Antecedents of system trust

the influence of competence and shared values

Breugelmans, J.M.W.H.

Award date:
2011

Antecedents of System Trust: The Influence of Competence and Shared Values

Jeffrey Breugelmans

Antecedents of System Trust:
The Influence of Competence and Shared Values

Jeffrey Breugelmans, Cees Midden & Jaap Ham
Eindhoven University of Technology, the Netherlands

Notes on Authors

Jeffrey Breugelmans, Human-Technology Interaction, Eindhoven University of Technology;
Cees Midden, Human-Technology Interaction, Eindhoven University of Technology;
Jaap Ham, Human-Technology Interaction, Eindhoven University of Technology;

Correspondence about the manuscript can be directed to Jeffrey Breugelmans,
at j.m.w.h.breugelmans@student.tue.nl

ABSTRACT

The topic of system trust is of great importance when it comes to persuasive technology, because an assistance system's efficiency will strongly rely on the amount of trust a user has in the system. For example, a system that projects or exhibits (before or during use) poor competence will normally be perceived as less likely to provide good advice, and therefore be less accepted. Little is known, however, about determinants of system trust. From the research area of Social Psychology, it is known that prominent among the determinants of trust in other people are whether he or she shares your social values (goals), and whether you judge this person to be competent or not. System trust, on the other hand, is commonly approached in terms of competence alone. In the current study, we investigate the influence of these two determinants (shared values and competence) on the trust people place in technology. In this 2x2 experiment, participants' trust and acceptance were measured at several instances: before, during and after system use. Results confirmed the existence of an interaction effect of Shared Values x Competence, in a sense that the level of Competence only started to play an important role once Shared Values were present. Thereby, results indicate that not only competence, but also system values can have a strong effect on system trust. This is an important implication for the development of persuasive technologies, because of their common application to situations when there is a conflict between actual and desired goals.

Keywords:

Man-Machine Systems, Social Psychology, Persuasion, Trust.

1. INTRODUCTION

Sustainability is widely viewed as crucial for our future. But while certain aids can be applied to promote sustain-ability, but a sustainable society cannot be constructed on the basis of technology alone (Eliot, 1997, p. 184). Its success will rely largely on its inhabitants' ability and willingness to cooperate. In pursuit of this, two main approaches to sustainability can be identified.

First, there is the implementation of clean or cleaner technologies, for example renewable energy sources and hybrid cars. These technologies are aimed at providing the same functioning and/or benefits to its users, but in a manner that reduces the strain on the environment and limited resources (Eliot, 1997, p. 49). This can be achieved by addressing the consequences of technology's direct use (e.g., fuel use and emissions from cars), or their indirect use (e.g., resources and energy used in the manufacturing process).

Secondly, there are the attempts aimed at creating awareness among people, through government campaigns for example. A well-known application of this approach is the campaign on recycling. But despite the fact that people generally acknowledge the importance of sustainability, their beliefs are often insufficiently sup-ported by actions. This can be due to the fact that the adaptation of a well-rooted behavior is difficult to achieve, especially when these new approaches seem to go against short-term vested interests (Elliot, 1997, p. 186). In other words, people find it harder to commit to a change in lifestyle when these actions will only be rewarded in the long run (e.g., countering global warming).

Then there are the systems that serve both approaches. These are systems that are specifically designed to aid in the pursuit of sustainable behaviors, by assisting its user along several steps of this process. Such machine assistance poses great opportunities, because it can be used to take over difficult, dangerous or undesirable tasks, or it can be applied to inspire more desirable actions. Depending on the task at hand, designers will have to decide whether the system should be aimed at taking over control or merely providing assistance. And whether this assistance should be aimed at a physical or cognitive level. This application to cognitive assistance is a relatively more novel approach.

1.2 Persuasive Technology

It is this cognitive type of assistance where persuasive technologies come into play, which are intentionally designed to influence a person's attitude, behavior, or both (IJsselsteijn, Kort, Midden, Eggen & Hoven, 2006; Fogg, 2003). They are commonly applied when there is an urgent need for change from an actual to a desired behavior, which is often the case in sustainability.

These systems are often developed to help people achieve a more optimal task performance by providing assistance. One example application would be an advanced navigation system that is capable of calculating the route that uses the lowest amount of fuel. However, whether people will agree to allocate control (e.g. over their vehicle) to such assistive technology will depend on user acceptance, which is highly related to the amount of trust people have in such a system (Siegrist, 2007; Vries, 2004). It is important to note the difference between trust, which is more of a feeling, and confidence, which is based on knowledge. The term "Trust" will be used throughout this paper in this sense that it describes a first impression.

1.3. Trust

Trust is one of those essential human values that everyone understands, until it comes into question and it is time to explain it or put it to practice (Lewicki & Tomlinson, 2003, p. ix). It is this fixation on practice that is important, because there is no point to building trust if it is never applied. Trust is a part of interaction. Its need arises from our inter dependency with others (Lewicki & Tomlinson, 2003, p. 46). Furthermore, it is often applied as a way of dealing with uncertainty, for example when dealing with an unfamiliar person. A similar need arises when using a new piece of technology for the first time, although only little is known about this buildup of system trust.

Much is known about interpersonal trust in Social Psychology. In this field, many factors were identified which facilitate instantaneous trust or more long-term trust establishment. For example, the projected or confirmed competence of the trustee, the overlap in goals between the trustor and the trustee have shown to be importance antecedents of trust in the trustee (Kenrick, Neuberg & Cialdini, 2007). In interpersonal trust, for instance, trust is often based on the perception of another person's good will. So in the absence of shared experience, an initial form of trust could be founded on a belief in positive outcomes.

System trust, on the other hand, tends to be described it in terms of confidence only. As a matter of fact, some researchers (e.g. Earle, Siegrist, & Gutscher, 2002; also Siegrist, Earle, & Gutscher, 2003) have argued that the difference between trust and confidence is based on the perceived agency of the cooperative party (trust in other person vs. confidence in a system/object). This paper chooses a different approach, however, in a sense that confidence is based on knowledge of prior task performance, regardless of the agency of the other party (human or system). This sense of confidence is based on direct or indirect experience.

