

# Trust in Online Technology: Towards Practical Guidelines Based on Experimentally Verified Theory

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**Abstract.** A large amount of research attempts to define trust, yet relatively little research attempts to experimentally verify what makes trust needed in interactions with humans and technology. In this paper we identify the underlying elements of trust-requiring situations: (a) goals that involve dependence on another, (b) a perceived lack of control over the other, (c) uncertainty regarding the ability of the other, and (d) uncertainty regarding the benevolence of the other. Then, we propose a model of the interaction of these elements. We argue that this model can explain why certain situations require trust. To test the applicability of the proposed model to an instance of human-technology interaction, we constructed a website which required subjects to depend on an intelligent software agent to accomplish a task. A strong correlation was found between subjects' level of trust in the software and the ability they perceived the software as having. Strong negative correlations were found between perceived risk and perceived ability, and between perceived risk and trust.

**Key words:** Trust, user modeling, empirical research

## 1 Introduction

“Without trust the everyday social life which we take for granted is simply not possible” [1]. Trust is fundamental to everyday life. Relationships between people could probably never build without trust. Clearly, trust is not only fundamental to our everyday social life, but also to many of our everyday interactions with technology. This is especially the case as we depend more and more on increasingly complex and even autonomous technology.

As trust is such a fundamental aspect of everyday life, much effort has gone into defining trust. Yet, for all the effort spent on defining trust, surprisingly little effort has gone into experimentally verifying what makes any given situation require trust. What characteristics or features of a situation make that situation require trust?

The purpose of the present work is to understand how the need for trust arises in given situations of human-technology interaction. We propose a model that describes the elements that characterize a trust-requiring situation and experimentally evaluate the proposed model. To achieve this, we will proceed as follows: in section 2 the topic of trust will be introduced. First, we will discuss what trust is not. Second, we will discuss what trust is by reviewing some of the main definitions given in trust research, and distinguishing between various stages of trust. In section 3 our model will be presented. A method to test this applied model will be discussed in section 4, followed by the results of an experiment in section 5 and a discussion thereof in section 6. Finally, in section 7 conclusions will be drawn from these results and suggestions will be made for future work.

## 2 Background

### 2.1 What Trust Is Not

**Trustworthiness.** Two terms that are often confused are trust and trustworthiness. Trustworthiness is a property of the person or thing being trusted (the trustee) as perceived by the person doing the trusting (the truster). Trust, on the other hand, is not a property of the parties involved in a situation of trust, but an attitude of the truster toward the trustee [2], or a mechanism that makes trusting behavior possible.

However, trustworthiness is not an immutable perceived property. Once a truster has assessed the trustee's trustworthiness, formed an attitude of trust, and acted upon it, the outcomes of that interaction influence the perceived trustworthiness of the trustee. If the outcomes were beneficial to the truster, the perceived trustworthiness of the trustee will be confirmed or reinforced. If the outcomes of the interaction were detrimental to the truster, that is, the truster's trust was unjustified, the perceived trustworthiness of the trustee will decrease. The perceived trustworthiness of a trustee could be viewed as a record of properties of the trustee that are relevant to a situation of trust.

**Confidence.** Trust is also frequently confused with confidence [3] [4]. Confidence can be described as a strong conviction based on substantial evidence or logical deduction [5]. On this view, confidence is an attitude that involves little regard of possible negative outcomes, because there is substantial evidence that the outcome will be positive.

Trust, on the other hand, necessarily involves the consideration of possible negative outcomes. Trusting involves recognizing and especially accepting risk; it involves choosing one action in preference to others, in spite of the possibility of being disappointed [3]. One can choose not to take such a risk, but in doing so one forgoes the benefits associated with taking that risk.

**Faith.** As a mental attitude faith is similar to the attitude of trust, though the concepts differ in an important way. Faith can be seen as an “emotionally charged, unquestioning acceptance”; it does not require evidence [5]. It is what we are left with if we remove all cognitive content from trust [6]. On this view, an attitude is formed that the outcome of the situation will be positive, but this attitude has little or no evidential basis, or no evidence is taken into account.

