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USABILITY ANALYSIS IN MILITARY SETTINGS: HOW ADVANCED WEARABLE COMPUTERS COULD AFFECT COMMUNICATION, DECISION MAKING AND OPERATIONS

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ABSTRACT

Both the market and academia strongly encourage the development of usable systems, and they do so by relying on a number of standards, guide-lines, research and good practice streams. Unfortunately, the military sector, whilst being the owner of standards under many purposes and topics, seems still falling and running behind as the conceptual issues and practical implications of usability are concerned. In our paper, usability has been analytically investigated throughout a simulated military operation setting and against a mock-up prototype wearable computing device, and several provoking conclusions in terms of “rethinking usability” applied to military operations and decision making have been derived. We expect that many stakeholders from within the whole sector (the “defence” industry) can leverage this study as a first step to challenge existing cultural, political, economical and even ethical biases and constraints acting against the full exploitation of usability potential. .

KEYWORDS: HCI, Military Device, Prototyping, Wearable Computer, Usability.

INTRODUCTION

No individual or organization, no matter which sector or field they operate, would ever consider managing any relevant amount of information without relying on some sort of Information Technology (IT) and Information Management System (IMS), today; and not so just in order to support more or less “demanding” (computationally speaking) tasks, but also and mainly for simpler reasons, from retrieving to sharing accurate information for example, especially when such jobs involve or occur within distributed environments. This is obviously even truer when large-scale, real-time complex systems are considered: and the larger and more complex the IMS, the more important its usability. Since its first appearance and within its ongoing meaning definition process, usability has been thoroughly investigated and pursued, mainly under a “civilian” perspective, by both industry and academia. As a result of this dual birth, usability has grown up into a typical area of trans-disciplinary studies and research, including –among the others- contributions from Cognitive Psychology, Software Engineering, Computer Graphics, Anthropology and Organizational Task Analysis. The military sector, notwithstanding the unaccountable amount of specific standards, regulations, guidelines and procedures it has developed to tackle a number of purposes and topics, seems still falling and running behind as the conceptual issues and practical implications of usability are concerned. Still, because of other intrinsic features and issues related to usability, operative users, trainers and decision makers from within the military field would greatly benefit from further understanding and elaborating their goals as well as developing their long-term objectives and strategies under a usability perspective.

This paper aims at highlighting a set of "affordances" (arguments, hypotheses, suggestions, issues and provocations) to let usability become a primary factor to this industry.

IMSS AND USABILITY IN THE MILITARY SECTOR

Information Management Systems are those software tools and applications developed in order to assist people with processing increasing quantities of information in order to perform complex tasks in possibly distributed environments. Every field of human activity can rely on their own IMSs nowadays, and that is also the case for the military and the defense sector. The most peculiar and crucial set of management tasks military organizations expect to perform comes along and under the so-called "Command and Control" label (or "C2": for a review, see Alberts & Hayes, 2006). The phrase "Command and Control" is ordinarily used in the context of military operations, and several software and technological systems and solutions are available to national armies and defense-related organizations to support their C2 activities: these range from a complex set of activities as defined by military doctrines like the "Network-Centric Warfare" (NCW), down to specific tasks like monitoring and assessing the situation in progress, etc. Whilst these applications (as well as their producers and suppliers) obviously comply with a number of military-related standards, especially as security is concerned, usability-wise they are usually designed and assessed by two main "regulating factors":

1. The adoption of international "content-neutral" standards for the evaluation of software systems (such as ISO 9126);
2. The specific "contextual" strategic and tactical traditions and expertise of the military commissioning bodies.

"Wearable computers" have entered our collective imagination, even without many of us having ever actually seen one. Wearable computers are computers that can be carried on ourselves (or "worn"), with no need for any surface to keep and use it. People could wear it on their wrist, head or any other part of their body and can/should use it easily. Wearable computers are expected to prove especially useful for applications that require computational support while user's hands, voice and/or eyes are engaged with the physical environment, the "surrounding"; within the so called "Augmented Reality". The most recent "wearable gadget" for military, the 'Integrated Digital Soldier System' (IDSS) appears and has been used for providing Command, Control, Communications and Situational Awareness to the infantryman, in order to "improve combat efficiency and survivability of fighting platforms and troops prior to and in contact with the enemy" (Cobham, Defence Communication Systems). Its usability seems similar to that of ordinary communication systems. The IDSS device, fully integrated within a "Command and Control" IMS, is in itself an application which usability has not been fully exploited, as it has been designed around a traditional organizational architecture, in which there is a leader (and a leading system), usually in the back-line, delivering transformational command and control capabilities through its position as a Mission Systems Integrator.

