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Situation awareness: some conditions of possibility

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Situation awareness (SA) has become a ubiquitous object of knowledge in our discourses of human performance and accident explanation. Based on Michel Foucault's archaeological approach, in this paper, we examine SA by mapping the 'conditions of possibility' for this object to emerge. By highlighting the logic that SA builds upon, the political need that it intends to address, and the knowledges that delimitate it in its constitution, we aim to display the contingent nature of this object. Ultimately, we argue that as a discursive object, SA has effects.

Keywords: situation awareness; human factors; Foucault; archaeology; conditions of possibility

1. Introduction

'The flight crew lost situational awareness and commenced takeoff from the wrong runway' (Aviation Safety Council 2002, 237). This was the 'probable cause' coming out of the investigation of the Singapore 006 accident in Taiwan in 2000, but could have been from almost any (aviation) accident investigation report produced over the last decade. Situation awareness – and the loss of it – is everywhere; there are books, scientific journals, conferences, training courses, operating manuals, design guidelines, and accidents investigation reports addressing it. Nowadays there are even people held criminally negligible for losing it. Typing 'situation awareness' into Google provides more than 500,000 hits, and these results do not even take into account the variations of the term such as 'situational awareness' or 'SA'. Situation awareness is a ubiquitous object of knowledge in our discourses of human performance and accident explanation.

Objects of knowledge, such as situation awareness (hereafter referred to as SA) are the contingent outcome of certain historical discursive practices. Michel Foucault's archaeology allows for a comprehensive examination of discourses to understand how particular conceptions of the world become fixed and pass as truth. The goal of an archaeological approach is not to make any judgements about the validity of discourses and its claims, but rather to investigate the 'conditions of possibility' that govern the production of discourses and objects in it.

In this study, we examine SA as an object produced by a complex discursive system. This paper is not a discussion about the usefulness or ontological status of SA as an

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object. Rather it is about mapping how – under what conditions of possibility – SA emerged and functions as a universal object in the human factors and safety discourses. We intend to highlight the contingent nature of this object by describing the logic that it builds upon, the political need that it intends to address, and the knowledges that delimitate it in its constitution. In conclusion, we argue that discursive objects, such as SA, have effects.

2. Archaeology, objects, and conditions of possibility

Every mode of thinking involves some implicit rules that restrict the range of possible discourses within a certain time and place (Foucault 2002a). In his archaeological projects, Foucault argues against seeing the objects of our (scientific) knowledges as natural or necessary – that is, as the logical endpoint of (scientific) progress – but rather as constituted by historically contingent discursive practices. Archaeology is 'an inquiry whose aim is to rediscover on what basis knowledge and theory became possible; within what space of order knowledge was constituted; on the basis of what historical *a priori* ... ideas could appear' (Foucault 2002b, xxi–xxii). Discourses, and objects in them, have a history, rather than a transcendental truth (Foucault 2002a). Through understanding how particular conceptions of the world emerge, we can see the arbitrariness of our discourses and objects. It opens up possibilities for the examination of taken-for-granted truths.

Social science disciplines – like psychology, sociology, and we will argue the same holds for human factors and safety science – suffer from a retrospective illusion, which prevents them from seeing that their objects are historically constituted (Rose 1996). Their objects are not 'out there' in the world waiting to be 'discovered'. As an example, Foucault explains that the 'psychiatric discourse finds a way of limiting its domain, of defining what it is talking about, of giving it the status of an object – and therefore of making it manifest, nameable, and describable' (Foucault 2002a, 46). Objects are the effects of certain discursive practices and do not rely on a reference to an *a priori* reality (Foucault 2002a). From an archaeological perspective, it is thus apt to examine the 'conditions of possibility' for the conception of social-science objects, such as SA.

With conditions of possibility, Foucault means:

> ... the conditions necessary for the appearance of an object of discourse, the historical conditions required if one is to 'say anything' about it, and if several people are to say different things about it, the conditions necessary if it is to exist in relation to other objects, if it is to establish with them relations of resemblance, proximity, distance, difference, transformation – as we see, these conditions are many and imposing. Which means that one cannot speak of anything at any time; it is not easy to say something new; it is not enough for us to open our eyes, to pay attention, or to be aware, for new objects suddenly lo light up and emerge out of the ground. (Foucault 2002a, 49)

New scientific objects, such as SA, do not 'suddenly emerge out of the ground', but are already tacit in the knowledges on which they finally find their manifest form. The conditions of possibility for SA thus address the particular conditions under which SA has been allowed 'in the true' (Foucault 1981, 2002a; Rose 1996).

