Interaction Design Patterns For Multi-touch Tabletop Collaborative Games

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Abstract
Characteristics of multi-touch tabletops, such as a large interactive surface and simultaneous multiple user inputs can be exploited in the design of interactions that facilitate positive social interaction among children during collaborative activities. Designs that facilitate behaviors like positive interdependence, group processing and social skills such as turn taking are discussed. We report qualitative observations regarding the effectiveness of the proposed interaction designs in trials involving two groups of children with contrasting psychological safety levels and formulated several generalizable design patterns that were observed to be effective in soliciting collaborative play on interactive tabletops.

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Multi-touch; interaction design; collaborative play.

ACM Classification Keywords
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Design, Human Factors

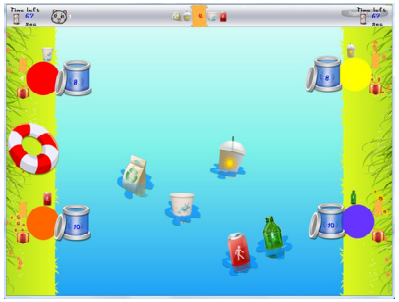

figure 1. A screenshot of the Keep Our River Clean (KORC) collaborative game.

figure 2. Four children playing the KORC game on a custom-built three-sided multi-touch tabletop system. Visually tagged circular tokens are placed on the tabletop to identify players.

Introduction

Studies by Johnson and Johnson [6] on cooperative learning suggest that a large majority of students learn more effectively when they work cooperatively. It is therefore important that designers of collaborative learning applications understand how appropriate interaction design patterns can be employed to motivate children to engage in collaborative activities.

Multi-touch tabletop systems have been suggested by Tse et al. [14] to enhanced co-located face-to-face collaboration. Yet recent studies by Fleck et al. [4] and Rick et al. [12] showed that such multi-player interfaces themselves do not always promote effective collaboration since users can be engaged with their own respective tasks with little consideration for others nearby. Additional cooperative design patterns such as enforced turn-taking [10] and enforced collaboration [1] may be needed to promote joint attention. However, many cooperative design patterns such as those investigated for board games and console-based video games [3] may not be directly applicable when designing collaborative interactions for tabletops. This paper discusses several collaborative interaction designs employed in a tabletop game called *Keep Our River Clean* (KORC). From qualitative observations during two field trials, we formulated several generalizable design patterns that were observed to be effective in soliciting collaborative play on tabletops.

Related Work

A recent study by El-Nasr et al. in [3] showed that a majority (55%) of computer game players between ages of 6-16 prefer to play in a cooperative manner. An even larger percentage (77%) prefers to engage in games that provided both options. The gaming industry has taken note of this trend and often provides games with an option for cooperative mode. Such surveys would probably favor cooperative style games more if the participants were engaging one another on shared interactive surfaces instead of gaming consoles. The cooperative design patterns identified in [3] were extended from the six basic patterns proposed by Rocha et al. [11] and are based on commercial cooperative video games played using traditional interfaces such as handheld gaming consoles. Unfortunately, these design patterns may not be effectively generalized to tabletop environments.

In recent years, there have been many interesting games designed on multi-touch tabletops that have demonstrated good potential for collaborative play. Khaled et al. [7] implemented the *Labour of Loaf* and *Laundry Game* and observed that the parallelism of interaction afforded by multi-touch interaction was a powerful factor facilitating collaboration. The division of labour naturally occurs among the team members who collaborated efficiently to get the overall task done. The physical proximity of acting together on a shared surface also seems to enhance this form of collaboration. Gross et al [5] presented the Puh Game played on the cueTable. Two players team up to play against another two players, thus creating a hybrid setting where both cooperation and competition co-exist. Successful collaboration was observed to depend on players in a team sharing a common view of the workspace and a constant view of each other.

