Trust in and Acceptance of Video-based AAL Technologies

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Abstract: Due to a growing demand and need for solutions that alleviate the strain on the overburdened healthcare system, video-based ambient assisted living (VAAL) technologies offer a good alternative to support individuals in need of help. In order to successfully implement such technologies into the living spaces of individuals with care needs, factors that determine their trust in, and acceptance of, such technology need to be examined in more detail. This study investigates perceptions on trust and its relationship with the acceptance criteria of VAAL technologies. In a mixed-methods design approach using focus groups and a questionnaire study, participants evaluated their trust and acceptance perceptions of VAAL technology and assessed its benefits and barriers. Results revealed significant relationships between the variables, signalling the relevance of understanding of how trust may influence the overall acceptance of VAAL technologies. Recommendations for future studies as well as applications of the findings are made.

1 INTRODUCTION

As of this moment, there is both a shortage of healthcare personnel that is expected to increase and a growing demand of people with care needs (Michel & Ercanot, 2020). These issues have been further exacerbated by the ongoing Covid-19 pandemic and will bring about multiple serious societal issues, such as maintaining the relationship with physicians in people with chronic diseases (Erquicia et al., 2020). In order to combat these challenges, there are several approaches to go about it. One of them, in an attempt of digitalising processes in all sectors of the public, are assistive technologies. These kinds of devices and systems are designed to enable people with care needs to live a more autonomous life and keep their quality of life while still having support for their requirements (Peek et al., 2014, Wahezi et al., 2021). Specifically, ambient and assisted living (AAL) technologies are a type of technology that is typically used for monitoring health status and behaviours, such as detecting falls or recognising movement patterns. These include wearable or ambient-installed sensors that are used in people's homes or permanent care facilities (Climent-Perez et al., 2020; Steinke et al., 2012). More precisely, video-based AAL technologies (VAAL) can be used to monitor people's behaviours and alert medical personnel and/or family members in case of a medical emergency without having to interact with the users. However, many of these solutions are still under construction and more information about their potential is needed. While studies often focus on technological or legal obstacles, the perspective of potential users is often missing. It is therefore important to investigate people's acceptance of AAL technologies and what plays into their decisions to use them, conducting studies from a user-centred perspective (Offermann-van Heek & Ziefle, 2019).

Perceived benefits and barriers are proven to make it more or less likely for people to accept such technologies (Jaschinski & Allouch, 2015; Wilkowska et al., 2021). Some examples of potential benefits are the (re)gained independence and health-related security of immediate help, while some examples of potential barriers include data management, usability, and trust issues (Schomakers

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et al., 2021). In addition, other factors shape the AAL acceptance by potential users, like privacy, perceived control, attitudes towards AAL, medical necessity, as well as the added value to their daily life (Jaschinski et al., 2021; Offermann-van Heek et al., 2019).

The Technology Acceptance Model (TAM; Davis, 1989) has been widely used in technology acceptance research. This model assumes that two key components significantly influence the attitude towards its use: 1) perceived ease of use a given technology, and 2) perceived usefulness that relates to the idea of how useful the technology is. These components are closely related to the behavioural intention to use and the actual use of this technology. Current research on health-related technologies applied TAM in different contexts, confirming the predictive power and determining role of these criteria for innovative technologies (Rahimi et al., 2018; Alshammari & Rosli, 2020).

In line with trading off the benefits and barriers, potential users consider trust in these systems to be vital. Throughout the literature, trust has been conceptualised a human belief and expectancy and is considered and interplay of a trustors and a trustee (McKnight & Chervany, 2001). For trust in medical technology, three main dimensions are relevant: user, technology, and context factors (Xu et al., 2014; Bova et al., 2006). However, as the development and use of technologies is rapidly advancing, a more nuanced distinction of how people form trust in VAAL technology is necessary. Research shows that whether and how people trust a particular technology is dependent on both factors relating directly to the technology but also context-related influences, such as trust in their physician (Qiao et al., 2015). This suggests that trust is influenced by multiple aspects, and the way how people form trust in technology is complex. Specifically, trust in technology has been shown to be crucial for later acceptance (Wilkowska & Ziefle, 2019). Due to the different measurements of acceptance and trust in (V)AAL technology across studies, results might differ (Wilkowska et al., 2015). Considering this gap, this empirical study aims at identifying relevant trust factors for the use of VAAL technology, applying a mixed method approach.