In this study, we sketch some conditions of possibility for SA to emerge as an object of the human factors and safety discourse. The conditions of possibility for any discourse or object should not be seen as separate and autonomous, as they constitute a complex and contingent network of discursive practices that mutually constitute and reinforce each other. However, for analytical reasons, after describing the object of our analysis, we separate the logic, the political need, and the knowledges that make up the conditions of possibility for the emergence of SA.

3. The object of SA

Originally adapted from its more commonsensical use in the air force – SA was named as early as World War I by Oswald Boelke who realised 'the importance of gaining an awareness of the enemy before the enemy gained a similar awareness' (Endsley 1988, 97) – the concept of SA was picked up by the human factors and safety communities during the late 1980s. However, it was not until the journal of *Human Factors* published its special issue on situation awareness in 1995 that the concept really exploded as a scientific object (Patrick and Morgan 2010). Even though the usefulness and validity of SA as a scientific construct is still fervently debated, it is nowadays an important object in the scientific disciplines of human factors and safety science. SA has been investigated in various contexts, including aviation (Jones and Endsley 1996; Salas and Dietz 2011), health care (Gaba, Howard, and Small 1995; Schulz et al. 2013), driving (Ma and Kaber 2007; Horswill and McKenna 2004), nuclear power (Patrick and Morgan 2010), energy distribution (Salmon et al. 2007), and sport (James and Patrick 2004), to name just a few.

In addition to the plethora of scientific discourses in which SA surfaced, its conception and modelling was accompanied by various ways of measuring it in practice (for a comparison of three popular techniques, see Salmon et al. [2009]). This resulted in widespread rise of training programmes – as such, SA has become an integral part of CRM training – and assessment of individual operators and teams for SA (Robertson and Endsley 1997). We also see SA surface in the design of human–machine interfaces (Endsley, Bolte, and Jones 2003; Jin and Wang 2009). Additionally, 'losing situation awareness' or 'poor situation awareness' have become legitimate explanations for human error. Stanton, Chambers, and Piggott (2001, 190), for example, report that '[o]ne review of over 200 aircraft accidents found that poor situational awareness was the main causal factor'. Subsequently, the construct has spread into the judicial discourse, as we now see people held criminally negligent for losing SA (for example, Supreme Court of British Columbia 2013).

The application of SA throughout the vast range of academic disciplines and other institutions makes it difficult to understand and uniformly define the construct. To circumvent this problem, as well as a sign of its frequent use and status, some researchers leave it undefined, assuming that SA – an awareness of the situation – is a commonsensical notion. When it is explicitly defined, most studies refer to Endley's three-stage description of SA as 'the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future' (1988, 97). In her seminal articles on the theory (1995b) and measurement (1995a) of SA, Endsley presents SA as a 'crucial construct on which decision making and performance in such systems hinge' (1995b, 32).

Endley's hierarchical model promises to better explain (poor) human performance and provide a new approach to the design of human–machine interfaces by distinguishing between three levels of SA, in which the higher levels of SA depend on the success of the lower levels. The first step in achieving SA, or 'Level 1 SA', is to perceive the relevant elements in the dynamic environment. 'Level 2 SA' constitutes the formation of a holistic picture of the environment by comprehending the meaning and significance of these disjointed elements in light of the operator's goals. Finally, 'Level 3 SA' is about predicting future states of the environment, by projecting the actions of the elements into the future.

Even though Endley's (1995b) well-ordered structural model easily crosses domains and provides vast intuitive appeal, there is still little consensus on the theoretical and methodological approaches that have been used to study SA. Over the years, a plethora of other definitions and specifications for modelling SA have been proposed. Besides being conceptualised as the product of information processing (Endsley 1995b), SA has been referred to as cognitive management – 'the up-to-the-minute cognizance required to operate or maintain a system' – (Adams, Tenney, and Pew 1995, 85), as the process of dynamically directing attention and assessment (Gaba, Howard, and Small 1995), as 'a label for a variety of cognitive processing activities' (Sarter and Woods 1995, 16), as adaptive, externally directed consciousness (Smith and Hancock 1995), or even as a search for meaning within complex work domains (Flach 1996).

While different, these definitions do share to a large extend the same theoretical underpinnings. The largest divergence pivots around the question whether SA is the cognitive product of awareness (Endsley 1995b) or the process of gaining awareness (Salmon et al. 2007; Durso and Gronlund 1999; Tenney and Pew 2006). 'In this distinction, product refers to the state of awareness with respect to information and knowledge, whereas process refers to the various perceptual and cognitive activities involved in constructing, updating, and revising the state of awareness' (Adams, Tenney, and Pew 1995, 88). Conceptions of SA as a state often build their model of SA on a cognitive theory that uses an information-processing approach, whereas SA as a process, sometimes referred to as 'situation assessment', builds on an ecological cognitive approach underpinned by Neisser's (1976) perceptual cycle.