The mental attitude of trust does involve an amount of deliberation. As mentioned earlier, it involves recognizing and accepting risk. In recognizing risk one identifies evidence for possible negative outcomes of the situation. One also willfully accepts the recognized risk based on evidence that a positive outcome is possible. “[T]rust is an expectation based on inconclusive evidence [and] is tolerant of uncertainty or risk” [5].

**Reliance.** The acts of reliance and trust both involve depending on someone or something. Reliance can be seen as “complete confidence, a presumptively objective state where belief is no longer necessary” [5]. Reliance does not necessarily involve the assessment of the possible outcomes of the act of reliance. One can rely on someone or something without trusting that person or thing [7].

The act of trust, on the other hand, necessarily involves forming expectations and taking risks. It involves a prior assessment of possible outcomes and an acceptance of the risk involved in taking the trusting action. It is tied to the attitude of trust that precedes the act, briefly described above.

## 2.2 What Trust Is

The main focus of this paper is identifying what makes trust needed, not defining what trust is. Nevertheless, it is useful to discuss some conceptualizations of trust to place the present work in perspective.

Research on trust spans several disciplines, such as sociology, psychology, economics, and computer science, leading to a vast amount of different definitions of trust. Some of the most influential works will be discussed here.

Many definitions of trust assume the point of view of the truster. Trust is frequently defined as a set of expectations that the truster has regarding the actions trustee that are relevant to the truster[8]. Trust is also defined as a truster’s subjective probability regarding the trustee’s actions that are relevant to the truster [9]. Such views of trust are limited to the truster’s expectation that someone (or something) will perform actions that are relevant to the truster’s own actions. These conceptualizations describe an attitude that precedes trusting behaviors. In trusting behaviors “one party behaviorally depends on the other party” [10].

Trust is often defined as more than the truster’s expectations. Many definitions assert that trust invariably involves an element of risk [6]. Trust is described as an attitude that allows for risk-taking decisions [4]. Trust is similarly defined as “the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the truster, irrespective of the ability to monitor or control that other

party” [3]. This willingness may be one of the few characteristics common to all trust situations [11]. It also describes an attitude that precedes trusting behavior. The trusting behavior involves assuming risk [3], so the attitude of trust that precedes it must be a mechanism that enables one to cope with perceived risk.

### 3 Proposed Model of Trust-Requiring Situations

The studies described above and many others attempt to define what the attitude of trust is, what the attitude of trust is based on, or what the behavioral outcomes of trust are. Very few attempt to identify why trust is needed in certain situations. Here we will do exactly that. We will describe the type of situation in which trust is needed. For the remainder of this paper, we will view trust as a mechanism to cope with the uncertainty and perceived risk that elements that we describe bring forth.

#### 3.1 Human-Human Interaction

**Goals.** Goals are the primary characteristic of trust-requiring situations. They can be described as desired outcomes (of an event) toward which efforts or actions are directed. Though there is a lack of explicit mention of goals in trust research, this does not mean that goals are ignored altogether. The basis of trust is indirectly explored in terms of the truster’s goals by a number of authors [12]. Trust would not be a consideration if the truster did not depend on the trustee to perform actions conducive to the truster’s goals [12].

**Perceived Lack of Control.** Goals alone are insufficient for a situation to require trust. The truster must also perceive a lack of control over the relevant actions of the trustee. Perceived control is understood here to be the power the truster perceives having to influence or direct the trustee’s actions.

Trust is only necessary if there is a perceived lack of adequate control, as not having control over the actions of the trustee is a source of uncertainty regarding the the trustee’s actions [13], and thus regarding the achievement of the truster’s goals. Trusting another person might serve as a means of compensating for perceived lack of control in a situation [14].

**Perceived Ability.** Some other factors have to be taken into consideration. In the type of situation described here, the truster does not merely assess his or her own goals and proceed to form a trusting attitude toward the trustee. If a truster has a goal that requires the actions of someone else to achieve, the truster will always make some form of assessment about the ability of that person to perform the actions necessary to achieve the truster’s goals.