Of most interest to us are works that have endeavored to design collaborative interactions in more inclusive settings. Several have attempted to develop cooperative tabletop games for the development of

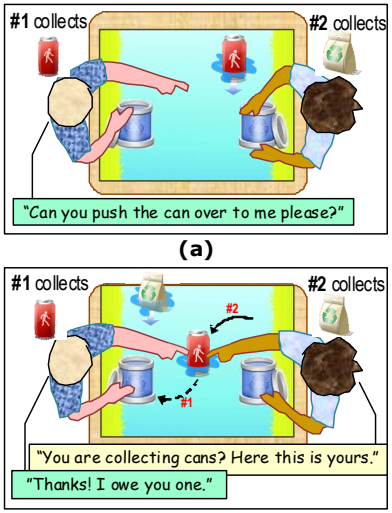

figure 3. The use of spatial separation to promote social interaction. (a) Player #1 can only collect soda cans and has difficulty reaching one that is floating by. He calls out to player #2 for help. (b) Player #2 helps by dragging the can closer to player #1. A paper bag comes floating down player #1's side. Could this be an opportunity to reciprocate the kind gesture?

social skills among children with Autism Spectrum Disorders (ASD). SIDES by Piper et al. [10] is a four player cooperative puzzle-like game. Their work suggests that such interactive gaming environment does have the potential of sustaining engagement and increasing communication between peers. Battocchi et al. [1] with their collaborative jig-saw puzzle game also arrived at a similar conclusion. They suggested joint actions by two persons that are enforced can help teach social skills such as shared attention, negotiation and imitative behavior to children with ASD.

Collaborative Game Design Objective

Figure 1 shows a screenshot of the KORC collaborative game during a trash collection run. Each collection bin is associated with one player via the placement of a physical token on the river bank (see figure 2) and virtual items are collected by dragging them into the bin. Each bin can only collect certain types of items (e.g. bottles, soda cans, etc). The game's goal is for the group to collect as many items as possible within three collection runs. Each run ends when all bins are full or the play time expires. Some items are designed to be collected collaboratively as will be described later.

Embedded within the game play are various interaction designs that we believe will create opportunities to promote collaboration and positive social interaction between players. Zea et al. [16] summarized five components identified in [6] as essential for effective cooperative learning. *Face-to-face promotive interaction* - occurs when there is helpful verbal and gestural communication among players. *Personal accountability* - is observed when individuals contribute their best to the group goal. *Positive interdependence* - is exhibited when there is evidence of cooperative behavior like one player helping another with their task. *Group processing* - expresses itself when team members analyze together how best to tackle the problem at hand. *Social skills* – where players demonstrate leadership and conciliatory gestures such as turn taking, trust-building and making decisions that are for the collective good.

As a computer-supported collaborative environment, interactive tabletops possess unique affordances such as large interactive surface and simultaneous inputs from many users, which require us to reconsider how collaborative interactions on tabletops can be designed. Some of these design considerations were implemented in the KORC game and are discussed next.

Using the Large Physical Space

During our design, we asked the paradoxical question, "Can large spatial separation help promote more collaboration?" Indeed, spatial separation afforded by large physical interactive spaces has strategic collaborative potential. It can be used to create an inconvenient out-stretched arm reach situation for the players, especially so with children due to their shorter arm spans (see figure 3a). Such situations may facilitate social interaction (i.e. verbal or gestural communication) and positive interdependence behavior. Player #1 could call out to player #2 for help to push his collectable items over. Large physical spaces also prevent players from having full visual view of all items in the river. This creates an opportunity for another player to spot an out-of-view item for her partner and voluntarily pushes it over to him; thereby demonstrating positive interdependence (see figure 3b). Such scenarios that facilitate expression of positive social behavior can create context-relevant learning

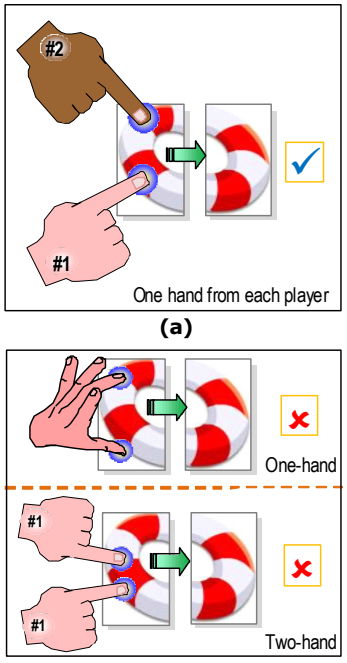

figure 4. (a) The Enforced Collaboration rule proposed in [1] that allows puzzle pieces to be dragged when each player (#1 and #2) places one of their finger on the desired piece and move it together. (b) However, a single player can perform the same operation using one or two-hand interactions.

opportunities for educators to teach various aspects of social skills to children.

