

16.422 - Human Supervisory Control of Automated Systems

- Literature review -

Reminder about my project:

My project will study the role of instant messaging on task performance and level of arousal. Basically, it is aimed at evaluating with how much impact the use of instant messaging modifies task performance and the level of arousal of subjects, and finding out if there is a correlation between these two. The experiment will feature subjects playing an ATC simulation game (primary task), while being occasionally interrupted by instant messages (secondary task). The subject's skin conductivity and performance on the game will be measured. This project is a common project with MAS.630 - Affective Computing.

Note:

This literature review only focuses on the 16.422 part of the project, that is the impact of instant messaging on task performance.

With the increasing use of instant messaging as a communication tool, psychological research on alerting and disruption have recently produced a lot of studies aimed at better understanding the impact of this communication interface on daily working tasks. May IM users be teenagers or naval officers, it remains that conversing through this interface modifies deeply their behavior and aptitude at handling other tasks at the same time. Concerns have raised that instant messaging (IM) was disruptive enough to degrade one's performance on concurrent tasks. Finding ways to limit these interruptions' impact on ongoing tasks have also been studied, and several forms of IM infrastructures have been tested in the past few years. Dealing with IM and its effect on workload seems to require interruption management capabilities: considering the type, time of occurrence and frequency of disruption by IM, its impact on cognitive abilities might change, and be optimized.

A new control system for the Tactical Tomahawk missile is currently under development in the U.S. Navy labs. This system mainly features a radar-like display that presents the missiles, their route, and their targets, a decision matrix with all the information summarized in a spreadsheet, and a chat box interface that allows real-time communications (Cummings 2003). This example illustrate the embedded use of IM in supervisory control task. Monitoring a radar can be considered as a vigilance task, as defined by Wickens and Hollands (2000): the Air Traffic Controller (ATC) has to detect "intermittent and unpredictable signals over a long period of time (the watch)". Several past studies have shown that the vigilance level in such tasks dropped deeply during the first thirty minutes of watch in a phenomenon referred to as the vigilance decrement (Mackworth 1948; Harris and Chaney 1969; Parasuraman 1986). Therefore, it is legitimate to think that IM, simultaneously with the unavoidable vigilance decrement, can have a tendency to worsen it, by interfering with ongoing cognitive workload. Workload refers to the "cost of accomplishing task requirements for a human involved in a man-machine system" (Hart and Wickens 1990). With this in mind, IM can be thought as interruption processes that sneak into the current workload. Therefore, interruption

management should be of primary concern in traditional task management processes. Latorella (1998) defines interruption management as the ability to "attend appropriately to and to accommodate new, interrupting stimuli and tasks".

More than 60 million users have registered to the AOL Instant Messaging (AIM) services (Andrews 2001) and the increasing number of available clients (MSN Messenger, ICQ, Yahoo! Messenger...) makes this communication technology one of the most popular and expanding. Companies use IM professionally, for communication between teams located in different sites (Tang, Yankelovich and Begole 2000). The military use it as a collaborative, real-time, informal communication tool (Cummings 2003). Nagel (2002) refers to IM as "a computer mediated conversation" that allows "distributed collaboration". All these ways to use and definitions are consistent with very recent research that proved that informal communication facilitates collaborative work tasks (Huang, Russel and Sue 2004). This is explained by the IM being flexible and expressive (Nardi, Whittaker and Bradner 2000). But Nardi et al. also found out that IM was used a lot for "outeraction", which they define as all communication processes but information exchange: IM appears as a communicative process aimed at maintaining a sense of connection, negotiating availability, and sustaining social interactions. Furthermore, in spite of the possibility for direct communication, several studies have found out that one of the primary goal for IM was the initiation of communication bridges to other media: IM is used to start a conversation after checking the recipient's availability, then the users switch to another media, like telephone, or real face-to-face conversation (Tang, Yankelovich and Begole 2000; Nardi, Whittaker and Bradner 2000).

