Supporting Social Protocols in Tabletop Interaction through Visual Cues

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Abstract. Multi-touch tabletops provide new means for co-located people to work together on a task by directly manipulating objects and tools on a single display in unison. Despite their benefits they also entail new challenges. One major concern is how to help users avoid conflicting actions. Previous work discusses if social protocols are sufficient to regulate coordination, and if policies are needed to enforce specific behaviours. Our study on different variants of a tabletop game shows that providing visual cues on ownership can help to follow social protocols and therefore reduce the need for policies.

Introduction

Multi-touch tabletops provide new means for co-located people to work together on a task by directly manipulating objects and tools on a single display in unison. Despite their benefits they also entail new challenges. One major concern is to help users avoiding conflicting actions. For example, users could accidentally manipulate others' documents, perform actions simultaneously that are incompatible with each other, or alter global preferences that influence other users. Since all users' actions compete for the same display space at the same time, solutions need to support users in minimising the number of conflicts while keeping effort for coordination low.

Previous work basically takes up two opposite positions for addressing conflicts: One states that social protocols [5]—socialised norms of good and polite behaviour—take effect automatically, and help to regulate or even avoid conflicts. The other position points out that social protocols are not sufficient and as a consequence imposed rules and policies have to be established.

An example for the first position is Greenberg and Marwood's work [3] on concurrency control in real-time distributed groupware. They argue that social protocols enable users to naturally mediate and coordinate interactions in order to minimise conflicts while working together with a groupware system. Also Tse et al. [8] noticed in two case studies with multiplayer games on multi-touch tabletops that natural social protocols regulated some aspects of the game (e.g., turn taking).

On the other hand Morris et al. [5] suggest coordination policies for groups using a shared tabletop display to reduce conflicts, assuming that social protocols are not sufficient. Such policies however come along with an administrative overhead for the users.

Besides their advantages both positions have their drawbacks for the user, whether it is the chance of accidental conflicts where social protocols cannot proactively come into action, or the burden of a coordination overhead in order to avoid conflicts by imposing policies. We suggest a balanced solution by providing visual cues to users in order to activate social protocols. In the following we discuss how visual cues can help to avoid conflicts on multi-touch tabletops. We report on an empirical study using visual cues on ownership in a multi-touch game to reduce conflict.

Concept: Visual Cues to avoid Conflicts

Providing awareness information is a fundamental concept in order to support group activity in shared workspaces [2]. In co-located single display environments that allow direct and synchronous manipulation for several users, physical and social cues provide users with a basic level of awareness on others' actions and currently used artefacts and objects. However, as multi-touch tabletop applications allow people to easily switch between personal and group work [7], users are often not able to monitor all activities taking place when concentrating on a personal task. Further, people are sometimes not able to judge the impact of their action towards others and hence lack the necessary information allowing them to act without interfering with other people's activities. Basically these two aspects can be seen as causes for conflicts that arise in co-located work and where social protocols fall short of coming into action [3, 5].

We suggest that improving the awareness of users by providing visual cues is beneficial in activating social protocols and thus is helpful to reduce conflicts in coordination. It can reduce the need for more restrictive methods. In our example we assume that ownership is related to social protocols and norms since out of a commonly agreed moral concept of respecting ownership we can derive behaviour that is socially acceptable. Thus, when people are aware of ownership structures they will act according to these social protocols and not break them intentionally. We suppose that in a multi-touch tabletop environment perceived affordance of ownership can be supported through visual cues. In our case ownership is beneficially communicated via distinct borders of territories and colours of artefacts.

Therefore, we came up with the hypothesis that by providing visual cues that reveal ownership of digital artefacts people are triggered in holding on to social protocols, and thus show adequate behaviour in cooperative and competitive tabletop interaction.

The Study

We conducted a study based on a multi-touch tabletop game that uses basic visual cues in order to subconsciously activate social norms that are related to ownership. In this section, we describe the implemented game and multi-touch tabletop, the experimental setup and its execution, as well as the data analysis with its results.

The PuhBox Game on the cueTable

The PuhBox game is a multi-touch game for four players split into two teams and is loosely based on the classic arcade game Pong by Atari. The goal of this cooperative-competitive game is trying to score a goal while hindering the opponent to shoot a ball behind the own goal line. The difference to the classic version of the game is the fact that the PuhBox game instead of two paddles provides 16 small squared boxes, which are equally divided between the two teams by placing them close to the player's position when the game starts. Each player can freely move these boxes by dragging. Once the ball hits a box, it bounces back. So, by rearranging the boxes, the players are able to protect their goal line, as the ball cannot be manipulated directly.

