A Model for Human-Computer Trust
Contributions Towards Leveraging User Engagement

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Abstract. Trusting is a rather complex phenomena and this complexity has been increasing with the pervasiveness of computing systems. In this virtual realms, Human-computer trust represents a key issue in today's organizations, and it has a significative role in leveraging interactions and mediating interrelationships and auto-regulate knowledge sharing processes.

This paper reports an research framework, which aims to facilitate the use of the acquired understanding of the role of trust in (A) Human Computer Interaction; and in (B) Computer mediated Interaction.

Results situate the model as a key contribute for leveraging people's interactions and their technological artefacts.

Keywords: Human-computer Trust, User experience, Trusted interactions, Social engagement, Collaborative Learning.

1 Introduction

Computing is at one of its most exciting moments, playing an essential role in supporting human activities, facilitated by the growing availability of services, devices and interaction modalities. With the evolution from the large-scale computing to the contemporary pervasive and ubiquitous computing interaction paradigms, users were brought from the periphery to the successive waves of the personal, networked, collaborative, mobile, augmented and virtual reality interaction paradigms.

This article describes a research framework that builds on the previously body of knowledge on Trust and uses it to contribute towards leverage higher levels of engagement and overall systems sustainability.

The first part come in line with authors attempt to situate Trust as a contribute to better understanding of the role of trust in Human Computer Interaction; and in Computer mediated Interaction. This part provides a comprehensive introduction to Human-computer trust conceptualisation and it address it dynamics. The following parts addresses authors' conceptual contribution on Human-computer trust, then it ends by provide possible future directions.

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2 Human-Computer Trust

Everyday, and often without any reflection, we place our trust in people and in services those people provide. We trust our friends will not betray our confidence; that our food will not be poison; we trust our teacher and parents to tell us the truth and teach us well; trust our country; the list here is practically endless and staggeringly broad. Trust was always a topic, which is of ubiquitous importance to people.

Trust is referred in a relatively broad set of constructs. Is a topic that has been attracting research from many fields like sociology, economics, psychology, cognitive sciences and lately from computer science. Yet, Trust is a topic, rather complex to address, making it difficult to compare or to provide clear insights about the nature of trusting relations (e.g. Rotenberg, 2005; Mayer et al., 1995; Goudge, 2005; Fukuyama, 1995; Lewis and Weigert, 1985).

Trust's cross-disciplinary nature has originated a considerable debate about what trust is, how it is influenced, and how it is represented; makes it difficult to be defined in a narrow definition, or just as a "single static" concept; trust per si, carry's many meanings and play a role in divergent contexts.

While sociologists tend to see trust as structural in nature (e.g., Garfinkel, 1967; Lewis & Weigert, 1985; Shapiro, 1987), or in terms of behavior (e.g. James S. Coleman, 1996;) or even as a moral choice (e.g. Francis Fukuyama, 1995; Tyler and Degoey, 1996).

Psychologists examines it as a personal attribute (e.g., Erikson, 1968; Rotter, 1967) and analysis trust as behavioral intention (relates to the predict acceptance of behaviors by others). (e.g. Erikson, 1968; Rotter, 1971)

Social psychologists tend to view trust as an interpersonal phenomenon (e.g., Deutsch, 1973; Holmes, 1991; Mishra 1996; Weber 2003; Meyerson, 1996), a social structure to provides interpersonal relationships, known as institution-based trust or willingness to trust if within a more social physiological perspective.

Economists are more inclined to view trust as a rational choice mechanism, as a game (the game theory) (e.g. Levy and Razin, 2003; McKnight, D., H., Chervany, N. L., 2001).

The philosophic perspective sees trust and distrust attitudes as something that affects our feelings and the way we think and act (e.g. Baier, A. 1986; McLeod, C., 2006).

Computer scientists on the other hand, tend to approach the Trust topic from two distinct perspectives. One that reflects the tendency to examine Trust from a more deterministic approach; observing it as a sort of rational choices vs a measurable risk. Examples can be found in literature that addresses issues like Trust management or computational trust associated with security, reputation and privacy (e.g. Kini, 1998; Abdul, 1999; Walter, 2008).

