# “It sounds like automation” – Towards Users’ Understanding of Adaptive Systems

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## ABSTRACT

IT-based Adaptive Systems (*ITbAS*) are understood as information technology artifacts capable of changing to fit different situations, environments, and users. Still, little is known on how users understand ITbAS, and which risks they associate with their use (if any). We conducted a survey with $n = 62$ participants to discover what people know about ITbAS, whether they are aware of using them in their everyday life, and what possible risks they can imagine. We found that, even though 72.58% of our participants heard of ITbAS, only 56.5% could define them. Further, the examples the participants provided partially suggest a lack of knowledge about the full potential of ITbAS in their everyday lives. Risk-wise, the more common code was security-related (27.59% of entries), e.g., “Data breaches,” with privacy risks as second (18.72%), e.g., “Profile and targeting.” As this, our work should be seen as a first investigation into what users know about and how they understand ITbAS.

## ZUSAMMENFASSUNG

Unter IT-basierten adaptive Systemen (*ITbAS*) werden Informationstechnologien zusammengefasst, die sich an unterschiedliche Situationen, Umgebungen und Nutzer anpassen können. Dennoch ist wenig darüber bekannt, wie Nutzer ITbAS verstehen und welche Risiken (falls vorhanden) sie mit deren Nutzung verbinden. Wir haben eine Umfrage mit $n = 62$ US-amerikanischen Teilnehmer:innen durchgeführt, um herauszufinden, was diese im Allgemeinen über ITbAS wissen, ob sie sich bewusst sind, dass sie diese in ihrem Alltag nutzen, und welche möglichen Risiken bei der Nutzung von ITbAS sie sich vorstellen können. Wir haben festgestellt, dass zwar 72.58% unserer Teilnehmer von ITbAS gehört hatten, aber nur 56.5% eine angemessene Definition bereitstellen konnten. Darüber hinaus deuten die von den Teilnehmern genannten Beispiele teilweise auf einen Mangel an Wissen über das volle Potenzial von ITbAS in ihrem Alltag hin. In Bezug auf Risiken wurden häufig Sicherheitsrisiken genannt (27.59% der Einträge), z.B. “Data breaches”, gefolgt von Datenschutzrisiken (18.72%), z.B. “Profile and targeting.” In diesem Zusammenhang kann unsere Arbeit als eine erste Untersuchung angesehen werden, das Wissen und Verständnis von Nutzer:innen über ITbAS zu erfassen.

## CCS CONCEPTS

• **Security and privacy → Social aspects of security and privacy**.

## KEYWORDS

IT-based adaptive systems, knowledge, user study, Prolific, survey

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## 1 INTRODUCTION

IT-based Adaptive Systems (*ITbAS*) are information technology (*IT*) artifacts capable of changing to fit different situations, environments, and users [3]. The specific goals may differ, but all ITbAS focus on *personalization*. Personalization is understood differently in different fields [7], but in IT it usually means fine-tuning systems to the users [2].

ITbAS are an everyday occurrence: personalized music playlists, targeted advertisement, generative AI chatbots, to name a few. Given their ubiquity, and the impact that ITbAS have on people’s lives, we believe it is important to understand the users’ understanding of them. Furthermore, to adapt to their users, ITbAS collect and analyze enormous amount of personal and (sometimes) sensitive data, used to make inferences that predict the users’ behavior (mentioned in, e.g., [12, 13, 22]). We already know from related work that people are not aware of the privacy risk of smart home adaptive systems (shown in, e.g., [9, 10, 16]). Our goal with this research is

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to expand the investigation from the smart home field to ITbAS in general. Thus, we pose three research questions:

**RQ 1.** What do people know about IT-based adaptive systems?
**RQ 2.** Are people aware of using IT-based adaptive systems in their everyday life?
**RQ 3.** Can people mention possible privacy risks and consequences of IT-based adaptive systems?

