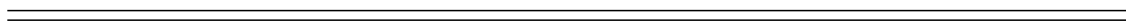July 2022

My Roommate Alexa

The Impact of Digital Voice Agents on Trust and Roles Within a Household

Ghislaine Lex van den Boogerd

Supervisor:
Dr. Ruud Hortensius

This thesis project was carried out in association with Utrecht University.

Abstract

Digital voice agents (DVAs) aid in the task to provide information for the user and while they are part of a social system, earlier research has not analysed or ignored how the DVA impacts social systems. This study researches in what way long-term usage of a DVA affects trust and roles of the user and associated household. The assumption is that DVAs impact trust and roles within a household from the user toward the DVA, but also from the user toward other household members. Using a multi-methods approach, two experiments are performed to measure to what extent the DVA has an impact on the social system. Specifically, it is tested to what extent the social systems are impacted by the DVA on the level of trust and roles (experiment 1) and on the level of relationships within the household (experiment 2). During the first experiment, the roles and level of trust are examined with dilemma tasks where participants (n = 75) are asked to order their household members and DVA from who they would approach first to last. These dilemmas were categorized between different domains (knowledge, social, domestic, entertaining). Afterwards, participants were asked to rate their trust in the answers from the others. Results from a mixed effect repeated measures ANOVA showed that the level of trust and the roles are influenced by an interaction of agent and domain. The level of trust is also dependent on the order in which the agent is placed, with the agent being chosen first if the level of trust is high. In the second experiment, the impact of the DVA on households, relationships, trust, and roles was analysed more in-depth. Participants (n = 14) were interviewed about their DVA and their household. The results found no change in trust from the impact of the DVA. An effect on roles and relationships within the household was found, especially within the group that owned the DVA for longer, which indicated that changes in roles and relationships can come over time. Together, these results suggest that the DVA does not impact inter-relational trust, but does affect the roles of the user and associated household. The findings point to an effect that develops over time.

Keywords: trust, roles, relationships, smart home systems, digital voice agents, information.

Contents

Chapter 1

Introduction

Information is an important aspect of human life, but trustworthy sources can be difficult to select. The rise of the internet helped with the urge for more information, but also made it more difficult to select and find the things you need in the mountain of knowledge [24, 23]. When information is sourced, the internet also poses a second obstacle; because of it vastness and anonymity, finding trustworthy sources can become a difficult task [53, 17, 31, 30]. In the past few years, the rise of digital voice assistants (DVAs) has aided in the task to fulfil the information need while also forming more intimate and personal relations with the user [39]. While DVAs are a part of a social system, earlier research has not analysed or ignored how the DVA impacted the social system itself. Instead, it has focused more on the interaction with the DVA. In this research, the level of trust in DVAs and its role within a system (household in specific) will be analysed.

Information in the Digital Age

In this digital age, trustworthiness of information is listed as one of the components of credibility [36, 54]. But what makes information trustworthy? Research shows that people trust sources they have prior experiences with more easily. Receiving information from a trusted source influences the trustworthiness of the information [52]. Other research shows that people tend to believe experts over systematic reasoning about arguments in almost all cases [37]. So if the information comes from an expert source, people tend to see it as trustworthy information. Deutsch (1973) defined trust as "confidence that one will find what is desired from another, rather than what is feared" [13]. When applying this to information, trust is defined as the belief that the information given is reliable.

Secondly, trust in information can be affected not only by what, but also by how someone says something. For example, children are easily influenced by the level of confidence in someone's vocabulary [22, 42, 43]. The higher someone's confidence, the more easily the information is believed to be right. Buckland researched information and concluded there are three types; information-as-process, information-as-knowledge, and information-as-thing [7][1].

Trust

Besides trust in information, trust can also be experienced on a more dyadic level. Studies show a strong correlation between the level of trust in a person and the quality of the relationship and commitment to the relationship [10]. For members of a household (e.g. families, roommates, or partner-relationships), the level of trust is higher if there is a strong connection between them. Additionally, studies show an appearance of trust where there is a healthy and strong relationship [26].

However, a high level of trust in one's family member does not necessarily translate to a high level of trust in strangers, which is mainly influenced by personality and emotion [10]. Trust can be impacted by the individual differences in attachment, self-esteem, or self-differentiation [47]. When people are highly attached, have high self-esteem, or experience more self-differentiation, they have a

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[1]In this paper, when we speak of information, we consider both information-as-knowledge and information-as-thing. Meaning, we consider information as something where knowledge is communicated concerning a particular fact and information as objects such as data and documents.

higher level of trust in their partner. They are also more likely to develop more trust over time. Trust also plays a big part in roles within a system such as a household. Social roles require interaction with other members of the group, which leads to more positive relations with others [28]. Moreover, positive role fulfilment can create higher self-esteem and authenticity in oneself [28, 48, 44, 11]. Research shows that the latter can promote a higher degree of trust within the group or on a dyadic level [46, 47].

Social Systems

Positive roll fulfilment can lead to a higher degree of trust. But what roles can be expected to be found within a group? Benne and Sheats (1984) curated a list of group roles [4]. This list contained an overview of task roles, personal roles, and individualistic roles. Within a social system, like a household, not all roles are always fulfilled. There is often times a set of defined roles for each member. Within a household these roles can be social, entertaining, advisory, emotional, or domestic in nature. Most of these roles are unconsciously assigned based on personality, the patriarchy, biases, and hierarchical expectations of members [5] and can be associated with certain expectations or duties [6, 14, 49]. Fulfilling these roles within a social group leads to a greater sense of community and connection to the group [28, 48].

Digital voice agents

Roles within a system do not necessarily need to be fulfilled by humans. Technology can in some cases fulfil all duties expected from a role. Accessibility to DVAs within a household can ensure that some roles are taken over. For example, a DVA can take over the domestic role of planning by taking over all related tasks and duties. By setting reminders, updating the calendar of its users, and setting alarms automatically based on appointments, the DVA positively fulfils this role. Previous research has already shown that voice interfaces have their own role in a home setting. An experiment that collected Amazon Echo data from households showed that users held themselves accountable for commands issued to the assistant and the subsequent actions committed by the assistant [38]. Furthermore, the experiment showed that family members integrated the use of the assistant in conversations. Talking to the assistant became an embedded part of life at home, instead of an isolated event. This implies that users have at least a rudimentary relationship with their smart home assistant. This same research showed that DVAs are mostly used in domains like factual domestic (such as planning and scheduling), entertaining, or knowledge within a household [38].

One of the characteristics that makes the DVA distinct from other answering technologies is that it is spoken, as opposed to written or printed, interaction. How this affects the level of trust is still an under researched subject, but it is a characteristic that humans tend to easily connect to. A study where older adults used a DVA showed that the simplicity of speech-based interaction was a reason for why the participants rated their first experiences with the DVA positively [25]. However, the quality of conversations of the DVA is sometimes still lacking. Forming structured sentences for a command for the DVA was perceived to be difficult. Furthermore, concerns about privacy, security, and misperceptions about how a voice assistant operates resulted in a more unfavourable experience [25]. Although most DVAs try to incorporate better conversational aspects, most still have only very factual responses [27]. Research shows that particularly older children (over 5), initially trust DVAs more than humans because they are believed to have the most information [34]. However, when a DVA fails to answer their questions consistently, this trust drops and children tend to not use the device in the future.

Research Gap

Although research discusses trust in DVAs based on its conversational aspects, no real research has been done in trusting the DVA for just its information. Research by Abrams et al. (2003) [2] did show that humans trust other humans over digital options when it comes to question answering, but this research only focused on digital written answers and did not account for DVAs. Because the rise and accessibility of DVAs is a more recent trend, there are still few studies that show in-depth research on

the specific characteristics and their effects. Newer studies about DVAs analyse how they are used, on both short and long-term, but lack analysis on their effects in groups or system households [39, 25, 38].

