Modeling the Propagation of Public Perception across Repeated Social Interactions

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Abstract. In this paper we develop an operational, quantitative method for the propagation of public perception. The model is presented as an extension of the culture-sanctioned social metric framework. We use the technique to model an extended version of the Spanish Steps flower selling scam, where a seller manipulates the belief of the clients and the public perception to pressure the clients to buy overpriced flowers.

1 Introduction

Humans are social beings. Even when pursuing selfish goals, they need to consider the impact of their actions on their public and peer perception. A simple model would only consider public perception as an *output* of the actions of the agents, for instance, a measure of their popularity. The reality, however, is different: the public perception is also an *input* into the actions of the agents: a "popular" agent can get away with actions which are out of reach to an "unpopular" one. Sometimes the *belief* of public perception is sufficient to affect actions - an agent which only believes itself to be popular will act as if it would be popular in reality.

The objective of this paper is to develop an operational, quantitative model for the propagation of public perception. It is part of our ongoing work with regards to modeling autonomous robots acting in social and cultural contexts [9,8,3]. The goal is to have a model which has explanatory power (why did the human act the way it did?), predictive power (how do we expect the human to act in a given situation?), and decision making power (how should a robot act in a given social setting?).

In [3] we have introduced the Spanish Steps scam, a scenario where the behavior of the participating humans can only be explained if we allow that they are simultaneously considering a number of factors, including financial gain or loss, loss of time and public and peer perceptions of dignity and politeness. We developed a modeling theory called the culture-sanctioned social metrics (CSSM) which allows us to perform an explanatory and predictive simulation of this scenario and other scenarios. CSSMs provide a relatively high-detail model of the social behavior: in its spirit, this technique falls close to the KIDS (Keep it Descriptive Stupid) approach advocated by Edmonds and Moss [6].

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The simulations where CSSMs had been deployed, however, up to this point were always considering a single interaction of several minutes at a time. However, the public perception can evolve over longer time frames spanning multiple interactions. Some of the most intriguing questions of public perception modeling are how the knowledge of individual actions propagates in space and time, how interactions at different spatio-temporal locations affect each other through the public perceptions and how does the general public (such as a crowd of bystanders) forms and forgets a public perception.

The work described in this paper extends the CSSM model towards the modeling of the propagation of public perception across multiple social interactions. For a concrete example, we will use an extended version of the Spanish Steps scenario which follows the interaction of a seller with multiple clients over a longer period of time. We make an effort to realistically model the public perception as provided by the ever changing crowd at a tourist attraction.

The remainder of this paper is organised as follows. The mechanism of the Spanish Steps scenario for an isolated instance of single seller/single client case is outlined in Section 2. Then, in Section 3 we discuss the mechanisms for multitasking from the point of view of the seller: how can the seller interleave the actions of multiple selling scenarios? How does the knowledge and beliefs propagate among the clients of the same seller? We show the results of an experimental study in Section 4 and discuss related work in Section 5.

2 The Analysis of an Isolated Spanish Steps Scenario

The Spanish Steps scenario is a flower selling scam perpetrated in many touristic sites across Italy, such as the Spanish Steps in Rome[1]. The intention of the seller is to pressure a client (typically a woman or a romantic couple) to purchase a rose at an inflated price:

- The seller offers a bouquet of flowers to the client. The client declines to purchase.
- The seller offers a single flower, relying on gestures implying that it is a gift. If the client refuses to take the flower, he repeats the offer several times, pushes the flower into the client's hands, or inserts it into her bag.
- The seller waits for 15-60 seconds several steps away from the client, who assumes that the interaction had concluded.
- The seller approaches the client and requests payment.
- The client attempts to return the flower. The seller refuses to take it. The action concludes by either the client paying or by escalating her verbal efforts to return the flower until the seller decides to take it back.

Let us now consider the ways in which this scenario can turn out. Real world observations of the scenario show that the scam sometimes succeeds *i.e.* the seller is able to make a sale and sometimes it fails: the client escalates her efforts

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[1] A closely related scam is perpetrated by water-sellers in traditional costume in the Sultanahmet area in Istanbul.

to return the flower until the seller, begrudgingly, accepts it. A purely rational model centered on financial gain cannot explain the cases when the client buys the flower, well knowing that she is cheated. It also does not explain the cases when, in other situations, the seller abandons his high pressure selling tactic and accepts the return of the flower.

In our recent work, we argued that the participants in such transactions do not consider only tangible values such as financial worth, but also a number of *culture-sanctioned social metrics* (CSSMs), such as politeness and dignity, seen from the perspective of the self, significant peers, or the public at large. These values are not fully independent (one would give up politeness when confronted with a large financial loss) but they are not linearly convertible into each other.