We answered these questions by conducting an online questionnaire with 62 English speaking participants from the United States of America, recruited via Prolific. Our results show that only 56.5% of our participants could provide a suitable definition of ITbAS, even though 72.58% said that they heard of ITbAS. While we found that our participants were aware of some ITbAS they use in their everyday lives (e.g., Navigation, Entertainment, Social Media, or Browsing), they could not imagine the full potential of ITbAS (e.g., for manufacturing or healthcare). Regarding risks, most participants mentioned security based ones (27.59% of entries), e.g., "Breach of information and data," with privacy ones as second (18.72%), e.g. "Tracking and Profiling."

## 2 RELATED WORK

*Definition of Adaptive Systems.* As mentioned in Section 1, the term adaptive systems is used in different contexts, which leads to several definitions. Feigh et al. [8] define adaptive systems as systems that "can change their behavior to meet the changing needs of their users, without explicit instructions from their users." Mohabbati et al. [18], instead, defines them as systems that change to aid the users in the best possible way. Jameson [14] calls "adaptive," systems that build user models involving learning, inference, or decision making.

Considering all the definitions, we extrapolate the one used in our work. Note that the term "adaptive systems" covers any system, be it natural or human-made, that adapts to changing circumstances. We focus on adaptive system in IT. Thus, our definition reflects that focus: IT-based adaptive systems are information technology systems capable of tailoring their output to support the user in the best possible way based on the user's needs. They do so by sensing and tracking information about their users, current tasks, and environment, to create a user model. Note that "best" in this context is not used in the sense of "most beneficial," but rather as meaning "most effective to achieve a certain goal." As such, it might be that the "best" way to support a user's needs is dangerous for their privacy. A somewhat extreme example of this could be a smart health device sharing sensitive health data of a user with drug vendors to be updated on the most recent solutions for their health problems. Such an exchange would allow the user to get the "best" (as in, "latest," "most advanced") drugs for their conditions, but it would also disseminate the users' sensitive data.

*Risks associated with Adaptive Systems.* While ITbAS offer clear benefits to users, such as providing health or energy consumption advice, their use can also be controversial. Critiques revolve, for example, around the characteristics of the system, i.e., the lack of transparency on how such systems arrive at their decisions [3]. Concerns are also raised about extensive data collection without users' consent [15], limited possibilities for users to control which data are utilized [11], and the unethical trade of user data that was non-consensually obtained [5]. Furthermore, adaptive systems such as recommendation algorithms in social networks or entertainment apps, may promote addictive behaviors and create – or reinforce – filter bubbles and echo chambers [3].

*Research Gap.* As described by Benke et al. [3], the design of ITbAS and user interactions with them have been investigated for several systems, such as robotics, speech communication, or home assistance. However, a fundamental understanding of users' knowledge and perception of ITbAS has not yet been thoroughly investigated. In order to understand how users evaluate these systems, it is essential to first understand what they *know* about them. In particular, understanding the perceived risks of ITbAS is important to avoid exposing users to privacy threats [11]. Therefore, our work aims to be an initial investigation into what users understand about ITbAS and the risks tied to their use.

## 3 METHODOLOGY

To answer our research questions, we conducted an online survey using a SoSciSurvey instance[1] hosted at our institution. Participants were recruited via Prolific.[2] We are aware that recruiting participants via online panels has some limitations, namely self-selection bias and the potential for low-quality answers. However, as related work has shown, Prolific is regarded as one of the more reliable panels with usually high-quality answers [6, 19]. We selected our participants using three criteria: desktop users (no mobile or other platforms[3]), English as their first language, and from the United States of America. We also added a further constraint, namely, a balanced sample between females and males. Our study design followed the principles of good scientific practice. Participants were informed about the purpose of the study and the data processing in a consent form which they had to agree to before they could continue with the survey (see [1]). Participants were not exposed to any physical or mental risk during the survey. Our study design was also subject to review by the ethical board of our university, and approved.

The questionnaire contained a total of ten questions (see Appendix A.1 or [1] for the questionnaire). Five were used to assess the participants' understanding of adaptive systems ([MQ]). Two questions were used to test the participants' attention ([AT]), and three questions were used to collect demographic information on the participants' competence, age, and gender ([DE]). To answer **RQ1**, we asked participants whether they had ever heard about ITbAS [MQ08], asked them to provide a definition [MQ02] and give at least three examples of ITbAS [MQ10]. We then provided a definition and, again, asked participants to provide five different examples of ITbAS they use in their everyday lives [MQ10] to answer **RQ2**. Then, to answer **RQ3**, we asked participants to name at least three possible privacy related risks or consequences of ITbAS [MQ06].