The rectangular playing field consists of two goal lines on the opposite shorter sides of the table and two reflective borders on the longer sides. When a goal is scored the ball disappears from the playing field and reappears in the scoring teams' playing field, as this team is next to serve. To serve, the ball is hit with a box and gets an impulse. At the beginning of the game, the serving team is chosen randomly. Each team starts with eight boxes spread over their side of the playing field. The game ends when the first team reaches 21 points. The current score is presented in each team's field near the centre of the playing field.

Every eight seconds one randomly chosen box slowly dissolves at its current location and reappears in the centre. This behaviour is called teleporting. The box indicates teleporting by fading out over a few seconds until it completely disappears. The fading mechanism helps the players to anticipate the teleporting and to take action (e.g., by rearranging the boxes). Further, the time span of fading out was implemented to help each player recollecting from which half of the playing field the box was teleported when reappearing in the middle. Teleporting was introduced to make the PuhBox game more dynamic.

The PuhBox game was developed and implemented for the PuhBox hard- and software [4] and runs on our own low-cost implementation of a FTIR multi-touch table. The PuhBox Framework is written in Java and encapsulates the low-level image processing, from capturing over filtering to blob tracking and finally gesture recognition, from the application layer by an event-based architecture. The PuhBox game leverages the PuhBox Framework.

Experimental Setup and Execution

In the following we give insight into the experimental setup and its execution. To examine our hypothesis we implemented three variants of the PuhBox: No Colour (NOC), Background Coloured (BGC), and Box Coloured (BOC) (cf. Figure 1). In the NOC variant no visual cues are given to the players. The screen is plain black, representing the whole playing field. In addition, all 16 boxes are coloured blue and there is no middle line. In the BGC variant visual cues regarding ownership are

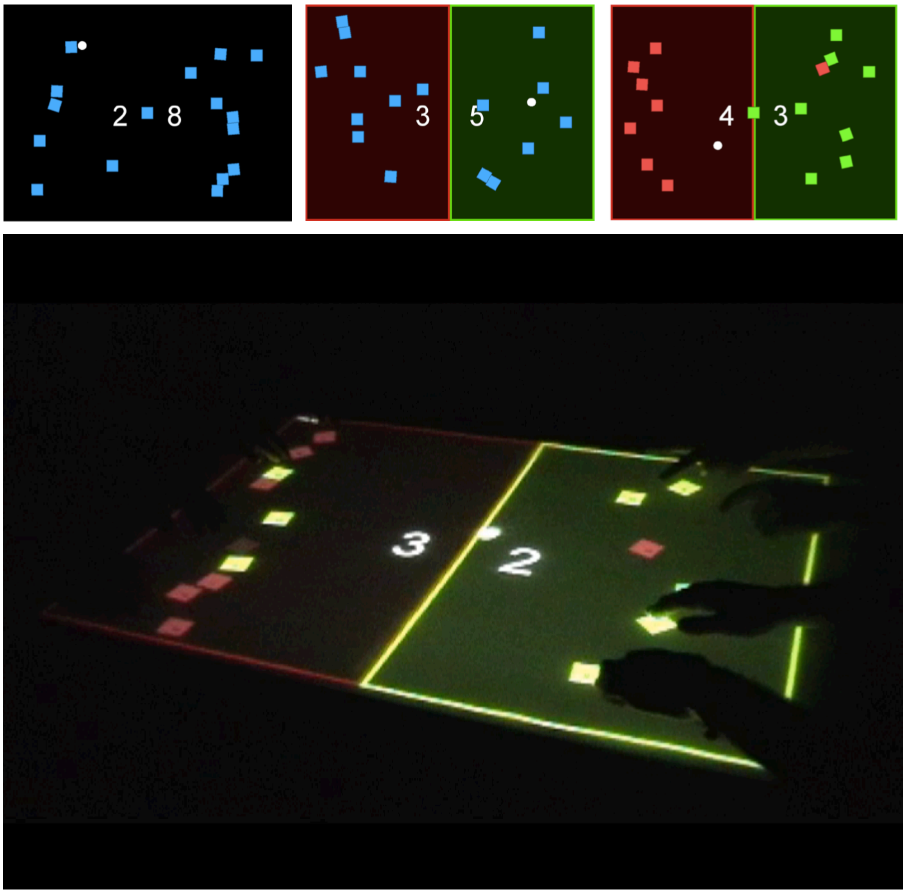

Fig. 1. PuhBox variants No Colour (NOC), Background Coloured (BGC), and Box Coloured (BOC); participants playing the BOC variant.

implemented in form of distinct borders of territories. A line surrounds both halves; the left side is red, the right side is green. In the BOC variant, additionally visual cues regarding artefact ownership are implemented through distinct colouring of the boxes, where half of the boxes are coloured in red, the other half in green.