2 QUALITATIVE APPROACH

First, an interview study was run with the purpose of identifying trust factors that are considered relevant for trusting VAAL technology.

2.1 Procedure

Both interview groups were recruited in the social network of the researchers and volunteered to take part. Informed consent and permission to record was obtained prior to the beginning. During the interview, first, trust perceptions in the healthcare system were explored. Secondly, AAL technologies with a focus on video-based systems were explained. Next, trust perceptions, requirements for trust, and benefits and barriers about trusting VAAL technology were discussed and participants were asked about how trust changes and develops in health decisions. Lastly, demographic variables (e.g., age, gender, health status), but also, technical affinity, and experience with medical technology were assessed.

2.2 Sample

Two focus groups were held on two occasions with each five participants (50% female). Both interview groups lasted roughly one hour, were audiotaped and transcribed later on. The age range was 22 to 55 years (M=30.2; SD=12.39). On a scale from 1 to 6, technical affinity ranged at M=4.2 (SD=1.48). Seven participants completed vocational training, two of them are students. Four participants work in the medical and four in a technical field. Eight of them have experience with medical technology and two have professional care experience. None of them neither dependent on care by others nor have acute diseases, but four of them reported chronic diseases.

2.3 Results

There were two key topics in users' argumentation lines that were relevant for trust in the VAAL technology: data protection and information and communication flow. Also, several trust-associated criteria were found and are discussed below.

2.3.1 Data Protection

In this category, participants mostly referred to their data being sealed from third parties. While they reckoned that any technology can theoretically be hacked, they did agree that in order for them to trust the VAAL system, **access to their data** should have the highest possible protection mechanism.

> *"Just as important is the issue of data protection, because of course no one wants to be filmed in their own four walls or have any sound recordings of them published for whatever purpose. There are enough crazy people who abuse data like that [...].*

So data protection is a very important point for me." (male, 24 y)

Data protection was also an important aspect for trust in VAAL technologies. In addition, participants felt more comfortable if they could decide who has access to their data and how it is shared.

"In any case, data will be stored somehow if the [VAAL system] is installed in my bedroom and if I knew that someone could access it, of course I wouldn't like it at all." (male, 26 y)

The key component was knowledge about the technology brought to the users in a truthful way. According to them, the topic receives growing interest over the last years (**relevance**). For this factor, five items were constructed in the questionnaire (**data access** and **relevance).**

2.3.2 Information and Communication Flow

This category was defined as the context in which the technology was introduced, monitored, and used. Participants mentioned that they would more likely trust a VAAL system in their home if their physician explained it to them well. Moreover, they felt more secure in trusting if the person monitoring their activity, e.g., in case of a fall, was someone with a professional medical background. Conversely, they would not trust a VAAL system if they felt that the systems did not understand the severity of the incident. Participants agreed that an overall professional appearance mattered for their trust development (**professionalism).**

"I would then, if something like that [a detected incident]is checked again by another person, then I would like to have the experienced person and not the one who was maybe a gardener before and says, "oh, let's have a look" and then sends someone off. [...] It would be important to me that it is checked again by competent people who have medical experience." (female, 52 y)

Another aspect of this was that participants referred to understanding the mechanisms both behind the actual technology, i.e. the source code, and behind the bureaucracy, i.e. the financing of it. One participant, working as a computer scientist, said that his only condition for trust in VAAL technology required an open-source code. Other participants argued that this would not affect them as much seeing as they lacked the technical know-how. They did, agree that they wanted to be able to retrace how VAAL systems end up with the user. Moreover, they worried about financing these systems and who would pay for the usage. They also referred to trusting the systems more if the costs were covered by their insurance companies.