To analyze the data, two researchers were involved in developing a codebook to (1) classify the participants' definitions of ITbAS whether they were (nearly) accurate, did not fit, or were too vague;

[1] https://www.soscisurvey.de/en/index
[2] https://www.prolific.com/
[3] We implemented the survey to be usable on desktop, and viewing it on mobile or other devices might have made completing it difficult.

(2) assign the examples for ITbAS that the participants provided into categories to better compare their answers; (3) categorize the risks that were named in the open answers (see [1] for the final codes). For (1) and (2) one researcher reviewed the answers and derived categories, while the other checked the codes. For (3), we analyzed the answers with an inductive coding approach (described in [20, 21]) to identify frequent, dominant or significant aspects in the answers. Two researchers independently coded the answers, and, after a round of discussion, calculated the *Inter-Rater Reliability* (IRR) using Cohen's kappa [4]. They reached an IRR of $k = .96$, which was deemed acceptable.

# 4 RESULTS AND DISCUSSION

## 4.1 Demographics

Our aim was to recruit 60 participants, but we increased the number to 62 in case of exclusions. No participant who completed the survey was excluded, so our results are based on the data from all 62 participants.

As shown in Table 1, our sample was relatively balanced gender-wise. Regarding age, the sample was skewed towards the 25-34 and the 35-44 age groups. Regarding the self-reported IT knowledge, 83.87% of participants were in the average and experienced groups, with only two participants identifying as inexperienced, and six participants with a computer science background. Please note that although our research questions targeted "people" in general, our sample only contains a small, not representative, and probably biased part of the population. Our results should, therefore, be viewed as a preliminary exploratory study in this field.

For the quantitative analysis, we checked the influence of gender, age, and IT knowledge on having heard of ITbAS prior to participation in our study. We first used three Pearson's $\chi^2$ tests to determine significance. There was none from either gender, $\chi^2(1) = 1.67, p = .19$, and age group, $\chi^2(5) = 4.70, p = .45$, but there was significance from IT knowledge, $\chi^2(3) = 8.89, p = .03$. We used logistical regression to determine which groups were significantly different, and found that the only significance was between the average IT knowledge group and the experienced group.

## 4.2 RQ1 – Knowledge about IT-based Adaptive Systems

To answer **RQ1 & RQ2**, we asked participants whether they heard of ITbAS before, give a definition of ITbAS, and provide at least three examples. Nearly three in four participants (72,6%) answered that they had heard of it before, while 27,4% did not. Of all 62 participants, 56.5% provided a suitable definition (e.g., "IT-based adaptive systems are technological solutions that adjust their behavior in response to changing environments, user needs, or system performance."), 12.9% of the definitions were too vague (e.g., "they suggest products based on user history of preference and interest"), and 30.6% of the definitions were found not suitable (e.g., "It sounds like automation."). Overall, our findings suggest that our participants had a rough idea of what ITbAS are.

This is also supported by the examples the participants named. For question [MQ10], all 62 participants named, on average, three examples (3.3), with one participant naming seven examples, three naming five examples, and eight naming four examples. We categorized the examples into 16 categories (see [1]). The number of examples mentioned for each category is provided in Table 2. We found that most of the participants named examples in the category Mobility / Navigation (38 examples), namely, self driving or autonomous cars, smart or adaptive traffic management, or navigation apps / GPS. Interestingly, we also saw that several participants provided examples from contexts that we had not expected, such as the IT context (28 examples, e.g., malware monitoring, fraud / intrusion detection, or cloud systems) or from Online Learning / Education (26 examples, e.g., Adaptive Learning Systems in general or specific examples such as Coursera or Duolingo). Further, it was remarkable that only a few participants named examples from the Social Media or Entertainment context, which we would have expected to be named more often.

