Decision making in exceptional circumstances: experts' attitude towards artefacts as preparation for encountering unexpected situations

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Abstract: Operational ability in unexpected situations and exceptional circumstances may require an ability to let go of the tools and operating models that have proven effective in anticipated situations and normal conditions. This article examines the relationship between actors and physical and cognitive artefacts whose purpose is to enable actors to tackle an increasingly diverse range of problems and to solve them in a more perceptive, stable and confident manner. What is rarely discussed, however, is the flip side of this dimension of improved operational ability. The research data was collected by in-depth interviews in order to examine the cognitive processes explaining this type of operational ability displayed by top experts in emergency medical care, trauma surgery, and bomb disposal. The finding of the study is that rather than being neutral, artefacts trigger conditioned responses in their users. These responses are not always unequivocally useful for solving the situation at hand.

Keywords: exceptional situations; artefacts; operational ability; crisis situations.

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1 Introduction

In literature on the security of societies, the 9/11 events are often referred to as a game-changer, something that pushed the boundaries of what was considered possible. They were a reminder of how situations and their contexts may differ from what was expected and considered likely. Lagadec (2007) argues that crises are transitioning to *a new era*, not only because of their severity, complexity and dynamism but also because of the instability, sensitivity and interlinkages of their event contexts. This poses a significant challenge to decision making and operational ability, as the resources and

operating models designed to be adequate for and compatible with responding to various situations may be lacking or unsuitable (Farazmand, 2014).

This article approaches this set of phenomena from the perspective of artefacts integrated with individual actors' cognition and actions. Generally speaking, the term artefact refers to a human-made object that is intentionally made to accomplish some purpose (Hilpinen, 1992). For example, a physician may need tools, such as a laryngoscope to secure a patient's airway, and algorithms or procedures to guide her/him to accomplish an intubation. In this sense, artefacts can be divided into two categories; physical and cognitive. The core issue in this article is the actor's relationship with artefacts which have expanded the possibilities of tackling new problems and solving them in a more perceptive, stable and confident way (Gao et al., 2018). As artefacts create possibilities for taking action and improving the existing actions, attitudes towards them are positive in principle, and new solutions are welcomed as a starting point. Significantly less attention has been paid to the flip side of artefacts: when they are integrated with the actor's cognition and operational ability depends on having access to them, the result may be inability to operate and unintended negative consequences when faced with unexpected situations and circumstances. Revealing this flip side is important when striving to reduce and tolerate the vulnerability caused by reliance on artefacts and to strengthen operational ability *in the new era*.

An exceptional, unexpected situation and drastically under-resourced conditions reveal aspects of operational ability that do not come to light in anticipated and normal conditions. In other words, whereas response to routine crises and emergencies can be based on the planned and allocated artefacts, their relevance is questionable when the complexity and chaotic nature of the situation exceeds the critical point (Farazmand, 2009). The time pressure and high stakes of the situation test the actors' cognitive capacity (Comfort, 2007; Mendonça, 2007). The actors should be able to perceive the multi-layered nature of the problem, prioritise important problems over less important ones, and improvise solutions to manage the situation successfully. This may require the actors to let go of the artefacts that normally guarantee the quality and legitimacy of their activities. In critical fields, it may mean breaking the rules, modifying or rejecting established plans, guidelines and algorithms, and using tools creatively (Borodzicz, 2004; Devitt and Borodzicz, 2008). Then the use of artefacts involves not only an assumption of cognitive and functional effectiveness but also ethical consideration; certain ways of using artefacts are assumed to be ethically correct, but in an exceptional situation the actor may have to weigh the rationality of such assumptions and make their decisions on this basis.

Actors accumulate operational ability for such situations throughout their careers – it does not appear from nothing when one is faced with an unexpected situation with all of its requirements. In this sense, operational ability includes operating models stored in the actor's memory and body, possible solutions, pattern storage, heuristics and other building materials of the *internal operating environment*, in which elements can be found that help solve the encountered problems (Okoli and Watt, 2018; Salas et al., 2010; Kahneman and Klein, 2009).

This study aims to describe the role of artefacts in enabling and limiting operational ability. In particular, it wishes to illustrate the aspect that emerges as a by-product when artefacts are developed and become a standard part of the activity. Furthermore, the article illustrates actors' attitudes towards artefacts. The research question is thus formulated as follows: what types of cognitive capabilities and attitudes towards artefacts

explain actors' ability to rise to the occasion and meet the requirements of an exceptional situation? Rather than listing these abilities and attitudes, the idea is to describe their manifestations in their event context. The article is structured as follows: First, the role of artefacts as the cradle of ever-improving operational ability and the potential source of destruction in unexpected situations is discussed. After that, the research methodology and the interviewees are presented. The results section provides empirical illustrations on the research problem. Then, the results are discussed and summarised in the table. The article ends with conclusions.

2 The double-edged sword of improving operational ability

2.1 Artefacts and the actor's identity

Tools can be seen as extensions and reproductions of the human body. This is why the creation of new tools also reflects our intentions to change the world in the desired direction (Steinert, 2016; Rothenberg, 1995). The tools are used to perform the desired tasks, and they consequently expand the range of manual skills. The tools also have an impact on cognitive capabilities, which is the essential point made in this article. They support the users' cognitive processes and remind them of the steps of and methods for performing the task, in other words structure and narrow down the problem space encountered by the actor. Understood in this sense, the tools are artefactual representations of routines (d'Addeiro, 2011), and training in the skills of using them helps to 'forget' the tool and focus on the actual task (Baber, 2003).