An important point of the theory is that the impact of the actions on the CSSMs do not depend only on the action itself, but also on the *public perception* as seen by the players. These public perceptions or, more exactly, the beliefs of the players about them are critical in the personal calculus of the social values. For instance, it is not considered undignified to expose a scammer, but one looses face if he reneges on a publicly accepted transaction.

A model of the Spanish Steps scam using this model is described in [3]. The critical step is the manipulation of the public perception, such that the client will perceive herself as reneging on an accepted transaction. If this happens, then escalating the return of the flower will become very expensive in terms of dignity and politeness. The public knowledge of the crowd is critical to the success of the scam. The scam would never succeed in an empty street - as it relies on the reluctance of the client to lose dignity and perception of politeness by making a scene in public. Ironically, the best strategy of the client also relies on the public perception - if the client commands the sympathy of the crowd, she can escalate her efforts to return the flowers.

In this section, we describe the way in which an individual instance of the Spanish Steps scenario can be modeled and analyzed in the CSSM framework. The participants are the seller, the client and the general public. We will consider the client to be one member of a romantic couple, who also needs to consider the peer values from the point of view of his partner. We need to consider the action-state graph (with its associated detail variables), the culture-sanctioned social metrics and beliefs and public perceptions of the agents.

2.1 The Action-State Graph

The unfolding of the Spanish Steps scam can be relatively well separated in discrete steps, allowing us to draw an action-state graph as shown in Figure 1. This graph is not a full description of the interaction, only an aid in organizing our representations. Being in a certain node does not fully represent the state of the scenario - we need also to consider a number of *detail variables.* For instance, S6 is a state where the client holds the flower and had just attempted to return it to the seller. The details of this state include the judgment by the seller and the client of the current situation, as well as their emotional state. If the client believes that the public assumes that she had already accepted the transaction, she will be more reluctant to force the return.

Similarly, the actions represented by the edges of the graph are also parametrized by detail variables. In our model, A7, A9, and A16 are parametrized by their “loudness” x which determines how many onlookers will overhear the transaction and their “offensiveness” y which will determine how the action will impact the values of the actor and target of the action. The action A14 is parametrized with the waiting time t it involves.

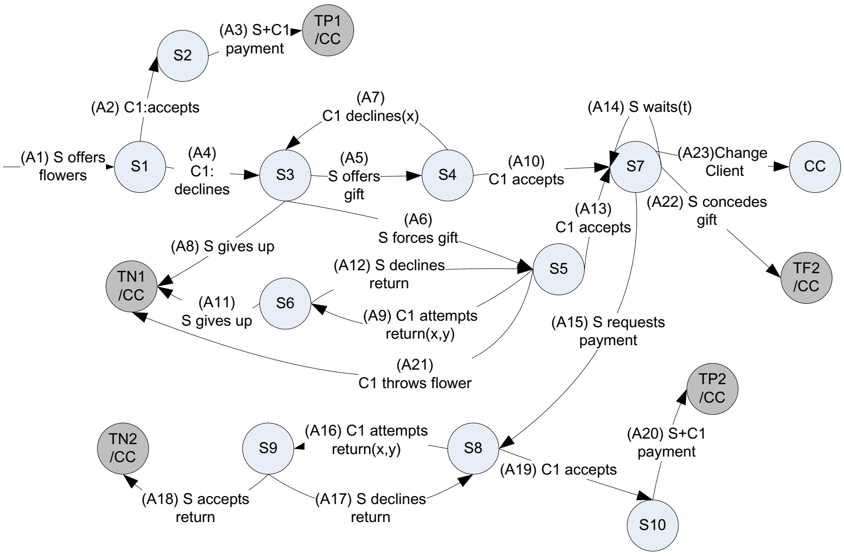


Fig. 1. The action-state graph of the Spanish Steps scam. The states marked with CC allow for the change of clients.

2.2 Culture-Sanctioned Social Metrics

Our modeling technique assumes that the agents explicitly maintain a vector of *metrics*, separated in two classes. *Concrete* metrics such as financial worth or time are easily measurable and come with their native measurement units (*e.g.* dollar or euro for financial worth, seconds or minutes for time). The second class of metrics are *intangibles*, which we model with culture-sanctioned social metrics (CSSMs). We say that a culture *sanctions* a metric if (a) has a name for it, (b) provides an (informal) algorithm for its evaluation, (c) expects its members to continuously evaluate these metrics for themselves and salient persons in their environment and (d) provides rules of conduct which depend on these metrics.

To model the Spanish Steps scenario we used two concrete metrics: the *financial worth* W and the *time* T and two CSSMs: the *dignity* D and the *politeness* P. Both sides consider the metrics from the perspective of the self and the public; the client also considers a peer (the other member of the romantic couple). With these assumptions, the vector of metrics for the client is $\{W^c, T^c, D^c, D^c_p, D^c_r, P^c, P^c_p, P^c_r\}$ while the vector of the seller is $\{W^s, T^s, D^s, D^s_p, P^s, P^s_p\}$.

