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An Investigation into Changes of Focus between Activities of Varying Attention Requirements over Multi-View Systems

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0.1 Introduction

Integrated awareness systems have become standard features in many industries with power stations and air traffic control just two of the more well known. These systems have the advantage that they deal with homogeneous data often controlled by a single source. While this is a desirable state from the point of view of data integration and analysis it is a rare one in general terms. Work is currently being undertaken in a semantic web driven project to investigate situational awareness of heterogeneous information. As with the two situations mention above, power stations and ATC, we are dealing with time sensitive information requiring the information not only be processed quickly and accurately but that the providence of the data is also taken into account to facilitate rapid decision making. This experiment begins the investigation into the best way to support a user having to prioritise related but separate information feeds by looking at how there reactions to events change depending on the attention requirements of their current task and their involvement with that activity.

0.2 Related Work

Better systems and better system designs are allowing people to deal with increasing amounts of information concurrently. Work by Cutrell et al. (2001); Czerwinski et al. (2000, 2004) has looked at how users react to interruptions and how these effect the users efficiency. Their research suggests that some type of tasks are more sensitive to interruption than others.

> Notifications reliably harm faster, stimulus-driven search tasks more than effortful, cognitively taxing search tasks... A possible explanation for this is that for tasks centering on high-speed visual scanning, users need to disengage and then re-engage their scanning mechanism(s) after an interruption. (Czerwinski et al., 2000)

As well as type of task users respond differently depending on how far into the task they are.

> Some task phases are less amenable to interruption that others... [the results demonstrated] harmful effects of notification delivery on memory for the prior task early in a task's lifecycle despite earlier findings that sending notifications earlier is better for overall task time. (Cutrell et al., 2001)

Going by those finding it seems likely that in our experiment we will be looking at some of the worst conditions for interruption since, while our users will not be performing a search task, the tasks undertaken require quick, reactive judgements rather than cognitive tasks. Further, because of the time critical nature of the situations that we are considering there is no possibility of delaying notifications to an opportune moment as has been suggested by Czerwinski et al. (2000); Cutrell et al. (2001) as a means of reducing the disruption caused by a notification.

While a notification can be just that, it is far more frequently an request for action of some type on the part of the user. The research into interruptions also includes the important extension of that - switching tasks. As might be expected task switching is most disruptive than a simple notification of an event although in both cases the user has to make the decision how and whether to respond. One factor that the notification experiments did not look at directly was how receptive the user was to the interruptions. It is possible that differences observed of the effect of the notification within the life cycle of the task are indirectly caused by this with the user in the earlier stages finding the task harder to get into and therefore happier to be distracted while the third quarter represents a peak in their interest. We are hoping to see a distinctly different reaction from our subjects between when they are involved in something and uninvolved. It could be argued that the psychology of the user was taken into account when it came to task switching.

> The costs were discovered to be related to the nature of the current and pending activity, as well as the user's proficiency at both tasks. (Czerwinski et al., 2000)

If the user was disinterested in their current activity or in the pending activity then that would necessarily effect how they approached the switching process. It is interesting that user motivation is not included in the conclusion drawn by Czerwinski et al. (2004) that

> Task complexity, task duration, length of absence, number of interruptions and task type influence the perceived difficulty of switching back to tasks. (Czerwinski et al., 2004)

This possible omission is unlikely to have become apparent in the short, directed experiments from which the list was concluded. It is hoped that this experiment will be extended enough that the user will have periods where they are very open to interruption and indeed pre-empting it by looking for a situation in which they will be able to involve themselves as well as periods at the other extreme when they are inundated.

