Decision-Making on Fire: Cognitive Load and Commanders' Decisions on the Fireground

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"There is no dearth of evidence in everyday life that people apprehend reality in two fundamentally different ways, one variously labelled intuitive, automatic natural, non-verbal, narrative and experiential, and the other analytical, deliberative, verbal and rational"
– Epstein (1994, p. 710)

1. Introduction

August 5, 1949, a wildfire was reported on the slopes of Mann Gulch, Montana. Fifteen smokejumpers, firefighters that are dropped by plane to deliver them quickly to areas that are not easy to access, were dispatched to fight the fire. The fireground commander, Wagner Dodge, directed the crew to move downhill to fight the fire, as this position close to the Missouri river would be safer than staying uphill. Meanwhile he left his crew behind and left the second-in-command in charge. Not too long after, he noticed that the fire was blowing up, making it impossible for the crew to reach the river. Immediately Dodge decided to direct the crew back uphill, but by this time the fire had already become a race that could not be won (Turner, 1999). He then ordered his crew to drop their tools so they could move faster and commanded them to lie down in the area he had just burned. However, not all men understood what Dodge was aiming for when burning the grass area down. Instead of following his instructions, they made their own decision and tried to outrun the fire, causing the flames to catch up on them.

Both Dodge's too late realization that the fire was becoming more intense rapidly and the misunderstanding of his orders among the smokejumpers turned out to be disastrous for the operation (Weick, 1993). Evidently, Dodge was unable to provide clear commands to his crew. The Mann Gulch disaster, therefore, demonstrates that incident command plays a crucial role during emergency operations.

Working on the fireground generally implies operating in a highly dynamic environment, requiring people to deal with high levels of time pressure, ambiguity and uncertainty (Klein, 1993). Increases in such work intensity ask for large mental effort, which enhances the mental workload or cognitive demand of the job. This cognitive demand, or cognitive load, is the mental load related to a task that is imposed on someone when performing this task (Paas, Tuovinen, Tabbers & van Gerven, 2003). It is argued that cognitive load negatively affects task performance in fast-response decision-making among medical personnel (Laxmisan, Hkaimzada, Sayan, Green, Zhang & Patel, 2006), navy personnel (De Greef & Arciszewski, 2007; Loft, Sadler, Braithwaite & Huf, 2015), aviation personnel (Lichacz, 2005) and military personnel (Adams-White, Wheatcroft & Jump, 2018; Kerick & Allender, 2006). This implies

that the higher the mental workload, the less accurate one's decision and the higher the chance is that one will be making errors.

There are several approaches to decision-making. The main distinction in decision-making styles is made between System 1 and System 2 thinking (Groenendaal & Helsloot, 2015). System 1 thinking implies making decisions based on intuition and recognition of previous experiences, whereas System 2 thinking relies on rationality and the capacity to analytically weigh potential courses of action. It is found that in complex and dynamic circumstances when people are confronted with tasks with a high level of difficulty a more intuitive approach leads to better performance (Nygren & White, 2002). Similar results were found for the relationship between time pressure and recognition-primed decision-making (Hilbig, Erdfelder & Pohl, 2012). Thus, in fast-response situations, settings that are associated with less perceived time and high task complexity and difficulty such as emergency operations, rational approaches seem to lead to poorer decisions and people turn to making decisions based on their intuition.

In relation to this, rationality-based standardized emergency management models are perceived to be causing poor performance in emergency operations as they do not consider the role of cognition in making decisions and steering the operation (Comfort, 2007). Cognition is one's capacity to recognize risks and act upon them. Not for nothing, Rake and Bøhm (2018) recognize that incident command is closely related to the cognitive capabilities of the incident commander. One's cognitive capacity, that is the amount of information one can process at one point in time, is however limited (van Merriënboer & Sweller, 2005). Cognitive load is the mental effort required to execute a task or set of tasks, and is highly determined by task complexity and time pressure (Galy, Cariou & Mélan, 2012). Due to the high complexity and dynamics of emergency situations, cognitive load can prove to be too high and cause an overload. Cognitive overload can consequently cause incident commanders to err if they do not try to adjust their strategy to the complexity of the situation (de Greef & Arciszewski, 2007). Again it is shown that during emergency response operations adaptation is preferred over systematic thinking and acting.

Considering these observations, it can be argued that a relationship exists between cognitive load and the style of decision-making applied by incident commanders. Considering the limited amount of evidence on the link between cognitive load and incident command decision-making styles despite the demonstrated essence of cognition for emergency management performance, the current study aims to answer the following research question:

How does cognitive load influence fireground commanders' decision-making style?

1.1. Relevance of the research

A better understanding of how Dutch fireground commanders make decisions during emergency responses is important for improving training and exercises of the Dutch fire service. Research has already been carried out by the Dutch Fire Academy and Crisislab to analyse the potential of situational command as a way of improving command by fire ground commanders (Hazebroek, van 't Padje, Groenendaal, Geerstema & Hagenaars, 2015). This research had a primary focus on large scale incidents. In order to improve training, and therefore improve actual operations, it is important to also study operations of a smaller scale. Moreover, the existing research on the Dutch Fire Service does not yet focus on the impact of cognitive load on commanding. More specifically, examination of the impact of cognitive load might result in valuable information that can be used to improve communication and collaboration during emergency response. Using the outcomes to improve training and educational purposes can make the performance of duty officers more effective and efficient.

Moreover, from an academic perspective, although scholars have been paying more attention to incident command in general, research on fireground commanders is still limited (Groenendaal, Brugghemans & Helsloot, 2014). Whereas command has already received plenty of attention within the military field, there is a lack of research done within the field of firefighting, and other emergency services as well. Especially considering that research on fireground commanders primarily takes place in Scandinavia (e.g. Bøhm, 2017; Rake & Njå, 2009), the United States (e.g. Klein, Calderwood & Clinton-Cirocco, 2010) and the United Kingdom (e.g. Cohen-Hatton, Butler & Honey, 2015). Research on the link between cognitive demand and the applied decision-making style is in particular scarce. With the exception of some (e.g. Nygren and White, 2002; Hilbig et al., 2012) the relationship between cognitive load and decision-making style has not been thoroughly examined. As cognitive load has been proved to significantly affect decision-making accuracy in several settings, there is a need to further study this link. Moreover, scholars emphasize the general need for using real-time data in research on incident command (Njå & Rake, 2009). As of right now most research on incident command in the firefighting field has been carried out based on training sessions and interviews conducted after an incident happened. Although studies based on simulated incidents and recall lead to valuable insights, research based on real-time data is more accurate as it is not biased by the knowledge that it is not a real incident or memory gaps.