"If the source code behind it is open source, i.e. if I can see it, modify it and, as a computer scientist, I can understand exactly what is happening there, then for me trust is already given because I can identify that for myself." (male, 25 y)

"I have also written down transparency. So how does the system work, how does it recognise that there is a problem. Of course, people have to be taught this, made aware of it, and older people in particular understand it even less than we do now.." (female, 24 y)

"Who finances this? Does the health insurance or the long-term care insurance cover part of it, or do you have to pay the whole cost yourself? Of course, not everyone can afford that." (male, 24 y)

Participants mentioned that information should not only consider the technology, but also about the processes and involved parties behind and around it (**information transparency)**. Participants also agreed that whether or not the system worked well was relevant to trusting it.

"I would also say competence, so it doesn't set off a false alarm twenty times. That it works reliably and doesn't notify someone when really only a pen fell down. I mean once or twice is no problem, but if it's all the time, I'm thinking 'Why do I have the thing in the first place?'" (female, 22 y)

Regarding the **technical competence** of the system, it was agreed that this was one of the most important predictors of trust in the VAAL system.

Taken together, this factor consisted of **information transparency** about and around the technology, **professionalism** toward the potential users, and **technical competence.** For this factor, seven items were constructed in the questionnaire.

2.3.3 Associated Trust Criteria

This category pertained to individual perceptions of benefits of VAAL systems bringing a surplus value to their life, coded as **health aspects**. They also brought up examples of having less strain on medical personnel as well as more independence with the VAAL system, i.e. **relief in care**.

"It [the VAAL system] would have to be a good added value somehow. When I see that I am limited, I would like to be able to try it out and be told that if I

really fall down or hit the corner and hit my head and can't press a button any more, that someone will come. So if I could recognise an added value, that it would make me more independent of other people, I would trust it more." (female, 52 y)

"So, of course, for the people who rely on the system, it must be ensured that the system works well, because normally you save a caregiver who is with you 24/7 and who watches over you, or relatives who make sure that nothing happens to you, that you are well and that you don't lie in your flat for two days and can't move." (male, 25 y)

Some aspects were highly individual, respecting the need of empathy (i.e., **emotional aspects**) of the system as a relevant trust considerations. Seven items were constructed in the questionnaire (**emotional aspects**, **relief in care**, and **health aspects)**.

3 QUANTITATIVE APPROACH

On the basis of the focus group study, trust factors were identified and classified in three categories. Considering other variables in literature, i.e., acceptance measures, the following research questions emerged:

RQ1: How are the identified trust factors evaluated?
RQ2: Which role do the associated trust criteria play?
RQ3: Are trust and associated trust criteria related to the evaluations of VAAL technology?
RQ4: Which role do the trust categories play for the evaluation of VAAL technology?

3.1 Methods

Data was collected by an online survey in summer 2022. Participants were recruited mostly via social networks and the participation was voluntary.

3.1.1 Design of the Survey & Care Scenario

We first introduced participants to the main purpose of the study, i.e. trust in, and acceptance of, VAAL technology. We assured participants of a high standard of data protection and informed that none of their answers can be referred to them personally.

The online survey was divided into four parts. First, participants indicated their demographic data (i.e., age, gender, education, and professional background). We also surveyed the respondents' perceived health condition (1="very bad" to 6="very good"), the health status as well as need for nursing care. We also surveyed the usage of health-related digital technologies as well as the purpose of the use.

