Asset Distribution with a Multitouch Table

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ABSTRACT

We examined to what extent a MultiTouch Table (MTT) can support a collaborative Operational Planning Asset Distribution task as compared to traditional Spreadsheet methods. Participants were given different and complementary specialist roles and were then asked to distribute different sets of assets over an area of Operations with multiple known and unknown 'needs'. Additionally, participants had to satisfy a series of real time intelligence recommendations regarding *potential* needs. Of interest were subjective usability ratings and objective performance measures in terms of need fulfillment and satisfying intelligence recommendations. We found that on all but one usability measure participants rated the MTT more positively than the Spreadsheets. There was also a non-significant trend for greater needs fulfillment and resolving intelligence recommendations using the MTT than the spreadsheets. On the basis of the results we suggest that MTT technology offers a viable tool for supporting collaborative Asset Distribution tasks in general.

Keywords

Collaborative Operational Planning, Collaborative Asset Distribution, MultiTouch Table, Affordances

INTRODUCTION

During a crisis, there are multiple challenges associated with having the best resource at the correct place and time. Difficulties in access, standardization, communication, situational awareness, decision making, and inter- and intra-organizational cohesion all contribute to the challenge of successful asset distribution (Meeds, 2006; Chen, Peña-Mora & Ouyang, 2011). Of all these challenges, managing spatially distributed assets has been recognized as a key feature of a successful response (Haldon, 2006). Unfortunately, there is little scientific data that can be used to support the development of crisis management asset distribution tools. Indeed, Wijnia and Herder (2009) acknowledge the lack of research in this area and claim that asset management is still a 'juvenile science'. Despite this relative immaturity, there is a growing body of work investigating specific tools to support resource allocation (e.g. Chen, et al., 2011). The focus of the current study, however, was not on any specific tool, but rather on the potential benefits of using a MultiTouch Table (MTT) to support asset distribution. We examined to what extent the capabilities afforded by a MTT changes performance on an asset distribution task when compared to using traditional technologies (spreadsheets). Prior research has shown that compared to pen-and-paper tasks, MTTs promote task engagement (Stewart, Benderson, & Druin, 1999). Additionally, the larger space afforded by an MTT promotes interacting with content, discussions, annotations, and manipulating digital artifacts (Piper & Hollan, 2009). MTTs are also useful for facilitating small group collaboration (Morris, Paepcle, & Winograd, 2006). Although prior studies have investigated the value of MTTs for crisis and emergency management (e.g. Hofstra, Scholten, Zlatanova, & Scotta, 2008), the research reported here is the first controlled study that attempts to examine the effect of the technology affordances rather than any specific interface. Two interfaces were created, one implemented on an MTT and the other using Microsoft Excel where developed to exploit the affordances of the two technologies. A list of affordances is presented in Table 1. By creating representative task interfaces that exploited affordances in a simplistic way, the goal was to compare technologies' capacity to support task performance that remained to some extent independent of the specific interface design. In light of this absence of existing literature, we consider the current research exploratory.

METHODS

The experiment was conducted with four participants at a time that formed an Operational Planning Group. For each mission participants were told that a hostage situation had just occurred and that a specialist force was being prepared to save the hostages. The role of their Operational Planning Group was to secure the wider Area of Operations (AOO) from a range of known and potential threats. Participants completed two planning tasks (Djibouti, Kabul) one-at-a-time. For both tasks their objectives were the same (1) Deploy five battalions to the AOO, (2) Assign assets, (3) Reduce the number of Known Threats, and (4) Respond to the real time intelligence recommendations. To complete the tasks, participants were given either a series of Microsoft Excel spreadsheets

or the same information was represented on a MTT. Figure 1 presents a screen image showing the completed task results from the two conditions. Mission location and technology was counter-balanced across groups. Participants were told that they would receive a base payment of €15 to €20 according to team performance on threat neutralization and the intelligence recommendations followed plus an individual bonus (see Participant Roles). All test sessions were video recorded.