1.2. Reading guide

In the next chapter of this thesis the theories relevant to incident command decision-making and cognitive load are discussed as a way of creating a framework through which the current study is conducted. The third chapter of this thesis addresses the research design and methods applied, as well as addressing the ethical, reliability and validity concerns associated with the study. In the fourth chapter the organization of Dutch emergency response and the Dutch fire service in particular are outlined. The fifth chapter subsequently deals with the analysis of the data. The sixth chapter consists of the discussion of the results, including some recommendations for future research. This is followed by the last chapter, that is the conclusion, in which an answer to the research question is provided as well as some practical implications and recommendations.

2. Theoretical Framework

Incident ground commanders are of main importance to the overall incident response. From the start of a response, that is even before they reach the location of the incident, incident commanders already need to start assessing the situation and making decisions. Several theories on decision-making have been developed over time. The two main theories on incident command decision-making, being the rational and intuitive decision-making models, are deemed most relevant for this research and elaborated upon in the following few paragraphs. Thereafter, the Cognitive Load Theory is introduced and its relationship with decision-making is presented. But first, an introduction is provided to emergency response and the role of incident commanders in general.

2.1. Emergency response

The emergency context is highly complex. Emergency response operations are generally characterized by high levels of risk, time pressure and ambiguity, and the involvement of many actors (Bigley & Roberts, 2001). Actors often include public, private and non-profit organizations, as well as citizen communities. People operating in emergency response are expected to be able to cope with this highly complex and dynamic environment.

Especially inter-agency emergency operations require some organization to operate collaboratively with the other agencies involved. Whereas some scholars argue such operations call for an integrative approach where all actors involved need to come to a unified and coherent set of actions (e.g. Majchrzak, Jarvenpaa, & Hollingshead, 2007), others demonstrate that in practice this is not necessarily the case. They claim that fragmentation between organizations operating in extreme settings that require a fast response is inevitable and even a key characteristic of emergency operations (e.g. Wolbers, Boersma & Groenewegen, 2018). This is because fragmentation "provides a way of achieving the very flexibility, sensitivity to operations, and improvisation that are claimed to be the hallmark of swift and effective crisis management" (Wolbers et al., 2018, p. 1540). This tension between integration and flexibility is clearly recognized in incident command systems. Incident command faces the fundamental challenge of finding a balance between the development of a set of standards that is systematically applied to the situation and the maintenance of a sufficient amount of flexibility in order to adapt to the dynamic conditions of emergencies (Boersma, Comfort, Groenendaal & Wolbers, 2014). Applying standardized procedures originates from the desire to immediately regain control over complex and chaotic situations, but in practice it is proven that gaining

control over emergency situations in the first few moments of the incident is hard to achieve. As the use of standardized models of emergency management seems to be inadequate to tackle an emergency situation, the ability to adapt operational strategies to the rapidly evolving circumstances of disasters is argued to be an essential characteristic of emergency response operations and incident commanders in particular (Comfort, 2007). Incident commanders are hence expected to operate with some degree of flexibility.

2.2. Fireground commanders

Incident commanders are the predetermined leaders on the scene at any emergency situation, be it from the police, ambulance service or fire service. Making a reference to the Dutch emergency response and the fire service in particular, in the Netherlands fireground commanders are referred to as the duty officers of the fire service. They are responsible for the actions that are carried out, the coordination of the activities, the individual fire fighters and eventually for the outcome of the emergency response (Bigley & Roberts, 2001). The general expectation of fireground commanders, therefore, is that they have command and control within the emergency situation. This includes determining the strategy, working out an action plan, setting priorities, arranging the required resources, informing other organizations of the current status of the incident and requesting new information from others, and arranging relief when necessary (Rake & Bøhm, 2018). Hence, fireground commanders are the ones on scene who make the important decisions and determine how the operation should be carried out. In order to make these decisions, a commander "effectively utilizes support staff, is knowledgeable about emergency response technologies and is up to date on the latest information in a rapidly changing world with new threats, hazards and risks" (Bennett, 2011, p. 28).

2.3. Decision-making

Decision-making is the process or act of setting out a course of action. The subject of leader decision-making has been a popular research topic for years. Traditionally, strategic decision-making has been studied in more bureaucratic circumstances, especially focussing on decision-making by managers in several organizational sectors using rational methods and a logical sequence in order to arrive at a decision (see Eisenhardt & Zbaracki, 1992). According to some, however, findings from studies on traditional decision-making should be treated with caution when applied to incident command.

Traditional decision-making models should thus not be dealt with through a one-size-fits-all approach when it comes to incident command decision-making. Factors like

high time pressure, highly ambiguous information, high uncertainty and the many stakeholders that are involved in emergency responses make it impractical, or even undesirable, to apply these established models and steps to incident command (Klein, 2014). Hence, a new model to understand how people make decisions in such complex situations was developed: Naturalistic Decision Making (NDM). Unsurprisingly, naturalistic decision-making is characterized by "dynamic and continually changing conditions, real-time reactions to these changes, ill-defined tasks, time pressure, significant personal consequences for mistakes, and experienced decision makers" (Klein & Klinger, 1991, p. 16). The distinction between both models has been referred to as reflective versus reflexive (Cohen-Hatton et al., 2015) and System 2 versus System 1 (Groenendaal & Helsloot, 2015) decision-making.

2.3.1. Rational decision-making

The notion of the rational style of decision-making was first introduced by John Dewey, who stated that people make decisions according to a predetermined logical sequence of steps that will lead them to come up with an adequate solution. The principle of rational decision-making theory is that people aim to solve problems in an analytical and rational way by following an orderly sequence of steps and phases (Lipshitz & Bar-Ilan, 1996). Although several models have been developed in a large variety of contexts, the basic principles of the models remain similar. Rational, or normative, decision-making thus generally involves the gathering of information, considering the various available options and making a decision out of those options before implementing them (Lipshitz & Strauss, 1997).