Latorella (1999) identified five possible responses to an interruption: oblivious dismissal, unintentional dismissal, intentional dismissal, preemptive integration, and intentional integration. In the first of these, oblivious dismissal, the user is not aware of the notification and thus does not act on it. A distinctly different case from unintentional dismissal the user is aware of the interruption but misinterprets it and so does not act on it. In the other responses the user correctly identifies and analyses the interruption and makes a conscious decision on how to react and weather integrate it into there work flow or not. In all cases the user ends as they began - working on the “ongoing task” that is there primary task. While they are important divisions the underlying model assumes that the ongoing task is the primary one with the interruptions coming from discrete, related events that can can be dealt with and then put aside. It does not allow for the interruption to become the the ongoing procedure as could conceivably occur if the user was dealing with multiple feeds of related but distinct information. It could be argued that the model still occurs over a longer time span since the user will in all likelihood have to come back to the information feed they were working on before the interruption but there is a point at which that argument breaks down. After a significant time has passed the user is not so much returning to an interrupted task as starting a new one.

If we take Grudin’s definition of the primary task being the one on which most keyboard and mouse time is spent (Grudin, 2001) then we have to acknowledge that is some cases that metric is not clearly defined and cannot be known until after the event. One task needs to be designated “ongoing” or “primary” to recognise that even when multitasking the user can only be focusing on one thing at any moment. However when the information feeds are of equalling importance the “ongoing” task could be decided by which, on comparison, seems to in more need of attention or it could be whichever catches the users eye first, or the one on the right hand screen or by some other random method rather than through any analytical or conscious decision leaving it possible that it will actually become the secondary, interrupting task during that session. A lot of research has been done to compare the way multiple-screen and single screen displays are used. The evidence suggests that

> second monitors are generally used for secondary activities related to principle tasks, for peripheral awareness of information that is not the main focus and for easy access to resources. (Grudin, 2001)

As already mentioned a lot of the research that has been done has studied the user being interrupted by secondary activities such as instant messaging. We have argued that our definition of primary and secondary information information is different from those used in the previously mentioned experiments because we are working with dynamic rather than static assignment of these priorities. Similarly it could be argued that while a lot of the lessons that have been learned about interacting with peripheral information would apply the assumptions that are connected with the term do not necessarily fit with our usage.

> Peripheral information is information that is not central to a person’s current task, but provides the person the opportunity to learn more, to do a better job, or to keep track of less important tasks (Maglio and Campbell, 2000)

If we take that definition then we have to consider how we are defining the user's current task. In the broadest sense the task is to monitor the situation and respond as and when appropriate whether the information breaks down into one information feed or many. With that definition of the user task then the information cannot be regarded as peripheral because it is directly relevant to the task. However if each separate stream is seen as a different task then any information feed not currently designated primary could be regarded as peripheral to the current task. By comparing both single and multiple screen systems we will be able to analyse any changes in usage and compare them to expected behaviour for a multi-view system to see whether the fluid nature of the priorities has any effect.

All of the previously mentioned research dealt with office scenarios. In the experiment carried out at Virginia State University in 2002 (Somervell et al., 2002) a simple game was used to create a primary task that would keep the Subject's interest and attention. A secondary visualisation would pop up for a set length of time about which the Subject would have to answer a multiple choice question after the round was over. There are two interesting features of this experiment. Firstly, that the secondary visualisation appeared at the same time in each round that the user played. It is not clear whether any of the Subjects realised the repetitive nature of the test and indeed whether their being able to anticipate when the visualisation would occur had any effect of the results but while this standardisation made the evaluation of the variables easier it appears to go against the model we are working towards. Secondly that since the experiment was looking at information visualisation as secondary displays the nature of the two tasks are fixed into primary and secondary tasks. In this experiment the primary and secondary tasks are fluid with the Subject determining at any point which is in the primary role. I would argue that while one of the multiple displays is secondary the information streams being displayed are both *primary* rather than what might be described as *peripheral* information. However the concept of using a game is one that is worth investigating. Games are well known interfaces and the more well known publications are as likely to be as familiar to the Subjects as the standard office type software.

