Chapter 23
A Socio-Cognitive Perspective of Trust

Joana Urbano, Ana Paula Rocha and Eugénio Oliveira

Abstract Trust and reputation are two distinct social constructs of high complexity that have been studied for decades in different areas of knowledge. In order to allow for efficient models of computational trust and reputation, one must first understand the nature and dynamics of each one of these constructs. In this chapter, we focus on the social and cognitive aspects of the trust concept, and overview its fundamental characteristics, such as its determinants, nature, and dynamics. Then, we present two distinct hypothesis one can state for the interplay between trust and reputation: either reputation is an antecedent of trust, or both are considered as two distinct contributions to the ultimate decision making process. If they are seen as isolated components, trust is no longer directly influenced by reputation. Finally, we briefly refer to current existing computational trust models, including those that integrate the management of computational reputation.

23.1 Introduction

Trust is a social construct that is present in the day-to-day routine of humans. In fact, every time a person (hereafter named *truster*[1]) needs to interact with, delegate to or rely on the intension of another individual, group or thing (hereafter named

Joana Urbano
LIACC / DEI, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal, e-mail: `joana.urbano@fe.up.pt`

Ana Paula Rocha
LIACC / DEI, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal, e-mail: `arocha@fe.up.pt`

Eugénio Oliveira
LIACC / DEI, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal, e-mail: `eco@fe.up.pt`

[1] Some authors use instead the word *trustor*, and some others even *trustier*.

trustee), a decision about trust is made. Intension is here considered as "choice with commitment" as defined by Cohen and Levesque [4] and may, or may not, lead to an action. However, it always denotes an agent (trustee) behavior that may interfere with the truster own goals.

Hence, due to the vital role that trust plays in society, it is of no surprise that it receives attention from academics in several areas of research, including sociology, social psychology, philosophy, economics, management, and political science (e.g. [37, 2, 32, 23, 6, 11, 10, 46, 15, 7, 47, 18, 36, 9, 13]). More recently, trust and reputation started receiving growing attention from the computer science community, particularly from multiagent systems academics. The underlying idea is to confer to intelligent agents the ability to estimate the trustworthiness of interacting partners, in order to improve their social interactions [34]. We say then that agents use *computational trust models* based on trust theories to assist their trust-based decisions.

Trust theory suffers from a diversity of notions and concepts that reveals a "degree of confusion and ambiguity that plagues current definitions of trust" [2]. This by no means eases the work of computer scientists when they attempt to formalize models of computational trust for assisting the decision making of artificial entities.

A frequent misconception in trust literature concerns the distinction between trust and trustworthiness, and the way they relate. This issue is addressed in section 23.2. Sections 23.3 to 23.5 overview different perspectives of trust, including its main dimensions, nature, and dynamics. In section 23.6, two distinct hypothesis concerning the relation between trust and reputation are provided. Finally, section 23.7 briefly refers some of the most representative models of computational trust, and the main conclusions are presented in section 23.8.

23.2 Trust and Trustworthiness

Trust and *trustworthiness* are two related concepts that must be distinguished. In fact, trust is a property of the truster in relation to the trusted entity, while trustworthiness is a characteristic of the latter. It is expected that a trustworthy entity presents high values of competence, integrity, benevolence, and predictability in the situation in assessment. Also, the trustworthiness of the trustee concerning the truster (and a given situation) is objective, but trusting agents deal with the *perceived* or evaluated trustworthiness, which is subjective [2, 25].

Besides trustworthiness, some authors consider that trust must account for other factors, such as the truster's propensity and disposition to trust [26, 2]. The propensity to trust is commonly viewed as a personality trait of the truster that is stable across situations, a kind of generalized trust of others that highly influences the trust for a trustee *prior* to data on that trustee being available [26, 37]. Some authors consider, however, that propensity is situational (cf. [6] for a study of propensity in the realm of nuclear power industry). In contrast, Hardin [14] assumes that the explanation of trusting in some context is "simply an epistemological, evidentiary matter

(...)[and] not a motivational problem". He considers that trustworthiness, and not trust, can be explained as dependent of motivation, and disposition to trust should not be understood as different from learning how to judge trustworthiness.