Current Research

The focus of this research is to answer in what way long term usage of a DVA affects the trust and roles of the user and associated household. With this, the study tries to 1) get a better understanding on how DVAs affect the level of trust between the DVA and user, 2) analyse how long term usage of DVAs impacts people and their relationships to others in their household, 3) see whether long term usage of the DVA affects the level of trust in members of the household and changes their roles. To answer these research questions, two experiments are conducted. First, a quantitative study with a questionnaire will be performed. During the first experiment, people who already own a DVA are asked to fill out a questionnaire analysing the roles in the household and measure the level of trust. The second experiment is a qualitative user experience interview, giving insight in specifically how the DVA impacts the roles and trust within the household. The interview is conducted with two participant groups. The groups are separated based on how long the participants have owned their DVA, with one group owning them for less than 6 months and the other group for more than 6 months. Conducting the interview within these groups, it is possible to analyse the effect of time on changes in roles and trust.

Chapter 2

Experiment 1

2.1 Methods

2.1.1 Ethics Statement

The studies involving human participants were reviewed and approved by Utrecht University Ethics Committee (number 22-1254). Participants under the age of 18 were not allowed to participate. Furthermore, written informed consent was obtained from each participant before starting the questionnaire. They were allowed to exit the questionnaire at any time.

2.1.2 Participants

The initial goal of at least 100 participants during a month-long period was extended and lowered due to difficulties finding participants who qualified for the research. Participants were recruited via online channels (e.g. Reddit[1], Amazon fora[2]) and social media. Furthermore, posters were distributed along the campus of Utrecht University and the University of Amsterdam (Appendix A). Over a two-month period, 215 individuals accessed the online study. Removal of incomplete entries (n = 119), left a total of 96 participants. Entries in the data from participants with no other household members were removed (n = 16), together with participants who showed no variability in their ratings (SD of <0.05, n = 1), and entries from participants without a DVA (n = 3). This left a dataset of 75 participants (45 male, 25 female, 2 non-binary, 3 preferred not to say) aged between 22 and 65 years old (M = 29.7, SD = 10.76). The sample included 8 different nationalities, with Dutch being the most predominant (n = 56, 74.7%). Participants took between 309 and 129877 seconds to finish the questionnaire (M = 4437.3, SD = 17556.25).

The goal of the study was advertised as research about trust in DVAs. Before starting the experiment, participants were notified about the general motivation and goal of the experiment; analysing trust in DVAs, but were not notified that the research would also look to analyse trust towards their household members and the roles within the household. Participants were required to already own a DVA, such as an Alexa, Google Nest, or Apple HomePod. Other brands of DVAs were allowed, but the DVA must be mass-produced and generally available (e.g. no home-built DVAs). There were no requirements for how long the DVA must already be owned or for the location where the participant was from. Furthermore, the participant had to have at least one other person living in their house with access to the DVA. Participants received no compensation for participating in the research. The majority of the participants owned a Google Nest (n = 49, 65.3%) and used it on a daily basis (n = 45, 60%). Most often, participants owned their DVA for between one and three years (n = 28, 37.3%). The distributions can be found in Figures 2.1, 2.2a, and 2.2b.

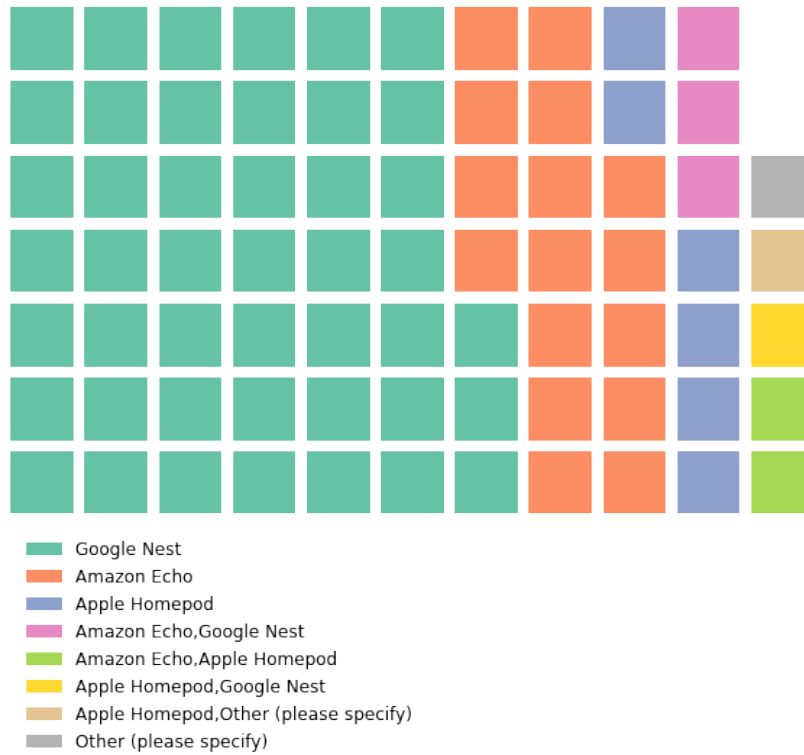[1] https://reddit.com
[2] https://www.amazonforum.com

Figure 2.1: Distribution of type of DVA, 1 square representing 1 participant

(a) DVA use
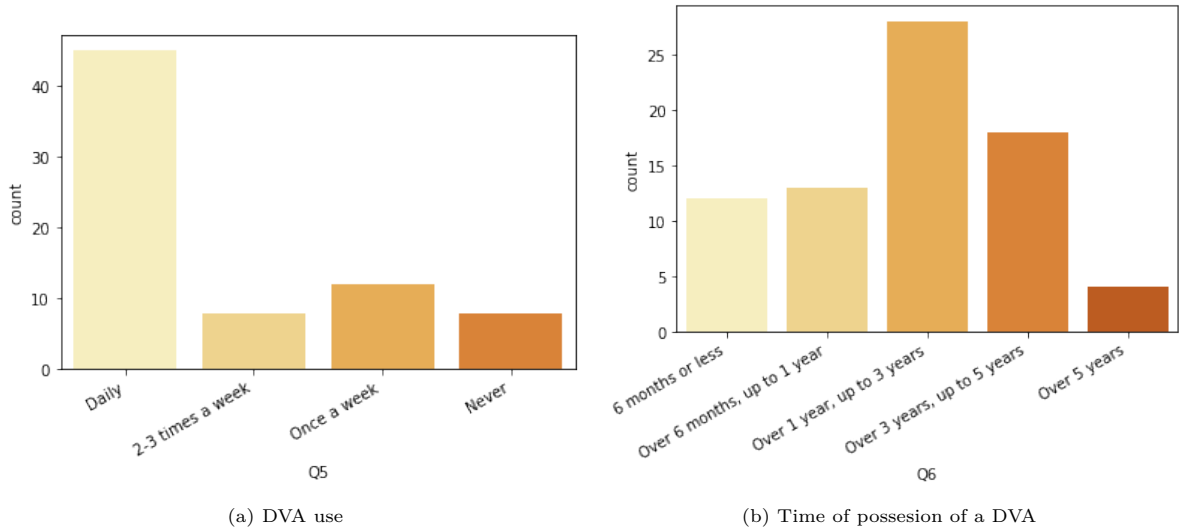

(b) Time of possesion of a DVA

Figure 2.2: Overview of the use and possession of the DVA

2.1.3 Experimental Design

A within-subject design was used for the experiment. During the experiment, the dependent variable was the level of trust. Furthermore, another dependent variable was when the DVA is chosen as the most reliable in information dilemmas. The independent variables were the type of agent and roles (domains).

2.1.4 Materials

Information Dilemma Task

The information dilemma task is a short questionnaire developed for the current study. The goal was to rank their household members, themselves, the internet, and the DVA for different questions in order of who they would approach first. The questionnaire took at most 5 minutes to answer.