In this paper, usability of a wearable device is investigated within a simulated military setting against a mock-up prototype, which we expect to highlight some significant issues and affect the way users and decision makers in the defence sector would understand and elaborate their goals and eventually make up their decisions. For doing so, we still need to add a further premise: how usability and distributed cognition relate to each other and support the current research.

DISTRIBUTED COGNITION AND USABILITY: AIMS FOR A JOINT RESEARCH

As mentioned above, one of the major contributions to HCI comes from Distributed Cognition, i.e. the cognitive psychology field mainly interested in the way people communicate and jointly use artefacts to accomplish joint work. Cognitive artefacts are involved in any process of organizing functional skills into cognitively relevant functional systems. According to Wright at al (2000), we believe now that cognition is not just a matter of internalising external representations. As Zhang (1997) points out: "[external representations] need not be re-represented as internal representations in order to be involved in a distributed cognitive task: They can directly activate perceptual processes and directly provide perceptual information that in conjunction with internal representations, determine people's behaviour".

Hutchins (1995, p.132) makes the point more concretely when he concludes, "As we have seen, a good deal of the computation performed by a navigation team is accomplished by processes such as hand-eye co-ordination.... The task of navigation requires internal representations of much less of the environment than traditional cognitive science would have led us to expect".

Also Yvonne Rogers (1997) agrees that "*a general assumption of the distributed cognition approach is that cognitive systems consisting of more than one individual have cognitive properties that differ from those individuals that participate in those systems. Another property is that the knowledge possessed by members of the cognitive system is both highly variable and redundant*", therefore suggesting that the "cognitive system" which emerges from human-human and human-computer interaction(s), as a whole, is more than the mere sum of its "human" components.

To our purposes, we consider cognition as a joint activity involving and occurring between several people and the technology they interact with. Many examples of cognitive analysis as a "network of people and technologies" are available: for instance, Hutchins' study (1995) of navigation on a ship; Rogers' study (1992, 1993) of engineering practice; Halverson's study (1995) of air traffic control. Whilst we assume the above statements to hold true also for our investigation, we are hereby betting on encouraging and eliciting new reflection and practice on usability in the military settings, by focusing more on the reinterpretation and the proposal of new problem solving strategies in the military field and less on individual classes of product. Only by achieving this reinterpretation goal, we can ensure that the traditional product-oriented perspective becomes fully open to the concept of "quality in use" (ISO/IEC 9126-1), defined as *"the capability of the software* product to enable specified users to achieve specified goals with effectiveness, productivity, safety and satisfaction in specified contexts of use". Also, we aim at letting military stakeholders and decision–makers focus and appreciate the importance of "cognitive diversity" in improving design and problem solving activities in making systems (and interactive systems in particular, as the military systems are) more reliable and efficient. By asking our users (within an experimental setting) to evaluate the usability of a simple low-fidelity prototype against its capability to support the military in doing a simulated operation in battlefield, we aim at actually assessing the capability for that prototyped device to encourage diverse (and even *lateral* and creative) thinking and to detect those factors which could make their operations in the ground more flexible, more effective and less damaging to the human and the environment. Last but not the least, the prototype itself could represent the starting point of a future project in designing digital spectacles for the industry and for the military.

CASE STUDY: COBHAM'S IDSS

Sir Alan Cobham founded Cobham Plc in 1934. Since then, they have been providing products and solutions for the aerospace and defence industry. Cobham's Integrated Digital Soldier System (IDSS) is one of their best-selling products, with over 115,000 systems sold to 18 armies worldwide. According to their website, IDSS "supports Command, Control, Communications and Situational Awareness for the infantryman, improving combat efficiency and survivability of fighting platforms and troops prior to and in contact with the enemy. The IDSS provides troops with a system to augment the battle plans they have received, providing a 'bottom up' capability to manage the immediate chaos of battle. The Eagle Close Combat Radio interfaces directly with the Division's intercom and IDSS systems to provide customers with a fully networked, integrated voice and data capability for both mounted and dismounted soldiers". A key to success in any military operation is the ability for soldiers at the combat level to manage and control their environment, and directly influence the battlefield situation in real time, through decisive actions based on intuitive and sound situational awareness information. IDSS provides the improved SA needed to achieve greater mission efficiency, and is available in three basic configurations:

1. The commander system
2. The soldier system
3. The tracking system

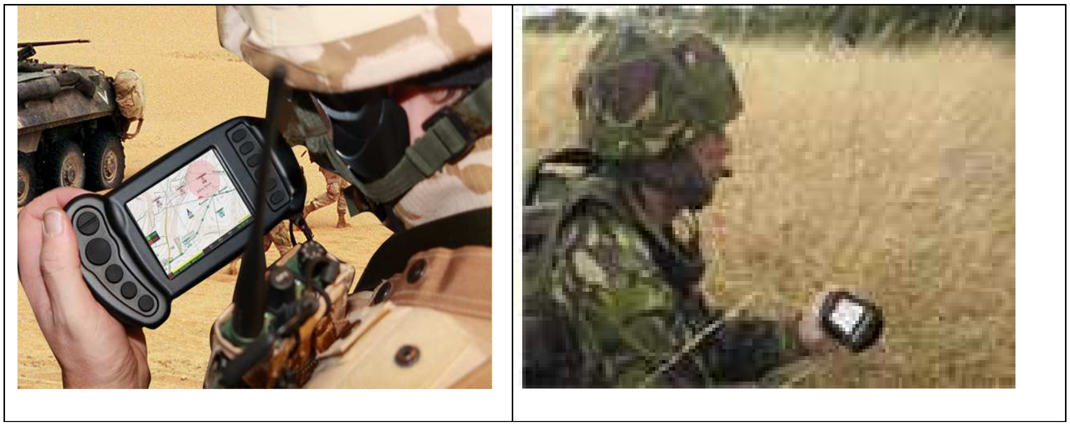

Fig 1: Soldiers are Using Handheld Battlefield Management System [1], [2]

Whilst the wearable components are actually wearable, it is noticeable that the main Soldier Interface Unit has yet to be held and managed manually, by relying on hands and fingers.

Fig 2: Devices of Battle Field Management System [3]

LIMITATIONS

Software/Hardware architects can rely on techniques to deal with many quality attributes such as performance, reliability and maintainability. Usability, however, has traditionally been relegated to a presentation layer and not been a serious concern of software architects, beyond separating the user interface from the remainder of the application (Bonnie E. John, 2003).

“Usability is a term used to denote the ease with which people can employ a particular tool or other human-made object in order to achieve a particular goal”.

Table 1: Possible Limitations of IDSS

Type	Example
System Load	Instability – fears of crashing
Cost	Higher than systems meeting similar functional requirements available in the “civil” market
Interface Constraints	• Screen size too small for text intensive portions of record
	• Text entry still too difficult
Network Constraints	Must use wireless network
Design & Development Constraints	Likely less prone to agile development
Architectural Constraints	Use of third-party software, which is risky
Physical Constraints	The major problem is that it is a handheld device. It will not allow soldiers to perform hand-free operation. Moreover, soldiers carry extra load, as they need to carry four different items with them in order to use the battlefield management system.

We are not sure how to rate the above listed limitations. Nevertheless, it is our opinion that any each issue should be tackled, especially those who might lead us to properly take into account. what Sun Tzu wrote in his famous book (translation 2005): “Seeing what others do not see is called brilliance, knowing what others do not know is called genius, Brilliant geniuses win first. Meaning that they defend and fight such a way as to be unassailable and attack in such a way as to be irresistible.” Whilst many psychologists, engineers and scientists are working hard in this direction, we are hereby suggesting that a crucial achievement would be represented by allowing the military to fight “hand free” and by supporting them to better manage their cognitive workload and decision making process. This is possible to achieve if we adopt an “enriched” usability analysis of such a wearable device.

OUR PROPOSED SYSTEM

“Speed & Coordination, central to success in battle”- Sun Tzu (6th century BC**)**

In order to proceed with our investigation, we have developed our own mock-up device, which we named OMUD (“own mock-up device”), on the groundings of what we have mentioned before and gathered about the Integrated Digital Soldier System (IDSS). Our major goal was to make OMUD more usable than the IDSS, whilst meeting most of the functional requirements that IDSS satisfies: in our proposed device, we have therefore assumed that an IDSS is integrated with a video-based eye tracking system, all within a pair of digital spectacles, to allow soldiers hand-free operation. In other words, our special kind of spectacles would contain all the functional parts of an IDSS together with a monitoring screen. The user/soldier can wear and interact with OMUD easily in the battlefield, and this would hopefully speed up their actions, facilitate communication and grant a better coordination between human-operated and computer-based systems.

In Figure 3 and the following Table 3, some features of our device have been outlined and graphically represented.