2.3 Beliefs and Public Perceptions

Every action of an actor impacts the metrics of his own and his interaction partner. The change in a specific metric, by a specific action, in specific circumstances is given by the *action impact function* (AIF). Let us now investigate mathematical form of AIF. In the first approximation, the AIF depends on the detail parameters of the action. Let us consider action A16 (client attempts return), which is characterized by the *loudness* x and *offensiveness* y. Obviously, the higher these values, the stronger the effect on the dignity of the seller and the politeness and dignity of the client.

However, the impact also depends on the *beliefs of the public perception* of the scene. For a given level of loudness and offensiveness, it is less of a loss of dignity to be offensive with a crooked merchant than with an honest one. Similarly, one looses more dignity when reneging an agreed-upon transaction compared to correcting a misunderstanding.

As the agents do not have direct access to the public perception, we need to model the impact of public perception through their beliefs. Our modeling approach relies on the use of the Dempster-Shafer theory of evidence [15,16]. Events witnessed by the public are acting as evidence and are integrated using the *Dempster-Shafer conjunctive merge.* While we will use the belief component of the Dempster-Shafer model for our belief in public perception values, we will also retain the plausibility component which helps us estimate the uncertainty associated with a belief.

To model observed behavior of the real world players in the Spanish Steps scenario, we need to consider at least the following beliefs:

$\mathrm{B}^c_{\mathrm{gift}}$ the client's belief that seller intends the flower to be a gift
$\mathrm{B}^c_{\mathrm{agr}}$ and $\mathrm{B}^s_{\mathrm{agr}}$ the client's and, respectively, sellers belief that the general public thinks that a transaction had been agreed upon.
$\mathrm{B}^{sc}_{\mathrm{agr}}$ the sellers estimate of $\mathrm{B}^c_{\mathrm{agr}}$

We consider a number of other beliefs in the scenario involving the periodic interaction of seller over longer span of time. These beliefs include

- $\mathrm{B}^c_{\mathrm{dec}}$ the client's belief that the seller is deceptive, being a function of past experiences.
- $\mathrm{B}^w_{\mathrm{dec}}$ the client's belief that the crowd perceives the seller as deceptive, dependent upon the visual or verbal communication with other agents in the crowd and by the cultural understanding of the place

Naturally, beliefs are not orthogonal: a certain action can be evidence or counter-evidence against more than one belief. Furthermore, the way in which beliefs propagate between the agents depend on many factors, including the temporal and spatial aspects of the scenario. Clients who are in close proximity have a higher probability of information sharing. A tourist who had spent some time in the location has a better knowledge about the seller's deception than a newly arrived crowd member.

3 Multitasking

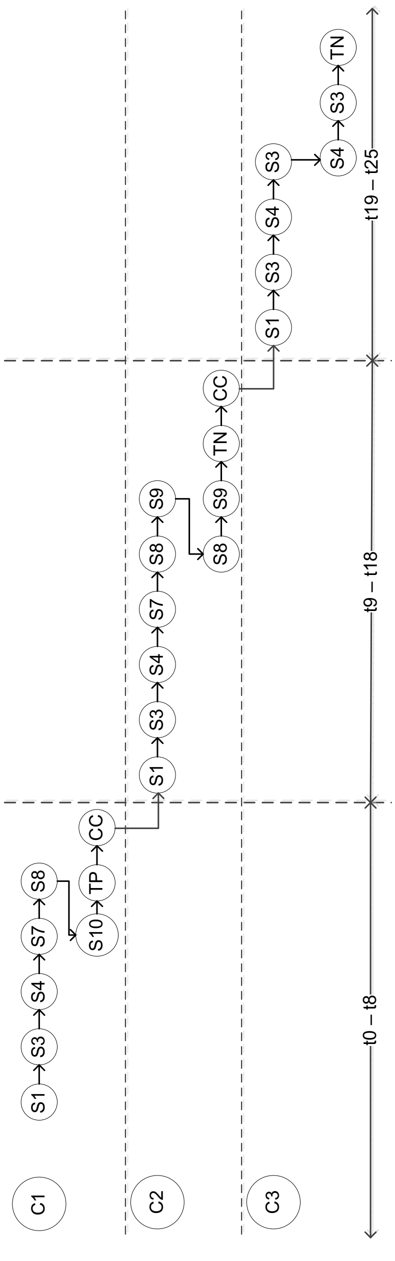
The seller in the Spanish Steps scam can not execute more than one action at a time, even if it involves multiple clients. Furthermore, basic rules of social interaction, such as the necessity to maintain physical proximity and eye contact prevent the seller from arbitrarily switching between clients. However, the Spanish Steps scam has certain states where switching away from a client *is* possible, and in some cases, such as state S7, even desirable. Exploiting these states, the seller can handle multiple simultaneous transactions, each in a specific state.