Tools, or physical artefacts, not only complement the user's range of functions but also strengthen existing capacities, helping to deploy existing skills more effectively or accurately (Steinert, 2016; Smith, 2007). Medical science and the military are both excellent examples of artefacts' significance in developing the operational ability and credibility of the profession. If the artefacts are believed to successfully improve the sector's capacity and credibility, they will be *re-produced*, which means that their cultural position is strengthened (Heersmink, 2016). However, while the reliance on artefacts lays the foundation for safe, efficient and credible actions and those deemed to be *right* in these professions, individual actors may have to face extremely complex, dynamically progressing tasks. Such tasks may involve a high level of uncertainty, are open to interpretation and require rapid decision making; doing things *right* is difficult to assess in these situations (Jenkins et al., 2011, 2010b).

Artefacts are not simply physical objects. So-called *cognitive artefacts*, which express and communicate desirable practices and serve the storage and recall of information, should also be examined (Brey, 2005). Cognitive artefacts include procedures, checklists, flowcharts, formal rules, and algorithms. They remind the actors of the division of labour, order of execution and authorities associated with performing the task. They complement and expand cognitive capacity by providing task-relevant information, which makes action easier, faster, more confident and often possible in general (Gao et al., 2018; Heersmink, 2016). This way they also reduce the cognitive load of the actor's short-term memory (Jenkins et al., 2010a). In professions, artefacts help individual actors to identify relevant problems and decide how to encounter and solve them. Consequently, they reduce the ambiguity and uncertainty associated with individual actors' decisions (Gao et al., 2018; d'Addeiro, 2011; Hutchins, 1995). When integrated with the actor's

cognitive system, artefacts help the actor make sense of, analyse and solve problems and understand themselves in their operating environment (Gao et al., 2018; Heersmink, 2016; Brey, 2005).

Artefacts structure the problem space encountered by the actor; they objectify its complexity, enabling the actor to start solving the problem. In other words, they participate in reshaping a problem, after which the actor relying on the artefact starts working on the representation of the problem structured by the artefact (Baber, 2003). In this sense, adherence to an artefact can also increase the distance between the actor and the 'original' problem and direct the way in which the actor makes sense of the situation more strongly than what is appropriate, as Weick's (2001, 1996, 1993) analyses show. It can be noticed that cognitive capabilities expanded and reinforced by artefacts are tied to specific implicit assumptions of the set of problems to be encountered, and if the problems deviate from the assumptions in critical respects, attachment to the artefact may jeopardise rather than enable success in the action.

In addition, artefacts play an important role in safeguarding error-free action. For example, checklists as cognitive artefacts have gained a permanent position as critical elements in many tasks, ensuring that none of the important phases of a complex set of tasks will be overlooked (Gawande, 2010). When integrated with actors' cognitive systems, they support a work approach in which errors can be avoided. This has an interesting connection to the development of adaptive expertise, key elements which are being guided by insights and searching for new things without external guidance. These elements are more likely to expose the actor to errors, thus reinforcing the association between making mistakes and learning as well as in-depth understanding of a problem (Klein, 2017; Bohle Carbonell et al., 2014).

2.2 On expertise in exceptional situations

At the conceptual level, a high ability to operate in exceptional situations can be approached from the perspective of adaptive expertise. Adaptive expertise is manifested as an ability to understand when it is worthwhile to use the learned and practised problem-solving skills, procedure or operating model; when they should be adapted to provide a more suitable response to the situation, and when a new solution is needed (Schwartz et al., 2005; Hatano and Inagaki, 1986). In a sense, this is a combination of models contained in the *internal operating environment* in relation to the external environment. This requires advanced metacognitive skills; the actor must perceive themselves as a problem-solver, put the problem at hand in proportion to the options available for solving it (internal operating models), and make the necessary decisions (Bohle Carbonell et al., 2014). Adaptivity is thus seen as an ability to apply learned problem-solving skills to new situations and transfer problem-solving structures learned and tested in one environment to another context.

This form of expertise and operational ability often plays a crucial role in crisis situations, in which the precondition for an effective response may be crossing established boundaries, identifying the problem in new ways, and an ability to take the action indicated by the new formulation of the problem (Weick, 1993, 1988). Perceiving that the situation differs from the problems for which the tools and other solution models were designed is essential. In other words, the situation may present with critical problems in which reliance on standardised tools, models and operating procedures would undermine operational ability and the prerequisites for success rather than

guarantee them. In this case, that which brings stability, certainty and legitimacy to normal situations and conditions may become a barrier for being able to operate in an exceptional situation or conditions (Pepper et al., 2019). Consequently, this is about using resources, about which Omodei et al. (2005) note that emergency and military actors predominantly believe that 'more is better'. They found that actors tended to use (excessively) the available resources and maintain a maximum level of activity. This is explained by the illusion of control created through activity and the willingness to make oneself count in the situation. The basic problem, in that case, lies in metacognitive skills.

In his well-known research, organisational theorist Weick (2001, 1996, 1993) discusses the activities of firefighters in fatal forest fires, in which inability to let go of standard tools and operating methods has been a key element leading to fatalities. The firefighters felt that by dropping these tools and methods, they would have ended up losing their ability to control the problem situation, the identity which had led to them being called to solve the situation, and any hope of completing the mission. The tools and operating methods were like a straitjacket that the actors learned to put on but never to take off. It can be noted that a high-level performance in routine tasks alone does not indicate a high-level performance in new, uncertain and exceptional contexts, except in the reverse: if the first-mentioned capability is expected to also be adequate for the latter situation. In other words, the criteria required for managing standardised tasks may not be commensurate with those that need to be met in the next exceptional situation (Weick and Sutcliffe, 2015). On this basis, it is interesting to look at tools and other artefacts as factors that improve expertise and operational ability while also being potential sources of vulnerability.