Other studies suggest that stereotyping, categorization and in-group situations must also be accounted for in trust assessment [13, 12, 45]. Castelfranchi and Falcone [2] refer that unknown agents can be put in different categories according to the characteristics or signs they exhibit – the *manifesta* –, and that these can be used to infer the internal factors of these agents (including moods and emotions), i.e., their *kripta*.[2] At the end, trust is inferred from kripta. Following this idea, Venanzi et al. [45] propose that *categorial reasoning*, which allows to infer hidden information from observable features, is considered a source of information for trust. In the same vein, Foddy, Platow, and Yamagishi [12] observe that a trustee is more worthy of the confidence of trusting entities if both entities belong to the same group and if the trusting part acknowledges that the trustee is aware of their group membership. That is, trusting agents have the *expectation* of "altruistic and fair behavior toward fellow in-group members".

It can then be concluded that there are different sources of evidence that can be used to judge the trustworthiness of trustees:

- Direct Contact, or *image* [5]. This is the most valuable of the information sources. By interacting directly with the trustee, the truster has a frank perception of the different dimensions of the trustee's trustworthiness. However, the effectiveness of this normally requires multiple and repeated interactions with the same party [45], which normally is not plausible in social environments characterized by high openness and dynamicity.
- Reputation. Another important source of evidence is *reputation*, which can be defined as the outcome of the social process of transmission of beliefs about the trustee; it is about social evaluations that circulate and are represented as *reported evaluations* [35]. Reputation is characterized by being highly available[3], but also by its low credibility, due to the bias introduced by partial reporters [45] and to the noise inherent in multiple transmissions. Also, the agents that spread the reputation information do not necessarily believe its content.
- Other sources. Other sources of information include opinions and information from trusted third parties (e.g. certificates [29, 17] and contracts [41]). The former is subjective and the latter is normally safe and objective. In both of them, availability and affordability are issues to take into consideration. *Indirect evidence*, including categorization, stereotyping, in-group situations, and organizational roles [3, 16], can also be considered.

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[2] The authors recover the idea of kripta and manifesta from Bacharach and Gambetta [2].

[3] Sometimes it can be the only source of information available to predict the trustworthiness of trustees.

23.3 Factors and Dimensions of Trust

When assessing the trustworthiness of a trustee, it is important to distinguish between its different dimensions. One of such dimensions is *competence* (also named *ability*), which relates to the potential and abstract ability of the evaluated entity to perform a given task [2, 26]. Ability translates into a set of qualities that makes the trustee able to perform the task, such as skills, know-how, expert knowledge, self-esteem and self-confidence [2]. Other qualities (depending on the situation) are common language, common vision, discretion [24], experience and maturity [14].

Besides competence/ability, Mayer, Davis and Schoorman [26] consider *benevolence* and *integrity* as key dimensions of trust. These authors define benevolence as "the extent to which a trustee is believed to want to do good to the trustor, aside from an egocentric profit motive". In a similar vein, Elangovan and Shapiro relate benevolence to "a feeling of goodwill toward the trustor" [9]. In turn, integrity is commonly referred to as a commitment to the principles acceptable by the truster [9, 26]. Individuals at higher levels of moral development tend not to trivialize trust violations and are less likely to switch to a different set of principles due to external reasons, thus scoring higher values for the integrity dimension [9].

Some trust academics also consider the *predictability* [2, 39] dimension, which relates to the ability and the willingness of the trustee in performing the assigned task.

23.4 The Nature of Trust

Some authors consider that trust is just a decision and not an act [13], where others consider that trust is a multi-layer concept that includes disposition, decision and act [2]. In a different perspective, trust is not necessarily mutual or reciprocal [37, 23]. Another important characteristic is the *degree of trust* [2, 13, 1]. As mentioned by Castelfranchi and Falcone, "only a trust decision eventually is a yes/no choice, and clearly needs some threshold" [2, p. 49]. In the same way, the *strength* of trust (i.e., the confidence that the truster has on his trust) serves as basis to the degree of trust [2, 1, 17, 28].

Finally, trust is by nature *contextual*: A trusts B to do X [13]. Mayer, Davis, and Schoorman [26] consider that trust varies across domains as trustees have different abilities in different domains. Dimitrakos provides a somewhat broader conception of situational trust by defining trust as a measurable belief that the truster has on the competence of the trustee in behaving in a dependably way, in a given period of time, within a given context and relative to a specific task [8]. In turn, in one of the earliest research on computational trust, Marsh [25] considers trust as situational, and provides this clarifying example: "I may trust my brother to drive me to the airport, I most certainly would not trust him to fly the plane".