Since assistance systems exhibit an increasingly adapted fit to users' needs and desires, it could be that the development of system trust also involves more than just projected or confirmed competence. Salient shared values could be expected to play a role as antecedent of trust in smart systems, as they are with trust in humans (e.g. Cvetkovich & Winter, 2007). Whether shared values by a system trigger the same psychological processes as those that lead to interpersonal trust is another important question, but it is not one that will be answered within the scope of this study.

1.4 Allocation of control

To recapitulate, there are two main paths identified that may lead to the allocation of control (see figure 1). First, as mentioned, there is the most common approach to system trust, which is triggered by direct or indirect experience and followed by an already confirmed competence. The other road describes the initial trust people form towards a system before prolonged experience has taken effect. Since this form of system trust is based on projected properties and functioning, these are combined into a belief of certain outcomes. This study will focus more on the latter approach, where projected Competence and Shared Values are manipulated in order to assess their effects on system trust and the allocation of control.

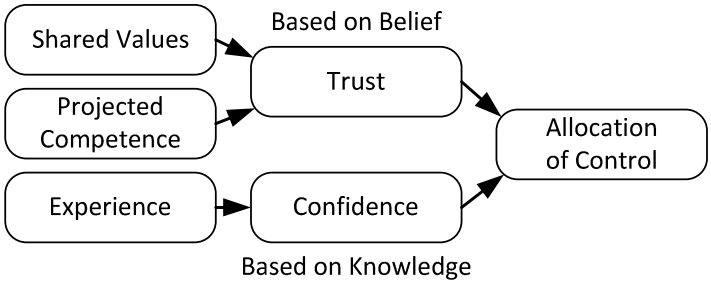


Figure 1. The two roads towards the Allocation of Control

One important consideration remains, however. And that is that a variation in system competences may be very common to users (e.g. software packages for home or professional use), whereas the presence of system values may not be. Nonetheless, some products that promote a distinct values have already been accepted (e.g. hybrid cars, low energy consumption home appliances). This rather unfamiliar aspect of system values may be driven to an even larger extend in the case of persuasive technologies, since these systems are often used to promote a goal that is in contradiction to the user preferences, due to the aforementioned discrepancy between actual and desired behaviors. So it may be a whole new experience for users to interact with a system that promotes actions that are different from the ones they prefer themselves.

2. CURRENT STUDY

This study investigates the role of two important antecedents of human-to-human trust: competence and goal overlap within the domain of human-technology trust. A simulated navigation was chosen as the application of interest. It is important to note that there was no manipulation of the main goal or purpose of the system. Regardless of the system properties, the ultimate goal would, of course, be to guide the user to the programmed destination. The goal manipulation did, however, affect the manner used to achieve this goal. Hence, the two systems would use different approaches in producing their advice. Apart from this variation in system goals, their competence would also be at one of two possible levels. As a result, these two properties were used to create four differently configured systems. The first sys-tem would project both a similar goal and high competence, while the opposing system would be aimed at a different goal with low competence. Finally there are the two trade-off conditions, in which either goal similarity or competence were at the high level, while the other property was at a low level. These four system configurations were investigated in order to determine their influence on trust judgments and system acceptance.

In order to assess the influence of these two aspects, an experiment was designed that incorporates three stages of trust assessment: (1) initial trust, based on impression be-fore use, (2) system acceptance during use, and (3) evaluated trust after interaction. Despite the fact that it takes place after interaction, this third stage is still considered a measure of trust (not confidence), because it describes an immediate assessment after use, rather than a knowledge based judgment that is applied to predict the outcome of future interactions. This trust assessment after use could establish a sense of confidence for a next trial, but at this stage (directly after first use) it is still considered trust. Whether this notion of trust is identical to trust before use might be another question to answer in a future study.

Because of the ways the concepts of shared values and competence function in the domain of interpersonal trust, it was expected that system trust and acceptance will also be affected by them. First, it was expected that trust and acceptance would increase when the system would show shared values, as opposed to dissimilar values (*hypothesis 1*). It was also expected that systems with high competence would achieve better trust and acceptance ratings, than low competence systems (*hypothesis 2*). Finally, an interaction effect between these two factors was also predicted, in a sense that participants who got to interact with a system with shared values, would show a stronger

increase in system trust and acceptance when the system showed high competence, than participants who would interact with a system that does not share their values (*hypothesis 3*). In other words, the importance of competence would rely on the similarity between user and system values. The interaction to unfold in this manner, because that is what we would expect in case of interpersonal trust. As in the case of politics. Because when rating two politicians, it makes a lot more sense to favor the person who promotes similar goals regardless of his or her competence, than to support a highly competent politician who aims to achieve goals that are opposing to yours.

3. METHOD

This section of the report describes the design and procedure of the experiment.

3.1 Participants and design

Sixty participants (39 Men and 21 Women, age, *M* = 23.6, *SD* = 8.8) were randomly assigned to one of four experimental conditions of the 2 (shared values: high vs. low) x 2 (competence: high vs. low) mixed design (see Table 1). Depending on the stage of the experiment, par-ticipant would either rate all four systems based on their first impressions, or judge one of them based on interac-tion. The experiment was carried out on-line and lasted for about 30 minutes, after which participants were paid €10 (approximately $13.5 at the time of the experiment).

2x2 Design		Shared Values	
		High	Low
Competence	High	C1	C2
	Low	C3	C4

Table 1. Experiment design

3.2 Materials

During the experiment, participants were presented with a simulated navigation system that provided routing recommendations (see Figure 2). Participants would download the program from a webpage and run it on their own computers. As a result, subjects were free to conduct the experiment at their time and environment of choice. The Experimental data were captured by the program and collected through email communication.

Figure 2. Screenshot of Authorware Experiment

3.3 Procedure

As participants progressed through the experiment, they encountered three main parts, which are described in the following sections.

3.3.1 Introduction and preference selection

After downloading and starting the experiment program, participants were introduced to the new navigation systems in this study. It was made clear from the start that two different systems were be available, which gave preference to contrasting values in pursuit of their final goal. The first system was labeled *Fastway*, and was described as a system that aims at getting its user to the final destination as quickly as possible. The second system was called Econav, and was described to be a navigation system that had a more environment-friendly approach in its attempt to select to best route possible. Their differences were emphasized by stating that the Econav system would prefer a longer route when avail-able, if it would eventually lead to a lower fuel consumption. The Fastway system, on the other hand, could be seen as the more self-centered solution, aimed at reaching the destination in as little time as possible, regardless of fuel consumption. Participants were then asked to select the system of their own preference. This was needed, because it facilitated the future system assignment.