Several authors have explicitly recognized the role of ability as an antecedent to trust, as reviews of literature in [3] and [13] clearly demonstrate. On this view, ability can be considered to be the ability of the trustee that is relevant to the truster’s goals. Without this ability, the truster’s goals could not be achieved.

**Perceived Benevolence.** The truster must also perceive that the trustee is actually positively willing to enact the ability the truster perceives. In other words, the truster must perceive an amount of benevolence in the trustee. As a characteristic of the trustee perceived by the truster, benevolence can be understood as the intention or willingness of that trustee to carry out the actions required to achieve the truster's goals [3]. If the trustee were not willing to carry out these actions, the truster's goals could not be achieved.

**Uncertainty and Perceived Risk.** In most situations, the truster will be uncertain of the ability and benevolence of the trustee. This uncertainty entails a possibility, increased by the perceived lack of control, that the truster's goals will not be achieved. So, there is a perceived risk that the truster's goals will not be accomplished. In trust-requiring situations, uncertainty and risk can be seen as consequences of the elements of the model proposed here.

**Interrelationship.** Perceived full control eliminates the need for trust, as does certainty regarding the presence of both ability and benevolence by eliminating perceived risk. Certainty regarding the absence of either ability or benevolence leads to certainty that the goal will not be achieved, forcing the truster to find another trustee or redefine his goal and eliminating the need for trust. In all situations between these extremes, ranging from situations in which the achievement of the truster's goal is almost certain, to situations in which the truster's goal will almost certainly not be achieved, there is a need for trust. Situations toward the positive end of this spectrum require little trust, and in situations toward the negative end of the spectrum high amounts of trust are needed to depend on the trustee to perform the actions necessary to achieve the truster's goal. The amount of trust needed to depend on the actions of another is influenced by the truster's propensity to trust. A truster with a lower propensity to trust will require more trust in all situations within the described extremes. A truster with a high trust propensity will require less trust in said situations. The importance or intensity of the truster's goal also influences the level of trust needed. The interaction of these elements can be expressed with the following formula:

$$T = G_i (1 - C) ((1 - A) + (1 - B)) - T_p \quad (1)$$

Where  $T$  is the amount of trust needed,  $G_i$  is the intensity of the goal,  $C$  is the amount of perceived control,  $A$  is the perceived amount of ability,  $B$  the perceived amount of benevolence, and  $T_p$  the propensity to trust or baseline trust.

### 3.2 Human-Technology Interaction

The truster's goal, perceived lack of control, and perception of the ability of a specific technology then interact to determine the amount of trust needed to

depend on that technology. Benevolence does not seem to be involved, as strictly speaking, technology does not possess such intention or willingness.

We hypothesize that the amount of trust needed to depend on a technology will increase as the intensity of the truster's goal increases, the perceived lack of control increases, and the uncertainty regarding the presence of ability increases (without there being certainty regarding inability). In a sense, the amount of trust required is a transaction cost of depending on the actions of another. Perceived control, perceived ability, and propensity to trust can lower this cost. The amount of trust the truster initially has while depending on the actions of the trustee will have to match the amount of trust required, or no depending can take place. In the following section we will describe a method used to test this model.

## 4 Methodology

To assess the applied model proposed here, we used an experimental survey approach to collect data from a cross section of internet users. Various methods were used to recruit subjects. Initially a group of 50 people was approached through personal messages on a popular social networking site and through e-mail. These messages stated that a new product was being evaluated in cooperation with a major Dutch university, and participants were needed to help evaluate it. All participants, it stated, were eligible to win 20 Euros. A second group of 429 people was approached by e-mail. In addition, advertisements were purchased through an advertising service of a large search engine. The advertisement was displayed next to search terms that included terms such as "investing software", "online investment", and "online investing tools". The advertisement was displayed 20,217 times. We intended to attract subjects interested in the type of software the experiment attempted to mimic. Also, an invitation to participate was placed on an internet forum for computer science graduate students at a Dutch university.