The study was carried out in seven days. The subjects (*N*=64) were between 18 and 48 years (*M*=25.6, *SD*=4.9), with 19 females and 45 males. Most of them had never used a multi-touch table; none of them had played or seen PuhBox before. For each trial a group of four subjects formed two teams. The assignment to each game variant occurred randomly resulting in 16 trials split up between the three variants (5 NOC, 5 BGC, and 6 BOC). In each trial the teams played two matches of the same variant.

The trials took place in a separate room. An overhead video camera recorded the participants' interaction on the table, conversations and utterances. Interaction logs recorded the position of all 16 boxes every five seconds; the logging interval has been proven beforehand to be adequate for recording the relevant interaction. Finally, all subjects filled out a questionnaire after the two matches, addressing the perception of visual cues and fairness ratings, as well as personal details like age, gender.

At the beginning the two teams positioned themselves on the opposite shorter edges of the PuhBox. Before the two recorded matches started the participants were instructed how to interact with the multi-touch table. A trial run allowed them to get a feeling for the interactions, while goal and basic handling of the game were explained. No specific instructions were given regarding territories and the ownership of boxes in all three variants. This condition was fixed over all three variants in order to see how the visual cues are able to evoke the impression of ownership structures and accordingly lead to an adaption of the behaviour.

Data Analysis and Results

In the following we describe our data analysis as well as the results regarding interaction logs and questionnaire data.

Interaction Logs

As mentioned above the interaction logs captured the position of all 16 boxes every five seconds during a match. From the log data we calculated parameters to explore our hypothesis. Since each match is individual in length all interaction log variables were standardised. The transfer density for steals TD_S and for recaptures TD_R were calculated as a ratio of match length and the sum of steals (boxes taken away from their home side) and recaptures (boxes taken back to their home side) within each match. The number of boxes on the home side *NH* was standardised by downsampling the number of measuring points of the interaction logs to the shortest match (25 points within 120 sec) and downsampling the values of all other matches to 25 measuring points. By taking the time a box spent on its home side and calculating the proportion of being home considering the length of a match we computed the percentage of time on home side *PH* for each box. Averages for *NH* and *PH* over all boxes were calculated per match.

In a first step, we applied an ANOVA with repeated measures to detect possible learning effects between the two matches and to check whether these differences interact with the game variant. Since there were no significant within-subjects effects of match number and no interaction effect of match number by variant of the game we computed average values for all interaction log variables from both matches.

In a second step, we conducted an ANOVA to identify group differences based on the three game variants. Looking at the parameters (cf. Table 1) there were no significant differences in TD_S [$F(2,13) = 1.886$, $p = .191$] and TD_R [$F(2,13) = 1.792$, $p = .205$], but a strong tendency that interaction in the NOC variant is characterised by a greater density than in both other conditions. Steals and recaptures of boxes seem to be more frequent when no visual cues on ownership are given. Significant differences between the three game variants could be found both for *NH* [$F(2,13) = 9.521$, $p < .01$] and *PH* [$F(2,13) = 9.607$, $p < .01$]. The Sheffe post hoc test revealed that the game interaction in the BOC game variant shows higher averages compared to both other conditions. So overall, more boxes are kept on their home side for a longer period of time when visual cues like distinct borders of territories and distinct colouring of artefacts convey the impression of ownership.

Table 1. Means (SD) for each game variant.

	Variant of the game		
Interaction logs	**NOC**	**BGC**	**BOC**
Transfer density of steals TD_S	10.97 (2.7)	17.64 (4.9)	20.07 (11.7)
Transfer density of recaptures TD_R	17.52 (6.2)	29.82 (10.8)	29.80 (15.9)
Number of boxes on home side *NH*	9.54 (0.9)	10.42 (0.6)	12.62 (1.7)
Percentage of time on home side *PH*	60.23 (5.8)	66.35 (3.3)	80.44 (11.2)