Yet, when reading the definitions and the examples in detail, we also found that quite a few examples were too vague (20 examples) or useless (17 examples). This raises the question of whether the participants had indeed a thorough knowledge of ITbAS. Further, as some of the examples and definitions sounded too similar or too perfect, we checked possible answers a Large Language Model (LLM) would give. We found that for both the definitions and the examples, our prompts resulted in very similar wordings to the ones provided by some of our participants. This raises serious concerns about the reliability of our results for **RQ1**, which we would like to discuss with the research community.

## 4.3 RQ2 – Use of IT-based Adaptive Systems in Everyday Life

Table 2 provides an overview of the examples of ITbAS that participants use in their everyday life ([MQ03]). Note that the total number is higher for [MQ03] than for [MQ10], as we requested at least five examples. We can see a shift in the categories, as after providing the participants with a definition and asking specifically for ITbAS they use in their daily life, most of the participants named examples in the category "Entertainment" (47 examples), namely Spotify, YouTube, or Netflix. The second most examples are still in the category "Mobility / Navigation" (44 examples), e.g., Google Maps, GPS Systems, or self-driving cars, with only a few additional mentions compared to before the definition. Interestingly, besides "Entertainment," we noticed an increase in the categories "Social Media Platforms" (before: 3, after: 25), "Browsing" (before: 7, after: 30), "Smart Home" (before: 4, after: 27), "Virtual Assistants" (before: 4, after: 24), and "Generative AI" (before: 13, after: 29), while there was a decrease in the categories "recommendation algorithms" (before: 14, after: 4) and "Online Learning / Education" (before: 26, after: 12). We also noticed that participants provide less "useless" (before: 17, after: 6), and "too vague" (before: 20, after: 11) examples, while they name more own examples ("specific examples" – before: 4, after: 6; "Other" – before: 4, after 19).

While we assumed that a few of the examples named before our definitions were AI generated, it seems that more participants had a better understanding of what ITbAS are after we gave them some explanation. While we acknowledge the risk that participants were primed by the definition and the examples we provided, we see the main benefit that this enabled the participants to provide more

**Table 1: Demographic data of our sample.**

| Gender | | Age groups | | | | | | Self-reported IT knowledge | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Male | Female | 18-24 | 25-34 | 35-44 | 45-54 | 55-64 | 65+ | Inexperience | Average | Experienced | IT degree |
| 32 | 30 | 3 | 24 | 16 | 8 | 4 | 7 | 2 | 26 | 28 | 6 |

**Table 2: Examples for IT-based adaptive systems named by the participants before [MQ10] and after [MQ03] we provided a definition.**

| Category | Example | Before Definition | After Definition |
|---|---|---|---|
| Mobility / Navigation | e.g., "Navigation Apps (e.g., Google Maps, Waze)", "self driving car" | 38 | 44 |
| IT related | e.g., "Malware monitoring", "self optimizing wi-fi networks" | 28 | 21 |
| Online Learning / Education | e.g., "Coursera", "teaching tools that adapt to the students level as it changes" | 26 | 12 |
| Too vague | e.g., "Phone", "Software Programs" | 20 | 10 |
| Useless | e.g., "an AI that helps teaches you about IT", "Intel was it called Watson?" | 17 | 6 |
| Recommendation Algorithms | e.g., "Pinterest algorithm", "personalized recommendation systems" | 14 | 4 |
| (Generative) AI | e.g., "Mid Journey", "ChatGPT" | 13 | 29 |
| Smart Home | e.g., "Smart Home Assistants", "Digital thermostats" | 10 | 16 |
| Devices | e.g., "Smartphone keyboards", "Smartphone autocorrect & predictive text" | 10 | 14 |
| Entertainment | e.g., "Netflix", "Streaming Services (Netflix, YouTube, Spotify) – Recommend movies, videos, or songs based on watch/listening history and user preferences." | 9 | 47 |
| Browsing | e.g., "Google Chrome", "Amazon" | 7 | 30 |
| Virtual Assistants | e.g., "Chatbots", "Alexa" | 4 | 22 |
| Specific Example | e.g., "Your phone screen gets brighter or dimmer depending on the lighting around you.", "Amritbaal Lic" | 4 | 6 |
| Healthcare | e.g., "Healthcare monitoring systems", "Adaptive Medical Devices" | 3 | 2 |
| Social Media Platforms | e.g., "Social media algorithms", "TikTok advertisements" | 3 | 25 |

specific examples (e.g., "Spotify algorithm" instead of "recommendation algorithm"), including ones that are closer to their everyday lives (e.g., from the Social Media and Entertainment context).