3 Methodology

The empirical data for this study was gathered through three in-depth interviews. Generally speaking, the author of this paper has been interested in the cognitive capabilities that have enabled certain actors to succeed in exceptional situations under time pressure and high stakes. In this sense, for the following three experts, their relationship with tools revealed as one of the key factors in their ability to rise to the occasion and meet the requirements of the exceptional situation at hand. Thus, they were selected as subjects of this study. The features that the operating environments of all three persons have in common are relatively strong top-down management, legitimacy of the activities based on legislation, and emphasis on established operating instructions and procedures; a relatively clear distinction between what is right and permitted on the one hand, and what is wrong and prohibited on the other, is typical of the operating environment. Unlike in usual studies on improvisation, deviating from the operating environments' blueprint is not desirable in principle, and the actors do not improvise for the sake of improvisation. As the activities involve significant liability issues, deviating from a pre-established procedure is always a critical risk factor. The relationship between anticipated problems and the solutions applied to them is thus relatively standard in normal conditions, which means that telling right from wrong is straightforward; the situations examined in this study, however, differ from the normal, and consequently this distinction is less clear.

Hutchins (1995) stresses that actors' cognition should be examined 'in nature' as the phenomenon to be investigated actually unfolds. While doing so is understandably not

possible in this case, certain methods can be used to get a little closer to real situations retrospectively. Thus, this study was conducted following the principles of cognitive task analysis. The method allows to examine the way individuals use information, what they base their decision on, and what problem-solving strategies they use (Militello, 2001; Crandall et al., 2006). It allows to examine the actors' cognition in a way that helps in understanding how an individual develops as an expert who can cope with exceptional situations. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Police University College, Finland. Due to the sensitive nature of the content, our interviewees reviewed and approved the manuscript for the part of their interviews. Each in-depth interview lasted for around three hours. Although the number of interviewees is relatively small, the in-depth interviews generated fruitful research data that was thought to be undeniably capable of addressing the research question and inspiring a critical scientific discussion (cf. Baker and Edwards, 2012; Morse, 2000).

When analysing the empirical data, special attention was paid to how the actors:

- describe standard practices and tools in relation to normal and exceptional situations
- feel about the lack of critical resources in a situation involving time pressure
- perceive the dimensions and priorities of the set of problems created by the situation
- reflect on the grounds of their decisions and actions
- put their authority and the measures required to solve the problem into proportion.

Table 1 provides a short introduction to the subjects. The table also explains the specific situation or context to which the interviews were anchored.

Table 1 Introductions to the subjects

Subject		*Situation/context*
A1	First response physician in a medical helicopter. Also a department head at a hospital.	A violent terrorist attack with a number of victims in a city. Worked as a first response physician in the field.
B2	Trauma surgeon at a central hospital.	To gain experience, regularly attends a foreign hospital in which the number of patients in need of immediate life-saving care dramatically exceeds the available resources.
C3	Bomb disposal expert in the defence forces. Has worked with improvised explosive devices (IEDs) in crisis hotspots around the world. By investigating explosion sites and using home-made tests, they seek to find out how the other side thinks and develops the devices.	Works in conditions where the other side is extremely good at improvising, using low-tech equipment to effectively cause damage to a highly equipped opponent, and developing new equipment and methods. A precondition for this is understanding the other side's mindset and adapting the strategy to it.

4 Findings: expertise is demonstrated as operational ability in authentic situations

4.1 Tools as a manifestation of artefacts

An increased range of tools is an indication of strengthening operational ability and a resource-rich operating environment. This has its flip side, however, which is not apparent in normal situations. A1 describes their irritation over their colleagues' enthusiasm for using the available tools as much as possible, as the value of the solutions achieved this way is often limited considering the original problem situation. A1 mentioned that "it is a fun additional activity and looks efficient, but I often question its added value in terms of the actual problem." However, the actual disadvantage is not only related to the low added value; the actors are also directed towards practices that can cause real harm when working under time pressure and in a more complex situation. By using a tool, the actor may tie up their own capacity to carrying out subsequent task phases: the actor is held hostage by the problem representations offered by artefacts. The most crucial aspect in terms of the overall situation may thus be overlooked and left without intervention.

The flip side becomes apparent in contexts which are dramatically under-resourced in proportion to the problems. B2 explains that the very reason for which they wish to expose themselves regularly to operating environments of this type is improving their operational ability and expertise. Key things learned in these environments are related to the ability to identify the priorities of problem situations and only focus capacity on what is essential. This means that the actor's ability to identify the most critical problems and the factors on which solving them hinges becomes crystallised in their problem-solving skills. They describe how choosing to work in an extremely tough operating environment builds expertise exponentially compared to normal circumstances.

> "In our operating environment [here in the home country], your professional skills can only be challenged up to a certain point. This is why I regularly expose myself to an operating environment where we always go from hand to mouth in the daily work and have undersized resources at all times, which forces you to improvise and improve your problem-solving skills."