23.5 Trust Dynamics

Social interactions are traditionally secured by both ongoing relationships and governance mechanisms such as contracts, incentives, and institutions. Legalistic remedies are usually costly and not always effective [47], but there are situations where the risk of loss justifies the expense of using them [13]. In opposition, the establishment of long-term relationships is cost effective and is widely used in one-to-one relationships and in commercial relationships.

However, the reality of present days indicates the urge for new forms of relationships, mainly in business and in social networks, where relationships are formed more quickly and, increasingly, with anonymous others, or strangers. There, the truster cannot ground his trust in the partners through ongoing relationships, and the use of institutional back-up may be inadequate. Therefore, in order to construct robust computational trust models, it is essential to understand how trust forms and evolves, both for allowing intelligent agents to promote their own trustworthiness, and to allow them to correctly predict others' trustworthiness even in case of new partnerships.

Next, different aspects that may alter the dynamics of trust formation and maintenance, namely, long-term relationships, betrayal of trust, formation of trust, asymmetry, and perseverance in trust building, are analyzed.

23.5.1 Long-term Relationships

Long and stable relations with others usually provide the conditions, and the incentives, for trustworthiness and trust [13]. In fact, there are several benefits associated with trust maintenance in a relationship, including the open exchange of ideas and information above normal levels [9], a certain flexibility concerning the fulfillment of contractual obligations, the easy resolution of short-term inequities [9], and mutual benchmarking with partners, improving the quality processes of the organizations [37].

Long-term relationships are initiated when one or more parties to the relationship demonstrate benevolence toward the interacting partners, initiating *norms of reciprocity* that, when established, lead to *goodwill trust* between the interacting partners [18, 36]. In long-term relations, it is expected that actors show high levels of benevolence and integrity. Also, they would do their best to tune hard and soft skills, in order to increase their competence dimension to the level agreed with the interacting partners, thus increasing their predicatibility.

23.5.2 Betrayal

Betrayal is often associated with the *breach of trust*. It is distinct from other negative incidents because it involves the *voluntarily* violation of known pivotal expectations and rules that govern interaction, causing harm to the victim [9, 10]. Also, the consequences of betrayal can be devastating [11, 30, 6]. If the relation can ever be repaired, it will imply that the victim forgives the betrayer. *Forgiveness* will depend on the severity of the betrayal [11], the emotions and cognitions that accompany the act, but also on personal values and long-term goals of the victim of betrayal [10].

Elangovan and Shapiro [9] present a general model of opportunistic betrayal in organizations. They propose that there are certain conditions (e.g. a financial crisis, unfulfilled needs or traits of the trustee) that prompt the trustee to assess the situation at present, taking into consideration: i) the benefits associated with betraying the truster; ii) the relationship with the truster; and iii) the principles involved in the betrayal decision. If the present situation is ranked poorly, the trustee is motivated to betray. However, the actual decision to betray is influenced by the trustee's perceived likelihood of suffering severe penalties due to betrayal.

23.5.3 Building Trust From Scratch

In practically all kinds of social relationships, the best way to create trust is to be trustworthy. And in this field, it is known that acts of benevolence increase the trustworthiness of the actor. Schoorman et al. refer that acts of benevolence from partners in inter-firm relationships (e.g. in joint ventures) helps to build trust [37]. A second form to give incentives to trustworthiness is through the reliance on societal and institutional devices [14, 47].

23.5.4 Asymmetry and Perseverance

Slovic [38] introduced the concept of *asymmetry principle* in a study in the realm of nuclear power plants, where he analyzed the effect that distinct information about positive and negative events had on participants of the study. From the results, he formulated that negative events tend to have a stronger impact on decreasing trust than positive events on increasing trust.

Subsequent studies [6] confirmed Slovic's asymmetry principle and showed that "existing attributions of trust persevere because they affect the interpretation and meanings of new information" (*confirmatory bias*), and that individuals at a trusting stage tend to maintain or increase trust as they acknowledge positive events while individuals at a distrusting stage tend to maintain or increase distrust as they learn negative events. In turn, contradictory evidence lead to a discount of information. The asymmetry principle was also confirmed in general terms in a study concerning

genetically modified food [30]. It was observed that participants with clear positive or negative beliefs tend to interpret new information in line with their prior attitudes, *ambivalent* participants find information about negative events more informative than positive events (*negativity bias*), and *indifferent* participants suffer the least impact from positive and negative information.