Questionnaire

Our questionnaire captured subjective assessments of the matches concerning the perception of the visual cues and judgement of fairness. Since the values of our interaction analysis are based on a group level we computed average values and cumulative values from the four members of each group. For the analysis of perceived visual cues we computed the sum of the answers whether the players had perceived their game field halves as their territories with exclusive access P_T (0=no, 1=yes) and the average of the impression whether boxes (i.e. artefacts) belonged to one team P_A (1= not at all, 4=totally). We also computed the average of fairness ratings of the other team F_O as well as of one's own fairness F_S. We conducted an ANOVA to see whether the groups perceived the visual cues differently between the game variants and whether the groups report differently about socially accepted behaviour in terms of fairness. Looking at the perception of the visual cues (cf. Table 2) we found significant differences between the three game variants only for P_A [$F(2,13) = 5.763$; $p < .05$]. A Sheffe post hoc test revealed that players in the BOC condition have a stronger impression than players in the NOC condition. For P_T we can only describe a trend between the game variants, which is in the expected ranking order (BOC ~ BGC > NOC). Looking at the subjective ratings of fairness (cf. Table 2) we did not find significant differences between the game variants, but above-average values in all groups as well as marginal higher ratings for the opponent's fairness than one's own.

Table 2. Means (SD) of the assessments of the matches for each game variant.

	Variant of the game		
Questionnaire Data	**NOC**	**BGC**	**BOC**
Perception of territory ownership P_T	1.40 (1.1)	2.40 (1.8)	2.67 (1.6)
Perception of artefact ownership P_A	1.80 (0.5)	2.10 (0.9)	3.13 (0.6)
Fairness of opponent F_O	3.95 (0.9)	4.55 (0.8)	3.67 (0.8)
Fairness of oneself F_S	3.95 (0.5)	4.20 (0.5)	3.50 (1.0)

Further we examined the relationships between the subjective assessments of the matches and the interaction logs. Significant correlations ($p<.05$) between awareness information and interaction logs could be found only in the BOC condition where P_T shows a positive relationship to TD_S ($r=.82$) and TD_R ($r=.82$) meaning that a stronger perception goes along with greater intervals stealing and recapturing boxes and conversely. Also, we found significant correlations between F_O and interaction logs only in the BOC condition. Significant positive relations ($p<.05$) can be shown for *NH* ($r=.81$), *PH* ($r=.82$) and TD_S ($r=.82$), meaning that teams rating the opponent as more fair interact in a way that the number of boxes and their time spent on the home side are higher, and the intervals between stealing boxes are greater and vice versa. The same tendency was found for the TD_R ($r=.79$, $p<.10$). In contrast, in all three game variants only tendencies ($\alpha < .10$) regarding the relation between F_S and interaction logs were found and they differ between game variants. F_S in the BOC condition show a positive correlation with TD_S ($r=.77$) and TD_R ($r=.76$), meaning that teams rating their own fairness as high also showed greater intervals in stealing and recapturing boxes and conversely. Whereas F_S in the NOC and BGC conditions show a positive correlation with *NH* (NOC: $r=.82$; BGC: $r=.83$), meaning that teams rating their own fairness high also kept the number of boxes on their home side high.

Conclusions

Our study shows that providing visual cues can support users to act according to social protocols. Although the instructions for the game did not change over the three game variant, the interaction behaviour of the participant changed with different visual cues that lead to the perception of ownership. Thus, visual cues like boundaries and colours in our study had an impact on the actual behaviour of the participants.

As in previous work [6] on coordination techniques on tabletop groupware we showed that a controlled experiment in the form of a game can show effects of coordination techniques. The usage of a game supports the immediate involvement of the participants in the experiment in opposite to a more abstract task. However, this comes with the trade-off of reducing the applicability of this technique in a more natural real world task.

Nevertheless, our suggestion is to give users visual cues to support the natural regulation of interactions through the subliminal activation of social protocols. As a consequence users demonstrate behaviour, which can commonly be perceived as socially acceptable. As a side effect this kind of visual cues also supports users to easily uncover a deviation from social protocols. The chance of being observed could further lead to a reduction of unaccepted behaviour. In our case, the perception of ownership was always mutual for both teams over the different variants. Hence, the fairness rating over the three variants did not vary that greatly. In the variants where the perception of ownership was low, taking boxes from the other side was not perceived as wrong from both teams; in the variants were the perception of ownership was higher, taking boxes from the other side was perceived as improper behaviour from both teams and accordingly rather rare. But when a infringement took place, the teams could much better identify that territorial or artefact ownership was ignored and react with protest.

Generally visual cues can help to reduce the social-technical gap [1] instead of widening it with imposed policies and locking mechanisms. Visual cues that reveal underlying information are a simple but fruitful way to reduce accidental infringements against social norms while preserving a high degree of freedom for all users. Accordingly, applying coordination policies should be considered as a last step when all possibilities for improving interaction through providing additional information to the users have been exhausted.

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