Using Multiple Touch Capabilities

The ability of interactive tabletop to detect multiple touch points provides interesting affordances in interaction design. Battocchi et al. [1] exploited this in their collaborative puzzle game for children with autism. They devised a set of interaction rules called Enforced Collaboration (EC) as shown in figure 4a, which require two players to jointly place their finger on a piece of the jigsaw puzzle in order to drag it around. An obvious drawback of this design is that a single player could easily simulate the same interaction using two fingers of one hand or one finger from each hand (see figure 4b), thereby allowing each child to progress independently with little incentive to collaborate. Given that most interactive surfaces are unable to differentiate the touches of different users, careful thought is needed in designing enforced collaboration interactions which children will comply with even in the absence of external supervision. In the following sub-sections, we describe several interaction design examples in the KORC game that exploit multiple touch capability to facilitate collaborative behavior.

Encouraging Co-touch using a 3-eyelet Log - Studies by Ryall et al. [13] suggest that users collaborating on a shared interactive space are often reluctant to grab virtual object near the vicinity of another user. This suggests an intrinsic respect for the territorial space of another person and this personal space seems to be partitioned between collaborators according to one's proximity to the interaction area [12, 15]. However, Fleck et al. [4] observe that children working together often reach over to each other's table space as and when needed without causing annoyance, despite the temporary disruptions. Such occasions seem to lead to closer working rapport and joint awareness. Our own observations suggest that children who are jointly engaged in a collaborative game do not exhibit significant territorial tendencies. They can move into another's personal space to help without incurring any reaction of annoyance. Based on this assumption, we designed a floating log object that employs the EC interaction proposed in [1]. This EC object (see figure 5) has three clearly marked dragging areas (i.e. eyelets attached to the log) that are placed some distance apart to make it difficult for a single child to touch all eyelets simultaneously. It is easier to move the log into the bin if one child uses the fingers from two separate hands to touch two eyelets and have the help of another child, who leans over and touch the remaining eyelet (see Figure 5b). Retrieval of the log is only possible when all eyelets are touched and any one eyelet is over the collection bin.

Verbal or gestural communication (promotive interaction) is likely to occur as a player needs to inform others of his intention to retrieve the floating log. This provides opportunity for positive interdependence when another child leans over to help with the retrieval. Whoever helps out will need to do so in an altruistic manner since the log and its associated points will go to the other person. Such situations can promote reciprocity and thus build mutual trust among the players. This nuance tension between competition (collecting more items for one's own collection bin) and cooperation (everyone can do their best for the group) is constantly employed in the KORC game play. This tension facilitates the development of personal accountability, where a child helps another so that the

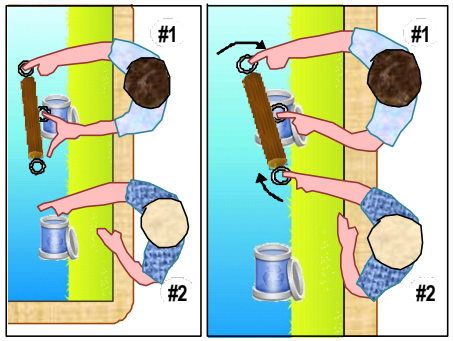

figure 5. The floating log. (a) It is difficult (but not impossible) for a child to retrieve the log alone. (b) It is easier when another player lends a finger to help touch the remaining eyelet.

