# Exploring Manual Interaction and Social Behaviour Patterns in Intensely Collaborative Teamwork

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**Abstract.** This paper presents the results of a comparative study of 4-person collaborative teams working at a traditional table with pen and paper vs. a multi-touch table with digital keyboards and notepads. We compare the social behaviours of 'giving' and 'taking' during intensely collaborative teamwork, namely the differences between paper-based behaviour, digital-object based behaviour and a mixed condition behaviour where both paper and digital objects were used. Differences in sharing behaviour may be attributed to the degree of ownership afforded by digital objects on a touch display vs. paper objects. Additional visual metaphors to help tabletop users are recommended.

**Keywords:** Manual gestures, CSCW, Multi-touch table, paper vs. digital.

## 1 Introduction

The recent development of multitouch interactive surfaces (e.g. using Frustrated Total Internal Reflection) has introduced a new interaction paradigm that allows teams of people to manipulate digital artefacts simultaneously, in natural and intuitive ways. Ideally, no learning or training for specific gestures is required in such a scenario: users can treat digital artefacts just as they would paper artefacts, thus supporting intense collaboration, such that the technology becomes transparent.

Previous research has investigated paper-based group behaviour and space allocation on shared surfaces [1] in order to inform digital surface interaction design. Other literature examines ways to provide support for documents on digital tabletops such as orientation and surface interaction [2]; still others consider the suitability of specific gestures to be used for various digital document functions to inform manual gesture interaction design [3]. Nevertheless, paper and digital objects are fundamentally different, comprising disparate physical, visual and tangible characteristics. For this reason, the paper-based collaboration paradigm cannot simply be translated into a surface implementation of digital objects.

In one particular study we found in the literature, survey responses were used to capture hypothetical differences between the manipulation strategies of paper and digital objects [4]. We further this notion of artefacts shared on interactive surfaces with a comparative study between digital, paper and mixed artefact scenarios. We

investigate the social interaction within teams, naturally sharing and handling both paper and digital artefacts, during an intensely collaborative – and meaningful – task.

In this study, we look at the *giving and taking* differences in sharing digital and paper objects. We hypothesise that more *giving* behaviour would be seen in the paper only scenario compared to the digital objects scenario. Giving behaviour is exemplified by directly handing objects over to another team member or to the public arena. However, more *taking* behaviour would be evident in the scenario with digital objects than in the scenario with only paper objects. Taking behaviour comprises actively taking objects held by other individuals or taking objects from the group's common resource. Finally, we expected that paper-based behaviours would converge into mixed condition (paper and digital artefacts) behaviour. The reasons for this, we believe, are related to the degree of feelings of personal ownership of paper objects versus digital objects. Drawing from everyday sharing behaviours, when an object is considered to be under one's ownership, it is more easily 'given' than an object that is part of the public domain. Likewise, objects that are considered to be part of the public domain are more likely to be 'taken' by individual team members. We believe that giving and taking patterns can affect the relative individual contributions of each team member in a group task, and the overall team performance, during intensely collaborative tasks.

## 2 User Study Design

Ten teams of four friends participated in the study, members ranging from engineers to corporate staff. The task required subjects to compile five lists, each with as many semantically related words as possible. A single word was provided to start off the semantic list, e.g. NURSE. Single related words such as DOCTOR or PATIENT were added by group members one by one.

**Fig. 1.** Digital, paper and mixed conditions

Three conditions were administered. In the paper only condition, subjects were required to write words using five different coloured pens on five matching pieces of coloured cardboards. In the digital only condition, five different coloured keyboards were used to input the words into five matching coloured note windows. A Multi-touch Cell [5] surface was used for the implementation of this task, supporting natural

manual movement of digital objects. Finally, in the mixed condition, subjects were required to use two digital item sets, as well as three coloured paper sets. Conditions were balanced to counter order effects (with the mixed condition always last). The paper condition was limited to 2 minutes duration, and the other two conditions limited to 3 minutes duration.