In the third part, using a scenario-based method, participants were introduced into the following situation: *"(…) You are 85 years old and live alone in your house (...). Because you have several chronic diseases, including hypertension and inflamed joints, you take daily regulating medication. Recently, you have been experiencing additional coordination difficulties and you are increasingly unsteady on your feet, especially at night. However, moving into a retirement home is unthinkable for you, as you would like to remain in your familiar surroundings. You decide to install a VAAL system in your home. Decisive for you is the technology for the fall prevention, intervention, and the control of the daily routine as well as the analysis of your mobility behaviour. You are free to decide who you share the data with (e.g., doctor, nursing service, relatives). If changes in your health condition and activity status are detected, these persons receive a notification."* Thereafter, participants assessed the acceptance of the use of assistive technologies for health reasons. They responded to statements referring to benefits (e.g., sense of security, emergency notification) and barriers for the use (e.g., invasion of privacy, concern about surveillance). Respondents also evaluated technology acceptance criteria according to TAM (Davis, 1989), i.e., perceived ease of use, usefulness, and the intention to use such technologies (7 items; α =.86) which were adapted to VAAL technology.

Finally, participants shared their opinions on trust in VAAL technology. The trust items were related to Data Protection (5 items; α =.89), Information & Communication Flow (7 items; α =.69), and Associated Trust Criteria (7 items; α =.75). All items were evaluated on six-point Likert scales.

3.1.2 Sample

After data cleaning, N=101 participants were considered for the statistical analyses. The age of the participants ranged from 18 to 83 (M=35.7 years, SD=10); 64% of respondents were females. Most of the respondents (50%) held a university degree, 22% indicated general university entrance qualification (22%). Of all participants, 12.9% had a vocational baccalaureate diploma and 10.9% held a secondary school degree as their highest educational qualification, whereas 3% reported to hold a PhD. The majority of the sample reported (very) good health (58%) and 10% as mostly bad. Additionally, 42% respondents reported to suffer from a chronic illness or physical impairment and 23% indicated to

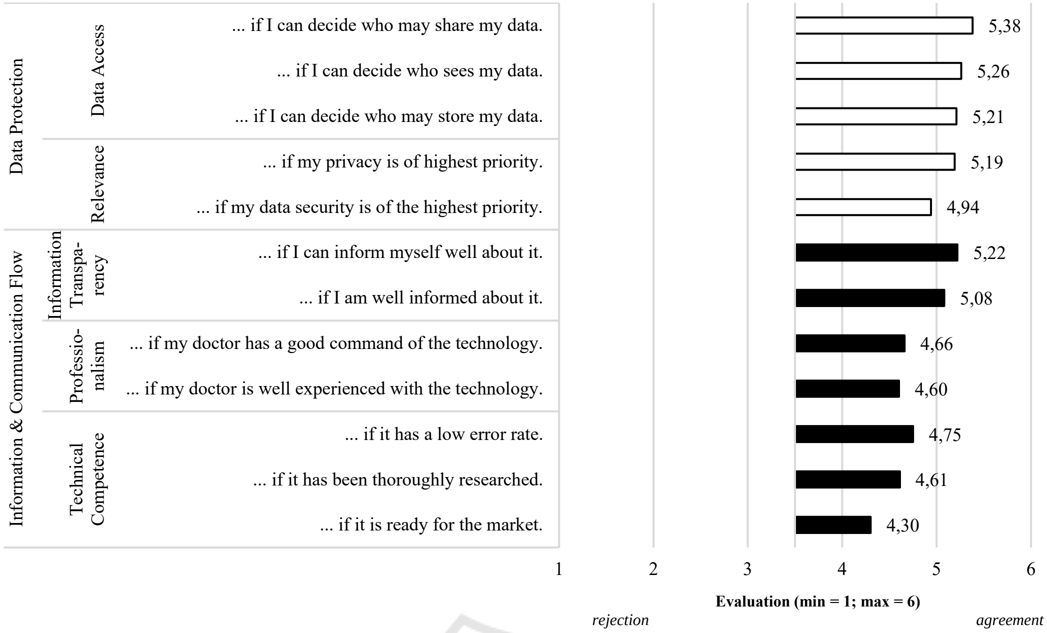

Figure 1: Evaluation of trust in VAAL technology (N = 101).

