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Human performance under two different command and control paradigms

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ABSTRACT

The paradoxical behaviour of a new command and control concept called Network Enabled Capability (NEC) provides the motivation for this paper. In it, a traditional hierarchical command and control organisation was pitted against a network centric alternative on a common task, played thirty times, by two teams. Multiple regression was used to undertake a simple form of time series analysis. It revealed that whilst the NEC condition ended up being slightly slower than its hierarchical counterpart, it was able to balance and optimise all three of the performance variables measured (task time, enemies neutralised and attrition). From this it is argued that a useful conceptual response is not to consider NEC as an end product comprised of networked computers and standard operating procedures, nor to regard the human system interaction as inherently stable, but rather to view it as a set of initial conditions from which the most adaptable component of all can be harnessed: the human.

1. Introduction

This paper is motivated by a number of intriguing observations made during a large-scale simulated command and control exercise (Walker et al., 2009; Stanton et al., 2009). The exercise had the explicit aim of testing a new method of collaborative working supported by a networked 'infostructure' commonly referred to as Network Enabled Capability (NEC; e.g. Ferbrache, 2003; Alberts, 2003; Alberts et al., 1999). When the subsequent task analysis was scrutinised it was found that this socio-technical system was exhibiting unusual behaviour. Over time it became progressively more preoccupied with the 'means' to achieve a given end (the 'process') rather than the massing of objectives or 'end states' (the 'output'). The latter focus on outputs is what is normally expected from NEC and what was expected in this case. Despite the provision of a networked information infrastructure, individuals and teams either used it in unpredictable ways or else adopted more familiar and presumably easier methods of working. To paraphrase Clegg (2000), what was witnessed were "people interpreting the system, amending it, massaging it and making such adjustments as they saw fit and/or were able to undertake" (p. 467). Paradoxically, what was designed to be a highly rational operation end up growing quite irrational (Ritzer, 1993, p.22). Experience over centuries of military command and control (e.g. Regan, 1991) make it possible to go further; the sociotechnical infrastructure put in place to manage large, complex, dynamic resource systems such as these can, if not designed correctly, actively create inefficiency (instead of efficiency), unpredictability (instead of predictability), incalculability (instead of calculability) and a complete loss of control (Ritzer, 1993; Trist and Bamforth, 1951). These are the antithetical problems, ironies, productivity paradoxes and 'irrationalities of rationality' (Ritzer, 1993) that, when all else fails – as in this case – fall into the domain of Applied Ergonomics.

On closer inspection findings such as these are common, both in the field of military command and control and more generally in the sociotechnical literature. In the former case several studies have observed sub-optimal performance in terms of performance time (or the so-called Observe, Orient, Decide, Act loop; Stanton et al., 2009), task accuracy (or more specifically fratricide/friendly fire;- Rafferty et al., 2012), not to mention overall system effectiveness. The UK's nascent NEC capability has already been the subject of a high profile parliamentary inquiry due to £4.7 bn of expenditure failing to translate into more effective command and control (House of Commons, 2007). The wider sociotechnical literature presents an interesting counterpoint. It abounds with examples of favourable 'joint optimisation' of people and management

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infrastructures (e.g. Walker et al., 2008; Teram, 1991; Trist, 1978; Davis, 1977), demonstrating the contribution a user-centred approach to organisational design can make. Indeed, if military operations really are as enormously complex as commentators feel, and complexity theory is the appropriate response, then by extension command and control should organise best from the bottom-up (Cebrowski and Gartska, 1998, p. 4–5). In other words, the component in these systems best able to cope with complexity is the humans. This creates a different interpretation of the results that motivate this study.

Drawing from the emerging world of networked technologies such as the internet (the world from whence NEC concepts seem to have been derived in most cases) it is possible to discern powerful new trends whereby this form of human adaptability, far from being commanded and controlled out of existence, is instead actively exploited. From the sublime (e.g. the Human Genome Project) to the ephemeral (e.g. Facebook), both are networked, highly distributed systems embodying the diffuse non-linear causality of peers influencing peers (Kelly, 1994; Tapscott and Williams, 2007; Viegas et al., 2007). These are entities where the boundary between designers and users has become "highly blurred, highly permeable, or non-existent" (Scacchi, 2004, p. 6–7). Under these 'initial conditions' highly effective and agile forms of organisational infrastructure have 'emerged' rather than been created. To use Toffler's (1981) or Tapscott and William's (2007) phraseology, the participants in the motivating case study behaved rather like 'prosumers', individuals who see the ability to adapt, massage, cajole and generally 'hack' a new technology as a birth right (p. 32). In the Ergonomics world Shorrock and Straeter (2006) remind us that people are still needed in complex command and control systems precisely because of this, and that human adaptability is inevitable (Hollnagel, 1993). So perhaps a more useful way to look at NEC is not to see it as an end product or an entity that 'is' something, but rather as a process, something that 'becomes' (e.g. Houghton et al., 2006). It seems possible to go even further, to argue that an alternative conception of NEC is not something that can be called a finished article, but rather as the initial conditions from which the most adaptable component of all, the humans in the system, create the end product most useful for their particular set of circumstances. Even then, this adaptation may prove fleeting and highly context dependant.