Another, point of view relates Trust to the human cognitive and affective aspects. An approach that focus on qualifying the trust attributes and in understand the potential Trust implications among human users. Examples can be found in literature that addresses issues like computer supported collaborative work, communities of practice, design for trustful interactions, social capital,

Table 1. Trust conceptualisation framework

Sociologist's	Trust is a reflection of behaviours, choices and decisions	Represents a intention
Psychologist's	Trust is an attitude or intention	Represents a personal attribute; an observable behaviour.
Socio-psychologist's	Trust is an interpersonal phenomenon	Represent a social structure
Economist's	Trust is a rational choice mechanism	Represent a rational decision
Computer science	Trust is user's confidence in a system and their willingness to act	represents a cognition and affect based perceptions of another person or group and an artifact.

Organizational Trust, Technology-Mediated Social Participation (e.g. Bachrach, 2001, Mcknight 1996, McKnight, 2002, Constantine, 2006; Weber, 2003; Yan, 2006).

3 Measuring Human Computer Trust

Human-computer trust is defined in this study to be a measurable risk, represented by a deterministic quality (measured during a snapshot in time) or a observable attitude, represented by more subjective and hedonic quality (measured during an episode in time).

Both tendencies are invariable reflected throughout and within the trust social dynamics; and this dynamics represents, not just, the interaction between individuals constituent of society or organisation and their communication artifacts, but also represents the interaction between a user or a group of users and their artifacts.

Trust within and interactive processes, represents users predisposition to interact (based on a calculative orientation toward the risky) ; i.e. by trusting we assume a potential gain, while by distrust we are avoiding a potential loss [1, 5]. Trusting, also represents a reinsurance elements, which often helps users to support their intended behaviours.

This reinsurance mechanisms can be combine through a set of measurable observable behaviours that emerge from social and technical categorizations, e.g. group or individual's political, economic and social orientation [4], or from institution-base properties [6, 10]; or even from certain social qualities like honesty, benevolency or reciprocity [**?**].

This reinsurance mechanisms give party's the structural assurance or confidence that support individuals' trusting predisposition, that further in time takes a form of trusting stance, i.e. belief in others.

In sum, Trust is a reflection of a a state of mind a confidence and one's predisposition to trust another. This based on a set of perceptions of other (a society, a person, and or a technological artifact) as 'trustworthy' [3, 9, 11]. Formed by a combination of observable behaviours which includes perceived affect and cognition based behaviours [2]. And, a violation of trust usually lies not in a simple isolated interpersonal event, but rather it is a significant event that is likely to have impact on the parties and on the relationship [12].

Trust dynamic, then contemplates a subtlety decision that lies on the complexity of the game that he or she find herself playing as Bacharach [1] describes it. Within this 'game' trust comes associated with a time anchor proprietary, represented by an initial trust moment (trust exist or not) and an ongoing trust moment (trust can be weaken or strengthen over time) [8].

More, the identification of trustworthy making qualities (what underlies people's trust beliefs) is not enough to induce trust, it is needed also to understand if this signs of trust are to be trusted (confidence) [1]. What addressees the question of the reliability of trustworthy making qualities, especially in a virtual environments where there is an increased omnipresence of social network services and communities.

Thus, this paper contribute towards the identification of possible trustworthy making qualities and signs that support user's predisposition to trust. It proposes a model, a model of Human-computer Trust and uses it to perceive how it can contribute to leveraging user's engagement with and through their technological artefacts.

This works herein presents aims in the future to contribute to the development of strategies for support interdisciplinary teams when assessing, designing and creating trust-fostering interactive systems; and or to support the design, development and evaluating of a toolset to monitor Human-computer trust levels, thus facilitating the deployment of trust level regulation interventions.

4 A Model of Human-Computer Trust

This model depict trust as a construct informed by individual attributes qualities such as, motivation, willingness, reciprocity, predictability, honesty, benevolence, and competence, and determined the extent to which one relates with one?s social and technical environment [14, 17].

This model was used as a research lens to establish relations that linked trust online interactive processes qualities, e.g. to openness [13], to sharing [18], to privacy [7] and to collaboration [15]

This model was achieved by an extensive literature review on trust and was complemented by a participatory design procedure, that resulted in

- the Identification of most common trust notions (design a concept map);
- An personal unified view of possible trust implications in today?s online communities structures (participatory design session with experts and users) [16];

This was complemented by a personal unified view of trust dynamics (see section 3) and Davis and Venkatesh Technology acceptance views [3] [19].