Interestingly, only a few participants mentioned the use of adaptive systems in the work context, other than IT-related work contexts (e.g., Microsoft Copilot, Amazon Web Services, or Intelligent System Monitoring Tools). The use of ITbAS in the manufacturing context (e.g., adaptive assembly assistance, autonomous robots, real-time production planning and scheduling systems) was not mentioned by the participants at all. Only one participant provided concrete examples from the agricultural context (e.g., "Precision Agriculture Systems," "Smart Greenhouse Systems," "AI-Driven Livestock Monitoring"), which suggests that they really use these systems in their daily work – or previous prompts related to agriculture biased their answers. Also, only very few participants named examples from the health context – and if so, it was only very generic, e.g., "Adaptive Medical Devices." All in all, this suggests that our participants are not aware of the full potential of ITbAS and the impact such systems have on their everyday lives.

## 4.4 RQ3 – Privacy Risks Related to IT-based Adaptive Systems

To answer **RQ3**, we asked participants to provide (in an open question) at least three examples of risks and consequences of using adaptive systems ([MQ06]). The results of the analysis are reported in Table 3.

As shown, 27.59% of entries referred to security, e.g., "Security leaks." This was followed by privacy concerns (18.72%), e.g., "Sensitive data exposure," and data collection (15.27%). We find this surprising, given that data collection is a necessary function for adaptive systems ability to fit to changing situations. Still, when considering the preoccupation for misuse (14.29%, e.g., "potential for discrimination"), lack of data control (13.30%, e.g., "using use data without consent"), and lack of transparency (6.40%, e.g., "low level transparency") this might explaining why data collection was considered in a negative light. Finally, more technical aspects were the least occurring, i.e., the presence of wrong information (4.93%, e.g., "incorrect results"), and IT related risks (2.46%, e.g., "intrusion detection"). Unfortunately, 9.85% of codes were hardly risks (e.g., "self-driving cars") or simply not understandable (e.g., "human performance risk").

The participants understanding of the relation between IT and ITbAS is somewhat limited. Besides a single participant mentioning the use of ITbAS as intrusion detection systems, most participants focused on the chance that the data collected could be breached. Further, no participant mentioned that ITbAS can be used as attack vectors, e.g., a previous version of ChatGPT has been shown by Liu et al. [17] to be open to adversarial induction prompt attacks[4]. This is surprising, as among the examples they provided in Section 4.2 there were several cases of IT security related entries, reinforcing our suspicion that the participants employed AI generated answers. Admittedly, our question was specifically on privacy risks and consequences, so that has likely influenced the participants' answers.

# 5 CONCLUSION

We have to acknowledge that our study is limited by a small, not representative sample of US participants. Thus, the results should only be seen as a first look into the topic of what users' in general know about ITbAS.

[4]Attacks where the prompt is used to trick the Generative AI into producing dangerous answers.

**Table 3: The results of the qualitative analysis. Each entry could be labeled by more than one code.**

| Code | Example | Found | Percent of all entries ($n$ = 203) |
|---|---|---|---|
| Security | e.g., "Data may be at times be breached" | 56 | 27.59% |
| Privacy | e.g., "Targeted advertising & manipulation" | 38 | 18.72% |
| Data collection | e.g., "Data collection and storage" | 31 | 15.27% |
| Misuse | e.g., "Potential discrimination and bias" | 29 | 14.29% |
| Data control | e.g., "Loss of control over personal data" | 27 | 13.30% |
| Surveillance | e.g., "Surveillance and tracking" | 25 | 12.32% |
| Other | e.g., "Laziness" | 20 | 9.85% |
| Transparency | e.g., "Lack of transparency" | 13 | 6.40% |
| Wrong data / Information | e.g., "Outdated information" | 10 | 4.93% |
| IT related | e.g., "System dependency and errors" | 5 | 2.46% |

Also due to the limited sample size, we are hesitant to provide strong recommendations to practitioners based on our results.