As the seller interacts physically with the clients, the clients will necessarily be in close physical proximity, and they will also likely be paying attention to the seller. Thus, we can make the assumption that the events unfolding in the parallel threads will be known to all the participants, and influence their beliefs.

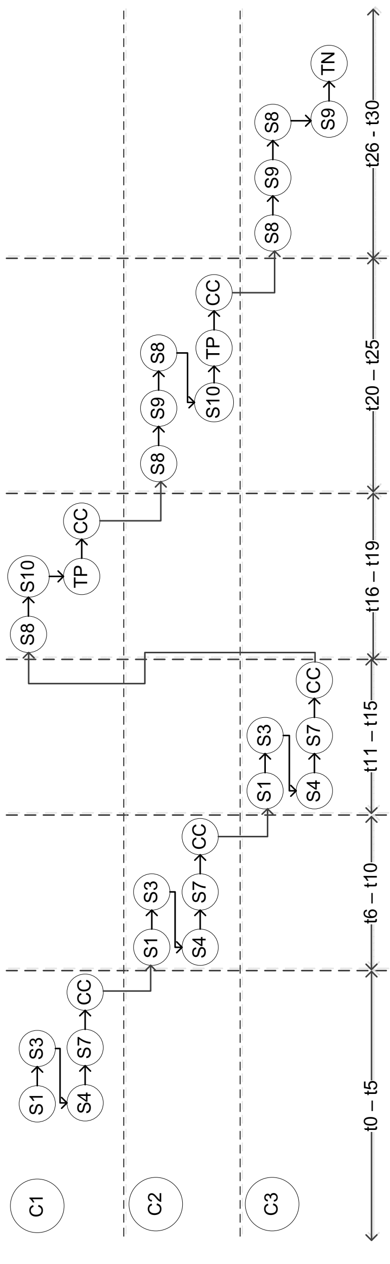
To model the actions of the seller, we have designated some of the states in the state-action graph in Figure 1 as *change client* (CC) states. These are states where the seller has the possibility to either start a new interaction, by approaching a new client, or to resume the interaction with an existing client. Naturally, all the terminal states of the graph are CC states - in this case the interaction is terminated and the seller does not need to return to the client. State S7/CC, however, is not a terminal state: the seller will need to return to the client holding the flower.

Fig. 2-a shows the flow of three instances of the scenario where transitions are only made at terminal states. We call this a *serial interaction.* A serial interaction is not equivalent to three separate scenarios. While there is no overlap between the scenarios, there is a leak of information from one scenario to the next. This happens through two mechanisms: (a) through the clients in the later scenarios directly witnessing the outcomes of the previous scenarios, and (b) through the impact of the scenarios on the public perception.

Fig. 2-b shows an example where the seller *interleaves* the interaction with three different clients. In this case, the close physical proximity guarantees that the clients are aware of the unfolding of the scenario with the other clients. One would think that more information would help the clients, but this is not necessarily the case: the received information can actually be deceptive. The seller can actually derive an advantage from multitasking, beyond the purely time saving aspect. Let us consider the case of client C3 when entering the scenario, at state S1. For the sake of simplicity, let us consider that C3 had witnessed the evolution of the scenario of C1 and C2. In the scenario described



(a) serial interaction



(b) interleaved interaction

Fig. 2. Two techniques for handling multiple clients in the Spanish Steps scenario

in Fig. 2-a, C3 had seen the complete unrolling of the scenario two times. She knows that the single flower offered is not a gift, as she had seen the seller ask money for it on two different occasions. Thus C3, although she might choose to buy a bouquet of flowers, if she feels like it, will not fall for the scam, by not accepting the single flower from the seller. Her best choice is to take the path $S4 \xrightarrow{A7(10)} S3 \xrightarrow{A8} TN1$ out of the scenario.

In the scenario described in Fig. 2-b however, what C3 had seen is that the clients C1 and C2 accepted the single flower and had not been asked for money. This information would encourage C3 to accept the flower, and reach state S7 in the scenario. Note that the client will still be able to escape without paying by escalating the return efforts on the path of the repeated iterations of $S8 \xrightarrow{A16(x)} S9 \xrightarrow{A17} S8$ with increasing values of the parameter x. However, this will be vastly more expensive in terms of time, dignity and politeness.

If the seller does not interleave the clients, his best choice is to pause between the instances for a sufficiently long time such that the client C3 would not have witnessed the previous scenario. Alternatively, the seller might choose a client who had recently arrived to the scene. One way to achieve this is to move to a different location, to make sure that the bystanders have not witnessed the previous scenario.