System competence was also manipulated, by describing the system as being equipped with either the Light or Plus edition software. This difference was explained by stating that the Plus edition has access to additional information that makes its recommendations better suitable to the current situation (e.g., through awareness of traffic conditions and road construction sites). The Light edition, on the other hand, had access to the static road map only. Tables 2 shows which system is assigned to each condition, after a participant would indicated a preference for the Fastway system. Similarly, Table 3 shows which system is assigned to each condition as a result of a participant's preference for the Econav system.

Subject prefers the Fastway system		Shared Values	
		High	Low
Competence	High	C1: Fastway Plus	C2: Econav Plus
	Low	C3: Fastway Light	C4: Econav Light

Table 2. System assignment linked to Fastway preference

Subject prefers the Econav system		Shared Values High	Shared Values Low
Competence	High	C1: Econav Plus	C2: Fastway Plus
	Low	C3: Econav Light	C4: Fastway Light

Table 3. System assignment linked to Econav preference

3.3.2 First impressions - Before use

After both system variables were discussed, participants were provided with an overview of all four systems and their properties. After reading these system descriptions, participants were asked to rate each of these on three initial trust measures using a 9-point scale (1 = *very little*, 9 = *very much*). As a result, this section followed a 2x2 within subjects design using the same sixty participants.

Three questions (dependent variables) were asked: "How much would you trust this system's advice?", "How much would you like to use this system?, and "To what extent does this system meet your preferences?". Each consecutive question would be presented on a new screen, and each time the same answer scale was provided (Appendix I, Table 1 also shows an overview of these questions). Participants were also able to give several systems an identical score, in case they could not differentiate. Results to this section were used to investigate people's initial trust towards these systems, based on descriptions alone. The reliability of these three trust measures per system was determined by calculating their Cronbach's Alpha scores. This score provides an indication of the extent to which questions are measuring the same concept. Since the test on these questions resulted in a high Alpha-value (> 0.75), a justification was found for combining them into one single trust measure per system (Cronbach's Alpha's: Fastway Plus questions = 0.81; Econav Plus questions = 0.78; Fastway Light questions = 0.78; and Econav Light questions = 0.80).

3.3.3 System Acceptance - During use

The next section in the experiment involved the interaction between system and participant. As mentioned, participants were assigned only one out of four navigation systems, resulting in a 2x2 between subjects design for these trials, which still involved the same sixty participants. Before using the system, participants received instructions on its operation and functioning. Among other aspects, they were told to take notice of the departure time and different route types, since these could have a substantial influence on the journey to be completed.

In ten trials, the provided navigation system would present its users with a route problem, containing a start point (square) and destination marker (flag). Participants were able to activate the system with the push of a button, after which it would produce a step-by-step path that would eventually connect the start point and the destination marker on the map. Once the route was completed, participants were asked to answer three questions about acceptance. Note, however, that each route was followed up by the exact same advise. The first question asked for a straightforward decision to either accept or reject the advice. For the remaining two questions, participants were asked to what extent the system advice met their preferences, and how satisfied they were with the recommended route (Appendix I, Table 2 provides an overview of these acceptance questions). These questions were answered using a 9-point scale. All three answers served as the dependent variables that measured acceptance of each of the 10 routes. Hence, after completion of the ten trials, a total of thirty acceptance measures was collected. The Cronbach's alpha on these variables indicated sufficient reliability (> 0.75) to allow the combination of these measures into a single Acceptance score.

3.3.4 Trust measure - After use

After participants had finished their interaction with the designated system, they were asked several additional questions aimed at assessing system trust (See Appendix I, Tables 3-5 for an overview of all the questions asked after use). Note that these measures assess a different aspect of system trust than the questions asked before use, because participants' original trust in the system was likely affected by their experience with it. Apart from some more generic questions, there were three questions that specifically asked about a trust rating: "How much did you trust the navigation system to always recommend the best route for you?", "How much did you trust the navigation system always had the same goals as you?", and "How much trust did you have in the knowledge of the navigation system?". The remaining items in the questionnaire also contained two manipulation checks on the levels of shared values and competence the participants had perceived. These measures were used separately as dependent variables. Near the end of the experiment demographics were collected, along with participants' payment information to enable transferring of the €10 compensation. Finally, participants were debriefed and thanked for their contribution.

4. RESULTS

In this section, the results of this experiment are discussed in correspondence to its three main parts. First, there will be an overview of the results found among the trust measurements before use. The second part discusses the system acceptance during use, and the third section describes the results of the after-use analysis of trust.

4.1 First impressions - Before use

The initial trust measures taken before use on all four systems were submitted to a 2 (shared values: high vs. low) x2 (competence: high vs. low) Multiple Analysis of Variance (MANOVA), with both variables as the within-subjects variable. In line with the first hypothesis, that predicted a main effect of shared values, it was found that participants trusted systems that exhibited shared values more (M = 7.00, SE = 0.09), than systems with opposing values (M = 5.78, SE = 0.14), $F(1, 59) = 71.80$, $p < .001$). Similarly, in correspondence to the second hypothesis which predicted a main effect of competence, it was found that participants trusted systems with high competence more (M = 7.16, SE = .10), than those with low competence (M = 5.62, SE = 0.13), $F(1, 59) = 142.09$, $p < 0.001$. In additions, results indicated an interaction effect of Shared Values x Competence, $F(1, 59) = 15.60$, $p < 0.001$), which was in line with the third hypothesis. Simple effect analyses indicate that for participants who interacted with a system that exhibited shared values, interacting with a high competence system led to a stronger increase in trust compared to interaction with a low competence system (M = 7.84, SD = 0.71, for high competence systems, versus M = 6.15, SD = 1.02, for low competence systems), $F(1, 59) = 141.47$, $p < 0.001$, than participants who interacted with a system that exhibited non-shared values, for whom interaction with a high competence systems led to a lesser increase in trust compared to interaction with a low competence system (M = 6.46, SD = 1.15, for high competence systems, versus M = 5.08, SD = 1.28, for low competence systems), $F(1, 59) = 92.14$, $p < 0.001$. A similar analysis of simple effect in the other direction revealed that for participants who interacted with a system that exhibited high competence, interacting with a system with shared values led to a stronger increase in trust compared to interaction with system with opposing values (M = 7.84, SD = 0.71, for the shared values system, versus M = 6.46, SD = 1.15, for a system with opposing values), $F(1, 59) = 71.75$, $p < 0.001$, than participants who interacted with a system of low competence, for whom interaction with a system with shared values led to a lesser increase in trust compared to interaction with a system with opposing values (M = 6.15, SD =

1.02, for a shared values system, versus M = 5.08, SD = 1.28, for a system of opposing values), $F(1, 59) = 62.33$, $p < 0.001$. Table 7 shows the mean trust ratings per experiment condition, and Figure 3 illustrates these same results in a chart.