The questionnaire presented multiple information based dilemmas focused on the different roles both humans and machines can have in a household. The types of dilemma questions were based on the roles humans and DVAs can have in a household. Questions ranged from 'knowledge' to 'social', 'entertaining', or 'domestic' questions. These domains are chosen from a combination of the list of group roles curated by Benne and Sheats (1948) and Siemon et. al. (2020), selecting the group roles that could be performed by both humans and machines [4, 45]. Furthermore, the selected domains were focused on group roles that could be found in typical households. For every question, the participants rank each of the members of their household, including the DVA, in order of whom they most likely go to for a question. For example, if they want to know how tall the Eiffel Tower is, they are asked to order their household members in order of who they would approach first. Directly after each dilemma, participants were asked to indicate the level of trust for each of their household members. The order in which the household members were shown is randomized compared to the corresponding answer of the dilemma before.

2.1.5 Procedure

Participants were first asked to fill out a couple of basic questions (e.g. age, nationality, how long they have had a DVA). They provided information on the composition of their household, how many household members they had and what their relationship to them was. They then answered both the self-reported trust questionnaire and three dilemma tasks per category (i.e. knowledge, social, domestic, entertaining). This was done online via an online surveying method (Qualtrics). Half of the participants first answered the self-reported trust questionnaire and later the dilemma tasks. The other half of the participants were asked to first answer the dilemma tasks and then proceed to the self-reported trust questionnaire.

2.1.6 Data analysis

The data was cleaned and analysed with Python[3]. The data was transformed for the ordering questions to represent the relation to the household member (i.e. Child, Friend, Parent, Partner, Pet, Sibling, Other) as opposed to their participant number. Their ordering score was then adapted to represent the relative ordering to the number of household members (see Equation 2.1).

$$normalized\ position = \frac{position}{number\ of\ household\ members} \tag{2.1}$$

The number of agents was reduced to four (Myself, DVA, Internet, and Other Family relations) to ensure each participant had the same number of agents. The agent group *other family relations* consisted of the aggregated answers for all the other relations indicated by the participant. The indicated level of trust was then summarized per domain. This was done by averaging the trust-score per agent-category within the domain. The level of trust was ranked on a 7-point Likert scale, with 7 indicating the highest level of trust. This same procedure was performed on the normalized position.

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[3]https://www.python.org

Where the results ranged from 0 to 1, with a lower score indicating that the agent was selected more as first-choice. The final output showed a mean score per agent and per domain.

A 4 x 4 x 5 mixed effect repeated measures ANOVA with dependent variable being the indicated level of trust, type of agent as within-subjects condition (DVA vs Internet vs Partner vs Family relation), domain as within-subject condition (Knowledge vs Social vs Domestic vs Entertaining), and time owned as between-subjects condition was conducted (6 months or less, over 6 months up to 1 year, over 1 year up to 3 years, over 3 years up to 5 years, over 5 years). To analyse the effect of the DVA on relationships and roles, another repeated measures ANOVA was conducted. A 4 x 4 x 5 mixed effect repeated measure ANOVA with the dependent variable being the normalized position, type of agent as within-subjects condition (DVA vs Internet vs Partner vs Family relation), domain as within-subject condition (Knowledge vs Social vs Domestic vs Entertaining), and time owned as between-subjects condition was conducted (6 months or less, over 6 months up to 1 year, over 1 year up to 3 years, over 3 years up to 5 years, over 5 years). Lastly, a Pearson correlation was performed to analyse if there is a correlation between the indicated level of trust and the normalized position of the DVA. This to see whether long term usage of a DVA affects the level of trust in household members and if it changes the roles (see Section 2.2.3).

For all statistical ANOVA tests, the assumptions are checked with Mauchly's test of sphericity. Cut-offs of 0.0099, 0.0588, and 0.1379 are used to determine the gratitude of the effect size η^2, implying a small, medium, or large effect size respectively [40]. For Pearson correlations, the assumptions are checked with the Shapiro-Wilk test for multivariate normality [56]. Cut-off of 0.20, 0.40, 0.70, and 0.90 are used to determine the gratitude of the correlation size. Implying a slight, low, moderate, high, or very high correlation [8].

Mauchly's test of sphericity indicates that the assumption of sphericity had been violated for the ANOVA on indicated level of trust. This for both agent ($X^2 = 47.996$, p = <0.001), domain ($X^2 = 14.235$, p = 0.014), and their interaction ($X^2 = 177.266$, p = <0.001). A Huyn-Feldt sphericity correction [1] is applied, after which the Mauchly's test of sphericity indicates that the assumption of sphericity had not been violated. Mauchly's test of sphericity indicates that the assumption of sphericity had been violated for the ANOVA on normalized position. This for both agent ($X^2 = 18.021$, p = 0.003), domain ($X^2 = 28.285$, p = <0.001), and their interaction ($X^2 = 103.358$, p = <0.001). A Huyn-Feldt sphericity correction [1] is applied, after which the Mauchly's test of sphericity indicates that the assumption of sphericity had not been violated. Shapiro-Wilk test for multivariate normality showed that the distribution of trust and normalized position departed significantly from normality (W = 0.876, p = <0.001).

2.2 Results & Discussion

2.2.1 Trust

A significant main effect of agent (F = 24.963, p = <0.001, $\eta^2 = 0.096$) and domain (F = 19.713, p = <0.001, $\eta^2 = 0.026$) was found. The interaction effect between agent and domain was significant, with a large effect size (F = 92.063, p = <0.001, $\eta^2 = 0.317$). Indicating that the level of trust in an agent is dependent on both the type of agent and the domain. There was no significant interaction of time owned and agent (F = 0.822, p = 0.594, $\eta^2 = 0.013$), nor on the interaction between time owned and domain (F = 0.856, p = 0.583, $\eta^2 = 0.005$). There was also no significant interaction found between agent, domain, and time owned (F = 0.636, p = 0.909, $\eta^2 = 0.009$). A post-Hoc Holm test between the interaction agent * domain suggested that there were highly significant differences between most pairings (p = 0.001). The results of the post-hoc test can be found in Table 2.1.

The first analysis found a significant interaction between domain and agent on the level of trust. This suggests that the level of trust is affected by both the type of agent and the domain. The results for the knowledge domain show that answers from the internet or the DVA are trusted significantly more compared to answers from family members or participants themselves. This in contrast to the social domain, where the results show that the DVA and internet were trusted significantly less compared to family members and themselves. For the remaining domains, it is notable that answers from the DVA in the domestic domain are trusted significantly less compared to all the other agents. Furthermore, the internet was trusted significantly more than the DVA for entertainment questions.