More serious than games a lot of research has been done into focus in high risk situations by the American military. The military are very interested in supporting decision making in critical situations. When the USS Vincennes to shoot down an Iranian Airbus during the Iran-Iraq conflict July 3 1988, the report into the incedent named the display set up as one of the contributing factors.

> The Fogarty report pointed out an obvious culprit: the computer screens that the crew members worked with were not easy to read. A very large screen display showed the big picture, but this display did not show altitude. Instead altitude was listed on a small alphanumeric display off to the side of the primary display. The altitude of a track was given as a four-digit number... This number was embedded in a list of other numbers showing range,

> speed, bearing and so on. This small screen was hard to read, especially if crew member had to abandon what he was watching on the large screen to search through the small one. (Klein, 1998, p.85-6)

Following this tragic error research projects such as the TADMUS (Tactical Decision Making Under Stress) program were undertaken to improve the human-computer interfaces that were in use at that time in an effort to reduce if not eliminate the possibility of similar accidents occurring in the future (Klein, 1998; Morrison et al., 1997, p.99). This research focuses mainly on supporting decision making including information presentation. Since this is the type of high risk scenario that we are interested in exploring it is important to take into consideration the suggestions put forward for military systems where applicable. For the most part these results go beyond the scope of this experiment, for example advocating the need to provide ways to make the raw data available to enable verification of information (Liebhaber and Feher, 2002), but the research does raise some interesting modelling issues. Klein (Klein, 1998, p.95) identifies four task conditions that make it more likely that decisions will be made using the Recognition-Primed model rather than the Rational Choice Strategy. These are greater time pressure, higher experience level, dynamic conditions, ill-defined goals. Conversely the Rational Choice Strategy is more likely to be used in case that involve need for justification, conflict resolution, optimisation and greater computational complexity. Ideally we want our subjects to be deciding whether they need to switch focus using the Recognition-Primed model since that is the method that was used the most in critical situations. To get the subjects doing this the experiment design will have to incorporate the four task conditions mentioned. As well as the time pressure inherent in the the experiments into military scenarios that is not present in the research mentioned earlier there is also a marked difference in how the resulting system would be expected to be used. Military operators could be working for indeterminate amount of time in difficult conditions for example alternating six hours on duty and six hours off duty (Klein, 1998, p.37). For a lot of that time they would be under stress but not necessarily able to do anything active other than monitor the screen. At other times the operator would be stood down and working under much more relaxed conditions where little was happening and less expected. While this is taken to the extreme in the military scenarios a similar work pattern can be found in other jobs which monitor potentially critical environments. This gives the user a totally different psychological profile to the average office worker and a much greater range of situations that the presentation of the information has to deal with. The experiment model needs to reflect this variation so that the results from the different periods can be compared against each other and against the results that were of in the office based experiments to see if it can suggest where the office tasks fit into the spectrum.

0.3 Experiment

0.3.1 Design

5 to 10 people will take part in the experiment. Preference will be given to those who have some experience with the software already. Each Subject will carry out each scenario with a Latin square used to regulate the order in which the Subjects undertake the tasks and the maps they use on each task. This along with some randomisation of events should help balance out any experience Subject's have gain in previous experiments. The Subject will play the game for 10-20 minutes [exact time to be decided based on number of subjects and amount of time available] during which time the Subject will be required to react to various events that take place at one of the the two areas that they have been assigned to guard. During each session the Subject will encounter periods where there is little they can actively contribute and periods where direct interaction of greater and lesser immediate importance is required on one or both of the views. The scenario will follow the same general pattern in that the AI players will be playing the game following the same set of rules each time but events will have a certain amount of randomness attached to their exact timing so that the Subject cannot predict events based on previous sessions. The events of the game will be captured throughout so that they can be compared to observations during the analysis. The Subjects will be recorded during each scenario. Whether they will be videoed with an observer present, videoed without an observer present or whether an observer will just make notes on their actions has yet to be decided.