Trust - Before use		Shared Values	
		High	Low
Competence	High	C1: 7.84 (0.71)$_{a\,c\,e\,i}$	C2: 6.46 (1.15)$_{b\,c\,g\,j}$
	Low	C3: 6.15 (1.02)$_{a\,d\,f\,k}$	C4: 5.08 (1.28)$_{b\,d\,h\,l}$
Note: a-b and c-d main effects, and e-f, g-h, i-j and k-l interaction effects, all at p < 0.001			

Table 4: Mean scores on trust measures before use
(standard deviations between brackets) in all conditions

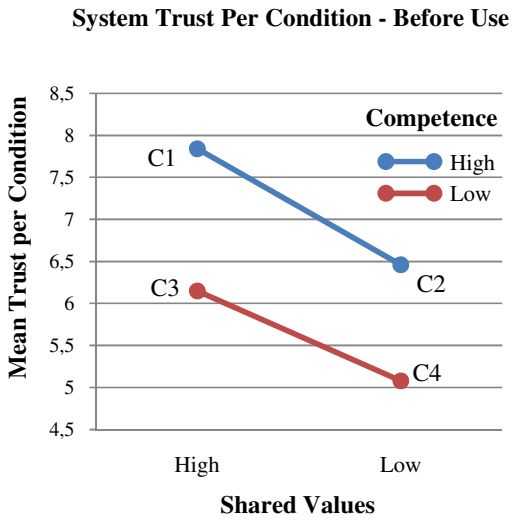


Figure 3. Main and Interaction effects on Trust before use

4.2 System Acceptance - During use

The acceptance measures taken during product use were submitted to a 2 (shared values: high vs. low) x 2 (competence: high vs. low) x 3 (acceptance measures) x 10 (routes) Mixed Analysis of Variance (MANOVA), with all 30 acceptance measures as the between-subjects variables. This analysis revealed an interaction effect of Shared Values x Competence x Route, $F(18, 1008) = 1.86$, $p < .05$. A closer look at the outcomes per route revealed a significant interaction of Shared Values x Competence on routes 2, 3, 4, 6, and 7 (all $p < 0.10$). Next, computation of the Cronbach's Alpha indicated a high reliability between all fifteen trust measurements of these five routes (Alpha > 0.75), which justified the decision to combine these acceptance measure into one average acceptance score for further analysis. This score was submitted as a new between-subject variable into a 2 (shared values: high vs. low) x 2 (competence: high vs. low) Analysis of Variance (ANOVA). In

confirmation of the second hypothesis, it was found that participants who were told they were using a system with high competence showed more acceptance (M = 4.33, SD = 0.91) than participants who thought they were working with a low competence system (M = 3.96, SD = 1.08), $F(1, 56) = 4.07$, $p < 0.05$. In confirmation of the third hypotheses, results indicated an interaction effect of Shared Values x Competence, by revealing that when participants interacted with a system that shared their values, telling the participant that the system had high competence lead the participant to more strongly accept the system (M = 4.67, SD = 0.52), than when he or she was told that the system had low competence (M = 3.73, SD = 0.79), $F(1, 56) = 9.83$, $p < 0.01$. On the other hand, such a significant change of acceptance scores were not found among the systems with different values, $F < 1$. Table 8 provides an overview of these results, which are also illustrated in Figure 4.

4.3 System Trust - After use

During this final section of the experiment, participants were asked some more trust-related questions about the system they had been using. This part also featured a between-subjects design, involving the same sixty participants.

After all trials with the navigation system were completed, participants received several questions that were aimed at system trust, including one pair of manipulation checks. These 15 measures were submitted to a 2 (shared values: high vs. low) x 2 (competence: high vs. low) x 15 (trust measures) Mixed Analysis of Variance (MANOVA), with the 15 individual trust measures after use as between-subjects variables. The next sections will discuss the results that were found in confirmation of the hypothesis. None of these measures indicated a result that would disprove any of the hypothesis. Hence the future sections will be used to reveal the hypothesis confirmations alone.

Acceptance - In use		Shared Values	
		High	Low
Competence	High	C1: 4.67 $(0.52)_{a\,c}$	C2: 3.99 $(0.75)_{a}$
	Low	C3: 3.73 $(0.79)_{b\,c}$	C4: 4.19 $(0.74)_{b}$
Note: a-b main effect = p < 0.05; c interaction effect = p < 0.01			

Table 5: Mean scores on acceptance measures during use
(standard deviations between brackets) in all conditions

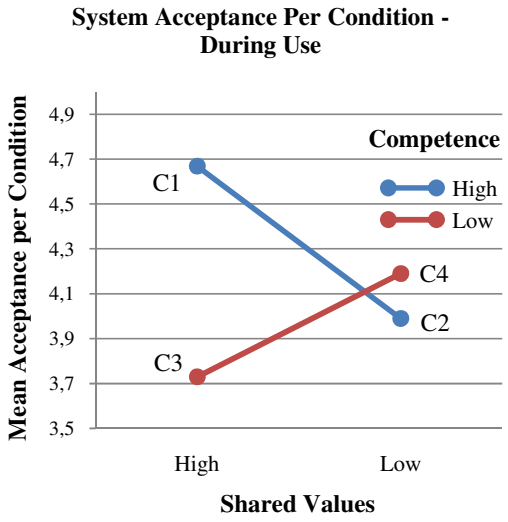


Figure 4. Main and Interaction effects on Acceptance

Results on the *Agreement* measure supported hypothesis 1, since it showed that participants who used a system with similar goals indicated a higher sense of agreement with the generated routes (M = 5.93, SD = 2.29), than those who used a system with different values (M = 5.20, SD = 2.36), F(1, 56) = 3.17, $p < 0.10$ (See table 6).