A possible explanation for this switching media phenomenon is the inherent disruptiveness of this form of communication. Thanks to its free availability and its huge compatibility through the various clients that exist, IM reaches both technical and non-technical communities, which makes it one of the first pervasive computational technologies (Andrews 2001). It is pervasive in the sense that its operational structure can lead to unwelcome distractions: the immediacy of contact permitted by IM can go against the recipient's need for privacy (Deckmyn 1999). Therefore, automatically popping-up windows are both visually disruptive and socially aggressive. Indeed, the lack of a transition or an introduction phase for a proper, polite initiation of conversation prevents IM from following standard social rules. In other words, IM is disruptive because of the absence of direct verbal feedback, as in real conversations (Tang, Yankelovich and Begole 2000).

A fair amount of literature has dealt with interrupted primary tasks, and its consecutive potential degradation, in human supervisory control. IM gives the users "a sense of ultra-compressed time, and foreshortened horizons" (McKenna 1997). Some IM users integrate this as an additional time constraint, that increases time pressure: they feel required to adapt to this high-pace time pattern generated by IM. But, past experiments have proved that primary tasks performed under consequent time-pressure, are degraded significantly (Cellier and Eyrolle 1992). Therefore, IM's structure itself can be seen as badly designed. And inappropriate human-computer interfaces tend to reduce both situation awareness and performance, for example in tele-operated vehicle command tasks (Ruff, Narayanan

and Draper 2002). Cummings and Guerlain (2003) confronted this interface problem during their experiments: subjects tended to focus on the IM chat box interface, while leaving their primary task, which led to their loss of situation awareness and a degradation of performance. Moreover, in the case of ATC and pilot communication, such interruptions have been shown to affect considerably performance on both sides, and thus the overall safety (Latorella 1998).

Therefore, it appears clearly that intermittent interruption, such as those provided by IM, lead to an overall degradation of primary tasks. Numerous projects have addressed this question, and tried to provide, in the case of IM, ways to decrease its disruptiveness. The literature shows that context awareness is of primary importance in IM, since it can provide a solution to decrease disruptiveness. But, whereas presence or availability information is clearly presented by current IM clients, context is not (Peddemors, Lankhorst and de Heer 2003). The ConNexus project was aimed at creating an IM chat interface that provides contextual information about the interlocutor, with the goal of disturbing as less as possible the recipient of the message (Tang, Yankelovich and Begole 2000). In the same idea, the SitComm project tried to minimize the cost of use, or intrusiveness, by integrating situation awareness data in the interface. One of its goals was respecting existing social protocols (Nagel 2002). Similarly, the PLIM framework (Presence Location and Instant Messaging) consists in an infrastructure that provides the distribution of presence (who is available) and location of presence (where they are physically). This was applied to the workplace (Peddemors, Lankhorst and de Heer 2003). Another method to reduce IM's disruptiveness was investigated: it consisted in finding the best timing for instant messages to be sent. Research have shown that interruptions that occur after important tasks or between non-dividable subtasks are less harmful (Czerwinski, Cutrell and Horvitz 2000). This is consistent with the "chunking behavior" initially introduced by Miyata and Norman (1986): tasks consist in a succession of subtasks or chunks that cannot be individually interrupted. The user first finishes the current task chunk before switching to the interruption.

Despite IM's obvious disruptiveness, users find it less pervasive than auditory interruptions, such as phone calls (Tang, Yankelovich and Begole 2000; Czerwinski, Cutrell and Horvitz 2000). This is consistent with other research, that showed that auditory interruptions had bigger impact than visual interruptions (Latorella 1998). In this perspective, Latorella also demonstrated that ATC's are more resistant to visual interruptions than aural interruptions, when performing visual tasks. This was later confirmed by Czerwinski, Cutrell and Horvitz (2000): they demonstrated that interruptions that are relevant to the ongoing task (e.g. both visual tasks), are less disruptive than if irrelevant. In addition, several research named visual persistence as the main reason why users could more easily handle visual interruptions than non-persistent auditory interruptions (Nardi, Whittaker and Bradner 2000).

In conclusion, in spite of being a disruptive way to communicate, IM's use is spreading very fast, from home to the workplace and in the military. But this expanding pervasive technology is far from being free of impact on other simultaneously executed tasks. Often, it implies a significant degradation of performance. Therefore, both the exact link

between disruptiveness by IM and performance degradation, and methods to reduce this degradation, have been and still need to be investigated. Current concern is aimed at increasing participants' awareness of the other's state and environment, or at optimizing the time and pattern of interruption. Further work should for example find out if the disruptiveness by IM impacts directly on task performance, or if there is a chain of reaction in between.

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