4 Experimental Study

In the following we will describe a series of experiments which model the propagation of the public perception across multiple instances of the Spanish Steps scenario. The CSSM model had been implemented in the YAES simulation environment [4]. The Dempster-Shafer model had been implemented using the JDS library [17]. The simulation had been connected to a visual representation based on OpenWonderLand [18].

We have traced the model in three different scenarios. Each of them represent the activities of a seller enacting the Spanish Steps scam with three different clients C1, C2 and C3. The three experiments are described in Table 1.

Experiment 1 is an example of a serial interaction with no breaks between the scenarios. As soon as the seller finishes a scenario, he immediately chooses the next client and starts the next scenario. Experiment 2 is a serial interaction with breaks (delays) between the scenarios. To model the effect of the break, we have applied the Ebbinghaus forgetting curve to all the beliefs of the agents (essentially pulling the Dempster-Shafer values towards ignorance).

4.1 B_{gift} and D_p^s

In Experiment 1 the seller was successful with the first client, as he succeeded to raise B_{gift} from 0.5 to 0.8. The second and third clients, however, had witnessed this interaction, thus their own B_{gift} values had started from much lower values. In the case of C3, for instance, the B_{gift} value starts at 0.3. This is so low

Table 1. Experiments

Clients	Actions	Transaction
Experiment 1: Serial without breaks		
C1	$\xrightarrow[t0]{A1}$ S1 $\xrightarrow[t1]{A4}$ S3 $\xrightarrow[t2]{A5}$ S4 $\xrightarrow[t3]{A10}$ S7 $\xrightarrow[t4]{A15}$ S8 $\xrightarrow[t5]{A19}$ S10 $\xrightarrow[t6]{A20}$ TP2 $\xrightarrow[t7]{A24}$ CC	pass
C2	$\xrightarrow[t8]{A1}$ S1 $\xrightarrow[t9]{A4}$ S3 $\xrightarrow[t10]{A5}$ S4 $\xrightarrow[t11]{A10}$ S7 $\xrightarrow[t12]{A15}$ S8 $\xrightarrow[t13]{A16(0.2,0.2)}$ S9 $\xrightarrow[t14]{A17}$ S8 $\xrightarrow[t15]{A16(0.4,0.4)}$ S9 $\xrightarrow[t16]{A18}$ TN2 $\xrightarrow[t17]{A24}$ CC	fail
C3	$\xrightarrow[t18]{A1}$ S1 $\xrightarrow[t19]{A4}$ S3 $\xrightarrow[t20]{A5}$ S4 $\xrightarrow[t21]{A7(0.6,0.3)}$ S3 $\xrightarrow[t22]{A6}$ S5 $\xrightarrow[t23]{A9(0.5,0.5)}$ S6 $\xrightarrow[t24]{A11}$ TN1	fail
Experiment 2: Serial with breaks		
C1	$\xrightarrow[t0]{A1}$ S1 $\xrightarrow[t1]{A4}$ S3 $\xrightarrow[t2]{A5}$ S4 $\xrightarrow[t3]{A10}$ S7 $\xrightarrow[t4]{A15}$ S8 $\xrightarrow[t5]{A19}$ S10 $\xrightarrow[t6]{A20}$ TP2 $\xrightarrow[t7]{\mathbf{A14(20)}}$ TP2 $\xrightarrow[t8]{A24}$ CC	pass
C2	$\xrightarrow[t9]{A1}$ S1 $\xrightarrow[t10]{A4}$ S3 $\xrightarrow[t11]{A5}$ S4 $\xrightarrow[t12]{A10}$ S7 $\xrightarrow[t13]{A15}$ S8 $\xrightarrow[t14]{A16(0.1,0.1)}$ S9 $\xrightarrow[t15]{A17}$ S8 $\xrightarrow[t16]{A19}$ S10 $\xrightarrow[t17]{A20}$ TP2 $\xrightarrow[t18]{\mathbf{A14(30)}}$ TP2 $\xrightarrow[t19]{A24}$ CC	pass
C3	$\xrightarrow[t20]{A1}$ S1 $\xrightarrow[t21]{A4}$ S3 $\xrightarrow[t22]{A5}$ S4 $\xrightarrow[t23]{A10}$ S7 $\xrightarrow[t24]{A15}$ S8 $\xrightarrow[t25]{A19}$ S10 $\xrightarrow[t26]{A20}$ TP2	pass
Experiment 3: Interleaved		
C1	$\xrightarrow[t0]{A1}$ S1 $\xrightarrow[t1]{A4}$ S3 $\xrightarrow[t2]{A5}$ S4 $\xrightarrow[t3]{A10}$ S7 $\xrightarrow[t4]{A24}$ CC	hold
C2	$\xrightarrow[t5]{A1}$ S1 $\xrightarrow[t6]{A4}$ S3 $\xrightarrow[t7]{A5}$ S4 $\xrightarrow[t8]{A10}$ S7 $\xrightarrow[t9]{A24}$ CC	hold
C3	$\xrightarrow[t10]{A1}$ S1 $\xrightarrow[t11]{A4}$ S3 $\xrightarrow[t12]{A5}$ S4 $\xrightarrow[t13]{A10}$ S7 $\xrightarrow[t14]{A24}$ CC	hold
C1	$\xrightarrow[t15]{A15}$ S8 $\xrightarrow[t16]{A19}$ S10 $\xrightarrow[t17]{A20}$ TP2 $\xrightarrow[t18]{A24}$ CC	revisited/pass
C2	$\xrightarrow[t19]{A15}$ S8 $\xrightarrow[t20]{A16(0.3,0.3)}$ S9 $\xrightarrow[t21]{A17}$ S8 $\xrightarrow[t22]{A19}$ S10 $\xrightarrow[t23]{A20}$ TP2 $\xrightarrow[t24]{A24}$ CC	revisited/pass
C3	$\xrightarrow[t25]{A15}$ S8 $\xrightarrow[t26]{A16(0.3,0.3)}$ S9 $\xrightarrow[t27]{A17}$ S8 $\xrightarrow[t28]{A16(0.3,0.3)}$ S9 $\xrightarrow[t29]{A18}$ TN2	revisited/fail