The various ways of conceptualising SA, either as a cognitive state or process, help to constitute and reinforce SA as an object in the analysis of human performance. As Salas and Dietz explain: 'Despite the absence of a unifying definition, theoretical issues surrounding SA coalesce to provide a foundation for its understanding (2011, xv)'. While at the surface these different conceptions of SA may seem vast, at an archaeological level they all refer to the same discursive object, as it can be captured under the same conditions of possibility.

4. Condition of possibility: the logic of representation

For SA to emerge as a possible object, we need a conception of the subject and reality that allows for an internal representation of an external material world – we need a particular rationality: 'This idea of separation between the human operators' [sic] understanding of system status and actual system status is at the crux of the definition of situational awareness' (Stanton, Chambers, and Piggott 2001, 189). According to Foucault (1981), around the time of Plato a certain division was introduced that separated true discourse from false discourse. This division gave rise to our 'will to truth', the will to produce true representations, to present accurate (true) 'copies' (using Plato's vocabulary) of our external reality. Since this Platonic division, we take this concern with representing the truth as necessary and self-evident. According to this 'logic of representation', there is a transcendental reality (i.e. meaning in the world), which can be discovered and represented. This rationality also endows humans with an *a priori* interiority, which can represent this external reality. Modern philosophy and science are also based on this logic, assuming a transcendental truth that can be accessed and represented by using the proper (scientific) methods.

In our modern western conception of the person, the self is construed as a naturally discrete entity, for which the boundaries of the body enclose an inner life of the psyche

(Rose 1996). Since the late eighteenth century, we started to understand the world through psychological categories such as interiority, consciousness, and identity, based on general laws of 'human nature'. Gergen points to the enlightenment as the birthplace of this modern conception of the individual endowed with an interiority, a consciousness: 'Most particularly [the enlightenment] gave intelligibility to the idea that each individual is capable of observing the world for what it is . . . that is, the capacities to observe for oneself, to think, evaluate, and then to choose one's actions' (1999, 7).

Such a conception of the self gives rise to a dualist ontology, which assumes a Cartesian divide between a psychological inner world – a consciousness – and a material external world. 'Virtually all theories of SA rely on the idea of correspondence – a match, or correlation, between an external world of stimuli and an internal world of mental representations' (Dekker and Lutzhoft 2004, 22). Moreover, not only does SA build on this Cartesian separation of mind and matter, it also assumes that the mind is capable of accurately representing this external world somehow. 'Strong correspondence between the interpretation and the objective situation means high situation awareness. Weak correspondence means low situation awareness' (Flach 1996, 3). The mind is supposed to work as a 'mirror' representing the world (Dekker, Hummerdal, and Smith 2010).

SA thus builds on a 'logic of representation' (Foucault 2002b, 2002a), also referred to as the 'correspondence theory of truth' (Willig 2008), as a condition of possibility. Such rationality suggests that there is a correspondence between the external world – objects, events, phenomena – and our internal understanding of it. However, this kind of representation does not only take place within the individual, when an operator has some degree of SA (has a correct or incomplete representation of the world, i.e. good or poor SA), but also at the level of SA as a describable and measurable scientific object, which is supposed to represent a psychological reality.

Our modern conception of the individual self is closely aligned with assumptions of truth and science (Gergen 1999). The dualist ontology and the modern conception of the individual contribute to the belief, first, that there is an *a priori* reality to be represented, and second, that there is only one correct representation of that reality. This conception of the individual as being able to objectively represent the external world is where SA as a scientific object stands on, as now it becomes a matter of assessing the accuracy of people's representations in regards to the true state of the world (Dekker 2012). 'SA represents a continuous diagnosis of the state of a dynamic world. As such, there is a "ground truth" against which its accuracy can be assessed (e.g. the objective state of the world or the objective unfolding of events that are predicted)' (Parasuraman, Sheridan, and Wickens 2008, 144).

Building on the logic of representation, the scientific object of SA becomes possible, as we can now ask questions about the nature and accuracy of people's representation. We can develop theories, devices, and experiments to specify and measure it. With this, we can quantify the accuracy of people's representations and, depending on the specificity of the model, we can locate people's 'errors' in obtaining this representation. For example, in investigating the type of SA errors in aviation, Jones and Endsley (1996) found that 76.3% of the errors were Level 1 SA (failure to correctly perceive information), 20.3% were Level 2 SA (failure to comprehend information), and 3.4% were Level 3 SA (failure to project information into the future). By providing a proper method to access reality, SA as a scientific object produces a predictable and normative reality.