This model takes into consideration seven trust observable warranty qualities, that help users to categorize their trust beliefs towards a system or another individual or even a third party. Those trust belief's support a set of constructed intentions, predispositions to trust that facilitates the interaction process (e.g. share, communicate and or relate online).

This is a iterative process, that evolves through time, see figure 2.

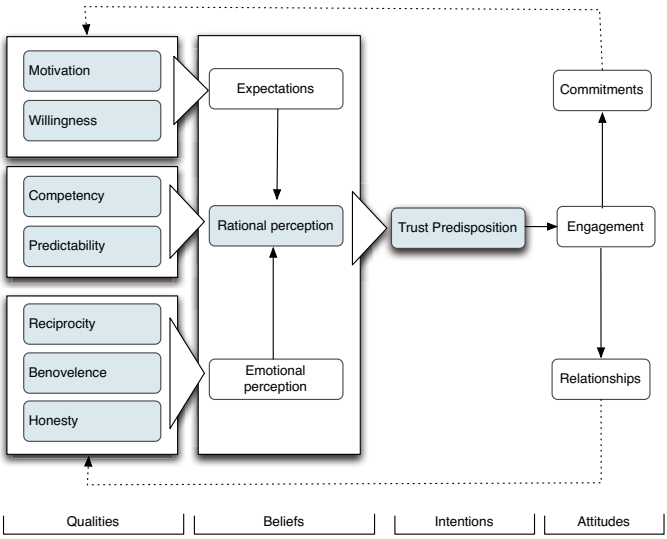

Fig. 1. A model of Human-computer Trust

Further section present the results on the validation of this model, its uses a mixed method study and it procedure is described in the following section 4.1.

4.1 Model Validation Process

Above presented model of Human-computer Trust aims to contribute to leverage higher levels of user engagement with other users and artifacts. This validation was achieved through mixed method studies, combining divergent research approaches over a period of time. During each validation process the set of constructs attributes underwent in a series of refinements to eliminate or refine the above presented model, see figure 2.

4.2 Attitudes Towards Others, Sharing and Communicate Online

This first research iteration aimed to determined the extent to which one is predispose to relate online in a specific social and technical environment.

To achieved above aims a survey was randomly conducted among 480 individuals, who interact online frequently for education purpose. From those three-hundred and forty (340) individuals were consider for analysis, the remaining where either incomplete or where consider biased. Participants where portuguese teachers 53.5 % or portuguese higher education students 46.5%).

A confirmatory factor analysis was applied to test if the empirical data was conform the proposed model. This factorial analysis process included question that assessed (1) individuals' trust towards others; (2) their expectations to engage in give and take actions, and (3) their predisposition to engage in online relationships. This analysis toked into consideration the proposed Human-computer trust warranty qualities addressed in the instrument and intercept those with the divergent nature of the online relationships (ranging from more close and intimate relations (e.g. friends, family, colleague), to open (e.g. acquaintance, strangers).

Results of the principal components analysis strongly support the relationship between users perceived trust and their intentions and attitudes towards others.

In sum, achieved results also stress a need for a clear understand this trust elements as a key factor for leveraging user engagement with and through interactive systems [18].

4.3 Attitudes towards Openness and Sharing Knowledge

This second study aimed to establish a relation between the proposed Human-computer trust warranty qualities and users believes towards using openness and open sharing knowledge systems.

This study included two main contexts of use:

- Estonian Higher education students (32), with experience in using open-base blogging systems; and
- Estonian Secondary education students (53), with no or little experience with open-base blogging systems.

Estonia is consider to be a peculiar country in terms of ICT use, as at the high school level the new National Curricula states an obligation for every school to have an e-learning environment. At the level of universities and vocational schools there are a lot of choices of open and non-open solutions to choose from, e.g. Wikiversity, Moodle, Blackboard, IVA, LeMill, WordPress, etc.

Results revealed that user's attitudes towards openness and sharing depends on the information they share and with who they share that information.