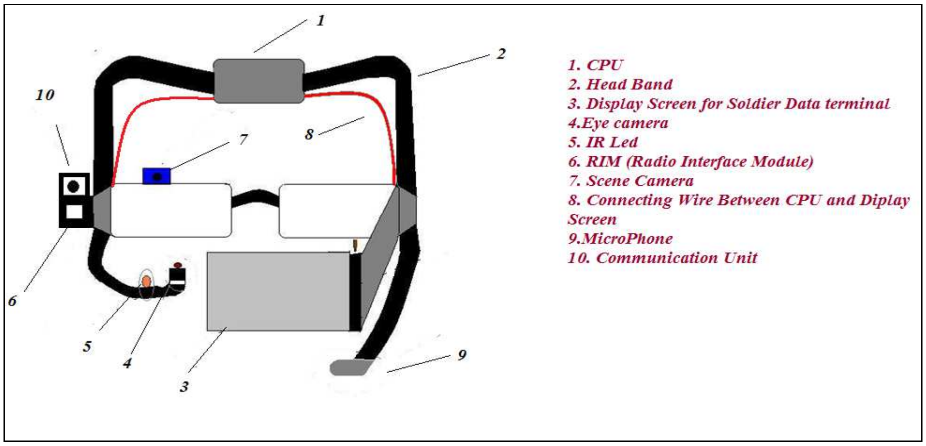

Fig 3: OMUD, Our Proposed Digital Spectacles

Table 3: Description of Our Device

No	Device Name	Description
1	Central Processing Unit	CPU will contain all the software required for Eye tracking and IDSS.
2	Head Band	Headbands will use to attach spectacle and head in battle field. In motion, soldiers cannot lose it in operation.
3	Display Screen for SDT	It will provide robust planning and visualisation functionality where wider situational awareness view is required by commanders.
4	Eye camera	A micro lens video camera. This camera is ideal for monitoring the eye because of its small size, low power consumption, and low cost.
5	IR LED	Infrared LED: an infrared (IR) source to illuminate the eye, usually with one or more IR LEDs (IRED).
6	RIM (Radio Interface Module)	The RIM provides a unique, compact, interface between the SDT and other IDSS components such as the radio and various sensors. In our device, it will be connected by wire with CPU.
7	Scene Camera	This camera provides a frame of reference by capturing the scene from the observer's point of view.
8	Connecting wire	One wire will make connectivity between RIM and CPU, another will be make connection between Display Screen and CPU.
9	Microphone	It will also used for communication with other soldiers.
10	Communication Unit	Though RIM can be mounted separately depending on radio technology but sometimes it needs communication unit attached with RIM.

In our research, we have asked several subjects to simulate some operations in a battle field. Whilst the experimental component of this project is still under progress and the details are left undisclosed yet, it is our aim to eventually disclose and compare similar attempts with those run by other researchers in the civil security and the military field.

EXPECTED BENEFITS

Some of the expected benefits that soldiers might gain from this device are listed below. The list is far from being accurate and exhaustive: it only includes sketched features that need to be further addressed by further research, part of which is already in progress.

Table 4: Benefits of Our Device

Usability	Navigation is much quicker using Eye tracking
Supportability	Allows hand free operation
Reliability	System can come to initial state and it is properly visible to user.
Extensibility	Based on Soldier's need, many other functions can be introduced with the device like Taser, Remote control machine gun controller etc.
Portability	Digital Spectacle for BMS is very easy to carry from one place to another in the battlefield.
Protection	Digital Spectacle will provide extra protection of soldier's eyes.
Safety	While using Digital Spectacle, a soldier's hand is totally free to protect himself from enemy.
Wearable	Digital Spectacle is very light to carry than handheld device.
Interface	Interface will show bigger than it shows in the handheld device.
Multi Tasking	Soldier can do various tasks in this single Digital Spectacle.

CONCLUSIONS

This paper is concerned about the usability analysis of military settings and how a new wearable device could help soldiers for their operation and decision making. Accordingly to our theoretical approach based on the distributed cognition paradigm, if such a device is developed, then sounder, leaner and more reliable cognitive and communication processes are supported, whilst allowing hand-free operation, the importance of which has been discussed previously.

By focusing on new devices and technologies to be adopted by and within the military sector, we have addressed several issues, mainly related to how military guidelines and standards would found the current requirements analysis and its underlying approach valuable and innovative.

Cognitive artefacts are the "Things that Make Us Smart" (in the title of Don Norman's 1993 book). The notion that cognitive artefacts amplify the cognitive abilities of their user is fairly commonplace. Somehow, this seems less than obvious in the military sector, where weaponry and other systems and technologies do not always give usability and cognitive ergonomics the appreciation they deserve. In our project case study, it has been our attempt to demonstrate how cognition can be distributed over the personnel, device and intelligence.

Suitable funding and further support become available, and then we could develop more prototype-based military scenarios and could add more functions in the conceptual definition of the device. This research has addressed and presented some of those both theoretical and practical issues related to applied distributed cognition. We also have developed a simple website (www.immibd.com/usability), whereby we share information and resources (e.g. videos) about this project, in the hope that the military as well as students would find there more ideas about new wearable, distributed-cognition devices.

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