The logic of representation is thus a necessary condition of possibility for SA to emerge as a scientific object. This rationality does not only endow the individual with an internal self, possible of representing an external world, but also enables SA as a describable and measurable scientific object (that represents a transcendental reality). Without such rationality, SA could not have emerged as a meaningful object.

5. Condition of possibility: the political need to address human performance in technological systems

The logic of representation enables the scientific study of people's internal awareness of an external situation; however, this rationality does not explain the emergence of SA as a possible scientific object. We need to have a particular need to invoke this object in our (scientific) explanations of the world. In other words, we need particular 'events' (Foucault 2002a) for which the object will provide us with new leverage, new insights, and new solutions. In this section, we will argue that the second condition of possibility for the emergence of SA is the political need to address the increasingly conspicuous problem of human performance in our socio-technological systems. This political need is entwined with, at least, two important historical issues: the increasing complexity and opaqueness of our modern technologies and the occurrence of a number of politically relevant accidents.

The twentieth century can be characterised by the rapid development of technological systems. From the simple mechanical 'amplification' of human physical strength emerged a new type of tools, aimed not only at physical tasks, but also at improving the efficiency and scope of perceptual and cognitive tasks. 'Amplification can therefore be seen as a way of overcoming the limitations of the unaided human – whether these refer to physiological, biomechanical, perceptual, or intellectual (mental or cognitive) functions' (Hollnagel and Woods 2005, 25). As mechanisation (as a manner to amplify human muscular power) has been rapidly followed by automation (systems being controlled by autonomous machines rather than humans), centralisation (controlling various systems from a single location), and computerisation of our systems (Hollnagel and Woods 2005), we currently live in a 'technologically intensive' age (Saleh and Marais 2006).

Amplification comes with a price. Consisting of an ever-increasing number of parts and interactions, our technological systems become increasingly complex, emergent, and non-linear (see Dekker 2011). Amplification also increases the distance between the human and the operations that they are responsible for. Particularly in the case of automation, computers mediate the interaction between humans and the current state of the system. As an example, '[m]any researchers cite the glass cockpit [the replacement of the multitude of dials in a traditional cockpit with a small number of digital displays that need to be accessed sequentially] . . . as responsible for psychologically distancing the pilots from their aircraft and the situation'. (Stanton, Chambers, and Piggott 2001, 189).

The increasing complexity, as well as the detachment of the operator from real-time operations, leads to an increasing opaqueness of our socio-technological systems. This, in turn, might lead to 'out-of-the-loop performance' (Endsley and Kaber 1999). As our systems become increasingly opaque, it gets harder for operators working with and within them to remain (situationally) aware of the system's current state. '"With old cockpits", explained one pilot, "the workload was high but you were always aware of what's going on"'. (Adams, Tenney, and Pew 1995, 86). In this sense, software has added greatly to the opaqueness of our systems: 'With software, the possible states that a system can end up in becomes mind-boggling' (Dekker 2011, 196).

Also adding to the opaqueness of our automated systems is the vexing amount of information that they can produce, 'both on the status of their own components and on the status of the external environment. . . . The problem with today's systems is not a lack of information, but finding what is needed when it is needed' (Endsley 2000, 4). This particular 'data overload' problem has been termed the 'data availability paradox', as on the one hand, we have more and more data available, but on the other hand, we realise that this abundance of data makes it increasingly difficult to find meaningful information in the light of our goals and tasks (Woods, Patterson, and Roth 2002).

With the rapid growth of technology, the tasks, roles, and challenges of the human in our socio-technological systems have changed. The changing nature of our socio-technological systems comes with 'opportunities for new kinds of system failure that did not exist in older, simpler systems' (Cook and Woods 1996, 594). This change, however, has for the majority of the twentieth century not been matched by a change in the strategy to control our safety-critical systems. The practical management and the scientific study of safety in the twentieth century mainly focused on increasing the technical reliability of our socio-technological systems. 'When therefore an accident – and in particular a spectacular accident – happened there was a natural tendency to look for causes that could be expressed in terms of technological failures' (Hollnagel 2004, 29). Safety, as the absence of accidents, was assumed to be achieved through ensuring technical reliability, which was often operationalised as technical redundancy, achieved through either duplication or overlap of parts.