Before each session starts the Subject will be reminded of the objective of the experiment and have the features of that sessions configuration explained to them. They will then be given a few minutes to play with the system and get used to the options and limitations. After the experiment the Subject's will fill in a short questionnaire.

0.3.2 Set Up

The experiment will run on a variety of physical configurations involving a single monitor, duel identical monitors and final a single monitor and a projector. In the case of the duel monitors, the screens will be placed next in line with each other but a small distance apart and angled slightly inwards. When the projector is used the display will appear on the wall behind the monitor and at a height such that it is not obscured by the screen in front of it but that the minimum amount of movement is required to view it. This will be configured to the height of each Subject.

The experiment will require two monitors of equal and reasonable size and a projector. Further work with the software will determine whether it can all be run off a single computer or whether multiple machines will be required, possibly one to host the game as a dedicated server and either one for the display or one controlling each of the displays in use during that session (maximum of two). Any machines connecting to the server and running the game will require at least

- Processor: Pentium 3 1.0 GHz or AMD Athlon 1.0 GHz (1.2 GHz recommended)
- Memory: 128 MB RAM (256 MB recommended)
- Hard Drive Space: 5.5 GB free space
- CD-ROM or DVD Drive: 8X speed CD-ROM or DVD Drive
- Video Card: 32 MB Windows 98/ME/2000/XP-compatible video card* (64 MB GeForce 2 or ATI Radeon Hardware T&L card recommended)
- Sound Card: Windows 98/ME/2000/XP-compatible sound card*
- Controllers: Mouse, keyboard and microphone
- DirectX Version: 9.0b

If a machine is used as a dedicated sever then it requires about half as much space on the hard drive. A machine is available to act as a dedicated server if that route proves to be the most effective.

0.3.2.1 Task Requirements

The Subjects need to be exposed to three states of attention requirement:

No attention required Events are continuing to occur but none directly effect or relate to the Subject's area. Monitoring is required in case the state changes but active interaction is not required.

Attention advised Events that could effect or relate to the Subject's area are occurring. Interaction may pre-empt later problems or provide some useful but not immediately relevant information. There may be some actions that the Subject can take that will improve their situation or their knowledge of the situation but there is no immediate critical actions that need to be taken. Some interaction might be expected in this state to aid the Subject to consolidate their position and continued monitoring it required in case the situation develops further.

Attention required Events are directly effecting the Subject's area. Unless action is taken there will be adverse consequences. Action on the users part may either prevent or minimise those effects.

These states need to occur in a dynamic and continuous manor throughout the experiment whether or not the Subject is paying attention to them.

Visual and auditory cues will be given when certain events occur. The type of cue given will depend on the importance of the event. With the Subject being alerted to non-critical events by a visual message that will appear on the screen and remain for a limited period of time. Critical events will be have both audio and visual notifiers.