Van den Heuvel, Alison and Crego (2012) have developed a decision-making model that has been applied to studies that involve emergency services, such as the police (van den Heuvel, Alison & Power, 2014). The three iterative processes identified are Situation Assessment (SA), Plan Formulation (PF) and Plan Execution (PE) (van den Heuvel et al., 2012). Situation Assessment is the phase in which the decision-maker tries to form an understanding of the situation by considering the information that is available; it is the phase where one needs to make sense of the overall situation. This includes creating expectations of what might happen next and what might be achieved, that is to what extent the problem can be solved and in what ways. Situation Assessment leads to situational awareness, which is "the perception of 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" (Endsley, 1995, p. 36). Hence, situational awareness is considered a state of knowledge, whereas Situation Assessment is the process of achieving this state of knowledge. It is important to recognize, though, that the quality of the

decision made does not relate to the level of situational awareness. According to Endsley (1995, p. 36) “even the best-trained decision makers will make the wrong decisions if they have inaccurate or incomplete SA. Conversely, a person who has perfect SA may still make the wrong decision”.

The second step in the decision-making process is Plan Formulation. Plan Formulation is about identifying the exact problem or problems and creating matching solutions, thus it involves the process of meaning making. It implies formulating a set of potential actions that can be undertaken and identifying the resources needed to execute them based on the environmental cues and expectations one creates of the situation and its development. In this phase, the decision-maker also decides what plan or plans to execute, mostly based on rationally weighing the pros and cons of options in order to make a decision (Lipshitz & Strauss, 1997). Plan Formulation in a nutshell, therefore, is about setting goals and prioritising the tasks that need to be carried out based on all information and situational cues the incident commander is confronted with (Owen et al., 2013).

The final step is Plan Execution. In short, this step implies the implementation of the chosen plan or plans. Monitoring of behaviour and communicating are perceived to be key during this phase of the emergency response (Owen et al., 2013). Communication mainly has to do with listening to and understanding what the others in the operation indicate and reflecting leadership by delegating a clear division of roles. In that sense, it is the common thread during the execution of plans, as it determines to a large extent how the execution passes off. Close performance monitoring is equally crucial, because it ensures that cues indicating that someone needs assistance or something does not go according to plan are noticed in time and can be acted upon immediately. Repeated supervision and feedback are required means to ensure that orders are carried out as intended by subordinates (Groenendaal & Helsloot, 2015).

2.3.2. Intuitive decision-making

Most trainings for fireground commanders are based on the previous sequential models. This does, however, not necessarily mean that it fully captures the way they make their decisions in practice. It is argued that some people might experience too high time pressure and therefore decide to follow their intuition based on previous experiences (Klein & Klinger, 1991). Using the rational approach namely requires considerable mental effort in order to adequately consider all options, which consequently requires time that is often unavailable during emergency situations (Kahneman & Klein, 2009). This implies that rather than a reflective approach where the pros and cons of each plan are considered, commanders turn to a reflexive one.

The notion of making decisions on the basis of recognition is referred to as recognition-primed decision-making (RPD). This model explains how people use their experience in similar previous situations to recognize and develop certain patterns (Klein et al., 2010). These patterns "highlight the most relevant cues, provide expectancies, identify plausible goals, and suggest typical types of reactions in that type of situation" (Kahneman & Klein, 2009, p. 457). This is especially useful in situations where decisions need to be made as quick as possible, so when there is no time to make a decision based on the simultaneous comparison of several potential courses of action, and in situations characterized by high ambiguity (Klein, 1993).

This is where the difference between the two modes of thought or the two-system view as described by Kahneman (2003) is of relevance. System 1 is referred to as a "typically fast, automatic, effortless, associative, implicit (not available to introspection), and often emotionally charged" way of thinking (p. 698). This is the decision-making process previously described as RPD. System 2, on the other hand, is a slow, serial and more effortful process. It requires the ability to reason. Although System 2 is argued to be monitoring the actions of System 1 in order to prevent errors caused by wrong intuitive judgements, it is observed that in reality this usually is not the case (Kahneman & Klein, 2009).

Switching from System 1 to System 2 thinking requires substantial mental effort and consequently is time consuming as all information should be processed deliberately. This means that, when operating in mentally demanding circumstances such as emergency response operations, often only one option at a time is examined as a way of making the decision-making process less time consuming (Klein et al., 2010). As shown, decision-makers in high-demanding situations tend to stay within System 1. This suggests that in practice most fireground commanders barely consider more than one option if this particular option has previously proven to be successful and is perceived to be workable in the current situation as well (Klein, 1993).

This is especially the case with experienced decision-makers. Most of the time the first course of action they identify they perceive to be an acceptable one, making it, from their point of view, unnecessary to generate and consider a range of other options. As a result, fireground commanders usually work according to the notion of satisficing: they do not necessarily try to find the optimal option, but rather look for the first workable one (Klein, 1993; Kahneman & Klein, 2009). The observation that fireground commanders often do not consider several potential courses of action to decide on the optimal choice suggests that the Plan Formulation phase of the normative decision-making models is skipped. It is indeed observed that in practice

Situation Assessment is more often than not immediately followed by Plan Execution rather than Plan Formulation (Cohen-Hatton et al., 2015). This suggests that the cues fireground commanders recognize when assessing the situation at hand directly prime certain decisions.

It is argued by some scholars that it is therefore necessary for fireground commanders to engage System 2 consciously in order to monitor and correct the limitations that come with primarily relying on System 1 (Groenendaal & Helsloot, 2015). One major issue that comes into play when primarily relying on System 1 is an assessment-bias (McLennan, Holgate, Omodei & Wearing, 2006). A decision-bias as such can emerge when the incident commander is caught in overconfidence, for instance because a previous incident that was very similar to the current situation has proven to be easy to resolve, causing the risk assessment of the current incident to be too optimistic. Another System 1 bias is the tendency to only accept information that confirms pre-existing views (Higgins & Freedman, 2013). This is related to what Epstein (1994) refers to as "experiencing is believing" (p. 711). When someone experiences something, especially under high pressure or emotional circumstances, it consequently appears self-evidently valid to them. This experiential and reflexive way of thinking causes the decision-maker to reject all information that disconfirms pre-existing perspectives or experiences, resulting in an incorrect understanding of the situation (Higgins & Freedman, 2013). A collapse of contextual sensemaking can have disastrous consequences for the operation and thus the development of the emergency situation (Weick, 1993). Not adequately understanding what the exact situation is one should deal with results in commands that do not make sense regarding the actual event.