The purpose of this paper is to take the anecdotal evidence observed in the field and try to recreate, if not the exact situation, then at least conceptually similar conditions in the laboratory. The advantage of this, of course, is the degree of control that can be imposed, control that was almost entirely lacking in the case study example that has brought us to this point. Caution, however, needs to be exercised. Paradoxically, too much control could conceivably prevent the emergence of the adaptive behaviour being sought, so a novel approach to experimental design needs to be adopted. In the present study what might be referred to as a classic hierarchical command and control organisation (so called 'classic C2') was created within a simulated environment, then pitted against a peer-to-peer NEC counterpart, both of which contained live actors who had to operate within a complex, adaptive, high tempo scenario. Both conditions represent 'frameworks' that people undertake a common task within but different constraints apply to the different conditions. For example, there is relatively little in the way of rigid task specification in the NEC condition (the focus is on outcomes not actions) and the technological infrastructure is configured to facilitate peer-to-peer interaction. The opposite is true for the C2 condition. Here there is a high degree of 'scripting of tasks' and a more constrained technological infrastructure within which this occurs.

Manipulations such as these have (and continue) to be of importance within the Ergonomic literature (e.g. Sinclair et al., 2012). The research question links to wider debates within Applied Ergonomics around collaboration (e.g. Patel, Pettitt and Wilson, 2012) and organisational/group learning (Guimaraes et al., 2012). The same artefacts have been observed beyond the field of Ergonomics in a number of recent studies in the specialised command and control literature (Stanton et al., 2012, 2009; Bordetsky and Netzer, 2010). Common to these studies is a break from the traditional human centred approaches wherein the interaction and subsequent representations are generally static (Lee, 2001; Woods and Dekker, 2000). In this study we continue to assume they are dynamic. There is a good basis for this. Patrick, James and Ahmed (2006) for one recognise the 'unfolding' nature of command and control in their particular 'process based' methodology. They state that, "A critical feature of command and control in safety critical systems is not only the dynamically evolving situation or state of the plant but also the fluctuating responsibilities, goals and interaction of team members" (p. 1396). Our experimental design needs to take such factors into consideration but there is a trade-off. The link between the 'unfolding' nature of command and control and the resulting human interaction is no longer a direct one. There is also the likelihood of hidden variables that cannot be known in advance. Despite this there is a wider cybernetic principle at work: "if all the variables are tightly coupled, and if you can truly manipulate one [or a few] of them in all its freedoms, then you can indirectly control all of them" (Kelly, 1994, p. 121). In regard to human performance under different command and control paradigms the central question is related as much to the outright relative performance of the two organisations, the 'short term' end product (and what is normally measured) as it is to the pattern of adaptation and how performance changes over time, or the 'long term' end product. In other words, the central question relates to the system that the users 'design for themselves' by undertaking whatever adaptations they feel able and necessary, factors that are not normally measured. Whilst the promise of NEC leads us to anticipate better initial conditions for more effective adaptation, the sociotechnical 'model' needs to be run in order to find out.

2. Method

2.1. Design

The experimental task is based around a simplified 'Military Operations in Urban Terrain' (MOUT) game called 'Safe houses'. The game creates a dual task paradigm. The first task involves a commander managing two live fire teams as they negotiate an urban environment en-route to a 'safe house'. The second task involves the commander managing the activities of ten further simulated fire teams within a much wider Area of Operations. The two tasks interact such that success in one does not necessarily connote success overall. It falls to the commander to effectively balance task demands under the independent, between subjects variable of command and control 'type', which has two levels: NEC and C2. The study is longitudinal in nature. The two teams (NEC and C2) separately undertook a total of thirty iterations through the same dynamic task paradigm and a form of time series analysis was employed to reveal the underlying 'adaptive model' embedded in the data. Participant matching and task randomisation were employed to control for individual differences and task artefacts respectively. The dependant variables focus on performance and were as follows:

- Task completion time,
- Attrition
- Enemies Neutralised.