Agreement		Shared Values	
		High	Low
Competence	High	C1: 6.40 $(1.77)_a$	C2: 5.33 $(1.63)_b$
	Low	C2: 5.47 $(1.46)_a$	C4: 5.07 $(1.71)_b$
Note: a-b main effect = $p < 0.10$			

Table 6: Mean scores for sense of agreement to system advise (standard deviations between brackets) in all conditions

Confirmation of hypothesis 1 was also found on the *Effort* measure. Participants claimed to spend more effort on studying the system's behavior in order to figure out it's functioning, when the system promoted the same goals (M = 5.50, SD = 2.67), than those subjects were assigned a system with different goals (M = 4.50, SD = 2.84), F(1, 56) = 3.95, $p < 0.05$ (See table 7).

Effort		Shared Values	
		High	Low
Competence	High	C1: 6.13 $(1.51)_a$	C2: 4.60 $(1.73)_b$
	Low	C2: 4.87 $(2.20)_a$	C4: 4.40 $(2.26)_b$
Note: a-b main effect = $p < 0.05$			

Table 7: Mean scores for amount of effort put into understanding the system (standard deviations between brackets)

Hypothesis 1 was also confirmed by the *Knowledge* measure. Results indicated that participants who thought they used a system with similar goals considered their system as having a larger knowledge-base (M = 6.33, SD = 2.27), than those who used a system with different values (M = 5.37, SD = 2.04), F(1, 56) = 6.03, $p < 0.05$ (See table 8). This is rather surprising finding, because it revealed an effect of one independent variable on the other independent variable's control measure.

Knowledge		Shared Values	
		High	Low
Competence	High	C1: 6.47 $(1.89)_a$	C2: 5.20 $(1.08)_b$
	Low	C2: 6.20 $(1.27)_a$	C4: 5.53 $(1.73)_b$
Note: a-b main effect = p < 0.05			

Table 8: Mean scores for question on system knowledge
(standard deviations between brackets) in all conditions

A similarly finding was also done in light of the second hypothesis for the *Goal Similarity* variable. In this case, participants who were assigned to a highly competent system indicated a higher trust in that's system similarity of goals (M = 5.70, SD = 2.38) than participants who were told their navigation system had low competence (M = 4.33, SD = 2.54), $F(1,56) = 9.25$, $p < 0.01$ (See table 9). This finding is equally surprising as the previously mentioned effect found for the knowledge rating.

Goal Similarity		Shared Values	
		High	Low
Competence	High	C1: 5.87 $(1.64)_a$	C2: 5.53 $(1.73)_a$
	Low	C2: 4.47 $(1.73)_b$	C4: 4.20 $(1.86)_b$
Note: a-b main effect = p < 0.01			

Table 9: Mean scores for trust measure on goal similarity
(standard deviations between brackets) in all conditions

Finally, results confirmed all three hypothesis in the measure that was focused on the user's *Motivation* to understands the system's functioning. The most significant effect was in line with hypothesis 1, because it revealed that participants using a system with similar goals were more motivated to understand the systems functioning (M = 5.63, SD = 2.35), than those subjects that were assigned a system with different goals (M = 4.40 , SD = 2.69), F(1, 56) = 7.16, $p < 0.01$. The second effect was in confirmation of hypothesis 2, as it indicated that participants using a system with higher competence were also more motivated to understand the systems functioning (M = 5.40, SD = 2.22), than the people using a system with low competence (M = 4.63, SD = 2.79), F(1, 56) = 2.77, $p < 0.10$. Finally, also the interaction effect in hypothesis 3 was confirmed in this measure,

revealing that the system's competence would only play an important role in case the system's goals were similar. For systems with shared values, a highly competent system lead to a higher motivation (M = 6.40, SD = 1.45), than a system with low competence (M = 4.87, SD = 1.85), F(1, 56) = 2.77, $p < 0.10$, while there was no effect of competence for systems with opposing values, $F < 1$. (See table 10 and figure 5 for an overview).

Motivation		Shared Values	
		High	Low
Competence	High	C1: 6.40 (1.45)$_{a\,c\,e}$	C2: 4.40 (1.68)$_{b\,c}$
	Low	C3: 4.87 (1.85)$_{a\,d\,f}$	C4: 4.40 (2.10)$_{b\,d}$
Note: a-b main effect = p < 0.01; c-d main effect = p < 0. 10; e-f interaction effect = p < 0. 10;			

Table 10: Mean scores for motivation to understand system functioning (standard deviations between brackets)

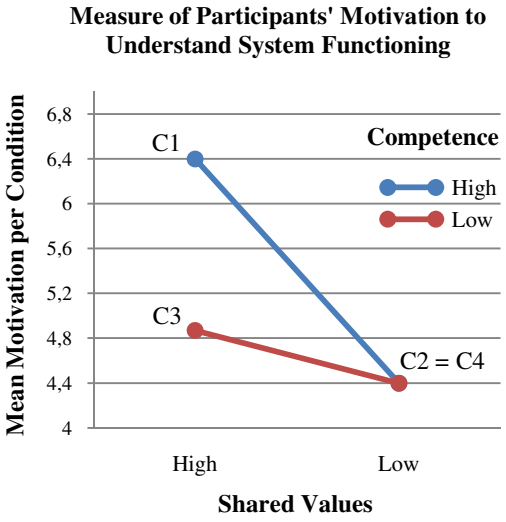


Figure 5. Main and Interaction effects on Motivation

5. GENERAL DISCUSSION

The introduction of the four different systems was followed by an a set of trust measurement. In this initial stage of trust formation (based on information alone), a confirmation was found for all three hypothesis, since participants' trust in each system was significantly affected by the different levels of Shared Values (hypothesis 1), Competence (hypothesis 2) and an interaction of these two (hypothesis 3).

This is similar to the build up for interpersonal trust, because people will often find themselves in a situation where they have to choose between two alternative based on information alone (e.g. when selecting a president among two candidates from different parties). In this case, weighing your options based on the extent to which they project goals similarity and competence might be a useful approach. Note, however that in politics, goal similarity seems to play a more prominent role. The next step in trust establishment would be to evaluate the system based on experience, which was also the next stage in this experiment.