As the resources are inevitably inadequate, improvisation is necessary to solve problems. One of the features of improvisation is *using tools incorrectly*, or applying them to new purposes to circumvent the resource problem. In one of the examples given by B2, they were operating on a person who had been stabbed in the neck. As they had used a clamp to close the patient's carotid artery to operate on a haematoma, a patient stabbed in the heart and on the brink of death was brought in to the accident and injury section of the hospital. B2 had to weigh the possible solutions: focusing on the patient with the neck injury would mean that the patient stabbed in the heart would die in less than five minutes; on the other hand, a delay of several minutes would mean that the neck injury patient would suffer a brain infraction.

> "The neck injury patient was under light anaesthesia and their blood pressure was elevated, which meant that the patient was compensating – the body was increasing the blood pressure, maintaining a sufficient blood flow into the brain from the other side. My assessment was that I could leave them for a few minutes. I went to accident and emergency, where I anaesthetised and intubated the patient stabbed in the heart. I opened their chest cavity. I had brought a

> stapler used to suture skin wounds in my pocket from the theatre. I used the surgical staples to close the holes in the patient's heart. I told the assistants to keep the patient alive until I got back. I returned to the operating theatre and finished with the neck injury patient. I had reserved a bed in intensive care for them, but I knew that if I gave it to this patient, the person stabbed in the heart would not survive because their need for intensive care was even more acute. While the door was open to bring the neck injury patient out of the theatre and into the recovery room, the patient stabbed in the heart was brought in with their chest cavity open. I replaced the staples with better sutures, performed the surgery and took the patient to ICU."

The problem at hand and the operating environment required extremely fast and tough decision making. While both patients basically needed intensive care, there were not enough beds to go around. In addition to making and executing medical decisions, in this situation it was crucial to perceive a different problem dimension: B2 compares operating in this other dimension to *playing a game of chess*. In this context in which "there are no free intensive care beds while patients still keep coming in, no one can have intensive care unless someone gets better or dies", it was necessary to learn to master this logistic problem dimension and minimise the number of deaths. However, the precondition for managing this problem dimension is that medical performance – in this case, performing the actual surgery and complete mastery of the surgical instruments – is a routine, leaving cognitive capacity free for the other problem dimension. Fumbling with the instruments or diagnostics would make it impossible to perceive the overall situation and its most critical points.

> "I learned from experience that a patient who was shot through the cervical spine, for example, could be stashed in a ventilator. This patient is completely dependent on the ventilator, but I know that if an intensive care bed is needed quickly for another patient, we can decide to turn it off, and the patient will die in 15 minutes. This means we suddenly have a free intensive care bed. We had to resort to switching patients around in this way, giving up on patients who cannot survive to care for ones who do have a chance. This allows us to artificially maintain at least a small resource."

When working in an under-resourced exceptional situation under time pressure, choosing the problems at which the actor targets their capacity is crucial. An illustrative feature of this is associated with the *treatment mania* described by A1, referring to an actor who ties up their capacity to a patient to provide them with the best possible care when, considering the overall situation, allocating the capacity to something else would be more effective. In the following sample, A1 gives an example of the effects and application of physical and cognitive artefacts used for opening the patient's airway. One can see how the established culture of using artefacts guides actors towards practices entailing further impacts that tie up capacity.

> "I have in my mind faster algorithm for opening the patient's airway. I have borrowed it from the military. It is rarely used by others on the civilian sphere. It allows me to insert a tube in the airway in a few seconds. If you use a normal tube inserted through the mouth, you must administer certain drugs and anaesthetise the patient, which means that you will not be able to get rid of them any time soon. You have already interfered with the patient in so many ways that you can no longer leave them. But I use local anaesthesia and do it through the skin directly into the trachea. For cultural reasons, we tend not to do it. I have also been criticised for this, for example in one major accident exercise, in which I informed my team that we would not intubate anyone

> under anaesthesia, not for any reason. If someone needs to be intubated, I will do it using this faster algorithm, because it does not require any monitoring resources."

The interviewees find that in a complex situation where they work under time pressure, the speed of technical performance and minimising the need to tie up further capacity are essential. As the previous sample showed, orientation to this may be unfamiliar or not permitted in the profession's culture, as the risks associated with it are different and higher than in recommended procedures. Errors in performing the task may lead to fatal consequences, which is why deviating from instructions and recommendations is always a risk. The actor also needs to consider their personal prerequisites for success. In this context, B2 describes how a deviation may lead the actor to "a problem from which there is no way out. It may destroy your career, especially if going your own way becomes a legal issue. In that case you end up with two victims." One can notice that an ability to improvise – to deviate from what is normal, anticipated and permitted – is also linked to the actor's perception of and relationship with certain background factors, including the potential consequences of failure.

4.2 Procedures and recommendations as demonstrations of cognitive artefacts

Procedures and recommendations are a form of artefacts that can be used to convey lessons learned during the history of the profession about what to do in different situations, what is permitted, what tools must be used, which are the stages of the task to be performed, and what information is needed to complete these stages. They result in clarity, high quality and reliability in the action and provide administrative and legal legitimacy. As cognitive artefacts, they protect the actor from the factors that create pressure in the situation, shaping the problem into a representation that can be monitored clearly and carried out feasibly.