		Mean Difference	SE	t	p$_{holm}$
dva, d	fam, d	-1.057	0.212	-4.996	$< .001$
	internet, d	-0.604	0.212	-2.851	0.149
	self, d	-2.500	0.212	-11.810	$< .001$
fam, d	internet, d	0.454	0.212	2.145	0.756
	self, d	-1.443	0.212	-6.815	$< .001$
internet, d	self, d	-1.896	0.212	-8.959	$< .001$
dva, e	fam, e	0.795	0.212	3.753	0.008
	internet, e	-1.409	0.212	-6.657	$< .001$
	self, e	-0.460	0.212	-2.171	0.756
fam, e	internet, e	-2.204	0.212	-10.410	$< .001$
	self, e	-1.254	0.212	-5.925	$< .001$
internet, e	self, e	0.949	0.212	4.486	$< .001$
dva, k	fam, k	2.404	0.212	11.357	$< .001$
	internet, k	-0.657	0.212	-3.102	0.075
	self, k	1.659	0.212	7.838	$< .001$
fam, k	internet, k	-3.060	0.212	-14.458	$< .001$
	self, k	-0.745	0.212	-3.519	0.018
internet, k	self, k	2.316	0.212	10.940	$< .001$
dva, s	fam, s	-1.746	0.212	-8.249	$< .001$
	internet, s	-0.798	0.212	-3.770	0.008
	self, s	-2.346	0.212	-11.083	$< .001$
fam, s	internet, s	0.948	0.212	4.480	$< .001$
	self, s	-0.600	0.212	-2.833	0.153
internet, s	self, s	-1.548	0.212	-7.313	$< .001$

Table 2.1: Post Hoc comparison Agent * Domain on trust

2.2.2   Relationship Effects

A significant main effect of agent (F = 28.783, p = <0.001, η^2 = 0.109) and domain (F = 29.101, p = <0.001, η^2 = 0.012) was found. The interaction between agent and domain also proves significant, with a large effect size (F = 51.647, p = <0.001, η^2 = 0.265). Indicating that the normalized position of an agent is dependent on both the type of agent and the domain. The normalized position indicated per agent and domain is shown in Figure 2.3. There was no significant effect found on the interaction of time owned and agent (F = 1.728, p = 0.056, η^2 = 0.037), nor on the interaction of time owned and domain (F = 12.065, p = 0.826, η^2 = 0.002). There was also no significant interaction found between agent, domain, and time owned (F = 0.926, p = 0.598, η^2 = 0.029). A post-Hoc Holm test between the interaction agent * domain suggested that there were highly significant differences between most pairings (p = 0.001). The results of the post-hoc test can be found in Table 2.2.

A significant interaction was found between the agent and domain for the normalized position. Suggesting that the position where a participant placed an agent was affected by the domain. Similar to the first analysis, it was found that the internet or the DVA was approached the fastest for knowledge questions and the least fast for social questions. For questions about entertainment, participants approached internet the first and, interestingly enough, the DVA last. Lastly, participants approached themselves or the internet the fastest for domestic questions, with the DVA again being approached the least fast.
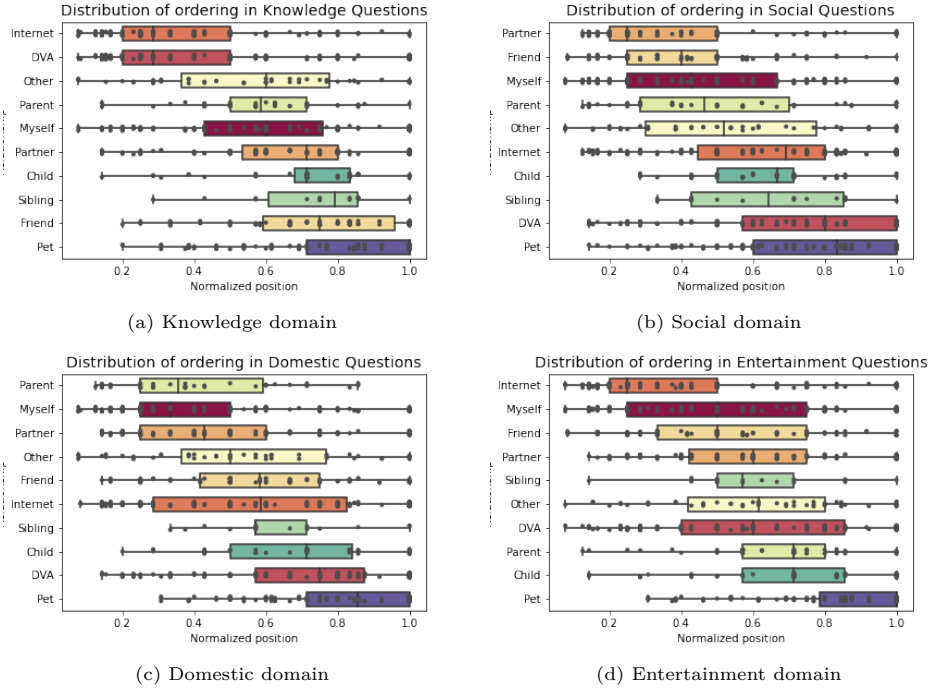
(a) Knowledge domain

(b) Social domain

(c) Domestic domain

(d) Entertainment domain

Figure 2.3: Normalized position indicated per domain and relation to the user.

		Mean Difference	SE	t	p_{holm}
DVA, D	Fam, D	0.123	0.033	3.769	0.009
	Internet, D	0.132	0.033	4.027	0.003
	Self, D	0.319	0.033	9.771	< .001
Fam, D	Internet, D	0.008	0.033	0.258	1.000
	Self, D	0.196	0.033	6.001	< .001
Internet, D	Self, D	0.188	0.033	5.744	< .001
DVA, E	Fam, E	−0.063	0.033	−1.916	1.000
	Internet, E	0.250	0.033	7.651	< .001
	Self, E	0.091	0.033	2.787	0.175
Fam, E	Internet, E	0.313	0.033	9.567	< .001
	Self, E	0.154	0.033	4.703	< .001
Internet, E	Self, E	−0.159	0.033	−4.864	< .001
DVA, K	Fam, K	−0.370	0.033	−11.320	< .001
	Internet, K	0.045	0.033	1.376	1.000
	Self, K	−0.212	0.033	−6.474	< .001
Fam, K	Internet, K	0.415	0.033	12.696	< .001
	Self, K	0.158	0.033	4.847	< .001
Internet, K	Self, K	−0.256	0.033	−7.850	< .001
DVA, S	Fam, S	0.253	0.033	7.758	< .001
	Internet, S	0.144	0.033	4.420	< .001
	Self, S	0.284	0.033	8.704	< .001
Fam, S	Internet, S	−0.109	0.033	−3.338	0.033
	Self, S	0.031	0.033	0.945	1.000
Internet, S	Self, S	0.140	0.033	4.283	0.001

Table 2.2: Post Hoc comparison Agent * Domain on normalized position

2.2.3 Correlation of Trust and Position

A significant negative correlation can be found throughout all domains, suggesting that the level of trust increases when the normalized position decreases (Figure 2.4). This suggests that when a DVA is selected above other household members in an information dilemma task (so they have a low normalized position), the indicated level of trust is higher compared to when the DVA would not be chosen above other household members. The results of the performed Pearson's correlations can be found in Table 2.3.

			Pearson's r	p
DVA__D__pos	-	DVA__D__trust	−0.296	0.013
DVA__E__pos	-	DVA__E__trust	−0.441	< .001
DVA__K__pos	-	DVA__K__trust	−0.472	< .001
DVA__S__pos	-	DVA__S__trust	−0.384	0.001

Table 2.3: Pearson's Correlations

The correlation in the Domestic question domain is significant at the .05 level (r(68) = -0.296, p = 0.013). This suggests a low correlation. The correlation in the Entertainment question domain is significant at the .001 level (r(70) = -0.441, p = <0.001). This suggests a moderate correlation. The correlation in the Knowledge question domain is significant at the .001 level (r(70) = -0.472, p = <0.001). This suggests a moderate correlation. The correlation in the Social question domain is significant at the .001 level (r(68) = -0.384, p = 0.001). This suggests a low correlation.