From the group of people that were contacted, around 80 people visited the initial page. Of these visitors, one had an IP address in the United States, one in the United Kingdom, and the rest in The Netherlands. 26 people actually completed the survey (23.1% female, 76.9% male).

A website was constructed to mimic various popular online investing tools. The intention was to create the impression that an actual novel product was in development, and that subjects were testing the performance of that product. A website was chosen due to the ease with which it allowed subjects to be recruited and due to the natural setting (subjects own computers) it allowed for. As stated by Bhattacharjee, the Internet is the most effective way to reach a population of online users [15].

After an initial test with 5 users, adjustments were made based on feedback and the experiment was launched. Participants were lead to believe they were evaluating a new online investment product, an autonomous software agent that invested users money. The interface of this supposed product was designed to

resemble existing online financial products. Participants were asked to select an amount to allow the software to invest. Participants were placed in one of four experimental situations in which the supposed ability of the software and the control of the participant over the actions of the software were manipulated.

To manipulate certainty regarding perceived ability, data on the software's past performance were provided in a graph, and attributed to either a verified source or the software itself. We assumed uncertainty regarding perceived ability would be higher if performance data was attributed to the software. Perceived control was manipulated by either offering an undo function, which allowed the invested amount to be changed before fully committing to it, or not offering one. We assumed that if the delegated investment could not be changed, subjects would perceive less control over the software.

For the questionnaire, component items for perceived control were adapted from [16]. The component items for perceived ability were based on [15]. For perceived risk, component items were adapted from [17] and [16]. Items for trust propensity were based on [18]. Finally, items for trust were based on [19]. Component items for the goal construct were constructed for the present work and not based on previous work.

## 5 Results

Each element of the model was measured with two questions in the post-task questionnaire. Internal consistency of the scales was measured by performing a reliability analysis of the questionnaire. This analysis yielded Cronbach alpha coefficients between .548 and .764. For an exploratory experiment with this sample size, we considered these coefficients to be acceptable.

Following the reliability analysis, a Kruskal-Wallis one-way variance analyses were conducted to assess statistically significant differences in the various variables across the four experimental groups. This non-parametric test was chosen due to the small sample size and lack of normally distributed data assumed in parametric tests. The analyses did not reveal any statistically significant differences in the levels of any of the variables, or even time spent on the task, across the four different experimental groups. The lack of differences between experimental groups suggests the ability and control manipulations did not have a significant effect.

The amount participants allocated to the agent was also included in the data for experimental situations B and D. A Mann-Whitney U test revealed no significant difference in the amounts allocated in situation B ( $Md = 13.695$ ,  $n = 6$ ) and in situation D ( $Md = 8.0$ ,  $n = 6$ ),  $U = 9$ ,  $z = -1.462$ ,  $p = .144$ ,  $r = .42$ . Again, this suggests a lack of effect of the manipulations, though in this case ability was the only element manipulated across the two situations.

Finally, relationships between the post-task questionnaire items were investigated using Spearman rho correlation coefficient. There were a number of significant correlations. There was a strong correlation was between ability and trust,  $r = .613$ ,  $n = 26$ ,  $p = .001$ , with low levels of perceived ability associated

with low levels of trust. Further, risk was strongly, negatively correlated with trust,  $r = -.684$ ,  $n = 26$ ,  $p < .001$ , with low levels of trust perceived associated with high perceived risk. Finally, ability and risk were negatively correlated,  $r = -.418$ ,  $n = 26$ ,  $p = .034$ . Here, low levels of perceived ability are associated with high levels of perceived risk.

## 6 Discussion

Our hypothesis was that the required amount of trust would increase as the importance of the goal, the perceived lack of control, and uncertainty regarding the trustee's ability increase. We also stated that the uncertainty regarding the trustee's ability entails a perceived risk that the truster's goals will not be achieved. The correlations we found between ability and trust, and the negative correlations between trust and risk, and risk and ability, suggest that when certainty regarding perceived ability is low, the perceived amount of risk will be high. When perceived ability is low, the amount of actual trust will also be lower.