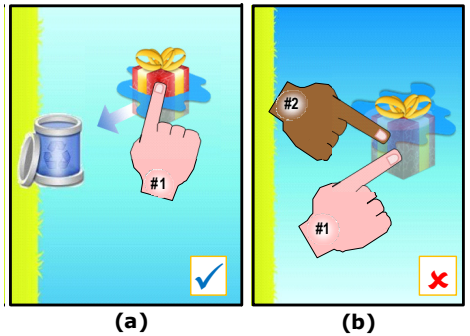

figure 6. The floating present. (a) It can be dragged into the bin with only one finger. (b) It sinks when more than one finger touches it.

group's goal is met. Another such competition versus cooperation tension is introduced in the next example, where multiple touches should now be avoided as part of the cooperative behavior.

Discouraging co-touch using a desirable present - This interaction design makes use of a floating object that consists of an attractive present (see figure 6a). This object is desirable because right from the start, all players can retrieve presents. In addition, they do not appear often in each collection run (rarity property). Using John Keller's ARCS model [9] for psychological motivation, Karoulis and Demetriadis [8] proposed a matrix to capture motivational factors in educational games. Under the Attention (A) element of the ARCS model, the arousal of curiosity through stimuli variability was considered an important factor in maintaining motivation in a learner. This same curiosity element is exploited to make the present a desirable object by awarding a random among of points when they are opened at the end of each run. Along with its rarity property and positive association (e.g. Birthday gifts), the presents can stir up competitive instincts among the players to retrieve presents for themselves. Indeed, in most of our game trials, few children have intentionally allowed presents to float away without some attempt to collect it.

Since this game is about collaboration rather than competition, a twist was designed into the game play. When more than one finger touches the present, it will sink into the river and disappear (see figure 6b). Once players understand that everyone rushing to collect the present does not pay, it gives rise to the establishment of some group-negotiated rules and this collaborative interaction design has essentially created a situation where social skills such as turn taking and conflict management can be learnt. Only a negotiated turn-taking strategy among players, built upon some trust-building resolution will allow these presents to be collected (i.e. "*You can take this one, the next one will be mine.*").

Promoting Large Group Collaboration

The EC interaction built into the floating 3-eyelet logs only facilitates cooperation between a subset of group members. Anyone working in a large team knows that it is more challenging to accomplish a task when every member in the team is required to work together. Such a situation often provides greater opportunities to teach social skills such as leadership, negotiation and conflict-management. It creates incentive for the more able group members to accommodate the weaker ones and offer assistance for the sake of the whole group.

The next collaborative interaction design uses a scenario where every player participate in saving a cat floating down the river (see figure 7). Once a life buoy is placed over Kitty in an attempt to secure it, virtual linkages appear and link the circular token of each player to the life buoy (see figure 7b). To save Kitty, the players work together to pull or push the life buoy to one side of the river. This scenario is likely to give rise to some elements of group processing and spontaneous leadership since the group has to decide which side of the river bank the life buoy is to be brought to and how best to do it. The fastest way to retrieve Kitty is for both players closest to Kitty to pull their links and the two opposite to push theirs (see figure 7c). Once Kitty has been saved, all members benefit by having bonus points added to the team score, reflecting the group effort.

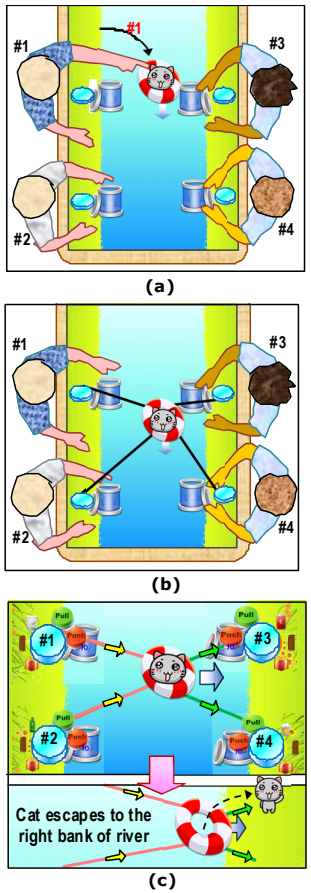

figure 7. The floating Kitty cat. (a) Player #1 drags a life buoy over to kitty cat to "capture" it. (b) Retrieval links are established to each circular token. (c) Group decides which pair should push or pull by pressing the respective PUSH or PULL buttons. This determines the side of the river Kitty moves to.