(a) Knowledge domain

(b) Social domain
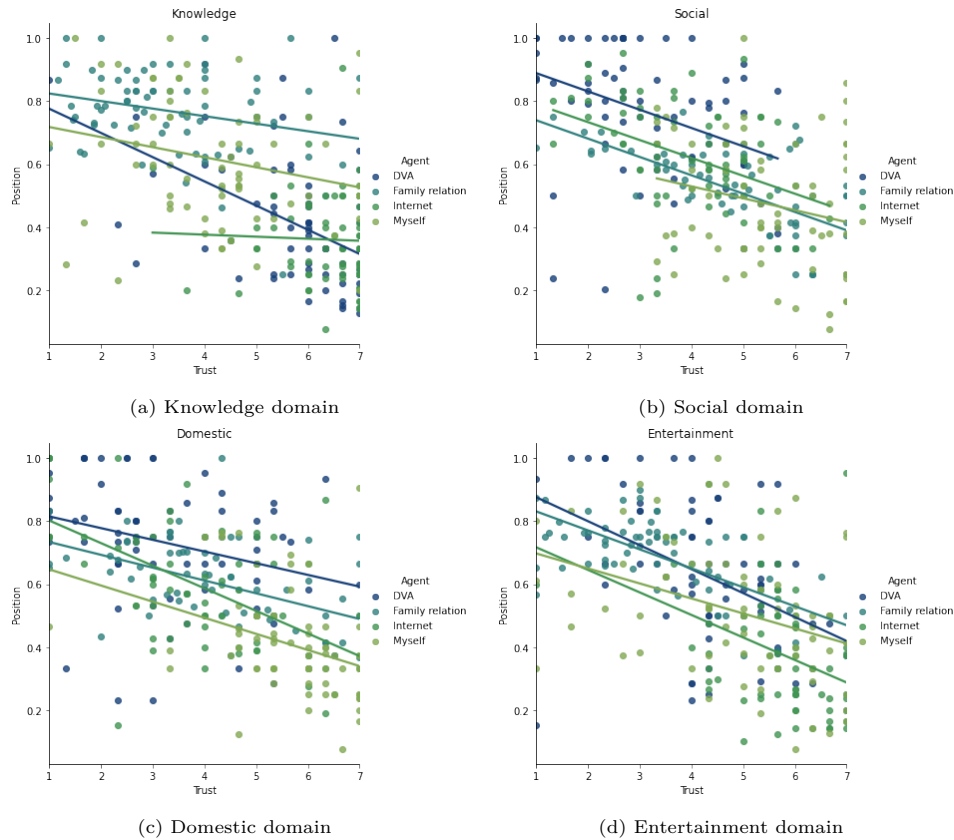
(c) Domestic domain

(d) Entertainment domain

Figure 2.4: Correlation between trust and position per domain

The similarity between the first two analyses (on trust and normalized position) can be explained by the significant negative correlation that was found in this third analysis throughout all domains. It

is found that when the agent is approached first, the level of trust in that same agent is higher. This correlation works both ways. It suggests that people make decisions on who to approach based on their level of trust.

However, as can be seen in the first two analyses, the level of trust and how fast an agent is approached are influenced by the domain. This implicates that the level of trust can vary for the same agent across different domains. The results suggest that people have a bias against some agents for particular conditions. It might be the case that people have preconceptions on the knowledge and abilities of agents.

Although the results of this experiment give a preconception of the influence of the DVA on trust, roles and relationships, they do not provide enough insight on why these effects are measured. To be able to provide this, a second experiment was conducted. This second experiment researched how the DVA specifically impacted these aspects using a qualitative study.

Chapter 3

Experiment 2

3.1 Methodolgy

3.1.1 Ethics Statement

The studies involving human participants were reviewed and approved by Utrecht University Ethics Committee (number 22-1659). All participants were over the age of 18 and consented verbally to their answers being used for this study. Furthermore, all participants consented to having the interviews be audio-recorded and confirmed they participated voluntarily. They also confirmed that the data from the interviews could be used for the purposes of this study. Participants were notified that they could stop the interview at any moment and were informed that their data would be anonymized.

3.1.2 Participants

Due to the study being a qualitative experiment focused on analysing differences in long- and short-term ownership of the DVA, the interview was used as a method to analyse usability of the DVA. For studies analysing usability, findings reported that results do not significantly change after more than five participants [35]. Therefore, the goal was to find at least five participants for each condition and have the same number of participants in each condition. With the conditions being; owning the DVA for less than 6 months, or owning the DVA for more than 6 months. This goal was eventually surpassed, with seven participants for each condition.

A total of 14 participants took part in the experiment (7 male, 7 female), aged between 18 and 56 (M = 29.1, SD = 12.88). Of these 14 participants, 6 also took part in the first experiment (2 owned their DVA for less than 6 months, 4 owned their DVA for more than 6 months). Seven participants owned their DVA for less than 6 months, with most owning them for 2 to 3 weeks (M_{weeks} = 6.1, SD = 6.27). The other seven participants owned their DVA for more than 6 months, with most owning their DVA for 2 years (M_{weeks} = 141.1, SD = 95.13). All participants were Dutch and were native Dutch speakers. No data was excluded.

Participants were informed about the general motivation and goal of the experiment; analysing DVAs over time, but were not be notified that the research would also analyse trust and the roles within the household.

Participants were recruited through a combination of convenience sampling and via online channels. Participants were required to own a DVA at home, and have at least one other household member who has access to the DVA. Participants could be from all over the world, as long as they could establish a video call for the interview.

3.1.3 Experimental Design

The study is a qualitative experiment performing a general interview guide approach [51]. A qualitative experiment provides the opportunity to ask open-ended questions and find possible themes to provide more context for the results of the first experiment. This method proves useful in analysing and

providing answers to why certain correlations can be found in the first experiment. Furthermore, the experiment provides a closer look at the influence of time by interviewing participants who owned their DVA for a short and for a long period of time.

3.1.4 Materials

General Interview Guide Approach

The general interview guide approach is used in this study [50]. This is an interview method which combines aspects from a standardized interview with those from an informal conversation interview. The general interview guide approach gives the interviewer the opportunity to establish a consistent structured interview, but at the same time allows them to deepen and broaden answers where necessary. A list of questions is created as a guide for during the interview.

1. What do you most often use the DVA for?

2. How does the DVA affect your lives in the household?

    (a) How does the DVA affect the roles in the household?

        i. Did you notice a change compared to before you introduced the DVA to your household?

    (b) How does the DVA affect the distribution of information in the household?

        ii. Did you notice a change compared to before you introduced the DVA to your household?

    (c) How does the DVA affect the trust in the household?

        iii. Did you notice a change compared to before you introduced the DVA to your household?

3. Do you trust the DVA? In what way?

4. How do you view your DVA?

5. How do you view that the DVA impacted your household?

Audio Equipment

To be able to transcribe the interviews verbatim afterwards, the interviews were recorded. For this, audio recording equipment in the form of an iPod was used. The iPod was provided by Utrecht University.

Transcription and Annotation Software

Automatic Transcription of Dutch Speech Recordings is a method for transcription developed by Yilmaz en Van Gompel, based on earlier research from 2018 [55]. The transcription software was created at Radboud University Nijmegen. Version 0.5.0 was used for the purposes for this experiment.

Atlas.ti is a computer program to aid with qualitative data analysis. The program was developed by Thomas Muhr at Technical University in Berlin [32]. The program has the goal to uncover and analyse complex phenomena in qualitative data. Atlas.ti accepts multiple forms of unstructured data. For the purposes of this research, only text transcriptions were provided to Atlas.ti. The program was used to analyse and code the findings and visualize them.

3.1.5 Procedure

Participants were asked to perform the interview via Teams[1]. The interview was audio-recorded with the participant's consent. The interviews were performed in the native language of the interviewee to ensure there was less chance of miscommunication or misunderstanding of questions.

The interview took around 7 minutes (M = 7.32, SD = 2.27). Question were asked in order, following the general interview guide approach (see Section 3.1.4). The interviewer was mindful to

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[1]https://teams.microsoft.com

not use any suggestive questions, e.g. "How do you view your DVA" instead of "Do you view your DVA as a roommate". For the interview with the first participant, the questions were in a slightly different order. With the sub-sub-questions of question 2 (i.e. *i, ii, iii*) being asked not directly after the sub-questions (i.e. *a, b, c*), but as a separate category after asking all the other questions of 2 first. Afterwards, it was obvious that the original order made the flow of the interview guide slightly repetitive and unnatural. Therefore, the guide was adapted to the current structure seen in Section 3.1.4 and this was kept for the remaining interviews.