Some scholars state that biases always continue to exist. Kahneman and Klein (2009, p. 523) mention the so-called illusion of validity: "the overconfidence that professionals sometimes experience in dealing with problems in which they have little or no skill". The illusion of validity basically implies that people are convinced they understand a situation well, even though this conviction is unjustified. This is caused by the fact that people lack the ability to identify correct intuitions and distinguish them from incorrect ones, because they do not know where their intuition came from. It is argued that engaging in System 2 thinking can correct these biases through logical reasoning and collecting objective evidence in order to justify the reflexive judgements made (Epstein, 1994). Nevertheless, people tend to not always apply this type of thinking, because they either cannot be bothered or it is too difficult (Kahneman & Klein, 2009).

2.4. Cognitive Load Theory

The many agencies involved in emergency responses all notice, process and prioritize information. Cognition is identified as an essential component of effective crisis management and emergency response. It is the capacity of incident commanders to recognize risks based on constantly incoming information and act on this newly acquired knowledge (Comfort, 2007). This means that cognition has the ability to shift the emergency response away from a static set of procedures to a dynamic and adaptive process, where decisions are based on specific cues derived from the current situation rather than predefined rules and procedures. Processing all these cues leads to a large amount of distinct situation assessments, ideas, tasks and courses of action. However, when this information is excessive, it increases the complexity of the operation and can overwhelm the commander (House, Power & Alison, 2014). This has to do with cognitive load.

Cognitive load refers to the demand that is imposed on one's cognitive system when performing a certain task or multiple tasks (Paas et al., 2003). Complexity of the task, and thus the demand thereof, is determined by time pressure, pacing of instruction and task format. Cognitive load, then, is based on both the content of the information decision-makers receive and the way in which this information is presented to them. When many tasks of too high complexity are imposed on the decision-maker at the same time or within a short time period, it induces cognitive overload (de Greef & Arciszewski, 2007). This implies that the additional resources provided to the decision-maker prove to be too high for his capability to process information. This is because exposure to a broad range of information causes noise, making it difficult to select and prioritize information to be used for decision-making (Hwang & Lin, 1998). Cognitive overload, therefore, can cause a commander's attention to drift away from managing primary tasks, that is the maintenance of strategic direction to the operation, to managing the extra resources and demands imposed (McLennan et al., 2006). This way they are unable to understand the big picture. The added processing of superfluous resources results in a lack of insight and oversight, causing situational awareness and performance to decrease. It is therefore not the case that more information would improve the quality of the decisions made on the fireground.

The Cognitive Load Theory (CLT) was first introduced by Sweller, Paas and Van Merriënboer. CLT assumes that people only have a limited working memory capacity (van Merriënboer & Sweller, 2005). Cognitive capacity refers to the amount of space people have to make calculations based on the information they receive. This implies that there is a limit to how much information a person can handle. To be more precise, someone's working memory

"is able to deal with information for no more than a few seconds with almost all information lost after about 20s unless it is refreshed by rehearsal" (p. 148). With that being said, limited cognitive capacity especially concerns short-term memory, or information that one has not been confronted with previously. The long-term memory consists of elements or cues one has experienced before, meaning that it consists of schemata that guide the organization of information. So, when being confronted with these familiar elements, one knows how to process and organize them. At the same time this means that, when these schemata are unavailable as someone is confronted with novel information, problems with information organizing and processing arise. This is because "as the number of elements that needs to be organized increases linearly, the number of possible combinations increases exponentially" (p. 149). This problem can only be addressed by limiting the working memory, hence severely reducing the amount of information that can be processed simultaneously. This brings along the consequence that one unconsciously ignores cues in order to be able to process at least some of the information.

Information processing, especially the ease of processing, is one of the focus points of CLT. As Van Merriënboer and Sweller (2005) argue, the load imposed on one's working memory is influenced by either intrinsic cognitive load or extraneous cognitive load. Intrinsic cognitive load involves the number of elements one needs to process simultaneously and the substantive difficulty of these elements. Extraneous cognitive load, on the other hand, is load generated by the way in which information is presented and has to do with information that is inessential for learning or confusing. Inadequate instruction thus increases cognitive load. Both types of cognitive load complement each other. When intrinsic load is high and extraneous load is low, or vice versa, the total cognitive load does not exceed the working memory limits and does not impose problems with information processing. Only when both are high, one speaks of cognitive overload and issues arise.

Considering all of the above, it can be argued that people working in complex and highly dynamic environments generally have a hard time processing all novel information they receive. As the human brain simply is unable to process so many new elements in such a short time period, it is inevitable that people operating in fast developing situations do not process all cues relevant to the operation. Within the context of incident command, the notion of limited cognitive capacity and cognitive load thus is particularly relevant. Frontline incident commanders often have to deal with a high cognitive load, caused by the various tasks that need to be executed simultaneously, the substantive complexity of these tasks and the large amount of information that is passed on to them at the same time (Kahneman, 2003). Combined with

the quickly developing situation and associated time pressure, this implies that frontline commanders might be particularly sensitive to cognitive overload.

2.5 Cognitive load and decision-making

Generally speaking, the more information is available to the person making the decisions, the more uncertainty is reduced and the better the decision is. Fireground commanders, however, and incident commanders in general, are subject to a lot of endogenous stressors. They are supposed to make decisions under highly complex circumstances that may change rapidly. In an emergency context, therefore, a large amount of information can prove to be excessive as circumstances are constantly changing, requiring new information to be presented rapidly and frequently to the commanders. The growing amount of decisions to be made combined with the limited time the duty officer has to decide, can impose a feeling of extreme time pressure. Time pressure is "the conflict between the imposed completion time for a task and the time it actually takes to perform the task" (Galy et al., 2012, p. 272). Such feelings can prove to be too much for the decision-makers and overwhelm them, making it difficult or even impossible to weigh all options (Streufert, 2005).