The ability to use artefacts alone does not mean that using them would actually be an effective response to the situation. C3 gives an interesting example of complementing the profession's established mindsets and ways of acting. C3's view is that in order to take action against a smartly operating, active threat, an understanding of the logic of that threat is required; one must learn to think like them. In other words, being guided by one's own, predefined plans is not enough; the terms of the action must be put in perspective of what one thinks *the other side* is thinking. The precondition is that the actor cognitively internalises a type of new problem layer. When one have to put their actions in proportion with the other side's intentions, a different type of decision making is required of the actor; a type of synthesis of the defender's and the attacker's mindsets is needed. C3 relates how, in order to get into the other side's mindset, they started recreating the opponent's activities with authentic substances and materials and in authentic conditions in their garage.

> "We must experiment with the same substances and under the same conditions as them to find out what is and is not possible. Understanding why a terrorist wants to do things in a certain way has been vitally important."

> "With very small quantities of explosives, of course, but I certainly could have been sent to prison for some of things I did. But my intentions were good all the time. It could not be done in the laboratory, because that would have ruined the actual idea. I had to do it using the tools and basic methods they have used."

Table 2 Observations on the role of artefacts, the interviewees' attitudes towards them and the flip side impact on the actors' cognition

Example of an artefact's role	*Interviewee's attitude to artefact*	*Excerpt from the interview*	*Artefact's impact on actor's cognition*
Purpose: Physical artefacts have been designed for a specific primary purpose. Using them correctly leads to the expected results.	The artefact should be used for its primary purpose. Similarly, the intended purpose should be served by using the appropriate artefact. Preparedness to apply the purpose and find alternative ways to solve problems should also be maintained.	"My colleague had placed vascular access into the patient's tibia. It annoyed me because, given the situation at hand, such a procedure was of no use to help the patient. My colleague wanted to be active, but the added value of this activity was zero. The time spent on it was out of the more useful procedures." (A1)	Attachment to the primary purpose of the artefact makes it an essential medium between the actor and the problem. Operational ability becomes dependent on the availability of the artefact. Greater distance in the association between the actor and the problem impairs the actor's ability to improvise when this would be necessary to solve the problem.
Specialisation: Increasingly fine specialist tools help carry out tasks more perfectly. They open up ways to carrying out entirely new tasks.	Specialisation has its place in the development of a profession. However, it is preferable to rely on simple and reliable tools in whose use one wishes to become particularly skilled. This results in efficiency, the benefits of which are realised when working under time pressure and in under-resourced contexts.	"I am concerned that we get accustomed to the idea that all resources must be constantly available. Take a surgical robot of many million euros, for instance. It may be justified to acquire it, but it also has its drawbacks." (B2)	It helps solve new and known problems more fully. Doing this results in more stringent quality standards placed on the actor's end result. It ties the actor to state-of-the-art, the pursuit of which may lead to lack of efficiency in a time-pressured context. Substituting perfection with something that is adequate in the situation becomes difficult.
Task-specific information: The more information on a problem one has, the better preconditions there are for resolving it. It makes sense to invest in acquiring information.	Better information improves the preconditions for better action in normal situations. However, the aim is to become as independent as possible from abundant information. Information can often be seen as a factor that suffocates operational ability. The interviewee also wishes to make space for 'other ways of knowing', such as intuition, in decision-making.	"When I go to a bombsite and look at where the pieces have flown, in my mind, they seem to be flying back into their original positions. When I look at those pieces, it's like watching a movie backwards." (C3)	Operational ability becomes dependent on the availability and accuracy of information. The activities are channelled towards avoiding risks and minimising errors. Undermines the ability for an aggressive cognitive approach to problems and drawing on situation-specific insights. Exposes frustration and inability to function when lacking information.

Table 2 Observations on the role of artefacts, the interviewees' attitudes towards them and the flip side impact on the actors' cognition (continued)

Example of an artefact's role	*Interviewee's attitude to artefact*	*Excerpt from the interview*	*Artefact's impact on actor's cognition*
Models: Models used to perform a task help to make conclusions on the observations. They are likely to provide relevant explanations regarding the nature of the problem.	Models offer an explanation for one type of reality approved by the profession. Statistically, this leads to a large number of correct interpretations. Since models do not guarantee that the next problem will be a good fit, however, they must be treated with certain scepticism.	"One can conclude the explosion based on the location of pieces. Usually, a grid or sector model is used for this. But let's take a car roof, for instance, which may whirl in the air by the force of the blast and then return to the same spot like a boomerang. Grid and sector models, then, leads one to incorrect conclusions." (C3)	The models tend to require actors' commitment to compliance with them, and complying with the model becomes a task in itself. It may prevent the actor from making observations or conclusions outside the model, or conclusions signalling that the model is inappropriate.
Authorisations: An authorisation is required to take certain actions which, in turn, often requires sufficient consideration and information.	Basically, one should act within the limits of the rules; compliance with authorisation procedures has its own added value. One needs to understand that obtaining an authorisation in itself can be a process that critically slows down action.	"I had a patient there, who was stabbed in her chest. She required immediate hospitalisation, but no ambulance was available. I put her in a taxi and said cabbie to drive quickly to the hospital. After all, I had no authority to do so." (A1)	An authorisation procedure put in place to guarantee safety and improve decision-making may turn against itself in critical situations.
Formal areas of authority: Ensure efficient, coordinated and legitimate action and quality control.	Formal areas of authority should be observed; they indicate each actor's role in problem-solving. However, their effectiveness depends on how well the underlying assumptions contained in them correspond to the actual situational factors. A preparedness to exceed the boundaries of these areas and reassign the roles in certain situations should be maintained.	"When it comes to some critical problem, if I see that one operating model is more preferable than other, I have no difficulty to choose it, even though it is not expressly authorised. I will do it if the situation so requires." (A1)	Formal areas of authority guide actors to stay within their own task areas. They direct the way in which the actor makes sense of the situation. As operational structures, they may be too slow for fast-paced situations. They undermine the possibility of making sense of the situation in other ways. They prevent one from taking action that would be essential in a specific situation.