that it allows the client to reject the offered single flower with high loudness and offensiveness values, which terminates the interaction (unsuccessfully for the seller) at state TN1.

Fig. 3a and Fig. 3b show the evolution of B_{gift} and the seller's public dignity D_p^s for Experiment 1.

In the second experiment, the seller performs the same scam, but this time he takes a break between the individual clients. This break guarantees that the clients did not see the unfolding of the previous scenarios, and the public perception had also returned to neutral. This is a result of both the gradual turnover of people in the crowd of the tourist attraction, and the natural forgetting of the individuals. As a result, all the clients are essentially starting from a neutral point. In Experiment 2 the seller had been successful in scamming all three clients. Naturally, we can have instances where a client would be able to avoid being scammed in this case as well, by escalating the loudness and offensiveness of her return efforts. However, even if she avoids the scam, the client will loose significant amount of dignity and politeness CSSMs, because she does not have the favorable support of the public. Fig. 3c and Fig. 3d show the evolution of B_{gift} and D_p^s for Experiment 2. Note, however, that taking long breaks is not an efficient way for the seller to maximize his profit W^s.

Experiment 3 shows an example of interleaved scenario. In this case, the clients are in close proximity, and aware of each other. However, up to state S7 neither they, nor the general public will be aware of the full flow of the scenario, thus they will actually have a higher B_{gift} then the two previous cases. On the other hand, once the seller starts to ask the clients for money, this information is quickly propagated to the remaining clients and the public perception as well. As a result, the public perception will gradually shift against the seller, eventually reaching the point where, in our experiment, client C3 can avoid being scammed, without significant loss of politeness and dignity. Fig. 3e and Fig. 3f show the evolution of B_{gift} and the seller's public dignity D_p^s for Experiment 3.

4.2 B^c_{dec} and B^w_{dec}

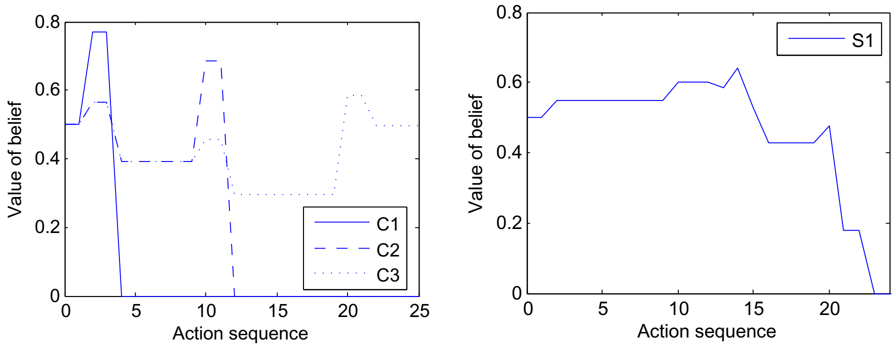
Fig. 4a and 4b shows the modeled values of of B^c_{dec} of clients and the evolution of B^w_{dec} for Experiment 1.

In Experiment 1, client C1 recognizes the seller's deception after time t=5, which raises B^c_{dec} to 0.5. As until time t5 the B^w_{dec} value is zero, C1 is not aware of the deception (which will be the ultimate cause of her buying the flower. Clients C2 and C3 recognize the seller's deception through the increase of their respective value of B^w_{dec} to 0.3. At time t=12 client C2 already has $B^w_{\text{dec}} \approx 0.5$ and $B^c_{\text{dec}} \approx 0.5$, which helps him reject those transactions in which the seller was loud and offensive.

