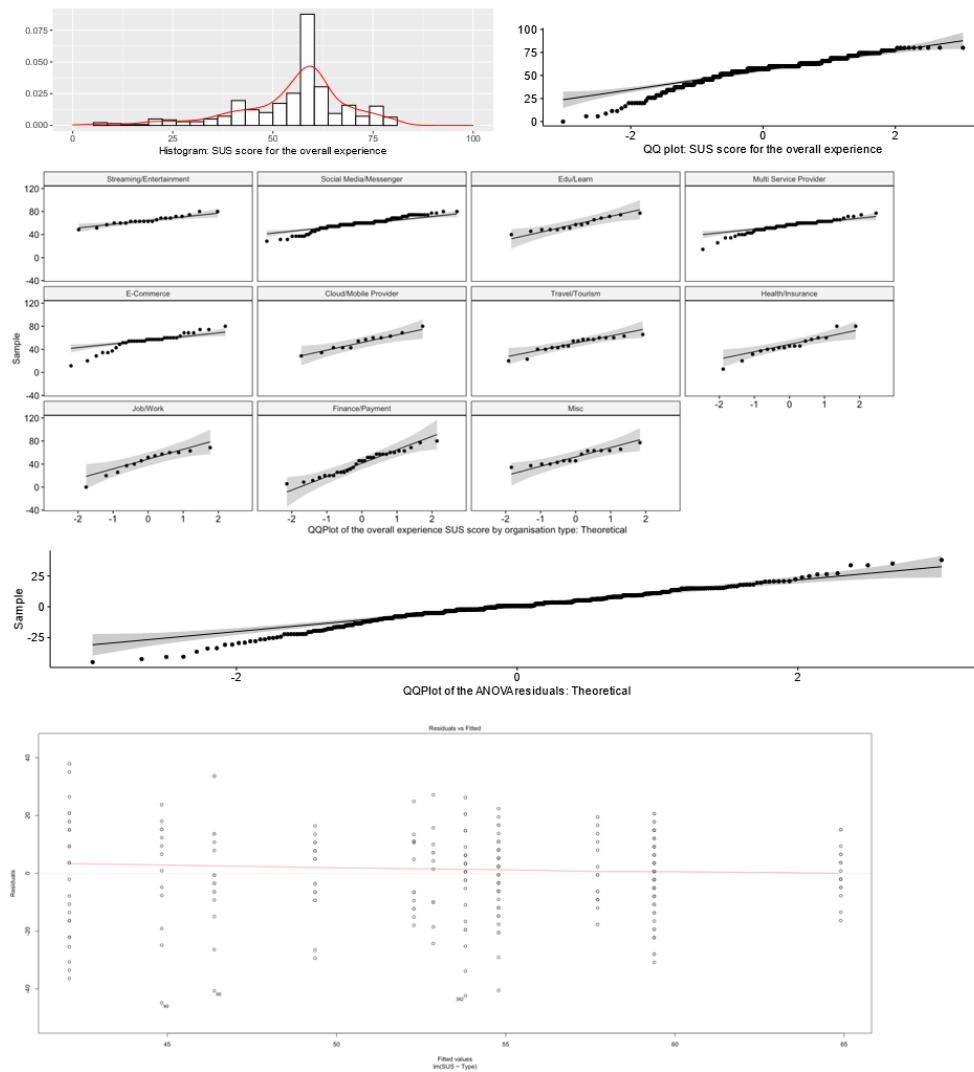
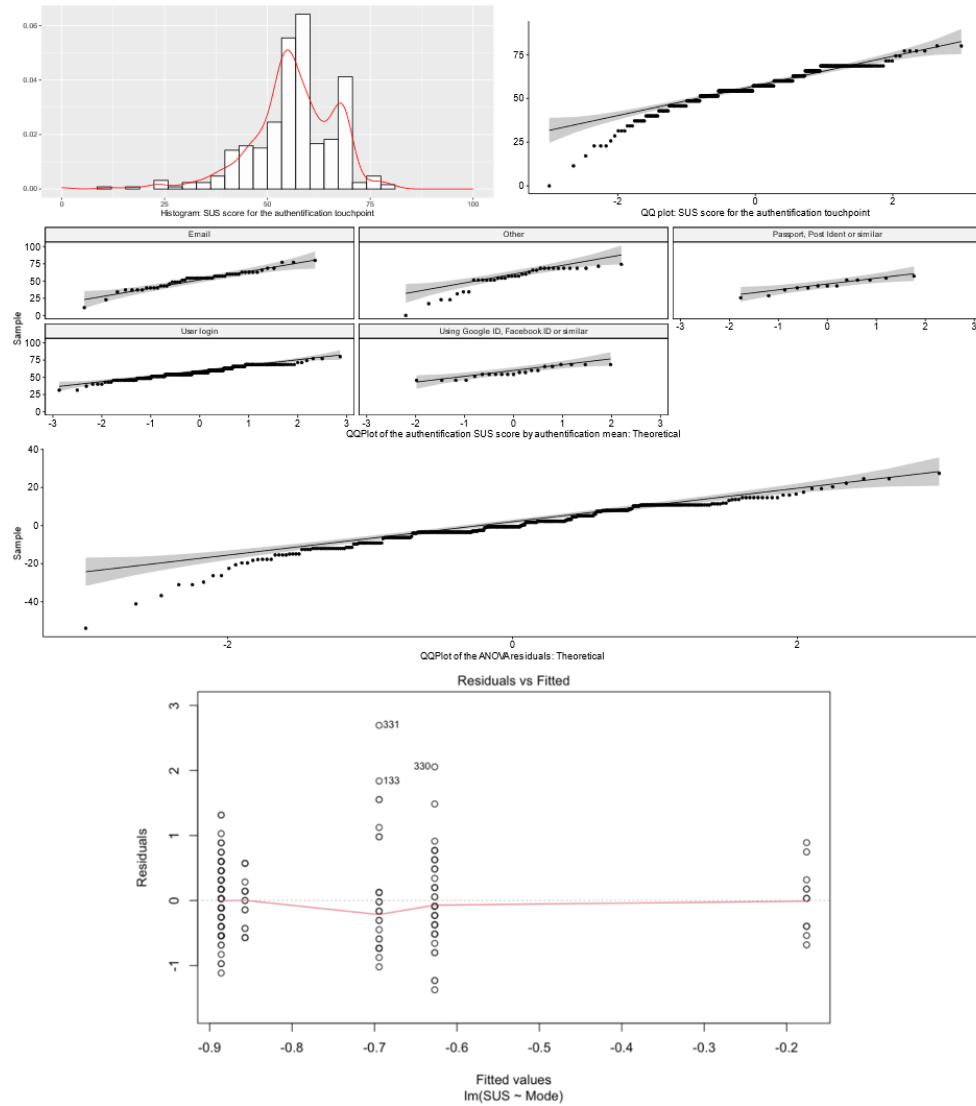
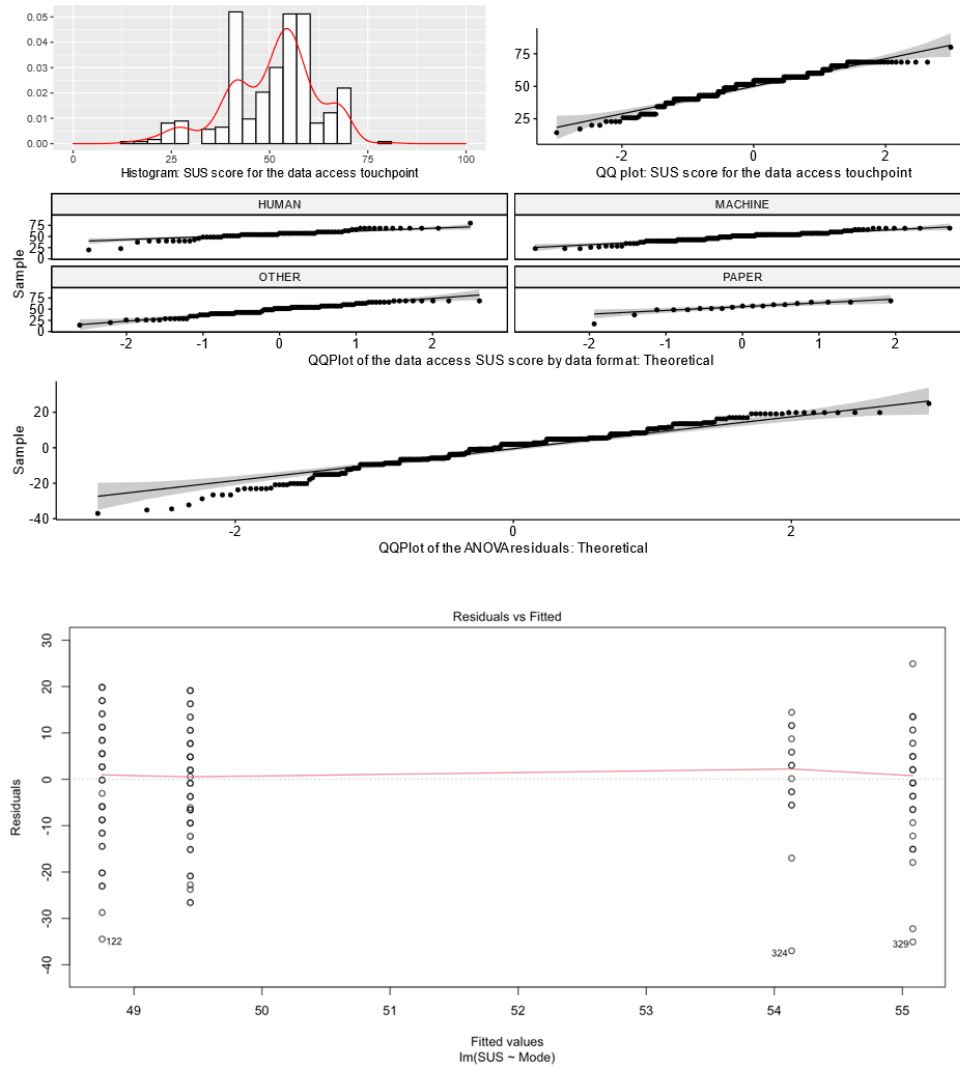


Figure 36

Plots for one-way ANOVA analyzing the overall experience SUS score by the organization type: the deviation from normality of the SUS score (top), by each group (center-top), the deviation from normality of the ANOVA residuals (center-bottom) and the relation relationships between residuals and fitted values to check the homogeneity of variances (bottom).

**Figure 37**

Plots for one-way ANOVA analyzing the authentication SUS score by the authentication mean: the deviation from normality of the SUS score (top), by each group (center-top), the deviation from normality of the ANOVA residuals (center-bottom) and the relation relationships between residuals and fitted values to check the homogeneity of variances (bottom).

**Figure 38**

Plots for one-way ANOVA analyzing the data request SUS score by the data format: the deviation from normality of the SUS score (top), by each group (center-top), the deviation from normality of the ANOVA residuals (center-bottom) and the relation relationships between residuals and fitted values to check the homogeneity of variances (bottom).

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