Table 2 Observations on the role of artefacts, the interviewees' attitudes towards them and the flip side impact on the actors' cognition (continued)

Example of an artefact's role	*Interviewee's attitude to artefact*	*Excerpt from the interview*	*Artefact's impact on actor's cognition*
Procedures: Support coordinated action in ways that previous experience has proven relevant.	Complying with procedures has its own rationality, which works in most situations. Particular difficulties arise in situations where one should adjust their actions to an intelligent and active opponent. One must make an effort to understand the opponent's actions, thus learning to understand the situation-specific requirements placed on one's plans of action.	"We cannot think solely from the perspective of our procedures. I felt that we must recreate the opponent's activities with authentic substances, materials, and conditions. It is the only way to understand their mindset. It puts our own procedures into perspective." (C3)	Procedures are incapable of independent thinking. Addressing an active and intelligent threat, for example, thus remains the actor's responsibility. Procedures may prevent one from seeing the context to which one's actions should be related.

Rules, similarly to formal areas of responsibility, power relations and the authorisation practices associated with them, are one form of cognitive artefacts. They include important guidelines which are binding on the professional community members, rules they have adopted, and cognitive artefacts that direct general morality. They point the way to an appropriate procedure and contain assumptions about the context of the situation. B2 describes a recent situation in which a patient needing emergency cranial surgery came in during their shift. In these cases, the protocol requires that the decision to start surgery should be approved by the neurosurgery clinic. The patient was a 70-year-old male who was still in working life, and he was just about to go for a CT scan.

> "I called to say that the patient was GCS-3 with one pupil dilated, which means that he will soon be brain dead. So will I go ahead with the surgery or what?"

The neurosurgeon was unable to make a decision before having the CT images and consulting a colleague. B2 explains how he prepared the patient for surgery and then again called the neurosurgeon, who had to take a closer look at the images before making the decision. "At that point I decided to go ahead. Whether I would get authorisation for it afterwards or not, the patient had to be operated on", B2 said. They felt that it would have been wrong to allow the patient to lie on the brink of brain death for the sake of waiting for authorisation, which is why "I had to reject the normal treatment practice concerning authorisations." This type of cognitive perception of the situation is demonstrated as an ability to weigh the costs of the various options and the passing of time. "Sometimes you have to have the courage to do what is right and trust that the authorisation will follow", they said. Seniority, the vision and judgement accumulated during a long career, undoubtedly plays a key role in weighing situations where rejecting or applying artefacts is meaningful and appropriate, and where it is anything but.

5 Discussion

Let's move on to make broader conclusions on the findings of the study. For this purpose, one needs to look at a compilation of examples in which the interviewees have something in common, illustrating their relationship with artefacts in exceptional situations and contexts. These examples have been collected in Table 2.

As it can be seen in Table 2, the interviewees' attitudes towards artefacts are described by their association with situational factors; even if most problems they encounter could be solved to a high standard relying on artefacts, they are still not necessarily relevant to the next situation. In this sense, an actor's attachment to an artefact creates a potential vulnerability that may affect action in exceptional situations (cf. Weick, 1993, 1988). This is why the interviewees actively maintain a sceptical attitude towards artefacts – even in normal conditions, they strive to operate in ways that minimise their dependence on artefacts.

Another observation that arises from the findings relates to how artefacts basically guide the actor in solving the representation of the problem formulated by them (d'Addeiro, 2011; Baber, 2003); this means focusing the actor's attention on what is *known*. An interesting aspect in the findings is the interviewees' tendency to direct their cognitive capacity towards the more ambiguous area of the unknown (cf. Ben-Shalom et al., 2012; Antonacopoulou, 2009; Shanteau, 2001); it is possible that their attitudes to artefacts have also increased their ability to be interested in the less obvious problem

dimension, in which the points critical to solving the overall situation may be found. The interviewees did not allow themselves to be carried away by the artefacts. In other words, the fact that the problem is structured and can be solved does not yet mean that it is worthwhile investing one's capacity in it. It can be said that this kind of expertise is key in preparing to face *unbelievable*, *unthinkable* and *inconceivable* problems (Lagadec, 2007).

This article examines actors who, while they have naturally been taught to use certain artefacts in certain situations, use them differently or refuse to use them at all, even if the general scientific and legal examination would be in favour of their (correct) use. Why do legitimate artefacts and legitimate ways of using artefacts not 'affect' these actors in certain situations in the same way as they affect some others? What gives them more freedom to improvise? Exploring these issues is an interesting topic for further research. This study provided indications for the hypothesis that the explanation can be found not only in metacognitive skills but also in an enormous volume of practice and number of repetitions; one can assume that these persons possess a wider repertoire of artefacts and their uses in their internal environment, which they can apply to different situations and which help them become independent from external artefacts. This also partly explains the actors' ability to perceive the priorities of a situation, their ability to visualise the progress of processes and the mechanisms that maintain them, and their resulting ability to focus attention on what is the most essential. In an exceptional situation, this appears to be the starting point for effective action.