Furthermore, the scope of the ITbAS considered is somewhat skewed towards entertainment and navigation support, which might also limit the generalizability of our results.

Nevertheless, due to the relatively small sample size, we gained a good overview of the individual responses. In particular, we found that some of the answers sounded pretty similar, if they were not exactly the same. Furthermore, when asking LLMs to answer our questions, we got nearly the exact answers that the respective participants in our survey provided. We do not expect that our questions were answered by Chatbots, as all participants passed the attention checks. However, we have to question the reliability of our results if participants just provided generated answers. This finding is only a by-product of our study. However, it would be highly interesting to discuss with the research community the usefulness of mainly qualitative surveys using online panels if most of the answers participants provide are probably AI generated.

Regarding out results, we can see that even if participants thought they knew what ITbAS are, it is noticeable from their definitions that they do not have as clear an idea as they think. Furthermore, it is important to notice that the focus of their attention is on the risks and consequences that using ITbAS can have on their data. Yet, that is only one aspect of the ITbAS influence on security and privacy, which may lead users to underestimate the potential risks of using such systems (e.g., malicious and dangerous generative AI answers). All in all, our survey showed that, although our participants are somewhat aware of ITbAS and what using them means, a great deal of awareness is still lacking.

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# A QUESTIONNAIRE

## A.1 Survey

*The questionnaire included two attention questions. Failing both led to exclusion. For this paper, some parts were omitted due to space. The full questionnaire is provided in our repository:*

*A.1.1 Welcome.* Omitted due to space.

*A.1.2 Data Protection Information.* Omitted due to space.

*A.1.3 Task Description.* Omitted due to space.

*A.1.4 Questions.*

MQ08 Have you ever heard of IT-based adaptive systems? [Yes / No]

MQ02 Please write down your understanding of IT-based adaptive systems. If you never heard of IT-based adaptive systems before, please try to think of what they might do and try to give a brief explanation. [Open Text]

MQ10 Please try to name possible IT-based adaptive systems. If you are not sure what IT-based adaptive systems are, try to think of examples that would fit your given definition. Please name at least three different IT-based adaptive systems. [Open Text]

AT02 This question is testing your attention, please select the answer "Never"? [Sometimes / Every time / Often / Never]

*Definition.*

The following text consists of a definition of IT-based adaptive systems and some examples. Please read the following text carefully, as you will need the information for the following questions. Adaptive systems are all kinds of **systems capable of altering their output to support the user** in the best possible way, based on the user's current needs. They do so by tracking and sensing information about their users, current tasks, and environment to create a user model, for more accurate alterations.

Examples of IT-based adaptive systems are for example:

- **Social media and online shops** recommend certain content or products based on previous choices of the users themselves or users that are considered similar.
- **GPS systems** change the UI depending on daytime, speed, and location. For instance, depending on the daytime and the users' location of being in or outside of a tunnel, the UI will swap between a brighter or darker default colour. Depending on your speed, the system will automatically zoom in or out of the map, to provide a better overview and decision-making.
- **Chatbots** are also considered adaptive systems, as they represent an intelligent agent, that can alter its behaviour and output depending on the needs of the user interacting with the chatbot. For example, certain chatbots allow the user to give information on how a generated text should sound, with commands like: 'Create a short explanation text on how a camera works for fifth graders.'

MQ03 Can you think of five different IT-based adaptive systems, that you use in your daily life? You may name previously used examples if you think they fit the given definition. [Open Text]

MQ06 Can you think of possible privacy related risks/consequences using IT-based adaptive systems? Please try to think of at least three risks/consequences. [Open Text]

AT01 This question is testing your attention, please select "No". [Yes / No / Maybe]

DE03 How would you grade your computer and technology knowledge? [Selection]

- I have a degree in computer science or a related field.
- I consider myself an experienced computer/technology user.
- I consider myself an average computer/technology user.
- I consider myself not an experienced computer/technology user.

DE02 I am [ open ] years old.

DE01 Please enter your gender: [male / female / binary / other: ]

*A.1.5 End.* Thank you for participating in our study. All your answers have been submitted. Use the code below to redeem your payment on "Prolific" or copy the link. Your Prolific payment code is: [CODE]

You may close the window after redeeming your payment.