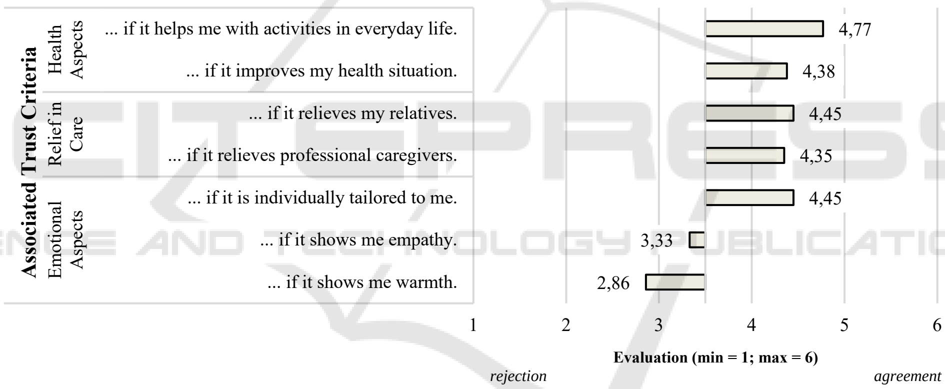

Figure 2: Evaluation of associated trust criteria (N = 101).

be affected by an acute physical or mental illness. 4% needed care assistance (professional nursing or family support). 53% of the respondents are actively using health-assisting technologies (e.g., documentation of vital parameters, monitoring of physical activities, control of sleeping patterns, or weight control.)

3.2 Results

The quantitative results are described based on the research questions. We used descriptive statistics for the analysis of acceptance and trust statements (M=means, SD=standard deviations). To examine relations between the constructs we calculated correlation analyses and examined the internal consistency of the scales using Cronbach's Alpha (α >.7). The significance level (p) was set at 5%.

3.2.1 Trust in Technology (RQ1)

Starting with **Data Protection,** all five items received confirming evaluations. For the participants, it was of major importance that they can decide "…who may share…" (M=5.38; SD=.81), "…who sees…" (M=5.26; SD=.91), and "…who may store…" (M=5.21; SD=.92) their data. Further, they showed strong agreements referring to the statements that their "…privacy…" (M=5.08; SD=.95) and their "…data security…" (M=4.94; SD=.97) are of highest priority. Moving to the category **Information & Communication Flow**, the results showed a more differentiated evaluation pattern. Here, the statements referring to *Information Transparency* (i.e., "…if I can inform myself…" (M=5.22; SD=.84) and "…if I am well informed…" (M=5.08; SD=.91) received the highest agreement and thus represent relevant factors for trust in VAAL technology. Further, the statements referring to *Professionalism* received agreement, but at a lower level: "…my doctor has a good command of…" (M=4.66; SD=1.03) and "…my doctor is well experienced with…" (M=4.60; SD=1.10) the technology. Finally, also the items referring to *Technical Competence* received agreeing evaluations: here, participants confirmed statements referring to "…a low error rate…" (M=4.75; SD=.89) and "…it has been thoroughly researched" (M=4.61; SD=1.10)), while the item "…if it is ready for the market" (M=4.30; SD=1.15) received the lowest, but still positive evaluations (Figure 1).

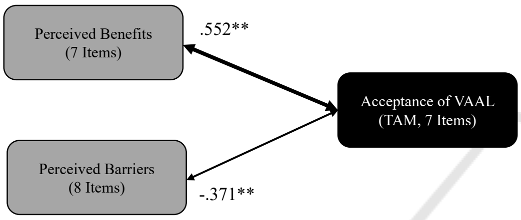

Figure 3: Correlations between technology perception and acceptance (N = 101).