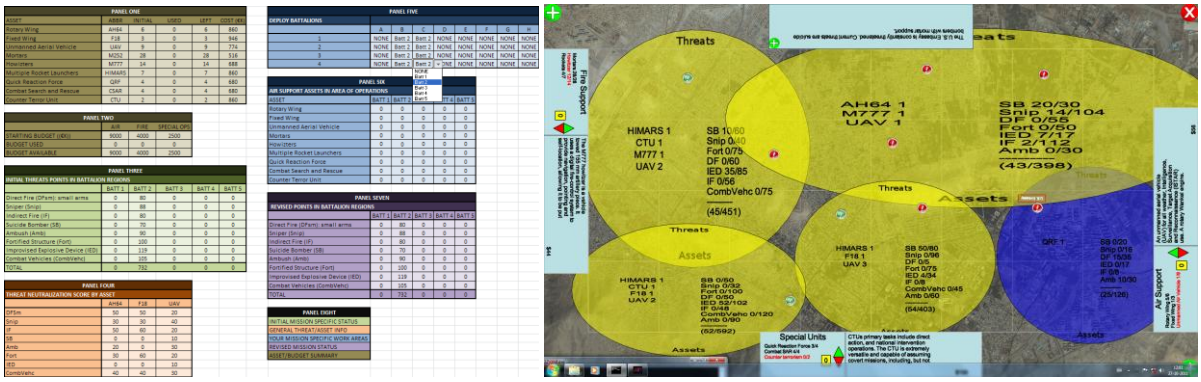

Figure 1. Shows task results for Spreadsheet (left) and MTT conditions (right).

Participants

Participants were recruited through Delft University of Technology mailing lists and word of mouth. Six groups of four people participated (13 men, 10 women; age range was 20 to 59; average = 32.09 years, SD = 10.69).

Scenarios

Two similar scenarios were used and for both, the participants' task was the same. For the Djibouti mission participants were told that the Djibouti Port was overrun by a flotilla of pirate ships, capturing the port and various strategic buildings. For the Kabul mission, participants were told that U.N. Headquarters in Kabul has been taken hostage.

Participant Roles and Assets

Participants were randomly assigned to one of four roles upon arrival at the experiment; Air Support, Fire Support, Special Operations, or Intelligence. The three 'asset' specialists (Air, Fire, Special Operations) each had three different assets. Each asset neutralized the threats differently and asset costs varied according to effectiveness (total effectiveness of each specialist was approximately equally). Participants could not exceed their individual budget nor deploy more assets than available. The Intelligence officer was not given assets but was given nine intelligence reports. Each report contained a threat description, location, probability, severity, and a solution. The threats contained in these reports were different to known threats (see below) and satisfying an intelligence recommendation may contradict efforts to mitigate known threats. Asset specialists were told that they would receive a monetary bonus based on their remaining budget. The Intelligence officer was told that their bonus was based on resolving the intelligence recommendations with higher probabilities and severity.

Known Threats

The AOO contained a range of known threats that would occur if no actions were taken. There were nine threat types with each having a differing number of threat points. Some threats were: snipers, suicide bombers, ambushes, fortified structures and improvised explosive devices. The planning group had to maximally reduce the total number of threat points. To do this, the group had to deploy five battalions to the AOO. As each battalion was deployed the known threats were displayed. To neutralize these threats, participants had to assign their assets. Group performance was calculated according to the remaining threats points and the number of intelligence recommendations followed.

Technology Support

In the Spreadsheet condition, participants were provided with a series of Microsoft Excel spreadsheets. Each participant was given their own spreadsheet on a different computer within the same small room. Spreadsheet contained eight panels affording/presenting the following; (1) asset summary (initial, used, remaining, asset cost), (2) budget summary (initial, spent, remaining), (3) known battalion threats (changed dynamically as the

battalion areas were manipulated), (4) asset effectiveness, (5) panel for deploying battalions to AOO (that matched a paper map of the AOO that was given to each participant). Participants had to use five battalions and each battalion needed to be a continuous shape. (6) Assign assets to the deployed battalions. When assets were assigned to a battalion, the number of threats to that battalion was (potentially) reduced. (7) The revised battalion threats following the assignment of assets, (8) a color-coded summary of the panel functions.

In the MTT condition, the information and functionality afforded by the spreadsheets was provided by a 55" Evoluce Multi Touch Table. Participants had a private work area on the MTT that provided asset specialists with an asset and budget summary and for Intelligence Officer a description of the intelligence information. To deploy a battalion, participants clicked a green "+" button in the four corners of the MTT. A circular battalion area of responsibility appeared and participants could move, reshape and resize this battalion. To assign an asset, participants selected an asset from their private work area and dragged the asset to the intended battalion. To view the assets or threats, participants pressed the "Asset" or "Threats" button.