During the interaction stage, confirmation was found for two out of three hypothesis. Results indicated no significant effect that was in line with hypothesis 1 on Shared Values. This might be due to the behavior of the system at the time. In this experiment, the manipulations were carried out through the supply of information alone. Thus, each route problem was solved using the same solution, regardless of the system people were told they were using. Therefore, any positive judgment of the system might quickly deteriorate once its behavior is not in correspondence to people's expectations. Despite the fact that results in this study did not reveal such an effect, it should remain an important consideration in future studies.

As confirmed by hypothesis 2, competence presents a different case, probably because it is more difficult to tell if complex behavior is the result of high or low intelligence. Since the high competence system was said to be aware of traffic conditions and road construction locations, a seemingly illogical route might still be accepted if users believe that the system knows more about the situation than they do. So as a result, unpredictable or complex behaviors might actually be confused for high competence.

Results also confirmed an interaction effect of Shared Values x Competence (hypothesis 3), in the sense that the system Competence has a much larger influence on system acceptance, once the presence of Goal Similarity has been established. This is something that would make sense in our earlier example as well. It does not make much sense to follow the suggestions of a highly competent candidate, if that person is trying to achieve goals that not in line with yours. In that case it would it make more sense to support the advice of a candidate that is somewhat less competent but who shares your aspirations.

Five out of ten routes failed to show significant results on any of the hypothesis, hence some further investigation may be desirable. In case the effects only occurred during the first couple of routes and gradually disappeared towards the later routes, this could have indicated a swift deterioration of the manipulations effects. This does not appear to be the case, however. It is important to note that each route was solved in the same manner, regardless of the system people thought they were using. A risk of this, might be that certain proposed routes might show too much contradiction to the goal it was supposed to follow. An example of this would be the solution to Route 10, as shown on the last page of Appendix II. The fact that this route would be suggested by a system that aims at lowering fuel consumption might be too hard to accept. The same might have occurred for the other routes that were left out of further analysis due to a lack of results. For future reference, it will be better to test the routes beforehand, to determine which alternatives would be the most suitable ones (e.g. which route suggestions could convincingly represent both system goals).

The final trust assessment in this experiment were taken after use. A large variety of trust measures were involved, all of which can be found among the antecedents of interpersonal trust. These revealed several effects that were in line with hypothesis 1 on Shared Values. Results indicated that persons who believed they used a system with similar values: (1) felt more agreement towards the system's recommendations during use, (2) were more motivated to gain understanding of the system's functioning, (3) put more effort into gaining this understanding, and (4) considered the system to have access to more knowledge. Hypothesis 2, on the presence of a Competence effect, was also confirmed by fact that participants who had interacted with a system of high competence would consider that system as having more similar goals, than people who thought they had used a system with less competence. Finally, the presence of an interaction effect of Shared Values x Competence, as stated in hypothesis 3, was also confirmed.

So apart from the implications of shared values and competence on trust before use and acceptance during use, the experiment outcomes also indicated an important effect of Shared Values on the cognitive aspects of Motivation and resulting Effort put into understanding the system. This could be used to support the findings at the second stage (system interaction) of the experiment. It was stated here that people may have a harder time tolerating a manipulation in system values, while it is much easier to understand and accept a variation in competence. This is because consumer products with different competence levels (e.g. high end vs. low end products) are much more commonly encountered in real life situations. As a result, this competence manipulation may not inspire people equally much to try and understand the way in which the competence levels were manifested in this practical application. In fact, the interaction effect found on the Motivation measurement, indicated that system competence only started to play a more important role once an agreement in system values had been established.

Throughout this paper, the concepts of interpersonal and system trust have been considered to be of similar substance. But other studies have made opposing claims. As a result, it might be an interesting topic for a future study to investigate the effects of human-human versus human-system interaction. As mentioned, the presence of system goals may be a relatively novel consideration for users, so their reaction to this might also be different when the cooperative party is not a human being, but a system.

The results in this study have important implications to the field of Persuasive Technologies, because of their general application to situations in which there is a conflict of goals (e.g. in the field of Sustainability) Hence, even the most intelligent system will receive less compliance, if it makes people feel like it is working against them. So it will be important for developers of systems that are aimed at persuading users to change their behaviors, to make sure that their system does not appear too contradiction to the user's own goals, perhaps by masking its purposes. Some examples of this can already be found on the consumer market. Think, for instance, of the home appliances that are designed to reduce energy consumption. Even though consumers may not care as much about saving the environment, they may still choose to buy the product because it will help them lower their electricity bill.

6. REFERENCES

Cvetkovich, G & Winter, P.L. (2007). The what, how, and when of social reliance and cooperative risk management. In M. Siegrist, T.C. Earle & H. Gutscher, H.(Eds.), *Trust in Cooperative Risk Management: Uncertainty and Skepticism in the Public Mind. London: Earthscan: 187–209.*

Earle, A. H., Siegrist, M., & Gutscher, H. (2002). *Trust and confidence: A dual-mode model of cooperation*. Unpublished Manuscript, Western Washington University, WA, USA.

Elliott, D. (1997). *Energy, Society, and Environment: Technology for a Sustainable Future*. Routledge, London.

Fogg, B. J. (2003)**.** *Persuasive Technology: Using Computers to Change What We Think and Do*. Morgan Kaufman. ISBN1558606432, 9781558606432.

IJsselsteijn, W.A., Kort, Y.A.W. de, Midden, C.J.H., Eggen, J.H., & Hoven, E.A.W.H. van den (2006). Persuasive technology for human well-being: Setting the scene. In W. A. IJsselsteijn, Y. A. W. de Kort, C. J. H. Midden, B. Eggen, & E. A. van den Hoven (eds.), *Proceedings of the First International Conference on Persuasive technology for Human Well-Being,* Berlin: Springer Publishers, 1-5.

Kenrick, D. T., Neuberg, S. L., & Cialdini, R. B. (2007). *Social Psychology: Goals in Interaction*, 4th ed. Pearson Education. ISBN 02-055-1715-3.

Lewicki, R. J. & Tomlinson, E. C. (2003) *Trust and Trust Building*. *Beyond Intractability*. Eds. Guy Burgess and Heidi Burgess. Conflict Research Consortium, University of Colorado, Boulder. Posted: December 2003

Siegrist, M., Earle, T. C. & Gutscher, H. (2003). Test of a trust and confidence model in the applied context of electromagnetic field (EMF) risks*. Risk Analysis*, 23, 705-716..