Using Sound

Appropriate use of sound and its timely rendition can support collaborative behavior. We discuss two examples of its use in KORC. Full group collaborative activity such as saving Kitty requires every player to simultaneously re-orientate their visual and cognitive focus to the cooperative task in the midst of their disparate individual activity such as filling up their own collection bin. With the tabletop's large display, each player's visual attention can be spatially localized in different regions of interest; we therefore need to employ an omni-directional cat meowing sound to simultaneously prime all members to the impending need to work together and visually focus on the cat. The meow sound is played just before the floating cat comes into view, thus allowing the team some lead time to prepare to cooperate. We observed that this sound often triggers one of the players to reach out for the life buoy in anticipation of Kitty's arrival.

The physical position of a player on an interactive tabletop can provide him a better game play advantage over others. For example, player #1 in figure 8 is closer to the entry point of floating items and thus has an unfair advantage in collecting items over a downstream team mate. This is especially so with desirable items such as the present, which all players can and want to collect. Before a present floats into view, a distinctive and pleasant melody is played to tell everyone to anticipate its arrival. This auditory cue provides the trigger to downstream players to begin negotiating with upstream partners to respect the turn taking agreement. With such common understanding established before the package comes into view, it is more likely that the upstream players will respectfully allow it to float by for the downstream player to collect.

The Field Trials

The observations reported were made through the analysis of video data captured during field trials with two teams having contrasting group profiles. Group A consists of four close friends (3 girls and a boy) with ages ranging from 11 to 12 years. They are all typically developing children collaborating within an atmosphere of high psychological safety. They were expected to exhibit advance collaborative play behavior that incorporates high levels of trust, rapport and conflict management skills due to their familiarity with each other. On the other hand, Group B consists of 4 male strangers aged between 10 to 16 years. Among these mixed-ability team, one is typically developing, one has mild autism spectrum disorders (ASD) with below average social and communication skills, one is dyslexic and another has Down syndrome. Their mutual trust, rapport and psychological safety level is assumed to be low since they are unfamiliar with each other. We expect their collaborative play behavior to be basic at best, thus providing a suitable stress test to the proposed interaction designs. While it is acknowledged that observations based on two trials prevents convincing generalization but these qualitative case studies can allow us to observe which design principles have managed to solicit their intended collaborative behavior. Such observations allow us to formulate some preliminary generalizable design patterns, which can be further evaluated when applied to other future collaborative game designs. The identity notation of a player is based on the player position numbering shown in figure 7(a). E.g., A#1 is a child in group A standing at the top-left position of the tabletop. The following sub-sections report the observed collaborative behaviors of the children based on each of the five collaborative components discussed in [6], [16].

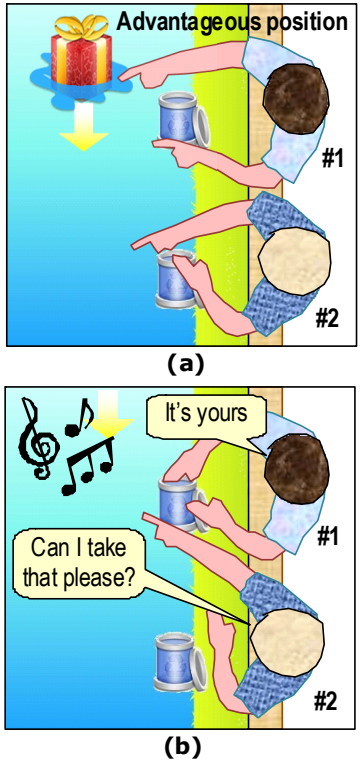

figure 8. Using sound to trigger negotiation. (a) Without sound, player #1 will always be able to collect a present before player #2 can see and reach over to it. (b) A timely melody associated with the package provides an early cue for player #2 to request player #1 to allow him to collect the present.