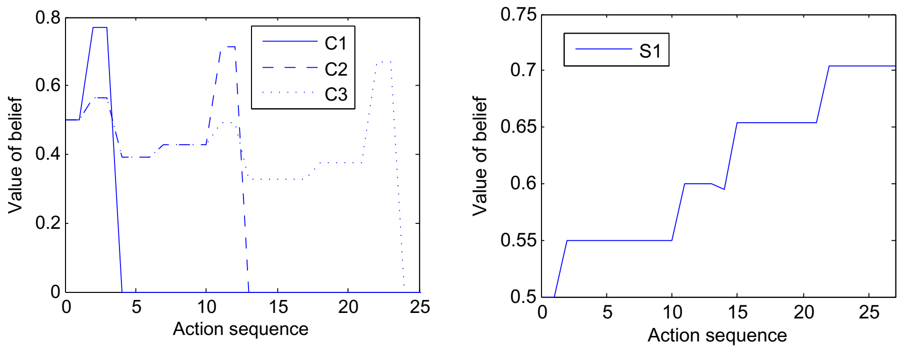
Similarly, when the seller approaches client C3, she already knows about the deception with $B^w_{\text{dec}} \approx 0.7$, acquired from information from surrounding environment. This helps her reject the offer of the gift and avoid any communication with the seller. However, we can observe that the B^c_{dec} of client C3 decreases by 0.05 due to the fact that client had no personal interaction with the seller due to which the decision was solely based upon the information gathered from environment.

In Experiment 2, the seller waited 20 minutes before approaching the next client. This delay helps the seller to lower the B^w_{dec}. Although the client C2 has high B^c_{dec} as shown in Fig. 4c, he does not have sufficient B^w_{dec} (0.3) as shown in Fig. 4d to reject the offer publicly. The client C1 has no prior knowledge of seller's deception till time step t3 but after time step t7 this B^c_{dec} is not taken into consideration by other client's B^w_{dec}.

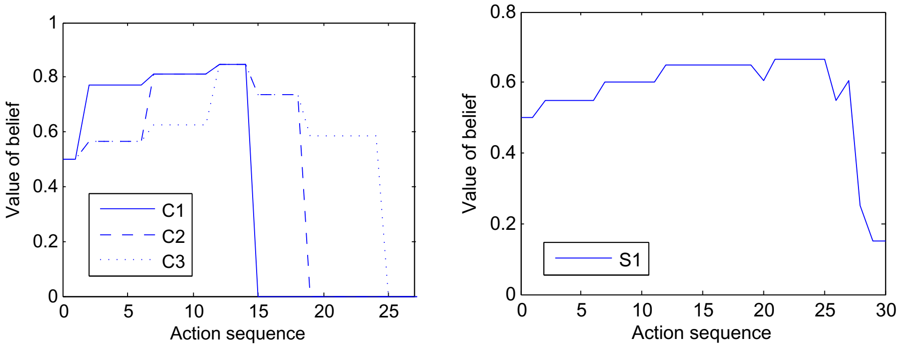
In Experiment 3, C1, C2 and C3 are not aware of the deception, having $B^c_{\text{dec}} = 0$ and $B^w_{\text{dec}} = 0$ until t=15 when the seller is asking C1 for money. Although C1 had witnessed the interaction of the seller with other clients, he had not seen any evidence of deception. Without having the support of the crowd in marking the seller as deceptive, C1 has no argument to reject the payment asked by seller. On the other hand, seeing this, C2 and C3 are rapidly raising their B^c_{dec} and B^w_{dec} values. Client C2 estimates $B^w_{\text{dec}} \approx 0.3$ when asked for the money. However, she judges this as an insufficent support for the crowd to escalate the effort to return the flower. On the other hand, C3 will have a value $B^w_{\text{dec}} \approx 0.7$ when asked for the money at t=23 as shown in Fig. 4e. This gives her sufficient confidence on the crowd's support to turn down the seller's offer. Thus, by the end of this interaction, the crowd became aware of the seller's deception. This is also depicted by the loss of the seller dignity D_p^s as shown in the Fig. 3f.