Siegrist, M., Earle, T. C. & Gutscher, H. (2007). *Trust in Cooperative Risk Management. Uncertainty and Scepticism in the Public Mind.* London: Earthscan.

Solomon, R. C., & Flores, F. (2001). *Building Trust: In Business, Politics, Relationships, and Life*. Oxford University Press, New York.

Vries, P. de (2004). *Trust in Systems: Effects of Direct and Indirect Information*. Eindhoven: Technische Universiteit Eindhoven, Proefschrift. ISBN 90-386-2157-4

APPENDIX I - DEPENDENT MEASURES: BEFORE, DURING AND AFTER USE

Three trust measures per system, before use.

Pre 1: How much would you trust this system's advice?									
Fastway Plus	1	2	3	4	5	6	7	8	9
Fastway Light	1	2	3	4	5	6	7	8	9
Econav Plus	1	2	3	4	5	6	7	8	9
Econav Light	1	2	3	4	5	6	7	8	9

Pre 2: How much would you like to use this system?									
Fastway Plus	1	2	3	4	5	6	7	8	9
Fastway Light	1	2	3	4	5	6	7	8	9
Econav Plus	1	2	3	4	5	6	7	8	9
Econav Light	1	2	3	4	5	6	7	8	9

Pre 3: To what extent does this system meet your preferences?									
Fastway Plus	1	2	3	4	5	6	7	8	9
Fastway Light	1	2	3	4	5	6	7	8	9
Econav Plus	1	2	3	4	5	6	7	8	9
Econav Light	1	2	3	4	5	6	7	8	9

Table 1. Three initial trust measures for each system

Three acceptance measures per route, during use

Acc 1: Response to route advice:	
Accept	Reject

Acc 2: To what extent did the advice meet your preferences?										
Very little	1	2	3	4	5	6	7	8	9	Very much

Acc 3: How satisfied were you with the recommended route?										
Very little	1	2	3	4	5	6	7	8	9	Very much

Table 2. Three acceptance measures for each route advice

Three trust measures, after use

Trust 1: How much did you trust navigation system {Name} to always recommend the best route for you?										
Very little	1	2	3	4	5	6	7	8	9	Very much

Trust 2: How much did you trust that navigation system {Name} always had the same goals as you?										
Very little	1	2	3	4	5	6	7	8	9	Very much

Trust 3: How much trust did you have in the knowledge of navigation system {Name}?										
Very little	1	2	3	4	5	6	7	8	9	Very much

Table 3. Trust measures

Two manipulation checks, after use

Goal Manipulation Check: To what extent do you think you and the navigation system were sharing the same goals?										
Very little	1	2	3	4	5	6	7	8	9	Very much

Competence Manipulation Check: How much knowledge do you think the navigation had?										
Very little	1	2	3	4	5	6	7	8	9	Very much

Table 4. Manipulation checks

Final ten trust-related measures, after use

Predictability: To what extent could you predict the routes navigation system {Name} was generating?										
Very little	1	2	3	4	5	6	7	8	9	Very much

Similarity: to what extent did the generated routes correspond with your own solutions?										
Very little	1	2	3	4	5	6	7	8	9	Very much

Agreement: To what extent did you agree with the routes navigation system {Name} was generating?										
Very little	1	2	3	4	5	6	7	8	9	Very much

Pattern: To what extent do you think the navigation system's routes were showing a certain pattern?										
Very little	1	2	3	4	5	6	7	8	9	Very much

Fixed Rules: To what extent do you think the generated routes were based on fixed rules?										
Very little	1	2	3	4	5	6	7	8	9	Very much

Information: How much information about its functioning could you collect through your interaction with the system?										
Very little	1	2	3	4	5	6	7	8	9	Very much

Effort: How much effort did you put into studying the navigation system's functioning?										
Very little	1	2	3	4	5	6	7	8	9	Very much

Difficulty: How difficult was it for you to gain understanding in the system's functioning?										
Very little	1	2	3	4	5	6	7	8	9	Very much

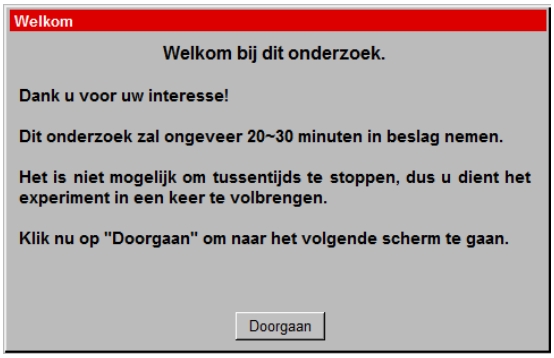
Motivation: How motivated were you to gain understanding in the navigation system's functioning?										
Very little	1	2	3	4	5	6	7	8	9	Very much

Impression: "What was your overall impression of navigation system {Name}?"										
Very little	1	2	3	4	5	6	7	8	9	Very much

Table 5. Additional trust measures

APPENDIX II - EXPERIMENT CONTENT

This section in the Appendix will take you through the experiment. It will provide a step-by-step overview of the information that was provided and the questions that were asked. In some cases, additional comments will be provided. Note that because the experiment was conducted using Dutch subjects only, the entire experiment was written in Dutch. Please follow the screens from left to right and top-down.

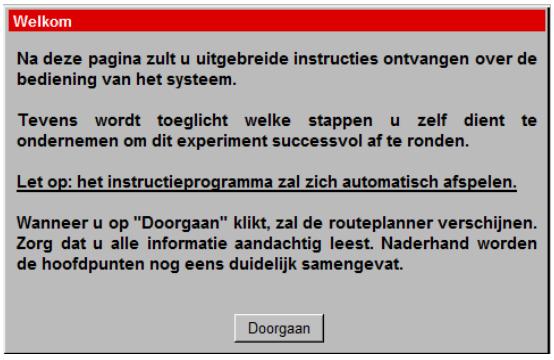


1. Welcoming Screen

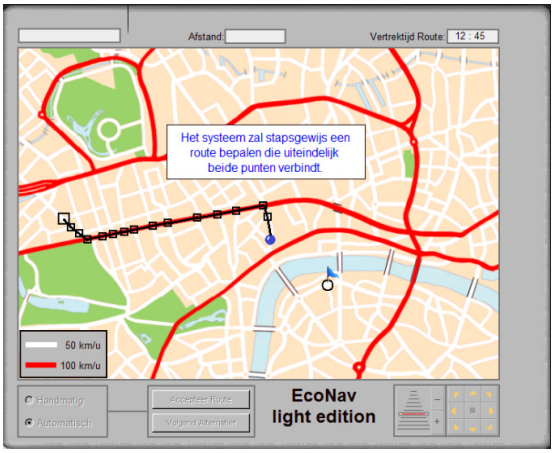
2. Introduction of experiment

3. Introduction of 2 systems with different goals. **Independent Variable 1: (Non-)Shared Values**

4. Participant selects his/her system of preference. Based on the experiment condition and the indicated preference a system will be assigned