23.6 Trust and Reputation

In Section 23.2, reputation was referred to as a source or antecedent of trust, especially relevant in open and dynamic environments, where other types of information about the trustee can be either inexistent or costly. However, reputation is, *per se*, a social phenomenon as complex as trust, and the interrelation between trust and reputation is a subject of, at least, as much ambiguity as the notion of trust itself.

We hypothesize that the relationship between trust and reputation can be understood at two different levels. On the one hand, reputation is an antecedent of trust, and it may or may not influence the trust put by the truster on the trustee, depending on the existence and relevance of other types of evidence. As put by Jøsang, Ismail, and Boyd, "I trust you because of your good reputation" and "I trust you despite your bad reputation" are both plausible [21]. On the other hand, the process of reputation building is subject to specific social influences that are not present in the process of building trust, such as badmouthing and win-lose games. In this perspective, it is possible to envision trust and reputation as isolated constructs, where both contribute (in conjunction with other factors, such as risk and utility) to the final desideratum of decision making. Therefore, in this vision, reputation *does not* influence trust.

23.7 Computational Models

In the last few years, several computational trust models have been proposed in the distributed artificial intelligence (DAI) literature in order to allow intelligent agents to make trust-based decisions. Computational trust academics have been busy in formalizing, implementing and evaluating models of trust that rely on trust theory, which in part was covered in previous sections.

Until now, most of the existing computational trust models have focused on the aggregation of past evidence about the agent under evaluation in order to estimate its trustworthiness. Several different algorithms have been proposed to this end. Some of them compute the trustee's trustworthiness by averaging the past experiences of the trustee and weighting them by their recency [17, 33], others are based on beta models [20, 28], fuzzy cognitive maps [45], and other mathematical techniques or heuristics. More recent models try to cope with specific properties of trust and its dynamics, such as context [40, 31, 42] and asymmetry [19, 27, 43].

However, there is still a long path to run in computational trust. As an example, only a few computational models [25, 45] deal with the inclusion of the truster's disposition in the trust equation, or consider some kind of categorization [45, 16]. In the same way, we have shown in a recent study [44] that traditional computational trust models fail to capture the evolution of the relationship between different agents (e.g. relations that evolve due to the establishment of goodwill trust or to the change of the power relationship between the interacting partners), and thus are not able to model the effect that the *relationship* has on trust. Indeed, we think that these last issues – as well as the introduction of emotions and affects into the trust loop – are critical points for the success and wide acceptance of credible computational trust models to be widely and safely used, for example in business and industry.

Although the field of *computational reputation* has its own set of research questions and challenges, different academics have proposed models of computational trust and reputation that integrate both social concepts, assuming the perspective of reputation as an antecedent of trust (e.g., [20, 48, 22, 35, 28, 17]).

The interplay between trust and reputation raises different challenges. On the one hand, computation trust models that use reputation need to estimate the credibility of both the transmitted information and the agent(s) reporting the information, in order to weight the received information accordingly. On the other hand, computational reputation systems must provide adequate incentives for referrals to provide reputational information; also, they must be able to tackle the problem of the heterogeneity (both syntactic and semantic) of the different images that constitute the reputation score being transmitted. Other challenges include discrimination and change in the quality of opinions of information providers [21].

23.8 Conclusions

This section gave a brief overview of trust, a social construct that is present in all humans interactions (be it with other humans, institutions or things), and that is viewed by several academics as a kind of fuel of society. The section started by distinguishing between trust and trustworthiness. Then, it focused on different perspectives of trust, including its factors, nature, and dynamics. It was referred to that most of the existing computational models of trust fail to capture these distinct perspectives.

Finally, its was hypothesized that the interplay between reputation and trust can be understood at two different levels: either reputation is an antecedent of trust, *or* both contribute to the ultimate decision making as isolate components, where trust is not influenced by reputation. In either view, the study of trust would be enriched if we had a deep understanding of reputation, in the same way that it is not possible to understand reputation without having a thorough knowledge of the trust phenomenon. In conjunction, trust and reputation constitute an extremely important dyadic mechanism of social order and a very cost-effective governance tool for all types of social interactions. As such, they are considered vital agreement technologies.

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