Face-to-face Promotive Interaction

Children in group A were in constant verbal communication during the game, often telling each other how to play the game better. Verbal exchanges increased when retrieving items that required collaboration. E.g. , A#3 alerted others to save the cat when he heard the meowing sound saying "*Life buoy! Life bouy!*" When the cat has been secured with the life buoy, utterances of "*Push*", "*Pull*" or "*No! We push*" were heard. The meow sound was found to provide effective priming to prepare the team for collaboration.

This same manner of verbal communication was also observed in group B, albeit at a more guarded level as expected of children unfamiliar with one another. These children were quieter when retrieving their respective items. However, when a cat was secured in the life buoy, B#2 could be heard telling B#3 "*Push! Push!*" The floating log was also effective in soliciting verbal exchanges from the both groups. For instance, B#4 was observed to spontaneously help B#3 to retrieve the log into his bin and B#3 immediately said "*Thank you*". We also observed that the physically large interactive space and the constraint of being able to collect limited types of items also encouraged verbal communications. B#4 was observed to reach diagonally across the table to retrieve a plastic cup and politely saying "*That's mine*" and B#1 spontaneously moves the cup closer to him so that he could retrieve it with greater ease and thereby receiving a verbal "*Thanks*" from B#4. Given that B#4 has mild ASD and have been diagnosed with below average social skills, such responsive social behavior towards a stranger solicited by this collaborative interaction design is most encouraging to us.

Social Skills

The floating present was observed to be very effective in teaching social skills such as turn taking, negotiation and conflict management. The children in group A were quite willing to assign one person (the boy) to collect the floating logs but because of the desirability of the present, they negotiated a fairer strategy where each would take turn to retrieve one. However, conflict between this equitable strategy and a more expeditious strategy was observed when A#1 (who demonstrated spontaneous leadership skills in many instances in the game) says "A#4 *you get the present, it's closer to you*". But A#4's sense of fairness cause her to point to A#2 and she retorted, "*But it's her's*". Meanwhile, as earlier agreed, A#2 reached out and retrieve the present without objections from A#1 or anyone else.

The less verbally engaged children in group B also displayed social skills such as turn taking. When the melody associated with the present was heard, B#1, B#2 and B#4 all moved their fingers to the top of the interactive tabletop, anticipating the present to arrive at any time. This demonstrates that the strategic use of sound has in this instance, neutralized the asymmetric advantage afforded by the spatial position of the topmost players. B#2 was heard saying, "*I take*" and the rest of the children backed off allowing him to retrieve the present. When the next present started arriving, despite the audio priming, B#2 no longer reached his hand out, suggesting that he was giving others a chance to take the present. It was observed that B#3 took the present twice when B#1 has yet to retrieve any. On hearing the audio priming, B#2 gestured to B#1 and was heard saying, "*You take*". This verbal demonstration of fair play by B#2 also suggests his spontaneous leadership within the group. It was

observed that as the game progressed and players experienced positive cooperative behavior, mutual trust began developing among this group of strangers.

Personal Accountability

When the collection bin of A#3 was full, he was heard saying, "*Mine is full, who can contain this?*", suggesting that he is willing to help someone else collect since he can no longer collect any more of his own. Most children in group B demonstrated similar sense of personal accountability. B#2 was observed to be filling up another player's bin when his own was full. An unexpected side-effect of bins with limited capacity was the occurrences of situations where some players' bin filled up earlier than others, thus encouraging them to demonstrate personal accountability as they started helping others to retrieve items. A child in group B who has Down syndrome was observed not to be doing so when his bin became full. An adult hinted to him if there was something else he could do under this situation, to which he replied, "*Nothing*". Such incident does create a meaningful contextually-relevant learning opportunity for special needs educator to teach a child positive social skills such as empathy and cooperation.