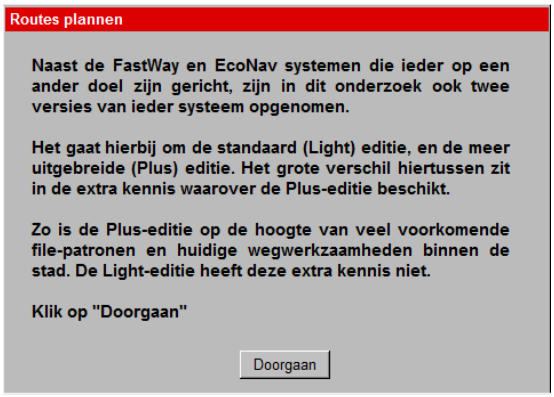


5. The following screens take the user through a step-by-step walk-through of the operation



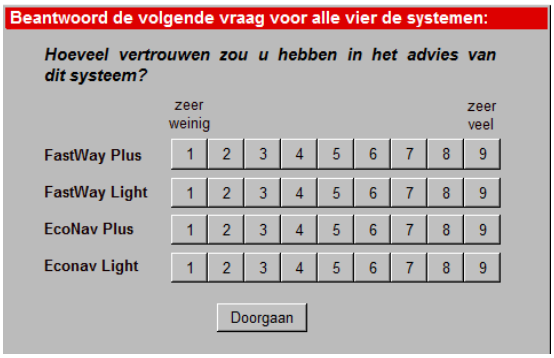
6-14. This is one of many screens used to explain the functioning and operation of the system

15. Summary of operation instructions



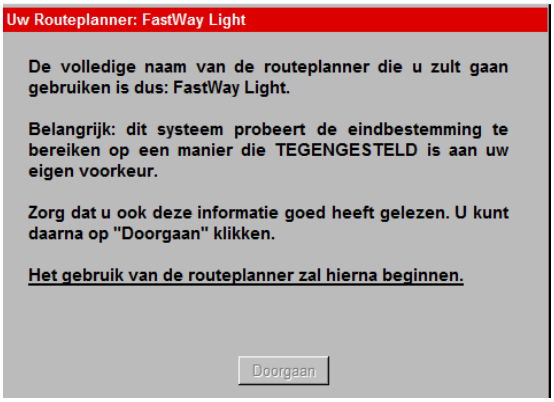
16. Introduction of different system qualities. **Independent Variable 2: Competence**

17. Overview of all four systems. The following 3 screens were used to measure system trust on all 4 systems, before use



18-20. **Trust measures before use.** For all three questions please refer to Appendix I, Table 1

21. Participants are introduced to the system that was assigned to them. They are told which of the two different goals the system pursues (in this case **Fastway**), and what the competence of this system is (In this case it is Low - **Light** edition). Both properties of the system are repeated to make sure that the participants understand what the system is trying to achieve and how competent it will be.



22. On this final screen of the introduction, participants are once more informed about the system's properties. In particular the condition of Independent Variable 1 is stressed: being either Shared (Identiek) or non-shared (Tegengesteld). Once the participant has read this information carefully and made sure it is well understood, he or she can click "Doorgaan" to start the first out of ten trials.

23. **Route 1**. The map is shown including the start point and end marker. Next, the participant activates the system by pressing "Automatic" on the lower left of the screen.

24-26. Solution Route 1, which triggers three Acceptance questions, please refer to Appendix I, Table 2. Each route is followed by these same questions.

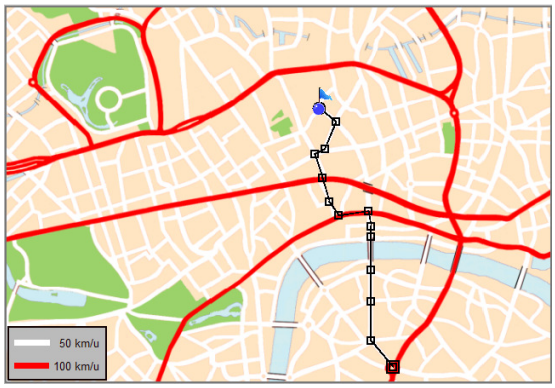
27. **Route 2**

28-30. Solution Route 2 and questions

31. **Route 3**

32-34. Solution Route 3 and questions

35. **Route 4**



36-38. Solution Route 4 and questions

39. **Route 5**

40-42. Solution Route 5 and questions

43. **Route 6**

44-46. Solution Route 6 and questions

47. **Route 7**

48-50. Solution Route 7 and questions

51. **Route 8**

52-54. Solution Route 8 and questions

55. **Route 9**

56-58. Solution Route 9 and questions

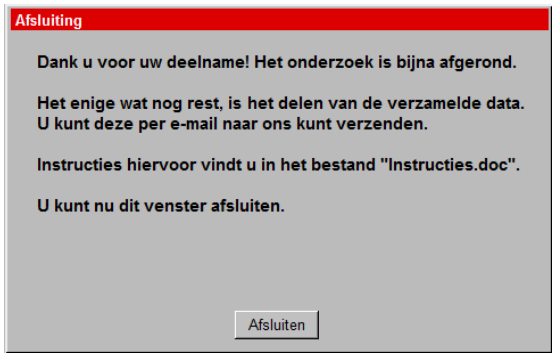
59. **Route 10**

60-62. Solution Route 10 and questions

63-79. Start after use trust measurements. Please see Appendix I, Tables 3-5 for all 15 questions that are part of this trust assessment

80-86. Demographics collection

87-89 Payment information collection



90. "Thank you", and debriefing