0.3.2.2 Computer Games and Simulations

0.3.2.3 Software Selection

There were a number of options available for what type of software should be used in this experiment. The software had to be able to fulfil all the requirements for the task (see above: 0.2, 0.3.2.1) while at the same time be simple enough to use that the Subjects would not need extensive training prior to the experiment. It is also important to get away from office type applications where focus and interruptions had already been studied (Czerwinski et al., 2000, 2004; Cutrell et al., 2001). The reason for this is that not only that the area has been comprehensively covered but because our underlining assumptions about the users and the situations they are in when using the software are radically different from those that might be expected in a typical office scenario. In our experiment model we are looking at situations more similar to those investigated by Kara Latorella (Latorella, 1999) in that we wish to allow both oblivious dismissal and unintentional dismissal reactions to notification to occur and events should develop even while they are not in focus. As previously mentioned (see above: 0.2) games software is almost as ubiquitous as office programs but provide a very different conceptual model for the subject to interface with. The office based experiments (Czerwinski et al., 2000; Cutrell et al., 2001) almost exclusively required the user to respond to the interruption as a way of confirming that it has been noticed. In some cases (Cutrell et al., 2001) the time it took the Subject to respond to a notification was studied as part of the evaluation. In this experiment the interest is in how the Subject responds to the notification that an event has occurred but taking into account the Subject's ongoing evaluation and reaction to the situation in which they find themselves. The interest is not in how long they take to react but under what circumstances they don't react at all and under which they make an analytical judgement to either react or not to react. It is our contention that the response to the notification will vary depending on how actively involved in the current task the Subject is at that moment and that the task they are currently involved in will automatically take precedence over any other of up to equal importance while the user is actively engaged otherwise the alternate task will be given priority. The fact that the text notification as available for a set period of time allows the user some leeway about when to interrupt their immediate task to read the information and decide whether they need to act on it while still allowing for the possibility of the user being too involved to notice. To be an appropriate model of the type of situations we are considering it should be possible for the Subject to ignore the visual and aural notifications to the point that there are hidden costs up until a catastrophic failier occurs. This time of behaviour can be expected in many games and suggests that they could therefore be used as a good conceptual model for the experiment to run in. The question would then be what type of game would best model the sort of time critical situation that we are envisioning.

0.3.2.4 Real Time Strategy

Real time strategy (RTS) games simulate combat situations. They are distinguished from turn based strategy games by the introduction of time as an extra limited resource that the player must take into account. The game can frequently be won or lost on the players time management skills as much as their tactics. Commercial games like the Total Annihilation series (1997-2000, Cavedog Entertainment), Starcaft (1998, Blizzard), the Earth series (1999-present, Zuxxez Entertainment AG) all the same basic features - a single player campaign in which the player is pitted against the computer in a series of linked missions and multiplayer fights in which the player can take on a number of other players either computer of human controlled.

Advantages:

- Close to the type of time-critical situations we are interested in. Game naturally provides the different types of attention states that we are exploring.
- Top down view of map.
- Simple select, point and click interface.
- Games have internal time systems.
- Computer controlled players available in all commercial games.

Disadvantages:

- Most commercial games not set up for serious modification and as a result little community and support.
- Limited support for open source variants with any alterations being needed to be carried out at game engine level.
- Players will have to be restricted to prevent them getting overly involved in the resource management aspect of the game.

0.3.2.5 First Person Shooter

A well known type of game, players are generally involved in running around they playing area shooting other combatants. Players may have conflicting objectives with brings them into conflict or the conflict itself may be the objective. The game engines themselves are designed to be highly configurable (space combat and 'point and click' adventure games have both been developed from them) with third-party variations (mods) becoming as popular as the games they were based on. Commercial games of this type tend to be aimed at either the single player or the multiplayer gamer with some companies such as Epic releasing one series of games with single player adventures to work through (Unreal, Unreal2) and another related series where the single player aspect of the game is little more than practice for the multiplayer game (Unreal Tournament et al.). To increase the lifespan of the game modification has been increasingly supported by the companies producing these types of games. This can lead to a merging of the multiplayer and single player games as the engines become more important than the games that were developed with them.

While Doom and its successor Quake were formative in creating the genre it was the Unreal series from Epic that lead the way in modification support with the first game including both a map editor and a scripting language, UnrealScript, for interacting with the game engine. A map editor and an SDK of some type are now the de facto minimum for release to the community with a game of this type and as a genre it is probably the most supported with regards to modification and conversion.

Advantages:

- Map editor and scripting language available.
- Large mod community providing help available.
- Possibility of voice as well the manual interaction (Unreal Tournament 2004).
- Games have internal time systems.
- Multiplayer games can be played against computer controlled bots.

Disadvantages:

- Probably need to be fairly heavily modified.
- Player ability could be a significant factor.
- Default view is side on rather than top down giving a more restricted view of the environment.

- The game is very rarely uneventful and adding any granularity of attention requirements might be difficult.
- Some practice required to get used to control of character since coordinated two handed input is required.