Positive Interdependence

It was observed that the floating log was effective in getting the players in both groups A and B to help one another. A few children did figure out how to stretch their fingers and contort their arms to drag these 3-eyelet logs into their bin by themselves. We are exploring the option of increasing the length of the log to remedy this but very long logs makes collection of the other items difficult. In any case, we have observed many occasions when the children will spontaneously come to the aid of someone who is attempting to drag a log into their collection bin or someone who has verbally requested for help. E.g., there was an instance when A#2 said, "*Let me get the log*", both A#3 and A#4 came immediately to her aid and all three of them successfully retrieve the log into the bin of A#2. We noticed that players are generally quicker in coming to someone else's aid when their own bin is full. But this was not always the case. B#1 was observed to use his advantageous topmost position to repeatedly move plastic bags downstream to B#2 (the only one who could collect plastic bags at that time) while at the same time collecting his own paper cups. This demonstrated his innate empathy and awareness of the needs of others around him and his willingness to help.

Group Processing

A collaborative game design feature in KORC that was observed to facilitate substantial group processing is the save-Kitty-cat scenario, where a decision has to be made by the group to push or pull the life buoy. In one instance, the children in group A were heard discussing if they should push or pull. A#2 said, "It is closest to us so we pull," and A#3 on the other side of the table instinctively caught on to what A#2 was implying and in turn instructed A#4, the team mate on his side to also press the push button so the pull-push combination quickly brought the cat over to the side of the river bank that it was closest to. This scenario also gave rise to group processing in group B. The player B#3, who has Down syndrome, had not yet grasp the concept of the mechanics related to the push-pull interaction and the preferred choice based on the cat's position in the river. An interesting observation was how B#1 and B#2 on the other side of the table accommodated B#3 and resolved this issue by agreeing with one another to use

a workable but less preferred choice of pressing the PUSH button since B#3 keep pressing the PULL button.

Discussion and Conclusions

Observations from both trials allowed us to summarize some of the generalizable design patterns that were observed to be effective in creating a collaborative tabletop environment that is conducive to collaborative play. They are as follows:

- *Use physical space (out-of-reach) and territoriality (in my space but not mine) when locating user-specific touch points* - In KORC, this was achieved by deliberately placing thrash items a player can collect away in the territory of another player. This creates opportunities for positive interdependence.

- *Use multiple (> 2) spatially distributed co-touch points to implement Enforced Collaboration* - Co-touch points are points that must be touch simultaneously to affect a desired event. In KORC, the 3-eyelet log facilitated verbal communication and positive interdependence among players during retrieval.

- *Use co-touch points to remove the availability of an item or event that is desirable to all parties* - In KORC, this design pattern was implemented in the floating present, which sinks when more than one player touches it. This interaction design was observed to be effective in facilitating voluntary turn taking through group negotiation. Conceptually, this particular mode of collaboration can be viewed as being encouraged and not enforced by the game play. This according to Benford et al. [2], is the preferred form of collaboration as it affords longer term educational benefits when the children discover the value of collaboration by themselves or through their peers.

- *Use sub-goals whose fast realization requires simultaneous correct action combination by all players but a slower realization if only a partial solution is provided by a subset of players* - In KORC, this design pattern was realized in the cat retrieval interaction. This is a form of enforced collaboration with multiple options (i.e. cat can be retrieve by pulling/pushing by all or a subset of players). Such design is suitable for an inclusive setting where players who are slower in understanding how to work out efficient solution to the problem will not severely penalize the progress of the whole group. Such design encourages the stronger players to accommodate the weaker ones, a valuable social skill to teach children. Moreover, it prevents better players from feeling exasperate by the poor game playing skills of their weaker team mates since slow progress is better than no progress at all.

- *Use recognizable sound cues to prime impending collaborative activity* - In KORC, both the arrival of a present and a cat is preceded by a musical tune or a meow sound respectively. The sound prime of the present was observed to be effective in triggering group negotiation that eventually led to turn taking.

Even though these design patterns have been observed to be effective in soliciting collaborative behavior in the KORC game, they must be further validated by their generalization into other collaborative applications. However, we see these preliminary findings as having taken several steps in the important journey to understand how effective tabletop collaborative applications can be designed.