In almost all cases, the predefined guide was sufficient in getting all the information necessary. Two interviews required follow-up questions because initial answers were insufficient or incomplete. In these cases, the interviewer probed the answers of the interviewee to get a more detailed response. For example, if the interviewee would mention that the DVA made their life easier, the interviewer would respond with asking in what way it made it easier. After the interview, the interviewee was asked if they had any further remarks. Afterwards, the recording was stopped. The interview was then transcribed verbatim and processed via Atlas.ti (see Section 3.1.6).

3.1.6   Data Analysis

The interviews were transcribed verbatim to raw text using *Automatic Transcription of Dutch Speech Recordings* (version 0.5.0). The setting "Daily Conversations" was used for transcription, because the quality of the audio recordings was sometime lacking due to the interviews being conducted online via Teams. The transcription were manually corrected in the case of any mistakes. The interviews were analysed using a reflexive thematic analysis approach [9], this was done in two iterations via Atlas.ti[2]. During the first iteration, transcriptions were coded per participant to highlight the most important findings. Afterwards, the codings found in the first iteration were merged to discover overarching themes. The differences between the two participant groups, namely the participants who had their DVA for more than 6 months versus participants who had their DVA for less than 6 months, were analysed based on the codings found in the transcriptions. Differences were highlighted per question or sub-question.

3.2   Results

3.2.1   Use of the DVA

In this section, it is first discussed what participants stated they use their DVA for the most. Secondly, a total overview of all mentioned use cases over the course of the interview is presented, this including the participants answers on what they use the DVA the most for.

The majority of users who owned their DVA for less than 6 months stated that they use their DVA the most for lighting (n = 6, 85.7%). This compared to users who owned their DVA for longer than 6 months that stated they use their DVA the most for controlling music (n = 4, 57.1%). This group also showed more variability in the use of the DVA, stating six different uses for the DVA, compared to only four stated by the participants who owned their DVA less than 6 months. The overview of the stated answers on where participants use their DVA the most for, can be found in Table 3.1.

The only overlap between the two groups was that they both stated they used the DVA for controlling the lights (e.g. turning them on or off) and to control music (e.g. playing songs on Spotify, turning on the radio). There seemed to be no overlap between the two groups for the other mentioned uses for the DVA.

During the interview, participants also mentioned other uses for which they used the DVA. These findings were coded and added to the overall total. Figure 3.1 shows the total mentions of the different use cases for the DVA. In general, *controlling the lights* was stated to be the most used feature of the DVA over the course of the entire interview, with 9 participants ($n_{<6\ months} = 5$, $n_{>6\ months} = 4$) indicating they used this feature often. As opposed to *controlling the Chromecast*, which was only mentioned by one participant who owned their DVA for less than 6 months.

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[2]https://atlasti.com

Code	Less than 6 months	More than 6 months
DVA controls light	6	2
DVA controls household appliance	2	0
DVA tells weather forecast	0	2
DVA controls TV	0	1
DVA controls Chromecast	1	0
DVA controls music	1	4
DVA sets alarms	0	1
DVA provides information	0	1

Table 3.1: Indicated answers on: What do you use the DVA for the most?
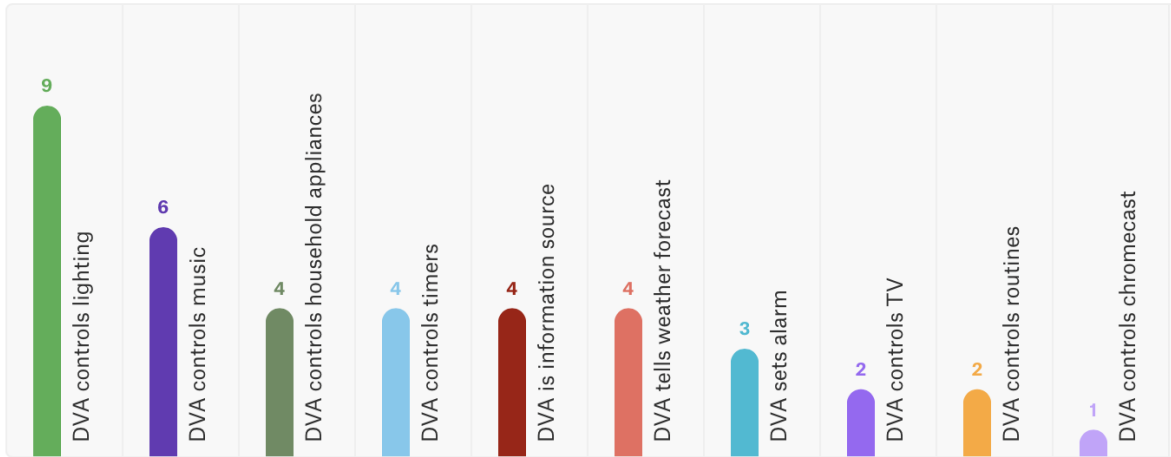

Figure 3.1: Mentioned use of the DVA in both condition groups

3.2.2 DVA influence on Trust

From the participants who owned their DVA less than 6 months, all indicated that they felt there was no change in trust towards their household members (n = 7, 100%). This compared to the group who owned the DVA for more than 6 months, where only five participants felt there was no change in trust (71.4%). Table 3.2 provides an overview of which participants indicated they noticed a change in trust towards their household members.

	Less than 6 months	More than 6 months
Change in trust	0	2
No change in trust	7	5

Table 3.2: Overview on change in trust within household members

Notable is that the participants from this last group that indicated they felt there was no change in their level of trust, did mention they felt they could more easily prove themselves right (n = 2, 40%) and indicated they would approach their DVA faster than their roommate (n = 2, 40%). These participants indicated that they would less easily concede during a discussion because they could use the DVA to check facts while discussing the argument and because they felt that the information provided by the DVA was more reliable than their roommate. The participants that did notice a change in trust stated they developed this because facts and statements could easily and immediately be checked via the DVA during arguments.

3.2.3 DVA influence on roles

Among both groups, participants indicated that they felt like the DVA saved them time ($n_{<6\,months} = 1$, $n_{>6\,months} = 2$). Participants also stated that they felt the DVA took over chores

within the household ($n_{<6\ months} = 2$, $n_{>6\ months} = 4$). This suggests that the DVA did take on or took over some role within the household. However, one participant indicated that they felt the DVA could never completely take over all household chores.

All participants who owned the DVA less than 6 months told the interviewer they felt the DVA did not change the roles within the household (n = 7, 100%). Two participants from this group indicated they did feel like there was a small change in small favours. They stated they now less often asked their household member to perform small tasks which the DVA could perform (e.g. turning on the lights, looking up a recipe). Participants mentioned that they felt the same change within their household members, given why they indicated they felt little to no change in roles.

For the group who owned their DVA for more than 6 months, only three participants indicated they felt no change in roles within the household (n = 3, 42.6%). Two participants indicated a large shift in roles since the introduction of the DVA. These participants stated that the DVA decided who did what chores. Other participants indicated that they felt the DVA took over the role of other personal appliances, such as their phone or computer ($n_{computer} = 1$, $n_{phone} = 3$).

3.2.4   DVA influence on information

Two participants who owned their DVA for less than 6 months stated they felt that there was no change in the distribution of information. Compared to two other participants who also owned their DVA for less than 6 months, who did notice a change. The rest of the participants from this group did notice they used the DVA as a source of information, but either found this exactly comparable to the internet or a computer. They therefore stated they did not feel like the DVA impacted the distribution of information.