3.2.2 Associated Trust Criteria (RQ2)

The participants also assessed criteria relevant for trust related to the interaction with VAAL technology (7 items, Figure 2). Participants evaluated *Health Aspects* to be relevant trust criteria when interacting with VAAL technology. Here, help and support "…with activities in everyday life" (M=4.77; SD=1.03) as well as an improvement of the "…health situation" (M=4.38; SD=1.22) received confirming evaluations. Likewise, statements referring to *Relief in Care* (i.e., relief of "relatives" (M=4.45; SD=1.13) and "professional caregivers" (M=4.34; SD=1.18) obtained approval. Regarding *Emotional Aspects* the most divergent evaluation patterns were found: the participants confirmed that if technology "…is individually tailored" (M=4.45; SD=1.22) represented a relevant trust criterion for them. In contrast, the participants tended to reject showing "empathy" (M=3.33; SD=1.56) and showing "warmth" (M=2.86; SD=1.46) to be relevant factors for trust in interacting with VAAL technology.

3.2.3 Relationships Between Technology Perception & Acceptance (RQ3)

Regarding the relations between technology perception and the acceptance of VAAL technology (Figure 3), correlation analyses identified a strong relationship between the **Perceived Benefits** and **Acceptance** of VAAL technology (ρ=.552; p<.001) and a moderate negative correlation between **Perceived Barriers** and **Acceptance** (ρ=-.371; p<.001). A correlation analysis was also run to uncover relations between **Information & Communication Flow, Data Protection, and Associated Trust Criteria** (Figure 4). The results showed a direct moderate relationship between **Associated Trust Criteria** and the **Acceptance** of VAAL technology (ρ=.379; p<.001). Further, **acceptance** correlated with the **Perceived Benefits** of VAAL technology as well (ρ=.263; p<.001). However, **Trust Criteria** were not related with the other trust constructs (n.s.). **Information & Communication Flow** was related with the **Perceived Benefits** (ρ=.331; p<.001) and the **Perceived Barriers** (ρ=.295; p<.001). Also, **Information & Communication Flow** and the **Acceptance** of VAAL technology (ρ=.238; p<.001) were related. Focusing on **Data Protection**, a relationship with the **Perceived Barriers** (ρ=.461; p<.001) was found. **Data Protection** was neither related with the other trust constructs nor with the **Perceived Benefits** and **Acceptance** of VAAL (n.s.).

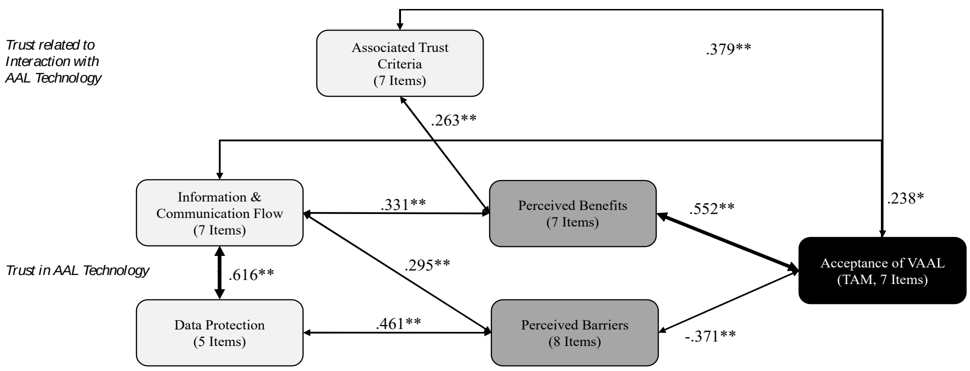

Figure 4: Correlations between trust and technology acceptance (N = 101).

3.2.4 Role of Trust for Technology Perception & Acceptance (RQ4)

To answer the underlying research question, linear regression analyses were run to reveal the role the technology perception for its acceptance (Figure 5). 39.6% variance of the **Acceptance** of VAAL technology (adj. r^2=.396; F(2,100)=33.77; p<.001) can be explained by the **Perceived Benefits** (β=.490; p<.001) and **Perceived Barriers** (β=-.350; p<.001).