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References

[1] Battocchi, A., Pianesi, F., Tomasini, D., Zancanaro, M., Esposito, G., Venuti, P., Ben Sasson, A. Gal, E. and Weiss, P.L. Collaborative Puzzle Game: a Tabletop Interactive Game for Fostering Collaboration in Children with Autism Spectrum Disorders. In *Proc. of ITS 2009*, (2009), 197-204.

[2] Benford, S., Bederson, B.B., Akesson, K.P., Bayon, V., Druin, A., Hansoon, P., Hourcase, J.P., Ingram, R., Neale, H., O'Malley, C., Simsarian, K.T., Staton, D., Sundblad, Y., Taxen, G. Designing Storytelling Technologies to Encourage Collaboration Between Young Children. In *Proc*. CHI 2000, (2000), 1-6.

[3] El-Nasr, M.S., Aghabeigi, B., Milam, D., Erfani, M., Lameman, B., Maygoli, H. and Mah, S., Understanding and Evaluating Cooperative Games. In *Proc. of CHI 2010*, (2010), 253-262.

[4] Fleck, R., Rogers, Y., Yuill, N., Marshall, P., Carr, A., Rick, J., Bonnett, V., Actions Speak Loudly with Words: Unpacking Collaboration Around the Table. In *Proc. ITS 2009* (2009), 189-196.

[5] Gross, T., Fetter, M. and Liebsch, S., The cueTable: Cooperative and Competitive Multi-Touch Interaction on a Tabletop. In *Proc. of CHI 2008*, 3465-3470.

[6] Johnson, R.T. and Johnson D.W. Cooperative Learning: Two Heads Learn Better Than One. *Transforming Education: In Context* 1988, 18-34.

[7] Khaled, R., Johnston, H., Barr, P. and Biddle, R., Let's Clean Up This Mess: Exploring Multi-Touch Collaborative Play. In *Proc. of CHI 2009*, 4441-4446.

[8] Karoulis, A. and Demetriadis, S. Motivation and Representation in Educational Games. In S. Demetriadis (Ed), Interaction between Learner's Internal and External Representation in Multimedia Environment, State-of-the-art report, Kaleidoscope NoE, D21-1-1, pp 296-312.

[9] Keller, J.M. Using the ARCS process in CBI and distance education. In Theall, M. (Ed), Motivation in Teaching and Learning: New Directions for Teaching and Learning, San Francisco: Jossey-Bass, 1998.

[10] Piper, A.M., O'Brien, E., Morris, M.R. and Winograd, T., SIDES: A Cooperative Tabletop Computer Game for Social Skills Development. *In Proc. of CSCW 2006*, 1-10.

[11] Rocha, J.B., Mascarenhas, S., Prado, R. Game Mechanics for Cooperative Games, in ZDN Digital Games, 2008.

[12] Rick, J., Harris, A., Marshall, P. Fleck, R. Yuill, N. and Rogers, T. Children Designing Technique on a Multi-touch Tabletop: An Analysis of Spatial Orientation and User Interactions, *In Proc. of IDC 2009,* 106-114.

[13] Ryall, K., Forlines, C., Shen, C., Morris, M.R. Exploring the Effects of Group Size and Table Size on Interactions with Tabletop Shared-Display Groupware. *In Proc. of CSCW 2004*, 284-293.

[14] Tse, E., Greenberg, S., Shen, C. and Forlines, C. Multimodal Multiplayer Tabletop Gaming. *ACM Computers in Entertainment 5* (2), 2007.

[15] Tuddenham, P. and Robinson, P. Territorial Coordination and Workspace Awareness in Remote Tabletop Collaboration. In *Proc. of CHI 2009*, 2139-2148.

[16] Zea, N.P., Sánchez, J.L.G., Gutiérrez, F.L., Cabrera, M.J., Paderewski, P. Design of Educational Multiplayer Videogames: A Vision form Collaborative Learning. *Adv. in Engineering Software 40*, 2009, 1251-1260.