This feeling was different compared to the group who owned their DVA for more than 6 months. There, a majority of the participants stated they felt the DVA impacted the flow of information (n = 5, 71.4%). From these participants, three indicated that they felt like their need for information changed since the introduction of the DVA, stating that they felt a need to check small facts because it was so easy to do. One of these participants also mentioned they felt like the DVA constantly provides information and that this came to them immediately.

Out of all participants who owned their DVA for more than 6 months, a majority indicated that they use the DVA often for small questions or to check facts (n = 6, 85.7%). With one participant even stating they felt that the DVA knew exactly what they wanted and needed at any point in time.

From the group of participants who owned their DVA for less than 6 months, three participants indicated they preferred internet over a DVA (42.9%), stating that internet provides the user with different sources and multiple perspectives. Something they felt was lacking with using a DVA.

3.2.5   View of the DVA

In this section, it is first discussed how participants viewed their DVA. Secondly, an overview of the level of trust in the DVA itself is presented.

All the participants who owned their DVA for less than 6 months answered that they felt the machine was more of a machine (n = 7, 100%), using words like 'gadet' or 'remote' to describe their DVA. This drew a high contrast between the participants who owned their DVA for more than 6 months, where a majority stated that they felt that the DVA was more personal (n = 5, 71.4%). This group described the DVA in much more personal terms, using words like 'friend', 'partner', or 'personal assistant'. This indicates that the DVA was seen in a very different way between both groups. Table 3.3 shows an overview of the responses from the interviews, classified as either *seen as machine* or *seen as personal*.

	Less than 6 months	More than 6 months
DVA seen as machine	7	3
DVA seen as personal	0	5

Table 3.3: View of the DVA

From the group who owned their DVA for more than 6 months, there was one participant who felt that the DVA could be seen as both personal and a machine, stating they felt the DVA was both a roommate and an extension of the house. Although extension of the house was classified as seeing the DVA as a machine, the participant did say they liked being able to - in a way - communicate with the house itself.
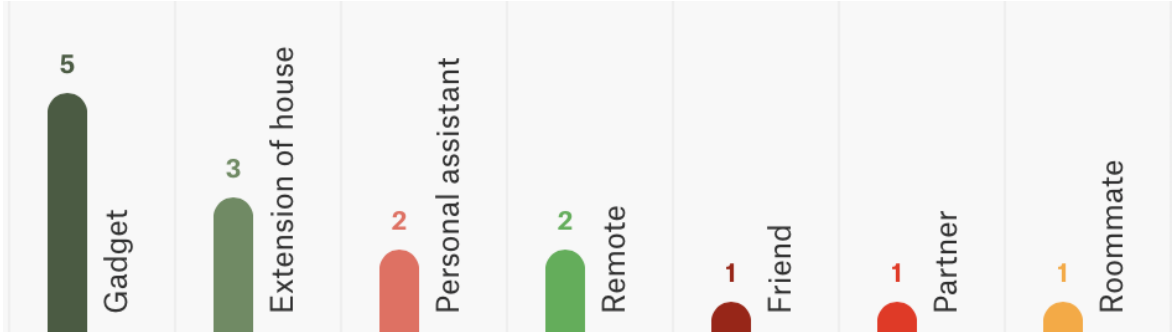

Figure 3.2: Breakdown of terms used to reference the DVA in both condition groups

Figure 3.2 shows a breakdown of the specific terms participants mentioned in the interviews. Notable is that participants who owned the DVA for more than 6 months talked about the system more with personal pronouns, as opposed to people who owned the system for less than 6 months who talked about the system with pronouns that referred to objects (e.g. he vs. it).

While participants from both groups indicated that they felt they could trust the information the DVA provided ($n_{<6\ months} = 4$, $n_{>6\ months} = 6$), most also felt that they could not trust the DVA on a privacy level ($n_{<6\ months} = 3$, $n_{>6\ months} = 3$). From this group, a few immediately mentioned that they felt this privacy issues was similar to other personal electrical appliances suchs as phones or laptops ($n_{<6\ months} = 3$, $n_{>6\ months} = 1$).

3.2.6 Influence of the DVA on household

The word that was used most to describe the DVA was *easy*, with participants in both groups mentioning this multiple times during the interview. Over the course of the 14 interviews, a total of 12 participants mentioned a total of 19 times that they felt the DVA made things easier. Consensus being that having a DVA had a positive influence on the house, because it made things more accessible and easier.

One participant who owned their DVA for less than 6 months stated they felt that the DVA changes the household for the better. Another participant who owned their DVA for more than 6 months indicated that they could not live without it anymore.

Besides finding the DVA easy, 4 participants stated they felt that they became lazier after introducing the DVA ($n_{<6\ months} = 3$, $n_{>6\ months} = 1$). The DVA was also often described as a luxury product, especially within the group who owned their DVA for more than 6 months (n = 3).

Two participants, who both owned their DVA for more than 6 months, stated that they felt the DVA took away a source of frustration. One of these participant mentioned that before introducing the DVA, the household member who had their hands free was the dedicated person to perform small tasks. This could lead to frustration among household members, which they felt was relieved after introducing the DVA who took on the role of the always-hands-free person to ask small favours from. The other participant who mentioned that the DVA took away frustration stated this was because the DVA took on the role of information provider. They indicated that their household member got frustrated with their questions before the introduction of the DVA. After the introduction of the DVA, the participant stated that they shifted almost all questions towards the DVA, relieving some frustration within their relationship with the household member.

Overall, the influence of the DVA is perceived as positive. Out of the participants, 4 stated that they wanted to automize their home more ($n_{<6\ months} = 1$, $n_{>6\ months} = 3$). Furthermore, one user

that owned their DVA for less than a month indicated that they felt DVA is the future. They also indicated that they felt a centralized system would be a great addition to a household.

3.3   Discussion

The aim of the experiment was to research how DVAs impacted trust, roles, and relationships within a household. Furthermore, the research provided more in-depth reasoning behind the results of the first experiment. The interview focused on 6 aspects of the DVA, i.e. - how it is used, how it influenced trust, how it influenced roles, how it influenced information distribution, how the DVA was viewed, and how it impacted the household.

The interview found no obvious differences within general use of the DVA between the two condition groups. The participants stated that the DVA was almost only used for practically controlling other things within the household, or setting thins like alarms or timers. These results suggest that the DVA is only commonly used for practical things and to provide information. Furthermore, how the DVA was used was also limited to the amount of other smart home appliances available in the house.

Most participants, in both groups, stated they felt no change in trust since the DVA towards other household members. Some participants who owned their DVA for more than 6 months, stated they would sooner approach the DVA than their roommate. Which could suggest that the level of trust in the answers from their household members could have diminished since the DVA. Other participants, again from the group who owned their DVA for more than 6 months, indicated that they could more easily prove themselves right. Suggesting that they trusted the answer from their household member less. This behaviour was not found in the group of participants who owned their DVA for 6 months or less. Which could imply that the DVA might have a small effect on trust over time.

For the influence the DVA has on roles, a noticeable difference was found between the two condition groups. The participants who owned their DVA for less than 6 months all stated they felt no change in roles since the arrival of the DVA. This compared to the participants who owned their DVA for more than 6 months, who stated they felt a difference and change in roles since the DVA. Multiple people from this group also mentioned that the DVA took over a role of distributing household tasks. Furthermore, among both groups people indicated that the DVA saved them time by taking over chores within the household. This suggests that the DVA did take on some role within the household. The findings imply that a change of roles within the household can occur over time. They also show that owning the DVA for a short amount of time might not be long enough to feel like it really impacts the role, even though it might do.

A noticeable difference was found between the two groups considering the distribution of information within the household. Participants who owned their DVA for less than 6 months felt no change in the distribution of information, whereas the majority of participants who owned their DVA for more than 6 months did. This follows a trend that a change can likely be developed over time. Participants from the group who owned their DVA for more than 6 months most used the DVA for small tasks, but some did mention they felt their need for information shifted since the introduction of the DVA. Suggesting that exposure to a central and easy source of knowledge could mean that people want to increasingly use it more.