6 Conclusions

The present study has gone some way towards enhancing the understanding of the role artefacts play in the cognitive abilities of experts. It shows that rather than being neutral, artefacts trigger conditioned responses. These responses are not always unequivocally useful for solving the situation at hand. Whereas reliance on artefacts ensures operational ability in anticipated conditions and situations, this may not be true in exceptional situations and circumstances where the actor is required to make tough decisions rapidly. The study revealed this flip side of artefacts and highlighted their potential incapacitating effect. The study indicates that, on the one hand, artefacts require their users to reflect on how suitable the artefact is for the situation at hand. On the other hand, the ability to do so is underpinned by keeping a certain distance and actively maintaining a sceptical attitude, even when the artefacts have proven relevant.

The study found that the subjects are striving to make themselves increasingly independent of the restrictions inherent in tools developed for limited purposes or problem-solving methods. This is manifested in their tendency to trust and rely on rather simple and 'old-fashioned' techniques and methods. Perfected skills in using these artefacts enable the actor to grasp the actual core of the problem to be solved. The actor, the artefact and the problem increasingly become one, making it possible to perceive the layers of the situation and prioritise tasks. This oneness, which describes operational ability, would appear to play a key role when aiming for high-quality action in exceptional and unexpected situations. Despite the relatively small number of subjects, which can be considered as one limitation of this study, it succeeded in illustrating the relationship between the actors and artefacts in exceptional situations, in giving

theoretical contribution by pointing to the reverse side of the use of tools, and in raising recommendations for further research work.

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References

Antonacopoulou, E.P. (2009) 'Impact and scholarship: unlearning and practicing to co-create actionable knowledge', *Management Learning*, Vol. 40, No. 4, pp.421–430, DOI: 10.1177/1350507609336708.

Baber, C. (2003) *Cognition and Tool Use: Forms of Engagement in Human and Animal Use of Tools*, Taylor & Francis, London.

Baker, S.E. and Edwards, R. (2012) 'How many qualitative interviews is enough?', *National Centre for Research Methods Review Paper* [online] http://eprints.ncrm.ac.uk/2273/4/how_many_interviews.pdf (accessed 25 January 2021).

Ben-Shalom, U., Klar, Y. and Benbenisty, Y. (2012) 'Characteristics of sense-making in combat', in Laurence, J.H. and Matthews, M.D. (Eds.): *The Oxford Handbook of Military Psychology*, pp.218–231, Oxford University Press, Oxford.

Bohle Carbonell, K., Stalmeijer, R.E., Könings, K.D., Segers, M. and van Merriënboer, J.J.G. (2014) 'How experts deal with novel situations: a review of adaptive expertise', *Educational Research Review*, Vol. 12, No. 1, pp.14–29, DOI: 10.1016/j.edurev.2014.03.001.

Borodzicz, E.P. (2004) 'The missing ingredient is the value of flexibility', *Simulation & Gaming*, Vol. 35, No. 3, pp.414–426, DOI: 10.1177/1046878104266221.

Brey, P. (2005) 'The epistemology and ontology of human-computer interaction', *Minds and Machines*, Vol. 15, Nos. 3–4, pp.383–398, DOI: 10.1007/s11023-005-9003-1.

Comfort, L.K. (2007) 'Crisis management in hindsight: cognition, communication, coordination and control', *Public Administration Review*, Vol. 67, pp.189–197, DOI: 10.1111/j.1540-6210.2007.00827.x.

Crandall, B., Klein, G. and Hoffman, R.R. (2006) *Working Minds. A Practitioner's Guide to Cognitive Task Analysis*, The MIT Press, Cambridge.

d'Addeiro, L. (2011) 'Artifacts at the centre of routines: performing the material turn in routines theory', *Journal of Institutional Economics*, Vol. 7, No. 2, pp.197–230, DOI: 10.1017/S174413741000024X

Devitt, K.R. and Borodzicz, E.P. (2008) 'Interwoven leadership: the missing link in multi-agency major incident response', *Journal of Contingencies and Crisis Management*, Vol. 16, No. 4, pp.208–216, DOI: 10.1111/j.1468-5973.2008.00551.x.

Farazmand, A. (2009) 'Hurricane Katrina, the crisis of leadership, and chaos management: time for trying the 'surprise management theory in action'', *Public Organization Review: A Global Journal*, Vol. 9, No. 4, pp.399–412, DOI: 10.1007/s11115-009-0099-2.

Farazmand, A. (2014) 'Learning from the Katarina crisis. A global and international perspective with implications for future crisis management', in Farazmand, A. (Ed.): *Crisis and Emergency Management. Theory and Practice*, 2nd ed., pp.461–476, CRC Press, Boca Raton.

Gao, D., Squazzoni, F. and Deng, X. (2018) 'The role of cognitive artifacts in organizational routine dynamics: an agent-based model', *Computational and Mathematical Organization Theory*, Vol. 24, No. 4, pp.473–499, DOI: 10.1007/s10588-018-9263-y.

Gawande, A. (2010) *The Checklist Manifesto: How to Get Things Right*, Profile Books, London.

Hatano, G. and Inagaki, K. (1986) 'Two courses of expertise', in Stevenson, H. et al (Eds.): *Child Development and Education in Japan*, pp.262–272, W.H. Freeman, New York.

Heersmink, R. (2016) 'The metaphysics of cognitive artefacts', *Philosophical Explorations*, Vol. 19, No. 1, pp.78–93, DOI: 10.1080/13869795.2014.910310.

Hilpinen, R. (1992) 'On artifacts and works of art', *Theoria*, Vol. 58, No. 1, pp.58–82, DOI: 10.1111/j.1755-2567.1992.tb01155.x.