0.3.3 Software Selection

While Real Time Strategy games provide the closest model to the time-critical type of scenarios we want to investigate they are not the easiest to modify. Starcraft is the most programmable of the real time strategy games and allows the most alteration to the game mechanics but access to the user interface is still restricted. It is a tribute to the game that the community is still in existence and that there are resources available to modify the game but consultation with people who have looked at Starcraft modification suggest that even it would not be modifiable enough for our requirements. Falling back to the first person shooter option Unreal Tournament 2004 has the advantage of being the most recent release with a lot of development support out of the box. It also introduces features such as speech recognition support that would be interesting to add in as an interaction option. Since it allows modification of everything above the level of the engine through the use of Unreal Script it is possible to make all the alterations that the experiment calls for.

0.3.3.1 Tasks and Procedure

The Subject will work in concert with a computer controlled team in a variation of an Onslaught game. The aim of the game is to take control of a number of “node points” across a map. When teams connect two “nodes” in a path a link will be created between them. The node in the path nearest a team’s base connects to their “power core”. When a path of linked nodes reaches to the opponents power core the shield protecting the power core is removed and the power core can be attacked directly. The game is won when one team destroys the other’s power core. In a normal game after a set time limit is reached the cores will start to drain with the more heavily damaged core draining faster. When one or both of the cores reaches zero it is destroyed and game is over.

In the version of the game altered for use in the experiment a strict time limit will be observed. The pathways will be arranged so that there are two possible paths between the opposing power cores. The Subject will personally defend the two final nodes in the pathways from attack by the opposing team of AI controlled players. These two nodes will be out of line of sight of each other so that the Subject will have to rely on the views on the two displays and any other cues they are given. The Subject will be given a visual warning when one of the nodes is under threat (an enemy player is within a certain proximity to it) and both an audio and a visual warning when the node is directly under attack. The Subject will be invulnerable but movement will be restricted to the areas around the two nodes. During this time the interactivity required by the situations visible in the two views will change as the gameplay moves around the map. The teams will be balanced so that neither team has a clear advantage and thus the focus of the conflict will shift throughout the duration.

The Subject will be able to interact with opponents directly when they come within their line of sight. They will also be able to give commands to the other AI players on their team. These commands cover a number of basic, general tasks such as "Attack", "Cover me" and "Hold position" and can either be given manually (by typing the command in) or through the speech recognition software. A short period of time will be spent during the introductory session to configure the speech recognition to the Subject.

The view on the active display (the one in which the Subject's avatar is currently located) will be straight ahead at the eye level of the avatar. The view in the secondary display will be top down so that the player can easily see at a glance the entire of the area around the node. In both cases there will be a small map in the top right hand corner which will show the nodes and the position and the audio call signs of the players on the same team as the Subject. Further analysis and testing of the software will determine whether the player will also get to see the positions of all the enemy players and if not consistently then under what conditions.

In the single monitor scenarios the currently selected window will be considered the primary one. The Subject will only be able to interact with the currently selected window although they may change their focus at any time. With the multiple screen scenarios the users will either be able to interact with each monitor separately or will also be able to switch which view is on which display with the display being interacted with being considered the primary display. Which of these two systems in implemented will be decided based on further investigation the hard and software limitations and a small trial run to decide which of the forms is more appropriate for the experiment. If both are equally viable and time allows than the possibility exists for them to be directly compared as part of the experiment or both options allowed and it noted which the user chose to use during the scenario and whether there was consistent usage by a Subject.

0.3.4 Results

It is hoped that distinct differences will be observed in the way the that Subjects deal with the two feeds of data depending on how much attention they judge they need to give the situation they are focused on at any given moment. This should confirm the work that has already been done regarding task management and interruptions in different situations as well as laying the ground work for further investigations into how best to support the presentation of multiple streams of critical hetrogenious data.

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