The DVA was seen in a very different way between both groups, with participants who owned their DVA for more than 6 months indicating a far more personal connection to the DVA as opposed to only seeing the DVA as an appliance. This anthropomorphizing over time could be explained that the participants start to feel that the DVA belongs in their household, seeing a similar effect was found in a recent study from Fraune (2020) [18]. This study showed that people tend to prefer robots from their group over other people from outside their group, leading to anthropomorphizing the robot.
There was no significant difference found between the two groups on privacy concerns and the trust in the DVA's knowledge. With participants from both groups stating they sometime did not trust the privacy aspect of the DVA, but they most often did trust the knowledge of the DVA. Implying that

these were not factors that change over time.

Lastly, the interview looked at how the DVA impacted the household. Participants from both groups mostly found that the DVA impacts the household positively, with many stating that they felt it made life easier. Participants also stated that they wanted to further automize their home. Implying more integration with the DVA.

Some also stated the DVA was more of luxury. Interestingly, participants who owned their DVA for more than 6 months found the DVA impacted the mutual relationships positively by taking away sources of frustration. Suggesting that the DVA can have a large impact on one's household.

Chapter 4

General Discussion & Conclusion

4.1   General discussion

In the present study, the aim was to further examine the relationship between DVAs and its effect on trust and roles of the user and associated household. Using a multi-method approach across two experiments, the changes in roles, trust and relationship with the DVA were measured. During the first experiment, it was analysed if the DVA impacted trust and roles within the household. The second experiment researched how the DVA specifically impacted these aspects. This was done to provide a more in-depth reasoning on why certain effects were measured in the first experiment. Across these two experiments, no evidence is found that DVAs have an effect on interpersonal trust. The results do suggest that the DVA has a positive impact on a household and over time can have an impact on the roles and relationships within a social system.

The results from the first experiment showed that the level of trust correlated with how fast participants approached an agent for questions. These findings are similar to previous studies, where it was shown that trust comes when there is a strong and healthy relationship between agents [10, 26]. The results also indicated that the level of trust is significantly affected by interaction of the agent type and domain. This could be explained by the biases and preconceptions people tend to have in the abilities and knowledge of others. People tend to immediately classify others in preconceptions based on biases [3], while they are often not aware of those themselves. This was apparent in the second experiment, where most participants stated they did not feel a change in trust, but did indicate that they would approach their DVA faster than their other household members if they wanted to prove themselves right. This implies that the participants trusted the knowledge of the DVA more. A study by Robbins (2016) [41] showed that people rely on schemas and stereotypes when forming beliefs about another person's trustworthiness with respect to a particular matter at hand. This is in line with the findings of the first experiment, providing a possible explanation on why the interaction of the type of agent and the domain proves significant.

The trust between the user and DVA is also impacted by the level of trust the user has in the DVA itself. During the second experiment, participants stated that they trusted the abilities of the DVA fully, but distrusted the DVA in the area of privacy. This was also mentioned in other studies. For example, a study by Kim et al. (2021) [25] showed that users have concerns about privacy and security while using DVAs. The first experiment showed users trust the DVA the most in the domain of knowledge, which is supported by earlier research [15].

Results showed that the order in which the agents were ranked were dependent on the interaction of the agent and the domain, suggesting that the roles are influenced by a combination of the agent and domain. This could be linked to the biases discussed earlier. People develop certain biases, for example based on gender or the patriarchy, for which they assume people take on certain roles [16, 33]. These biases can lead to inferring traits from people's activities, also known as correspondence bias [21]. Correspondence bias entails that people are what they do [20]. This bias could explain why the roles are influenced by the interaction of the agent and the domain. The first experiment also showed that the DVA had an effect on the roles. DVAs can take on roles for the user, such as domestic roles

[39, 29] or social roles [29, 19]. However, the results from experiment 1 did not confirm the roles as mentioned in other studies. The results indicated that the DVA took on roles within the knowledge domain, rather than in the domestic or social domain. This was different compared to the results found in the second experiment, where most participants did feel that the DVA took over domestic and social roles within the household. These participants still also mentioned that the DVA took on a role within the knowledge domain. Furthermore, the effect of social roles seemed to be isolated more towards the participants who owned the DVA for more than 6 months, suggesting that this could be a role that develops over time. The difference between the findings from experiment 1 and 2 could be explained by the types of questions that were created for the dilemma task. DVAs can take over most, but not all, roles. This was something that was mentioned during the second experiment. As the dilemma tasks from the first experiment covered as many aspects within the domestic domain as possible, it could be that the dilemmas included tasks the DVA would not be able to fulfil (strongly depending on the level of smart home integration). This possibly created the difference in results between the two experiments and other studies.

The DVA had an overall positive effect on the relationships between members of the household who used it for a longer period of time. During the second experiment, participants mentioned that they felt less frustrated with other household members after introducing the DVA. This in contrast with participants who owned their DVA for less than 6 months, who sometimes felt frustrated with the DVA itself. This was an effect that is also found in earlier studies, where participants who just got the DVA can often be frustrated with the machine itself [25]. This finding suggests that people get used to the DVA over time. When adapted to the DVA, users can benefit and create a more pleasant environment by relieving stress [38]. For example, almost all participants from the second experiment stated that they felt that the DVA took on small chores. These findings are backed by other studies where users indicated that they felt positively about the DVA [38, 25]. This positivity can be caused because the DVA is accessible and easy [25]. Furthermore, because the DVA can become an integrated part of the household [38] the user can get attached to the DVA shifting the DVA to an in-group member and with this create a more positive experience using the DVA [12, 18].

There were two notable cases found in experiment 2 from participants who owned the DVA for more than 6 months, where the DVA divided the domestic roles randomly over household members. This occurrence was not found in other literature, presumably because this is not a built-in feature of any standardized DVA, but a self-programmed addition. However, this could indicate that the DVA can have a much bigger impacted on the role-distribution than expected.

4.1.1 Limitations & Future Work

During the second experiment, the two condition groups were divided by the time that they owned the DVA. However, most participants from the group who owned the DVA for less than 6 months only had their DVA for less than 3 weeks. They indicated that had not used the DVA for certain tasks because the simply did not have the time to try them. This limits the results from the second experiment, because no real judgment can be provided on certain issues. Future studies could include a minimum time that the DVA must have been owned to avoid such issues.

The study showed that the duration of ownership of the DVA can have an influence on the roles and relationships within the household. In this study, participants who just owned their DVA (only for a couple of weeks) were compared to participants who owned their DVA for a wild variety of years. Future studies could see if this effects grows stronger with time. To further analyse the effects of time on the change in roles and relationships, an experiment could be set up where the participants are followed after they first get a DVA. A weekly test could be set up to monitor the levels of trust and the change in mutual relationships, combined with a test before the introduction of the DVA within the household. This way, the experiment could track possible changes in trust, roles, and relationships and report on when these changes become noticeable.

4.2 Conclusion

The aim of the study was to analyse the impact of DVAs on roles and trust of a user and associated household. The first experiment found that both trust and roles within a household are affected by the interaction between agent and domain. The influence of the DVA on the level of trust was minimal, with only small indications of change in trust reported over time. The level of trust was found to be correlated negatively with the order an agent was placed in, suggesting that people chose an agent for a domain because they trusted they could perform well. Experiment 2 found that DVAs have a positive impact on a household, and can over time change both the roles and relationships within a household. The DVA took on roles and small chores within the household, which allowed the DVA to alleviate frustrations by taking on frustrating roles. This had a positive influence on the relations between household members. The results of both experiments suggest that the DVA does not impact inter-relational trust, but does affect the roles of the user and associated household.

Appendices

Appendix A

Recruitement poster

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