(a) B_{gift} of the clients (b) D_p^s of the seller

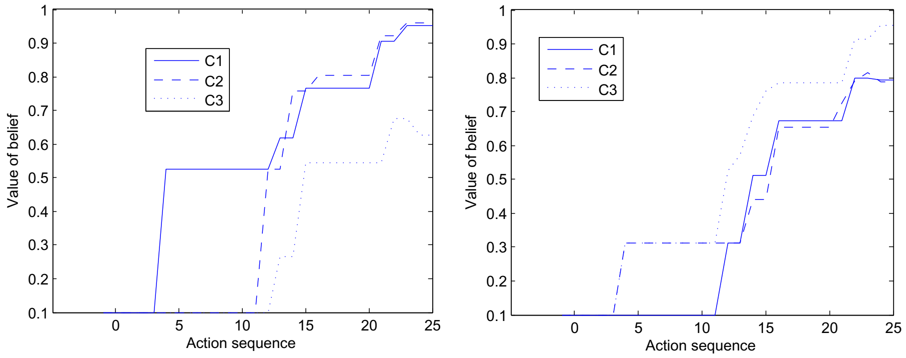


(c) B_{gift} of the clients (d) D_p^s of the seller

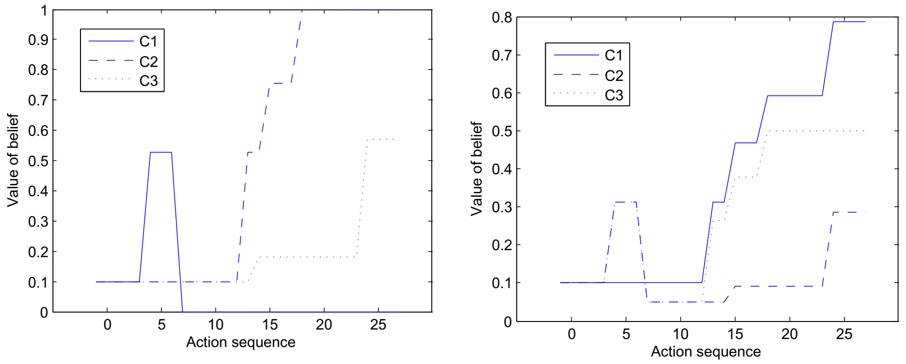


(e) B_{gift} of the clients (f) D_p^s of the seller

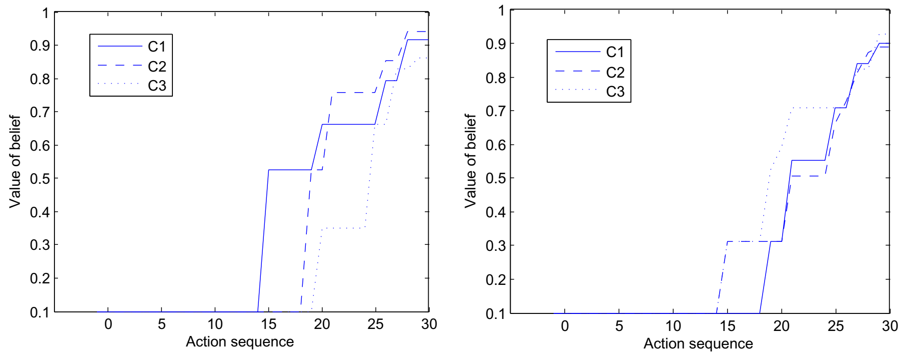
Fig. 3. Non-interleaving without breaks (top row), Non-interleaving with breaks (middle row), Interleaving clients (bottom row)



(a) B^c_{dec} of the clients (b) B^w_{dec} of the clients



(c) B^c_{dec} of the clients (d) B^w_{dec} of the clients



(e) B^c_{dec} of the clients (f) B^w_{dec} of the clients

Fig. 4. Non-interleaving without breaks (top row), Non-interleaving with breaks (middle row), Interleaving clients (bottom row)

5 Related Work

Modeling the information propagation in human societies is a research area which had gathered a significant momentum in recent years. One foundation of this momentum is the development of network science [2] which provides a theoretical foundation for many of the information propagation models. From a practical point of view, computer supported social networks such as Facebook and Google+ have made available large amounts of statistical data, and the financial motivation to analyze it. Well documented examples of information propagation such as the organization of political demonstrations through instant messaging and Twitter had underscored the power and importance of this type of communication. There is relatively less work concerning the more traditional way of propagation of information through direct sensory perception which is the case of our paper.

The literature being very large, we can only consider several representative examples. Kottonau and Pahl-Wostl [10] studied the evolution of political attitudes in response to political campaigns - while in earlier work they studied the problem of new product diffusion. C. Motani et al. [13] implemented a virtual wireless social network based on the information spread in real social network such as a marketplace. Gruhl et al. [7] and Adar et al. [1] analyzed the person-to-person information flow over blog space topic sharing. Recent analysis of Twitter followers by Cha et al. [5] had shown that the influence of user on the topic can be gained by a concerted effort over a long period of time and a large number of followers are not an assurance to fame.

A significant amount of research had been directed towards the epidemic propagation of information in social networks [14,11,12]. In these papers, the information spread is modeled as virus infection in computer networks.

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