As a result of experienced time pressure, incident commanders are un able to understand the big picture (Rake & Njå, 2009). They feel like they do not have the time to consider all available information and often primarily rely on information that is obviously and immediately visible. The latter is identified as WYSIATI: what you see is all there is (Kahneman, Lovallo & Sibony, 2011). Based on the evidence one directly observes, the mind creates a certain narrative despite the fact that some information might actually be missing. The human brain, however, automatically makes up for these information gaps based on cues it recognizes from previous experiences, because of which one overlooks the information that is missing without even realizing it. Hence, incident commanders often do not acknowledge nor consider all information there is before making any decisions. So people who feel like there is little time to make a decision tend to simplify decision-making processes by basing their judgement on incomplete knowledge and cues they recognize from previous experiences (Hilbig et al., 2012). It can also be the case that under high time pressure people do not find demanding decision-making styles, that is rationally considering all possible points of action and weighing the pros and cons of each option in order to find the optimal solution, worth the effort (Rieskamp & Hoffrage, 2008). This is because plans are often perceived to be of limited value, due to the uncertainty of how the incident will develop and inconsequentiality of outcomes of individual actions (Lipshitz, 1993). Making reason-based plans then is considered a waste of mental effort.

Especially in response of new tasks, developing associational cues and deciding mainly on the basis of previous experience is a way of reducing the mental effort required to make a decision (Evans, 2008).

Another consequence of the time constraints is that commanders primarily respond in a reactive way (Rake & Njå, 2009). On scene they learn about a new hazard and subsequently direct action to deal with this hazard in order to mitigate it and prevent it from increasing. Due to uncertainty and ambiguity it makes more sense to go along with the situation and react to feedback rather than investing cognitive effort in planning (Lipshitz, 1993). Incident command decision-making thus involves "real-time reactions to changed conditions" (Klein & Klinger, 1991, p. 17) rather than proactively searching for and tackling potential events. However, as emergency situations tend to expand exponentially when response is not executed in time, a reactive attitude causes incident commanders to play catch up when trying to mitigate the situation. Proactivity, therefore, is emphasized as an essential feature of incident command (Bennett, 2011). When acting reactively, the incident has free way to develop further, making it more difficult, in the case of the fire service, to fight the fire. In that case, it is not the incident commander that is in charge, but the fire. Being proactive, therefore, can minimize negative consequences and maximize efficiency during emergency response (Yarmohammadian, Atighechian, Haghshenas & Shams, 2013). As a consequence of falling behind, frustrations may arise. Indeed it is demonstrated that when the task load and feelings of pressure increase, people tend to show more negative emotions and the use of swear words increases (Khawaja, Chen & Marcus, 2014).

When studying decision-making on the fireground, Omodei, McLennan, Elliott, Wearing and Clancy (2005) found that a high task load, also referred to as task difficulty (Backs & Seljos, 1994), significantly influences System 2 thinking. This implies that a large amount of (interrelated) tasks, that is a high intrinsic cognitive load, has a substantive impact on the way in which commanders make decisions. When confronted with various complex tasks that have to be carried out simultaneously and large amounts of new information that have to processed, incident commanders do not have the cognitive capacity left that is needed to consciously consider the situation and courses of action. It is indeed found that when experiencing high task load people tend to prefer intuitive decision-making styles (Nygren & White, 2002). They do this as the analytic decision-making style makes multitasking impossible. When systematically going through each option, people are more likely to only focus on one element and thus have a hard time addressing the other tasks they need to perform. As a result, people tend to react to

new tasks by blurting out previously noticed information to reduce the load imposed on one's cognitive capacity (Kahneman, 2003).

Moreover, incident command decision-makers tend to avoid the systematic and analytical consideration of multiple options, as each option is often associated with negative sentiments such as riskiness and uncertainty (Slovic, Finucane, Peters & MacGregor, 2007). This causes some sort of bias, because people tend to go with actions that appeal to positive feelings or seek for information that confirms their preferred course of action. In fact, information that confirms early judgements is consciously processed, whereas inconsistent or conflicting data is abandoned (Perrin, Barnett, Walrath & Grossman, 2001). In such high risk and fast response circumstances such as emergency operations ususally there is no ideal option. Therefore, when subjected to such dynamic and pressuring circumstances as associated with emergency operations, it is often perceived to be better to satisfy than to optimize (Kahneman & Klein, 2009). This is why incident commanders tend to turn to reflexive decision-making and go with the first workable option rather than the ideal one.

2.6 Hypotheses

It appears that, although cognitive load is a returning topic woven into studies on decision-making, there only is a limited amount of research specifically observing cognitive load in and its relationship to incident command decision-making. Besides, most reasoning is based on the highly dynamic and fast-paced instances, whereas according to Van Merriënboer and Sweller (2005) cognitive load is not necessarily high at all times and emergency response also has its less pressured instances. Logically following from this, two hypotheses can be formulated that will guide the current study:

H1: In high-task load situations fireground commanders turn to recognition-primed decision-making (System 1).

H2: In low-task load situations fireground commanders turn to rational decision-making (System 2).

3. Methodology

This chapter will start by discussing the methods regularly used for studying incident command. Thereafter, the data collection method applied in the current study is justified. The data analysis procedure will be touched upon briefly, as well as the concerns about validity, reliability and ethics that are involved with this research. At last, the operationalization of the main variables is outlined.

3.1. Data source and collection

A lot of studies on incident-command decision-making involve interviewing commanders after an operation has ended (Njå & Rake, 2009). Respondents are then asked to recall their decision-making processes in that particular situation. The main issue with applying this method is that the complexity and dynamics of emergency response operations can cause big gaps and distortions in the memory of commanders (Omodei & McLennan, 1994). The respondent might forget important details of the response, mix up experiences of distinct emergency responses or confuse the feeling of how he should have acted with the way he acted in reality. Moreover, on the part of the researcher, interviews carry the risk of interviewer bias (Neuman, 2014). The interviewer then is no longer a scientific observer, but rather tries to look for answers that support the formulated hypotheses. Other scholars, therefore, suggest real-time observations, or action research, as a research method complementary to interviews (Njå & Rake, 2008). They argue that observations give the researcher access to the incident commander's non-verbal knowledge and skills, which is valuable information that might not be recalled afterwards in interviews. During observations it is even possible to conduct short informal interviews with the incident commanders, that are likely to be more honest than formal interviews that are conducted afterwards (Njå & Rake, 2009). Incident commanders are often suspicious of data collection and thus selectively expose facts, as they do not want to be judged for the way they acted. One of the problems with real-time observations in the context of incident command is also that emergency responders are potentially not very pleased with a scientist being present on scene. Not to mention the victims of the incident.