Hutchins, E. (1995) *Cognition in the Wild*, The MIT Press, Cambridge.

Jenkins, D.P., Salmon, P.M., Stanton, N.A. and Walker, G.H. (2010a) 'A new approach for designing cognitive artefacts to support disaster management', *Ergonomics*, Vol. 53, No. 5, pp.617–635, DOI: 10.1080/00140131003672007.

Jenkins, D.P., Salmon, P.M., Stanton, N.A. and Walker, G.H. (2010b) 'A systemic approach to accident analysis: a case study of the Stockwell shooting', *Ergonomics*, Vol. 53, No. 1, pp.1–17, DOI: 10.1080/00140130903311625.

Jenkins, D.P., Salmon, P.M., Stanton, N.A., Walker, G.H. and Rafferty, L. (2011) 'What could they have been thinking? How sociotechnical system design influences cognition: a case study of the Stockwell shooting', *Ergonomics*, Vol. 54, No. 2, pp.103–119, DOI: 10.1080/00140139.2010.539706.

Kahneman, D. and Klein, G. (2009) 'Conditions for intuitive expertise: a failure to disagree', *American Psychologist*, Vol. 64, No. 6, pp.515–526, DOI: 10.1037/a0016755.

Klein G. (2017) *Seeing What Others Don't: The Remarkable Ways We Gain Insights*, Nicholas Brealey Publishing, London.

Lagadec, P. (2007) 'Crisis management in the twenty-first century: 'unthinkable' events in 'inconceivable' contexts', in Rodríguez, H. et al. (Eds.): *Handbook of Disaster Research*, pp.489–507, Springer, New York.

Mendonça, D. (2007) 'Decision support for improvisation in response to extreme events: learning from the response to the 2001 World Trade Center attack', *Decision Support Systems*, Vol. 43, No. 3, pp.952–967, DOI: 10.1016/j.dss.2005.05.025.

Militello, L.G. (2001) 'Representing expertise', in Salas, E. and Klein, G. (Eds.): *Linking Expertise and Naturalistic Decision Making*, pp.245–262, Lawrence Erlbaum Associates, Mahwah.

Morse, J.M. (2000) 'Determining sample size', *Qualitative Health Research*, Vol. 10, No. 1, pp.3–5, DOI: 10.1177/104973200129118183.

Okoli, J. and Watt, J. (2018) 'Crisis decision-making: the overlap between intuitive and analytical strategies', *Management Decision*, Vol. 56, No. 5, pp.1122–1134, DOI: 10.1108/MD-04-2017-0333.

Omodei M.M., McLennan, J., Elliott, G.C., Wearing, A.J. and Clancy, J.M. (2005) ''More is better?': a bias toward overuse of resources in naturalistic decision-making settings', in Montgomery H. et al. (Eds.): *How Professionals Make Decisions*, pp.29–41, Lawrence Erlbaum Associates, Mahwah, NJ.

Pepper, M., Archer, F. and Moloney, J. (2019) 'Triage in complex, coordinated terrorist attacks', *Prehospital and Disaster Medicine*, Vol. 34, No. 4, pp.442–448, DOI: 10.1017/S1049023X1900459X.

Rothenberg, D. (1995) *Hand's End. Technology and the Limits of Nature*, University of California Press, Berkeley.

Salas E. et al. (2010) 'Expertise-based intuition and decision making in organizations', *Journal of Management*, Vol. 36, No. 4, pp.941–973, DOI: 10.1177/0149206309350084.

Schwartz, D.L. et al. (2005) 'Efficiency and innovation in transfer', in Mestre, J. (Ed.): *Transfer of Learning from a Modern Multidisciplinary Perspective, Information Age*, pp.1–51, Greenwich, CT.

Shanteau, J. (2001) 'What does it mean when experts disagree?', in Salas, E. and Klein, G. (Eds.): *Linking Expertise and Naturalistic Decision Making*, pp.229−244, Lawrence Erlbaum Associates, Mahwah, NJ.

Smith, O.F. (2007) 'Object artifact, image artifacts and conceptual artifacts: beyond the object into the event', *Artifact*, Vol. 1, No. 1, pp.4–6, DOI: 10.1080/17493460600610707.

Steinert, S. (2016) 'Taking stock of extension theory of technology', *Philosophy & Technology*, Vol. 29, No. 1, pp.61–78, DOI: 10.1007/s13347-014-0186-3.

Weick, K.E. (1988) 'Enacted sensemaking in crisis situations', *Journal of Management Studies*, Vol. 25, No. 4, pp.305–317, DOI: 10.1111/j.1467-6486.1988.tb00039.x.

Weick, K.E. (1993) 'The collapse of sensemaking: the Mann Gulch disaster', *Administrative Science Quarterly*, Vol. 38, No. 4, pp.628–652, DOI: 10.2307/2393339.

Weick, K.E. (1996) 'Drop your tools: an allegory for organizational studies', *Administrative Science Quarterly*, Vol. 41, No. 2, pp.301–314, DOI: 10.2307/2393722.

Weick, K.E. (2001) 'Tool retention and fatalities in wildland fire settings: conceptualizing the naturalistic', in Klein, G. and Salas, E. (Eds.): *Naturalistic Decision Making*, pp.323–338, Erlbaum, Hillsdale, NJ.

Weick, K.E. and Sutcliffe, K.M. (2015) *Managing the Unexpected. Sustained Performance in a Complex World*, 3rd ed., John Wiley & Sons, Inc., New Jersey.