Table 1. List of affordances of the two technologies

Multitouch Table	Spreadsheet (on an individual computer)
Presents information in an ecological way	Presents information in representative (numerical) way
People have less experience but can interact natural	People more experienced but interactions are learnt
Process work visible to all	Process work visible to self only
Data manipulated using coarse motor actions	Data manipulated using fine motor actions
MTT interpretations of user actions not always correct	Computer interpretations of user actions correct
Accepts multiple user input	Accepts single user input
Does not require additional input devices	Requires (standard) input tools – keyboard and mouse
The entire surface is an sensor/actuator	Only specific cells are sensors/actuator
More information can be presented on screen	Less information can be presented on screen

Although it is impossible to separate task performance from the interface used, an attempt to do this was made by exploiting the affordances listed in Table 1. Given that the two interfaces were equal in terms of information content (except where listed) and were developed to exploit the technology affordances, we argue that performance differences that arise are somewhat interface-independent. The key differences between the conditions were (1) total threats were represented using colors on the MTT (not possible using spreadsheets), (2) asset effectiveness was not presented on the MTT (but participants were given this information on paper), (3) adherence to the intelligence recommendations was visually presented and updated in real time on the MTT (not possible using spreadsheets). With spreadsheets, the intelligence officer had to locate the threats on their paper map, and to track assets distribution using the spreadsheets. In the MTT condition, the location of the intelligence reports was presented on the map using an Exclamation icon (see green/red icons in Figure 1).

Questionnaires

At the end of each mission participants completed two questionnaires; an excerpt of the Questionnaire for User Interaction Satisfaction (QUIS) version 7 (Past Experience and Overall User Experience; Chin, Diehl, & Norman, 1988), as well as a Short Usability Questionnaire. The scales from the QUIS were; Terrible to Wonderful, Frustrating to Satisfying, Dull to Stimulating, Difficult to Easy, Inadequate Power to Adequate Power, and Rigid to Flexible. For the Short Usability Questionnaire, participants answered five questions using a seven point Likert scale and three open-ended questions. The questions in the Short Usability Questionnaire were: (1) Did you feel comfortable working with the technology? (2) Did you feel frustrated using the technology? (3) How much did you enjoy working with the technology? (4) How well do you think you worked as a team using this technology? (5) How easy was it to complete the task using this technology? (6) What did you like most about working with this technology? (7) What did you like least about working with this technology? (8) Do you have any other comments regarding this technology? Results from these questionnaires are reported such that higher scoring answers indicate a more positive response.

Procedure

Participants were welcomed to the experiment room and informed consent obtained. The general experiment instructions were explained and a written version of these instructions was also provided. Participants were told that they had been called together to form an Operational Planning group and that they will be required to

perform one aspect of Operational Planning for two separate crises. For both crises, their objectives will be the same. They were told that a specialist operation is being planned to resolve the crisis and the role of their Operational Planning Team is to secure the AOO. Participants were told that to do this they must deploy five battalions and a range of assets and at the same time resolve a series of intelligence recommendations. Next participants were randomly assigned to one of the four specialist roles and an information pack (containing asset descriptions such as availability, cost, and effectiveness) was given to each participant. At this point the real time intelligence information was given to the intelligence officer. Next, participants were briefed on their mission and the technology (MTT or Spreadsheet). Participants were then given thirty minutes to complete the first mission. At the end of this mission, the two questionnaires were distributed. When all participants had completed their questionnaires, the second mission briefing was read and the second technology explained (the Intelligence Officer was also given the intelligence information specific for this mission). Participants were then given thirty minutes to complete their second mission. Immediately following the second mission, participants again completed the two questionnaires. When all participants had finished the questionnaires, participants were thanked for their time and given a general experiment debriefing document.

RESULTS

We were unable to retrieve one set of data due to an MTT technical failure and as a consequence, the remaining five groups (twenty people) included 12 males with an age range of 20 to 59 (average = 32.1 years; SD= 11.43). Despite participants having significantly more experience with Spreadsheets than with MTTs ($t(23) = -3.267$, $p < 0.005$), results indicate that participants were more favorable of the MTT on all QUIS scales except Computing Power where no difference was observed (Q1, $t(19) = 4.904$, $p < .000$; Q2, $t(19) = 2.763$, $p < .05$; Q3, $t(19) = 5.060$, $p < .001$; Q4, $t(19) = 2.372$, $p < 0.05$; Q5, $t(18) = 1.617$, $p = 0.123$; Q6, $t(19) = 3.943$, $p < 0.001$). On the second questionnaire, results indicated that participants were more favorable of the MTT with regards to 'Enjoyability' ($t(19) = 4.204$, $p < .001$) and Ease of Use ($t(18) = 4.456$, $p < .001$), there was an approaching significant difference between the technologies in Supporting Team Work ($t(19) = 1.889$, $p = 0.074$) and no difference in Comfortableness and Frustration.