In an attempt to overcome these issues, occasionally video recordings are used to support people in recalling the feelings and thoughts they experienced during a particular event. This is called video-cued recall and is mainly applied in order to reduce bias in self-report and help the respondent remember the event more accurately (Miller, 2004). Bodycam video recordings are perceived to be an even more useful and robust method for researching

decision-making in its natural setting (Omodei & McLennan, 1994). This is because it allows the data to be observed and analysed by an outsider, that is the researcher, in the absence of any effect coming from the person wearing the camera, hence removing a personal bias when evaluating the event. Moreover, the other research methods mentioned earlier such as interviews and observations, interrupt and disturb the natural circumstances and can therefore unconsciously influence the data.

The data used to study the decision-making processes executed by duty officers will primarily consist of bodycam video recordings as provided by the Dutch Fire Academy. As part of a larger research project, the Dutch Fire Academy provided several fireground commanders divided over different safety regions selected by the Dutch Fire Academy beforehand with bodycams to film incident operations executed by the fire service. The selection was done from 2017 to 2019. The commanders who participated in this project at the time voluntarily offered to wear these bodycams during the operations and could decide for themselves whether to share the recordings with the Fire Academy or not. This self-selection might have led to a sampling bias, which as a result might have influenced the data collected (Neuman, 2014).

3.2. Data analysis

The overall video database used for the current study consists of a total of 20 videos. Content analysis is used to analyse the data. The videos are analysed according to the main characteristics mentioned by the rational and intuitive decision-making models. Based on these characteristics a conceptual framework, also referred to as a codebook, is developed according to which the analysis takes place. This coding process through which raw data is transformed into a standardized form is performed to label and classify the statements made, enabling the researcher to systematically go through the data (Babbie, 2013). Both latent and manifest coding are applied in order to achieve a deeper understanding of the course of decision-making and how and why commanders make certain (non-)decisions. Using both coding procedures together with the development of a codebook also contribute to guarantee reliability of the study.

3.3. Validity, reliability and ethical concerns

The internal validity is also strengthened by using video recordings as the main source of data. Bodycam video recordings are an example of unobtrusive research. This implies that the collection of data does not interfere with the natural setting and decision-making process, and therefore does not substantially affect the behaviour of the fireground commanders studied

(Sechrest & Hill, 2001). This prevents a bias within the research, although at the same time the results of the study primarily rely on the interpretations of the researcher. It cannot be prevented that some matters are interpreted differently than was the case. Moreover, the researcher should be aware of the fact that the person wearing the bodycam may be conscious of the camera and adapts his behaviour accordingly (Farrar, 2013).

The main point of concern with using video recordings, and unobtrusive measures in general, is informed consent and confidentiality of the data (Babbie, 2013). Informed consent in this case was not an issue, as the duty officers wearing the camera did this voluntarily. Data captured by the video camera can be sensitive and invasive to the commander wearing the bodycam. Since I am not part of the Dutch Fire Service and still received access to the recordings, this might cause concerns in terms of confidentiality amongst the commanders. To overcome this ethical concern, a non-disclosure agreement is signed in which is stated that it is prohibited to share details about the incidents filmed and the information retrieved from the video recordings. Moreover, the images retrieved are only used for the purpose of this research.

The reliability of the research is mainly guaranteed through the coding process. A common codebook was developed beforehand, which was tested by four researchers through analysing a few pilot videos with the preliminary codebook. The stability in coding among the four researchers was examined afterwards to ensure all codes were understood in a similar manner. Based on these outcomes, the codebook was adapted to ensure that the study can be repeated and essentially leads to the same results. After these pilots, the remaining videos were coded by two researchers each and the coding results were discussed in order to clarify and solve potential differences. These steps were undertaken to guarantee intercoder reliability (Creswell & Poth, 2018).

3.4. Operationalization

Before the actual analysis was carried out, an operationalization of the main variables is desired. The dependent variable, that is decision-making, is operationalized with reference to the decision-making model proposed by Van den Heuvel et al. (2012). The three phases, that is SA, PF and PE are used as a guideline for identifying the several steps of the decision-making process. The characteristics used for this identification are in accordance with the study by Cohen-Hatton et al. (2015). For SA, attention is paid to the way in which the duty officer was gathering information and what information was gathered in order to get a better understanding of the situation. To determine PF, the formulation and mention of goals, the expectations expressed and the extent to which the duty officer was aware of the several potential courses of

action and considered them are observed. When determining PE, attention is paid to how long it took the duty officer to make a decision, the way in which the decision was communicated to others, how the execution of the plan was organized and how the performance of the plan was monitored.

Cognitive load has been analysed using various measures in previous research. They vary from subjective measures using questionnaires and performance measures to physiological measures, behavioural measures and analysing speech or linguistics (see e.g. Brünken, Seufert & Paas, 2010; Galy et al., 2012; Khawaja et al., 2014). As the data consists of video recordings from bodycams worn by the duty officers themselves, for the current study speech is analysed to examine the cognitive load experienced by the duty officer.

In line with previous research (e.g. Omodei et al., 2005) task load is defined by the number of tasks and goals established and presented simultaneously to the duty officer. Primary attention is given to the amount of cues the duty officer is confronted with during the operation, that is both developments in the surroundings and information presented to the duty officer by others, for instance in the form of goals or problems they mention. To study whether the duty officer is actually processing these cues or actively working on tasks by outlining a plan of action, attention is paid to comments made by the duty officer that indicate that he is concerned with them.

Other than the number of tasks presented to the duty officer, cognitive load is also determined by the difficulty of the task concerned (e.g. Backs & Seljos, 1994). In order to measure task difficulty, attention is given to the extent in which expertise or certain specialized knowledge is needed to figure out a plan of action or complete a task. For instance, a simple house fire is argued to be less difficult than an incident involving a gas leak. Moreover, task difficulty is studied looking at the uncertainty involved in the situation and the complexity of the site, that is, for example, the complexity of the structure of the building.

In addition to all this, attention is paid to comments suggesting the duty officer has missed certain elements and comments made by the duty officer that indicate amazement or frustration about something that has happened or is happening. Such amazements or frustrations can be recognized, for instance, by the use of swear words. On top of such statements, physical movements, like wild hand movements, could also suggest unrest. Taking it all together, such expressions can confirm cognitive overload.