There are some limitations to the present study. Most importantly, we cannot rule out the possibility that our definitions of trust and trustworthiness, and the distinction we make between them, were not shared by test subjects. For example, correlations found between perceived ability and trust could actually be indicative of a relationship between perceived ability and perceived trustworthiness.

Also, the sample size of 26 was small. Some e-mail responses to the invitation to participate suggested the invitation was seen as an unsolicited e-mail advertisement for a commercial product, which could explain why a large number of people did not even visit the site. If it was seen as an advertisement an actual product, on the other hand, the e-mail worked exactly as intended.

The low number of people that proceeded after visiting the first page could be explained by the length of the introductory text, or the fact that the text was in English and the majority of the people contacted was Dutch. The request to submit an e-mail address to be eligible to win the prize money could also have discouraged potential participants from participating. Another possibility is that potential participants could not muster enough trust to visit the site based on the e-mail, or proceed with the experiment based on the introductory text.

A further problem was the lack of sufficient differentiation between manipulations. Possibly, participants failed to notice the statements regarding the agent's ability or the participant's control. Although participants in a preliminary test deemed the interface understandable, there remains a possibility that participants in the eventual experiment found elements of the interface unclear. More than half of the participants spent less than a minute viewing the main interface, so it is also possible the manipulated elements were not noticed by participants.

Another problem with the task and subsequent questionnaire was mentioned by a participant in the preliminary test and a participant in the final experiment. They indicated that it was difficult to answer questions regarding the ability of

and trust toward the agent, because they had not had a chance to familiarize themselves with the website over a longer period. It is possible that other participants experienced this as well, however one of the purposes of the experiment was to study situations of initial trust with unfamiliar technology. Ideally, a balance would be found between letting participants familiarize themselves enough to be able to answer questions with some confidence, while still being able to speak of a situation of initial trust.

Finally, the present work only involved experiments involving one instance of unfamiliar technology. While this gives some insight into the characteristics of trust-requiring situations involving unfamiliar technology, to build a more complete picture of the general underlying mechanisms, experiments should involve several instances of technology.

## 7 Conclusions and Future Work

This paper set out to examine which features underlie trust-requiring situations, particularly situations of initial trust. It further sought to assess the extent to which these mechanisms can be considered universal, that is, extend beyond interpersonal trust to human trust in the things humans use. Throughout most of the literature reviewed here, though differences abound, the consensus is clear: everyday life would be impossible without trust.

To discover what defines a trust-requiring situation when humans depend on humans and when humans depend on technology, fundamental elements of the emergence of the need for trust in new situations were identified. For a situation to require trust, each of the following elements must be present: the truster's situation-specific goals, which required the actions of another to achieve; the truster's perceived lack of control over those actions; the uncertainty the truster has regarding the trustee's ability to achieve the truster's goals; and the uncertainty the truster has regarding the trustee's benevolence toward achieving the truster's goals. It was argued that this model, with the exception of benevolence, can be applied to human-technology interaction. As it is not clear that benevolence is a property of technology, it was left out in the present work. Correlations found between perceived ability, perceived risk, and trust offer support for this model.

Future work should take the limitations of the present study into mind. It is important to examine these mechanisms of trust across a wide range of ages. As younger generations are born into a world in which technology is increasingly ubiquitous, it will be intriguing to see how this affects their trust in technology, and, as a result perhaps, their trust in general. There is no need for future research to be limited to online environments, though. To truly assess the general applicability of the model proposed here to human interactions with technology, as many instances of technology as possible should be tested. New forms of technology emerge every day, and models that are too tightly attuned to specific technologies will become obsolete as soon as those specific technologies do. To be able to cope with such changes, models of trust should be tested on new technol-

ogy with every opportunity that arises. Ultimately, a thorough understanding of why we need to trust some of the technology we use every day, will help us make technology easier to trust.

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