The increased complexity and opaqueness of our socio-technological systems were particularly exemplified by a number of catastrophic accidents during the late 1970s and 1980s that turned safety into a topic of social – that is, political – interest. Accidents such as the Tenerife Airport disaster (1977), the Three Mile Island nuclear incident (1979), the Bhopal chemical accident (1984), the space shuttle Challenger blow-up (1986), the Chernobyl nuclear accident (1986), the capsizing of the MS Herald of Free Enterprise (1987), London's King's Cross station fire (1987), the Piper Alpha rig blowout (1988), and the Clapham Junction train crash (1988) dramatically showed the limits of improving safety through improving the reliability of the technical parts of our systems.

These accidents showed that highly automated systems with multiple layers of redundancy – systems that were assumed to be fail-safe – were still susceptible to failure. As such, the events in the late 1970s and 1980s clearly displayed safety science' inability to understand and control our increasingly complex and opaque safety-critical technologies. Public demand for explanations of these dramatic events triggered a vast amount of research into the complexities of accidents, with an increasing focus on the human and the social. Human performance in our socio-technological systems became a more salient issue.

The political need to address human performance – explain the social contribution to accidents and better designed human–machine interfaces – in our increasingly complex and opaque socio-technological systems constitutes a second condition of possibility for the emergence of SA as a scientific object. This need can explicitly be traced in justifications of SA research. Salas and Dietz explain in the introduction to their book on situation awareness in aviation, that 'the technological advances designed to improve safety and efficiency also increased system complexity, thereby engendering parallel challenges for optimizing human', as a result 'research related to SA burgeoned in the 1980s to address human performance issues associated with technological advances in the cockpit' (2011, xiv). Similarly, Endsley explains in her seminal 1995 paper, that '[a]s technology has evolved, many complex, dynamic systems have been created that tax the abilities of humans . . . The operator's situation awareness (SA) will be presented as a crucial construct on which decision making and performance in such systems hinge' (Endsley 1995b, 32).

Just like the logic of representation as a first condition of possibility, SA shares this second condition of possibility with many other scientific objects, especially those in the safety and human factor domains. The birth of scientific objects such as human reliability assessment (HRA), crew resource management (CRM), and safety culture can all be related to this same political need. In historicising HRA, for example, Hollnagel (2005, 160) shows 'the strong connection between the accident at Three-Mile Island (TMI) on 28 March 1979, and the growth in the number of HRA methods'. Similarly, we can link the conception of the objects, CRM and safety culture, to the Tenerife airport disaster and the Chernobyl nuclear accident, respectively. Having said this, an archaeological perspective is not concerned with finding the historical origin of these objects, but rather with understanding the particular discursive need out of which they emerged. With the saliency of human performance problems in our complex safety-critical systems, there is a strong impetus to explain human error, fix the human operator in our safety-critical systems, and better design human–machine interfaces. SA is an attempt to do so.

In summary, with technology changing the nature of our work and accidents came the political need to address the conspicuous issue of human performance in our increasingly opaque and complex socio-technological systems. This political need, to better explain the social contribution of accidents and prevent them through better training and (interface) design, was fuelled by the large industrial accidents of the late 1970s and 1980s, and constitutes the second condition of possibility for the emergence of SA as a scientific object.

6. Condition of possibility: the cognitive knowledges

The logic of representation and the political need to address the problematic human component of our increasingly complex and opaque safety-critical systems are two the conditions of possibility for the emergence of SA as a possible scientific object. As a third condition, we need particular knowledges in which, and upon which, this object can emerge (Foucault 2002a). In this section, we will argue that the cognitive knowledges (disciplines as cognitive psychology and human factors) provides a substratum of knowledge – a 'menu' of scientific theories, prepositions, and objects – for SA to take up and manifest upon.

In addressing the political need to fix the conspicuous issue of the human in our technological system, whom do we turn to? What discipline is concerned with the study of humans, or more specifically, with the study of humans in interaction with technology? Psychologists and human factors specialists, respectively. When Descartes suggested that mind and matter are separate, he also argued that these two realms should be studied separately (Dekker 2005), effectively constituting the need for a science of the mind: psychology. As the scientific study of consciousness or subjective mental life, Descartes, and later Wundt, argued that the realm of the mind can be accessed through psychological methods such as introspection. However, when at the turn of the twentieth century, the subjective method of introspection was deemed as unscientific, it was superseded by behaviourism, as an anti-subjective approach to psychology (Dekker 2005, Smith and Hancock 1995, Suchman 2007).