4. The Dutch Fire Service

Before turning to the data analysis and in order to put this thesis within a concise context and get acquainted with the Dutch Fire Service, a brief description is provided of its organizational structure and operating procedure. But before we get into this, the origin and composition of the Dutch emergency response structure is touched upon.

4.1. Emergency response in the Netherlands

In the Netherlands local and regional incidents are dealt with by the local safety regions. The country is divided in a total of 25 safety regions (Rijksoverheid, n.d.). The concept of safety regions arose after a few major incidents happened during which the coordination between the several emergency services showed to be inadequate and required improvement. In 2010 the *Wet veiligheidsrisico's (Wvr)* was introduced with the aim of improving emergency operations by organizing crisis and emergency management under one administrative organ (Inspectie Veiligheid en Justitie, 2016). The main implications of the safety regions are the legal obligations for all actors involved to cooperate in preparing and responding to incidents, a common public safety answering point and a regional safety office where the management of the safety region is organized.

Each safety region is managed by the mayors of the municipalities within the region in question. The safety regions are responsible for the coordination of the fire service, disaster and crisis management, and medical aid (GHOR) during emergency response. By integrating these features of emergency management, emergency operations should be executed in a more efficient and effective manner. The GHOR and fire service are the main actors within the safety regions. As the main focus of this research lies with the latter, this actor will be touched upon more elaborately.

4.2. The Dutch fire service

In line with the number of safety regions in the Netherlands, there is a total of 25 fire departments. The Netherlands has around 950 fire stations. A total of 24.300 people work as a fire fighter, of which circa 80% does their work voluntarily. This means that they work on call, as opposed to professional fire fighters who spend a few days and nights a week at the fire station. Following from this high percentage of volunteers, out of the 950 fire stations, 800 have a full voluntary occupation. Irrespective of being either primarily voluntary or professional, all fire trucks should arrive at the location of the incident within ten minutes. Roughly speaking,

the Dutch Fire Service has four main tasks, or types of incidents they act on: firefighting, control and assistance with hazardous substances, emergency and technical assistance, and management of water accidents.

On average, at least once a week the fire service operates in a so-called large scale fire incident (van ‘t Padje, Groenendaal & Hazebroek, 2014). Most incidents, however, are small or medium scale. During all these operations, the Dutch Fire Service operates with the same basic unit, that is a fire truck with a crew of six. This team consists of a crew manager, a driver and four regular fire fighters. When an incident proves to be too complex or large to address with a single unit, upscaling is required. Most regularly upscaling implies that more basic units are called up. During medium, large and very large fires respectively two, three and four basic units are deployed. Four basic units and the duty officer together form a platoon. Incidents of an even larger scale are upscaled per platoon. Some incidents call for a different approach. In such cases specialists are called up, for instance divers or specialists in hazardous substances.

The command structure of the Dutch Fire Service is hierarchically organized by nature (Hazebroek et al., 2015). The Dutch fire service works with a standardized working procedure. In practice this implies that during operations there is a fixed line of command and communication between all hierarchical levels. During small incidents, when only one basic unit is operating, the crew manager is the one in charge of the operation. In medium and large scale operations the duty officer is in charge of the several units on site. He determines how the operation is carried out and coordinates the cooperation between the units. In theory the duty officer gives orders to the crew managers who subsequently instruct their own crew, yet in practice the duty officer often maintains close contact with the crew itself as well. When a very large incident has occurred, the chief commanding officer also travels to the location of the incident and takes over the leading role that previously belonged to the duty officer. The duty officer then becomes the main connection between the chief commanding officer and the crew managers.

5. Findings

In this chapter the findings of the video analysis will be presented. It was expected that high cognitive load would cause the duty officer to turn to reflexive decision-making. This chapter starts with an introduction on the general ways of decision-making in incident command. Thereafter, decision-making under high and low cognitive load will be considered into depth respectively. This chapter ends with a review of the sequence of cognitive load during the process of the operation and the effects thereof.

5.1 Incident command decision-making

Duty officers are observed to apply both reflective and reflexive ways of decision-making. Regularly, they also switch between styles during one incident. Most of the time duty officers do not go through the complete decision-making cycle. In the first place this means that they do not follow the three phases of Situation Assessment, Plan Formulation and Plan Execution respectively. More often than not the Plan Formulation phase is skipped, especially when it comes to the careful consideration of options. In thirteen out of twenty incidents deliberate consideration of the possible courses of actions does not take place or takes place at a minimum. It can be observed that goals are formulated more regularly, though this is mostly done by others who come up to the duty officer with certain issues they perceive to be having a need to be addressed. Duty officers themselves do not necessarily always articulate what exact issues they aim to address, though in some instances they do: “I want to make sure we have sufficient water” (#15; 10:36). Yet, the objective the duty officer has in mind most regularly becomes apparent only once he or she divides the tasks. An important precondition for this is that the duty officer clarifies the task sufficiently. This appears to not always be the case: “Just see what you can do” (#2; 18:03) and commands similar to this are not unusual.

Another observation made in the context of not completing the whole decision-making cycle, is that duty officers often do not make concrete decisions. Instead, in many occurrences the duty officer immediately turns to organizing, and the decision is intertwined with the command: “I for sure think it is wise that you go to him” (#6; 09:25). Decisions, thus, are often not articulated explicitly. Yet, in some instances duty officers do articulate a decision, after which they give a command or organize their people or vehicles to execute this decision: “[Do you need] a crane in the back? Can do. […] Second crane, this is the duty officer, over. I need the second crane on location via street x to street y” (#15; 10:51-10:53). Such occurrences are, however, less common. This is not that surprising, as duty officers might find it excessive to

also explicitly state what exact plan they have decided on when the command that follows speaks for itself. In other instances they might forget to be more concise due to stress.

It can be concluded that, in general, incident command decision-making deviates notably from theoretical models. The decision-making steps are often not followed as might be expected and the decision-making process does not always arrive at a concretely articulated decision. Rather, duty officers tend to turn to organizing immediately.