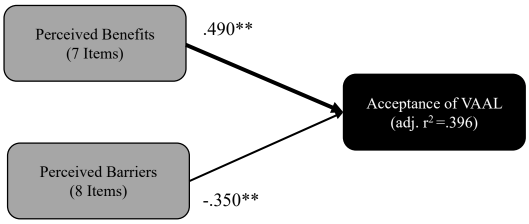

Figure 5: Regression analysis: Role of technology perception for acceptance (N = 101).

Next, the three identified trust constructs were considered in regression analyses as well. Based on the results of the correlation analysis, linear regression analyses were conducted. Starting with the **Acceptance** of VAAL technology, the regression model predicted 47.9% (adj. r^2=.479; F(2,100)=23.96; p<.001) variance of Acceptance based on **Perceived Benefits** (β=.364; p<.001), **Perceived Barriers** (β=-.382; p<.001) and the trust construct **Associated Trust Criteria** (β=.269; p<.001). **Information & Communication Flow** (β=.146; p=.082; n.s.) was not a predictor for the **Acceptance** of VAAL technology. Based on the results of the correlation analysis, the role of the trust constructs for the perception of VAAL technology was analysed (Figure 6: significant results).

For the **Perceived Benefits**, the regression model predicts 13.1% variance (adj. r^2=.131; F(2,100)=8.56; p<.001) based on the two trust constructs **Information & Communication Flow** (β=.260; p<.01) and **Associated Trust Criteria** (β=.244; p<.05). For the **Perceived Barriers**, the regression model explained 18.5% variance (adj. r^2=.185; F(2,100)=12.32; p<.001) based on the trust construct **Data Protection** (β=.391; p<.01). In contrast, **Information & Communication Flow** (β=.073; p=.54; n.s.) was not proven to be a significant predictor of the perceived barriers of VAAL technology.

4 DISCUSSION

In this study, a mixed-methods approach was used to explore the perceptions of VAAL technology on trust and acceptance.

From the interview study, two main themes emerged, **data protection** and **information and communication flow**. The category "Data protection" included relevance and data access. Information and communication flow consisted of information transparency, professionalism, and technical competence. These categories suggest an interplay of aspects pertaining to the technology itself and providers that are involved in its usage. In addition, a separate category covered aspects of **associated trust criteria**, consisting of health aspects, relief in care, and emotional aspects. These results suggest that there are multiple facets relevant for trust in VAAL technology. In the subsequent survey, four research questions in the context of trust components in VAAL technology and its relation to acceptance and, specifically, to the benefit and

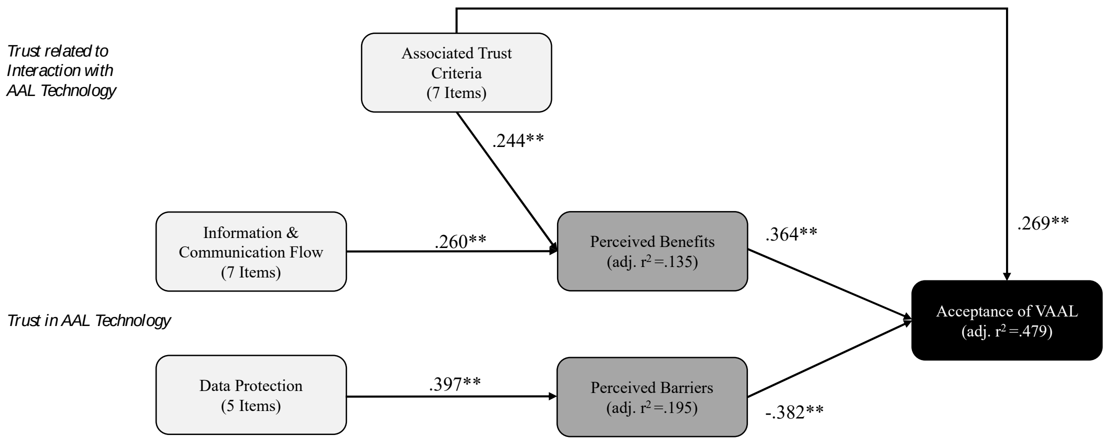

Figure 6: Regression analysis: Role of trust for technology perception and acceptance (N = 101).

barriers perceptions. The role that the trust dimensions played in the perception and acceptance of VAAL was identified with regression analyses.