According to behaviourism, 'psychology must discard all reference to consciousness' (Watson 1913, 163) as psychology should take behaviour as its object of study and needs to rely on 'direct observation under experimental conditions' (161) as its method. What goes on in the mind of the human should not be the object of psychological research, as his is something we cannot get to – a 'black box'. In studying behaviour (mostly that of animals) in an observable and systematic manner, behaviourist devised all sorts of laboratory experiments to understand stimulus–response behaviours acquired through 'conditioning' – a method of learning that builds on rewards and punishments of behaviour. The price that behaviourism pays for staying away from 'mentalist' explanations of behaviour was to 'confine experimental psychology to relatively simple memory and learning experiments, and to a preoccupation with laboratory rats rather than humans engaged in complex thinking and problem-solving task' (Simon 1980, 76).

Behaviourism works well for understanding simple human (stimulus–response) behaviour, particularly in controlled laboratory settings; however, for more complex behaviour it becomes problematic. With World War II bringing a new level of complexity to our socio-technological systems, the nature of human work changed. Behaviourism's principle to only study overt behaviour no longer seemed a viable way to understand human performance. 'No matter how clever a system of rewards and punishments psychologists set up, radar operators monitoring for German aircraft intruding into Britain across the Channel would still lose their vigilance over time' (Dekker 2005, 105). With the increasing opaqueness and complexity of human–machine interactions, the basic assumption that human performance could be described without making any references to what is happening inside the 'black box' became increasingly difficult. Psychologists needed different explanations than the ones that behaviourism was able to offer. In short, they needed to open the 'black box'.

In order to deal with more complex human behaviour, the 'cognitive revolution reintroduced "mind" as a legitimate object of study. Rather than manipulating the effect of stimuli on overt responses, it concerned itself with "meaning" as the central concept of psychology' (Dekker 2005, 105). Kick-starting the cognitive revolution, the cybernetics movement began during World War II, when a group of mathematicians, neuroscientists, and engineers tried to create a formal, mathematic 'science of mind'. By taking neurons as the basic elements of the brain, cybernetic studies tried to provide a description of the brain in formal logical terms. This approach turned out to be critical for the invention of computers, which in turn provided the conceptual basis for a new scientific study of mind (Capra 1996).

> The computer model of mental activity became the prevalent view of cognitive science and dominated all brain research for the next thirty years. The basic idea was that human intelligence resembles that of a computer to such an extent that cognition – the process of knowing – can be defined as information processing, i.e. as manipulation of symbols based on a set of rules. (Capra 1996, 66)

Building on the Shannon–Weaver model from information theory, cognitive psychology now aimed to describe the internal processes of the mind as a series of transformations of information (Hollnagel and Woods 2005). Information-processing models understand cognition as a system that receives information, represents it symbolically, and transforms these representations in various stages. As such, the information-processing approach, with its computational metaphor, provides 'a detailed analysis and specification of psychological activities in terms of component processes and procedures' (Barber 1988, 19). In outlining these various component processes, the computer metaphor provided the 'recipe for selecting, storing, recovering, combining, outputting and generally manipulating information' (Neisser 1976, 8). Humans, conceived as information processors, were now endowed with a vast number of cognitive 'components', such as attention, perception, decision-making, (sensory, short and long-tem) memory, problem solving, action selection, and many more.

The birth of human factors as a multidisciplinary science, concerned with the study of the interaction of humans and technology, largely coincided with the cognitive revolution (Meister 1999). Human factor researchers introduced experimental psychology's methods and theories to the study of human–machine interactions (Coury, Ellingstad, and Kolly 2010). As such, it took the information-processing objects of psychology – attention, perception, memory, etc. – into the realms of the design, analysis, management, and maintenance of complex socio-technological systems. 'Today, human factors have a sizeable stock of concepts that are used to express insights about the functional characteristics of the human mind – or covert information processes – that underlie complex behaviour' (Dekker and Hollnagel 2004, 79).

In accident reports from the 1960s and 1970s, we see human factor specialist brings the mentalist language of cognitive psychology, mainly that of information processing, to explanations of (poor) human performance and accidents. Accident reports are rich in explanations as: 'failure to monitor,' 'faulty' or 'poor judgement,' 'failure to take action,' 'distraction of attention,' 'spatial disorientation,' and 'pilot's misinterpretation,' to name just a few (National Transportation Safety Board 1976, 1974; Ministry of Transport 1968).[1] As these 'explanations' are all indications of problems that operators are having with technology, and given the political need to better understand human performance and prevent accidents, the next step for cognitive psychologists and human factors researchers was to refine the mechanisms underlying these 'labels'.