With regards to reducing the threat points, the results failed to identify a significant difference in the percent of initial threats remaining on the map between the two groups ($t(4) = -.913$, $p < 0.413$). It is important to note that for two groups, the initial battalion deployment in the MTT condition had multiple overlapping cells (resulting in a greater initial threat points than would be possible using Spreadsheets). Presented in Figure 2 (left) is the percentage reduction in threats according to the initial threats per battalion area of responsibility. No significant differences were observed between the MTT and Excel groups ($t(4) = -1.059$, $p = 0.349$).

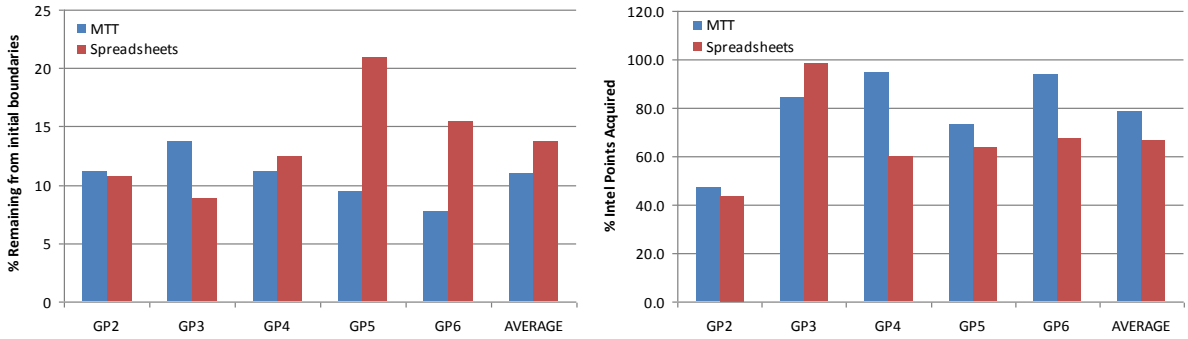

Figure 2. Percent of threat points remaining for two conditions (left); Percent of Intelligence Points acquired (right)

With regards to resolving intelligence recommendations, although four out of five groups performed better using the MTT than Spreadsheets, a paired sample t-test failed to identify a significant difference between groups.

DISCUSSION

In nearly all questionnaire measures, participants rated the MTT as more favorable than the Spreadsheets – this is despite that participants were significantly more experienced with spreadsheets than MTTs. The only QUIS question for which an MTT advantage was not observed was processing power suggesting that the MTT was not worse than the spreadsheets despite the fourfold greater amount of parallel processing. Additionally, the Short Usability Questionnaire clearly suggests a greater subjective affect towards the MTT than the spreadsheets. The non-significant difference in performance measures (need fulfillment and satisfying intelligence recommendations) between the two groups is most likely due to the low number of groups (five; in comparison, twenty people completed the questionnaires used for the subjective analysis). It is worth noting that three out of

five groups performed better on the MTT than with the Spreadsheets on reducing the overall threat level, and for four out of five groups there was an MTT advantage for satisfying intelligence recommendations.

One limitation with this study was the low number of groups. Additionally, the analysis was conducted with five groups and thus the design was not fully counterbalanced. As mentioned earlier, a potential limitation was that the MTT could represent more information, and do so differently, compared to the Spreadsheets; for example the MTT represented threat areas in color and give visual feedback regarding intelligence recommendations. We have attempted to mitigate this confound, by maintaining information consistency between the two displays and minimally exploiting the affordances of the two technologies. In other words, although the technical capabilities of the MTT are significantly greater than the Spreadsheets, the interface developed for the MTT made use of the technology capabilities but only in a relatively simplistic way.

Overall, the results suggest a potential for an MTT to support the Asset Distribution aspect of real-time Operational Planning. The MTT appeared to support team work and the visual and interactive nature of the technology assisted the groups in reducing overall threats and to resolving (potentially conflicting) real time intelligence information at least no worse than when using Spreadsheets. At the same time, there was a clear user preference for the MTT over the use of Spreadsheets. In future work the video recordings will be analyzed to more precisely identify how team work changed in the MTT condition. Anecdotally, we saw a reduction in verbal communication using the MTT compared to using the Spreadsheets. This finding suggests greater peripheral (or pre-attentive) awareness (Woods, 1995) of team members when using the MTT as compared to when using the spreadsheets. If true, then according to Wickens (2008) this finding suggests an opportunity for new or additional use of individuals' auditory channel to process additional information. A valuable contribution to research in this domain would be conduct a controlled study identifying the MTT affordances that most contribute to the performance and subjective results observed in the current study. Future MTT applications should be designed to maximally exploit the affordances of the MTT technology.

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