The findings revealed multiple significant relationships that are discussed in the next section. **Data protection** in line with **data access and security** was highlighted as extremely trust-relevant by participants. Regarding **information and communication flow**, *information transparency* was the most important predictor of trust, followed by *professionalism* and *technical competence*. This means that there are clear rankings of which factors are important for trusting VAAL. When it comes to the question of which **trust criteria** are applied, there were more diverse answers. While *relief in care* and *health aspects* are undisputedly trust relevant, *emotional aspects* received contradicting evaluations. Apparently, associated trust criteria vary more among participants and seem to be more individual.

In line with previous research on the acceptance of AAL technologies (Peek et al., 2014; Offermann et al., 2022), the evaluations of the technology are significantly associated with the overall VAAL acceptance. The higher benefits were perceived, the higher was the resulting VAAL acceptance, and also, higher assessments of perceived barriers lowered this overall acceptance. Associated trust criteria directly correlated with perceived benefits and overall acceptance of VAAL technology. Moreover, data protection significantly correlated with perceived barriers, while information and communication flow was significantly associated with perceived benefits. Both of these relationships are also associated with overall acceptance which signals an indirect effect of trust in VAAL technology through perceptions of VAAL technology.

With respect to the identified trust constructs, one trust construct directly and two indirectly correlated with the acceptance of VAAL technology. In line with previous research (e.g., Jaschinski, 2018; Wilkowska & Ziefle, 2019), these results confirm trust to be a decisive factor for the acceptance of medical assisting technologies. Beyond that, the study identified different facets of trust suggesting a network of influences relating to different constructs. There are not many studies combining the knowledge from qualitative and quantitative approaches as outlined by a review from Peek et al. (2014). Summarizing the approach and the methodology, we can say that the mixed-methods design provides a solid foundation for scientific practice, but also allows for flexibility and opportunity to extract in-depth knowledge.

When it comes to the limitations of the study, a first issue regards the use of “only” scenario-based evaluations of trust and the acceptance of VAAL. We cannot exclude that scenario-evaluations differ from the agreements or rejections and usage behaviours in real-life contexts, representing the well-known gap between (reported) attitudes and the (real) behaviour (Ajzen & Fishbein, 1980). Future studies might incorporate some sort of scenario comparison that would allow for an experimental manipulation of the targeted VAAL systems. It is further relevant to outline how trust perceptions alter the evaluations of acceptance as it represents one of the key predictors of the perception and acceptance including the intention to use VAAL technology.

Reflecting the sample of the quantitative study, the size was relatively small, and not very representative for the majority of people which are in need of care. Thus, we cannot exclude a sample selection bias, which reduces the generalizability of our findings to the whole population of care.

5 CONCLUSIONS

This study used two methodological approaches in order to investigate trust in VAAL technology and its relationship with the acceptance of such technologies. Several dimensions of trust revealed to be relevant in understanding how people evaluate potential benefits and barriers, but also, whether the users are more or less likely to accept such technologies. When designing these technologies, it becomes evident that not only the technological features are important to think about but also the context. Specifically the interactions of the people involved, such as technicians, physicians, and healthcare providers, are important to prepare and honour. It is important to remember that people still place their trust to a large extent in humans and by extension, on their recommendations of said technologies. Understanding these mechanisms can help in educating developers, computer scientists, healthcare professionals and even policy makers about the priorities of the potential users.

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