In further opening the 'black box', the 'interdependence of memory, perception, and action has been the focus of much cognitive theory and research, including basic experimental work, modelling efforts in the neural network domain, and work on plan and goal structures from the computing and engineering disciplines' (Adams, Tenney, and Pew 1995, 88). As a result, the human factor discipline saw a wave of new models that aimed to integrate various mentalist elements to better understand complex human performance. '[T]he concept of consciousness has enjoyed a gradual rehabilitation, albeit cloaked in many guises. Constructs such as attention, mental workload, and now situation awareness (SA) have arisen for consideration' (Smith and Hancock 1995, 137). Amongst other attempts, SA thus presents such a specification of the deeper mechanisms making up human cognition (another prime example is 'sensemaking', see Weick [1993]).

SA systematically addresses the relation between various cognitive elements. 'SA presents a level of focus that goes beyond traditional information processing approaches in attempting to explain human behaviour in operating complex systems' (Endsley 1995b, 32). Whether the object is conceptualised from an information-processing perspective – as the product of the interactions of a number of cognitive component (see Endsley 1995b) – or from a more ecological perspective – building on Neisser's (1976) perceptual cycle to explain how perceptual exploration of the environment modifies the schemata that in turn direct this perceptual exploration (see Adams, Tenney, and Pew 1995) – all models of SA aim to integrate a number of cognitive elements into a single mechanism. As such, SA is an object that opens the 'black box' by integrating various cognitive elements to better understand the mechanisms that underlie complex human performance (particularly in interaction with complex dynamic technological systems).

The cognitive revolution and its resulting knowledges can thus be seen as a third condition of possibility for the emergence of SA as a scientific object. Within the behaviourist paradigm of psychology the object of SA would not have been able to emerge.

Building on the other conditions of possibility, the mentalist psychological knowledges provide a 'menu' of cognitive elements and theoretical perspectives for SA to take up and manifest upon.

7. Conclusion

Once we have a particular logic, need, and knowledges, we see the object of our analysis emerge. SA is the product of the logic of representation, the political need to understand complex human behaviour in our socio-technological systems, articulated upon and specified by cognitive discourses of psychology and human factors. With SA, we now have an object that aims to better explain the cognition underlying complex human behaviour, and as such, helps with the design of human–machine interfaces and provides new insight into the occurrences of accidents.

Our archaeological analysis of the constitution of SA shows that this is not a natural object, but rather a historically contingent object – an artefact of discursive practices. The object is an effect of certain conditions of possibility, historically constituted through certain discursive practices. Describing this object as 'contingent' means that the historical emergence of it is not some logical end point of scientific progress, but merely one possible outcome of a complex network of relations between historical events, rationalities, and contemporary discourses. Foucault's archaeological approach is thus explicitly anti-teleological, as it does not involve any assumptions of progress (nor regress!).

Archaeologically, the discussion about whether SA is the cognitive product of awareness or the cognitive processes of gaining awareness is just a matter of delimitating the object differently. Both conceptions are different delimitations of the same discursive object, as they function under the same conditions of possibility – they address the same need, are based on same rationality, and largely drawn on a similar substratum of knowledge.

Similarly, the questioning – ongoing since SA's first scientific conception (see Dekker 2012; Dekker, Hummerdal, and Smith 2010; Sarter and Woods 1991; Flach 1995) – of the epistemology and usefulness of this object is not of archaeological concern. Whether SA is a cognitive state or a process, whether it is real or not, or even whether it is useful or not, does not matter from an archaeological point of view. Archaeology is not interested in the epistemological or ontological status of the object. This does not mean that, whilst outlining certain discursive practices as conditions of possibility, archaeology does not include certain ontological or epistemological assumptions as conditions that enable these discursive practices. For example, we identified the logic of representation – a positivist epistemology – as a condition of possibility for SA to emerge as a modern scientific object. The point is, however, that archaeology does not take a particular stance on the epistemological or ontological status of the object. What matters from an archaeological perspective is that this is an object at the level of the discourse.

Once the object is constituted, given its conditions of possibility, a number of (self-correcting and self-reinforcing) discursive practices start defining, delimiting, and correcting it. Various institutions provide a number of specifications for modelling the object and legitimising the further use of it. This is done through various 'enunciative modalities' (Foucault 2002a) such as scientific research, assessment methods, training programmes, statistical records, legislation, design recommendations, accident investigation reports, managerial reproaches, and recently even through court verdicts, to name just a few of SA's materialities. The use of the object in these kind of discursive practices reinforces its status – the more it is used, the greater the consensual authority on using it. Even this very paper is contributing to its status as an object.