**Annotations.** We devised an annotation scheme to capture various *giving* and *taking* behaviours, as shown in Table 1. To begin with, we annotated a one-minute sample from the middle of the task of each condition, for each team, and each participant.

**Table 1.** Annotation Scheme of Sharing Behaviour

| *Sharing* | *ID* | *Type* | *Description* |
|---|---|---|---|
| Giving | G1 | Direct Give | Directly passing an object to another individual |
| | G2 | Passive Give | Passing an object at someone's request |
| | G3 | Give to Centre | Actively putting an object in the public domain |
| | G4 | Reactive Give | Object in your personal space- allow others to take it |
| Taking | T1 | Direct Take | Directly taking an object from another individual |
| | T2 | Passive Receive | Taking an object given directly by someone else |
| | T3 | Take from Centre | Actively taking an object from the public domain |
| | T4 | Reactive Take | Taking an object that happened to be near you |

## 3 Preliminary Findings

The analysis included a total of 882 instances of sharing behaviour across groups. Given the inter-group dependencies in terms of strategy and performance, each group was first assessed individually, before acquiring an average across groups of *give-to-take* ratios, and normalized with a log function (Figure 2). A ratio value of zero means equal give vs. take, positive values mean more giving, negatives more taking.

In the digital-only condition, the ratio of *give-to-take* behaviour in each group ranged from -0.41 to -0.05, with a collective average between groups of -0.19. This means that subjects were more likely to display *taking* behaviours than *giving* behaviours when using digital objects, substantiating our first hypothesis. In the paper-only scenario, the group ratios of *give-to-take* ranged from -0.08 to 0.06, with an average across groups of 0.01, indicating the proportion of *giving* and *taking* were roughly equal. Finally, in the mixed condition, the group ratios of *give-to-take* ranged from -0.2 to 0.15, with an average of -0.02, indicating that the sharing behaviour converged toward the paper condition as expected. A one-way, correlated samples, ANOVA shows significant differences between groups ($df=29$, $F=18.05$, $p<0.0001$). Subsequent Tukey HSD tests show significant differences at the 0.01 level between the mixed and digital only conditions; and between paper only and digital only conditions. Analyses specifically on person-to-person (G1 and T1) and person-to-public (G3) or public-to-person (T3) 'pro-active' behaviours, where subjects directly move objects, highlight very similar patterns.

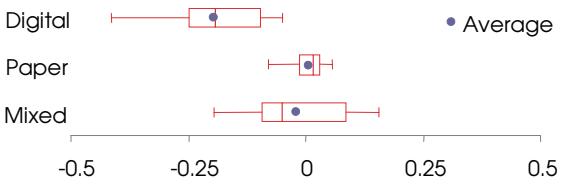


**Fig. 2.** Summary of *give-to-take* ratios across groups for each condition

## 4 Discussion and Future Work

As expected, subjects exhibited more *giving* behaviours in the digital only condition; likewise, more *taking* behaviours in the paper only condition, with the mixed condition converging to paper-like behaviour. Since the multi-touch table allows natural gesture to be used for movement of digital objects, these differences may be attributed to the feelings of ownership afforded by each set of materials. It is possible that tangible paper objects, due to their physical characteristics, *feel* more like the property of the individual manipulating them than digital objects. Proportionately fewer giving behaviours in the digital condition may be symptomatic of this. Though digital objects were far more malleable (could change in size and were more dynamic, bounced off the sides etc.), this plasticity did not seem to make any difference to their 'ownership status'. While they could be moved into each individual's personal space and into public spaces just like paper, they seemed to remain "behind the glass", engendering a feeling of perceptual distance between the team and the items.

Drawing more general design implications from this result, it seems that digital object scenarios may benefit from the implementation of visual effects or widgets that convey a greater sense of ownership. For example, 'magnetic personal areas' where objects are pulled towards, and attached to, personal spaces when passed around, may help encourage stronger notions of ownership between objects and participants. Future work includes further analysis of the social behaviour categories annotated.

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