For example uses that are more aware of potential threats of privacy tend to stress more for being assured that their open activities are protected from potential threats [7].

Also, in both cases users indicated they don't mind to share learning information openly with everyone (if they feel control on what they share in open environments). In fact as for example 37.93% of the Higher education students claim that this could contribute to increase the learning processes reliability and

credibility [13]. But, given the choice, they prefer to share personal information and comments with their friends; family and co-workers only.

Strong concerns where shown special on the need to have control with whom they share their grading, assignment comments and teacher's feedback information. They claim that should remain private by default.

Regarding the intention to share in open environments attributes like: honesty (48,28%), other users reputation (37,93%), respect and affinity attitudes (31,03%); as well as empathy and sympathy (41,38%) are consider very important qualities to be willing to share information and to trust online. Same regards to friendly and transparent attitudes (44,83%); Honesty (44,83%); sense of belonging (27,59%) and mutual respect (37,93%) are consider very important qualities for communicate online.

4.4 Human-Computer Trust and Collaboration

In this case study we focus on using the teacher role as lens to observe possible relations between Human-computer trust and collaborative activity patterns like:

- Individual commitments and group bound;
- Group support and articulation; and
- Social dynamic activity.

The observed course "Technology Enhanced Learning TEL course, was part of a European project called CoCreat — "Enabling Creative Collaboration through Supportive Technologies" (http://let.oulu.fi/cocreat). The course, was deployed by four (4) partners from eight (4) different European countries, Finland (University of Oulu); Norway (Norwegian University of Science and Technology Trondheim); Romania (Valahia University of Targoviste); and Estonia (Tallinn University).

Project main purpose was to find new solutions for promoting creative collaboration in terms of new and innovative learning models based on social media and mobile technology. Most activities performed in the course involve collaborative tasks, collaborative thinking and reflection. In the course students were initially divided into small groups (from 4 to 9 students maximum) and different tutors were assigned to the groups. All learning activities were design and coordinated by a teacher who coordinate overall group activities.

Be willing towards fulfilling a common goal (predisposition to interact) is consider to be an important key to establishing group collaboration and to ensure it success. The results indicated that those who were more predispose to interact (easily engaged in online activities) had more sucess in perform collaborative activities and in foster groups collaboration.

On the other hand, individuals competency and their appetency to be engaged in online relationships aren't always related (this was clearly reflected during group synchronous communications). The less social engaged, committed students tend to follow group and contribute punctually when requested.

Contradictory to what was expected open or close activities seamed less important for ensure the success of the group support and articulation. On the

other hand qualities like reciprocity, kindness and benevolence were important attributes to ensure students bound and work articulation.

Overall group-working methods differentiated from group to group, though in the end the majority of the groups achieved pretended results. Groups first activities were relevant to set the work climate and to establish future working actions (know how to behave and to observe other intentions and attitudes). Major group concerns regarded the previsibility, e.g. predict what actions will be need to be taken to ensure a successful collaboration. In return, system predictability and and it perceived competency were important attributes for selection of artefacts to communicate and use in their collaborative activities.

5 Final Considerations

Our contribution towards perceiving Human-computer Trust enabled to better understand the Human Computer Trust role in,

- providing effective social human relations;
- create, develop and maintain working, organisational, or networking relationships; and
- create, develop and maintain a learning environment which eventually could lead to sustainable online engagements.

As well this model future contribution is towards perceiving Trust as an interaction facilitator construct. Contributing to the development of strategies for support interdisciplinary teams when assessing, designing and creating trust-fostering interactive systems; and or to support the design, development and evaluating of a toolset to monitor Human-computer trust levels, thus facilitating the deployment of trust level regulation interventions.

The underlying hypotheses for this future aim is that real time monitoring of self and third party trust levels can in fact be used to trigger interventions designed to regulate (moderate, improve, recover) trust levels to adequate standings.

Thus, as on the design, development and evaluation of tools to monitor trust levels based on the current understanding of the construct, the proposed research questions are:

- What data can be used to monitor trust?
- How often should data be sampled to generate robust trust indicators?
- How should data samples be collected taking into account that the impact of the sampling process in the generation of confidence indicators should be minimized?
- What metrics should be used to express trust levels?
- How should trust indicators be interpreted?

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