The Singapore 006 accident investigation (Aviation Safety Council 2002) provides an example of the powerful manner in which the object of SA is used and reinforced. Not only does the report refer to SA, and the loss of it, more than a couple dozen times as one of the contributing factors of the accident, but the object also surfaces in one of the 'safety actions' that have been implemented in the aftermath of the accident: 'A new CRM training programme for pilots has been developed and implemented, which includes situational awareness and error management training as separate modules' (249). This kind of discursive use of the object contributes to produce and reinforce its status among other objects in the safety discourse.

As a critique to these kind of investigatory conclusions and recommendations, a number of researchers have questioned the causal power that has been ascribed to SA, saying that 'constructs don't cause anything' (Dekker and Hollnagel 2004; Flach 1995): 'We heard here that deficient SA was a causal factor in many airline accidents associated with human error. We must avoid this trap: deficient situation awareness doesn't cause anything' (Billing 1996, as read in Dekker and Hollnagel [2004], 80). Again, from an archaeological perspective, it does not matter whether the object provides the necessary specification of the mechanism responsible for such causation, it does not concern itself with such epistemological questions. What is clear from an archaeological position, however, is that constructs – objects such as SA – have (causal) effects: accidents are attributed to a loss of SA, corresponding training programs are set up, procedures are revised, operators are being criminalised, and people end up in jail for losing SA.

From an archaeological perspective, language does not represent reality, but constitutes it (Foucault 2002a). Words do not merely name certain phenomena, but they produce them – they produce meaning through particular political 'regimes of truth' (Foucault 1980). As artefacts of discursive practices, objects set up an entire agenda of institutional practices. With SA, we constitute a set of institutional techniques (aimed, e.g., at improving safety). We create performance assessment measures that are extremely powerful to subjectivate people in a certain manner. We create certain moralities based on this object. Objects are the effects of certain discursive practices and, in turn, objects have certain effects.

As an example, even though the accident investigation report does not explicitly lists SA as a direct cause of the sinking of the passenger ferry Queen of the North, it does state that, 'unsafe navigation practices persisted that, in this occurrence, contributed to the loss of situational awareness by the bridge team' (Transportation Safety Board of Canada 2008, 40). In the subsequent court case against the commanding officer, Karl Lilgert, the final verdict draws on the object of SA to make the case for the accused's 'dereliction of his duty' – which resulted in his conviction for criminal negligence:

> Maintaining situational awareness at all times and in all circumstances is key to proper navigation. The evidence of the expert, Mr. Flotre, was Mr. Lilgert failed to comply with the collision regulations by not standing watch using his eyes, ears, the ECS, and radar. (Supreme Court of British Columbia 2013, 6)

In short (whilst deliberately simplifying), Karl Lilgert is in jail for losing SA; objects have effects. The objects that we constitute in particular discourses for particular purposes – such as SA as an object to help explain complex behaviour in human–machine interactions – are borrowed by other discursive practices and used for different purposes– for example, as a convenient and holistic construct to explain criminally negligent behaviour. Future research might provide answers as to how certain objects are appropriated by other discourses. How human factor objects, such as SA, help to constitute a discourse on criminalisation? Or, vice versa, how criminality – with juridical objects as negligence, guilt, and recklessness – has become part of the human factors and safety discourses?

SA is thus not only a scientific object, to be discussed and analysed in terms of its specifications, its usefulness, and the methodologies to investigate it. By arguing for the contingent nature of our objects of knowledge, archaeology opens another agenda of inquiry. Archaeology opens an ethical discussion, asking questions about the consequences for operating a particular discursive object. Discursive objects that the human factor community once introduced to help operators better understand and deal with complex dynamic environments are now turned against them as they provide normative standards for behaviour. The contribution of this paper is not in making an argument about whether SA is real – or even useful – or not. It does not take a position on whether we are researching SA in an appropriate manner or not. Rather, we aim to argue that it is a historically constituted object – reinforced by science, institutions, practitioners, etc. – that emerged out of a particular logic, a certain political need, and historically available knowledges. And, as such, it is a pertinent look at the effects of our objects of knowledge.

Note

1. The three accident reports analysed here would nowadays probably have substituted these explanations for the label 'loss of SA'.

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Relevance to ergonomics theory

This is the first study that takes a Foucauldian, archaeological, perspective to study the emergence of a particular object – situation awareness – of the human factor discourse. We believe that this perspective provides a new agenda of inquiry, as well as an opening for ethical discussions about the consequences of the discursive objects that our field provides.

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