5.2 Making decisions under high cognitive load

At first glance, duty officers seem to be turning to reflexive decision-making. One factor that might be affecting this is the amount of cognitive load the duty officer experiences in that specific moment. In line with existing theory, it is expected that high cognitive load causes the duty officer to make reflexive decisions. High cognitive load occurs when the duty officer is confronted with a large amount of tasks in a relatively short period of time or tasks that are high in complexity. The following paragraph is presented in line with this division.

5.2.1 Dealing with many tasks simultaneously

Incident command can be highly dynamic, which can result in various tasks or issues that are presented to the duty officer within a short period of time. Consequently, cognitive load increases. In the videos it is noticed that when duty officers are confronted with many issues or developments simultaneously, they act more hastily. This is mainly recognized through the way they speak or behave, for instance by wild hand movements or that they suddenly start running. Such behavioural signals indicate that they are not always capable of handling large amounts of information calmly. In some cases, duty officers explicitly articulate that they have a lot going on and that they are having a hard time dealing with it: “Sorry I didn’t hear you; I obviously had a lot on my mind” (#1; 21:10). Usually this is expressed in an apologetical manner.

When unrest is apparent, duty officers seem to be more in a rush to make decisions and give commands. As a result they do not follow all decision-making steps: the Plan Formulation phase frequently is skipped completely and, as stated before, in some instances decisions are not explicitly articulated. There obviously is a need to tackle issues as quick as possible when they realize there is a lot to be addressed.

INCIDENT #2 – Gas leak at anti-squatter building
The duty officer has just arrived at the incident and immediately he is presented with several issues which need to be acted upon: there might be victims inside the building; there is a gas station right next to the building; and gas measurements show a lower explosive limit of 7%. When he gives commands, he speaks hastily and makes wild hand movements. Just two minutes later, new measurements show a limit of 19%. The duty officer responds shocked and instantly commands what he wants his crew and the police to do.

INCIDENT #5 – Fire at multi-company building

Within five minutes of time, several things happen and new issues come to light: more smoke is appearing; the building largely consists of wooden materials; something is falling down from the ceiling; and the cardboard castle, the source of the fire, might still smoulder from the inside. When busy finding a way to address some of these issues, it becomes apparent that the floor on which one of the crews is operating might collapse due to the heavy weight of the extinguishing water. Instantly, the duty officer repeatedly tries to contact the first crew manager and yells that he needs to get his crew down immediately.

INCIDENT #7 – Fire at multi-company building

On his way to the incident, the duty officer is presented with several issues and a status update on the fire. He also notices big clouds of black smoke right in front of him and immediately decides to scale up. Within ten minutes after his arrival, the duty officer has already been presented with several points of attention: a large amount of black smoke; there is a chance that the fire might spread to the other companies in the building; the possibility of dangerous goods; and the complexity of the building. The duty officer acts restless and immediately gives commands after learning about something new.

INCIDENT #9 – Fire at wood processing company

Until now, the fire has seemed to be under control. Then, the duty officer notices the smoke is expanding and he gets confirmed the fire seems to have spread. Immediately, the duty officer yells they need to put water on it using the crane and he decides to scale up. Shortly after, he is asked about logistics and extra support, while also being occupied with figuring out how the fire might spread further. Again, decisions are made and orders are given instantly.

When being confronted with many issues simultaneously, duty officers seem to experience some sort of pressure to respond rapidly. Instead of deliberately outlining the plan of action they have in mind and considering possible ways to carry them out, they instantly make a decision on what should be done. Making a decision immediately can help putting off the extra pressure that comes with an increasing amount of issues to address. As weighing several options demands a lot of one's mental capacity, not making decisions right away leads to a build-up of task load. This makes it more difficult for the duty officer to maintain an overview and make the right decisions. Regularly, a concrete decision is not even articulated; rather than communicating a decision, they instantly give orders to crew managers or any other person concerned. Either way, the Plan Formulation phase is mostly skipped when duty officers are burdened with a various tasks at the same time. They instantly react to the things they hear or see without considering any further.

Although duty officers oftentimes immediately give commands, this does not necessarily mean these commands are concrete and clear. It can be observed that, especially under high cognitive load, duty officers are at risk to be too vague in their orders. One reason for this could be that duty officers want to rely on the independence of their crews by leaving further interpretation to the crew managers. This way they can keep their cognitive load at bay, which can also explain that they sometimes get frustrated when others ask for more detailed instructions: "I don't know, I don't know! That is your business!" (#7; 02:07). Another

explanation is that the duty officer, in his rush or nervousness, might forget to further define his command.

INCIDENT #2 – Gas leak at anti-squatter building
The duty officer has a hard time assessing the exact risk that comes with the gas leak. He instructs the crew manager and his crew: "I want you to continue measuring and start ventilating now" and sends them away. A moment later he articulates to the police that by ventilating he means smashing the windows.

High task load places a burden on one's mental capacity, which can cause someone to handle issues in such a hurry that details are overseen. As a result, so-called 'empty commands' are given. This might imply that the duty officer does have an idea in mind as to how a task should be carried out, but might forget to communicate this clearly to the person who should perform the task. In other instances it can be observed that they get frustrated with the situation and simply want people to undertake action without having a concrete idea in mind: "Just go see if you can do something" (#5; 20:07).

It is also noticed that in many instances duty officers, be it unconsciously, prioritize certain issues over others. Filtering out information seems a logical consequence of our limited working memory capacity, as it ensures that cognitive overload is prevented and helps maintaining somewhat of an oversight. When being confronted with several issues simultaneously, apparently some of the tasks they are presented with are filtered out and not acted upon. For instance, as can be seen in incident #5, all other issues are put aside once the duty officer learns that the safety of his crews might be at stake.

INCIDENT #3 – Fire at industrial plant
The duty officer is on his way, receiving updates from one of the crew managers and learning that there is an issue with gas cylinders. Then suddenly explosions are reported and he is asked to scale up, shortly after which he is confronted with a potential water supply issue and is getting a different SITRAP including details of the fire from the company's duty officer. When giving the emergency centre a SITRAP, out of these issues the duty officer only mentions the explosions.

In incident #3 something similar happens. The duty officer has learned a lot from the updates given by both the company's duty officer and his crew manager, yet he only remembers the explosions that have occurred suddenly. Prioritization is essential in circumstances where a lot is happening simultaneously, especially since not all occurrences are as relevant. Nevertheless, not consciously remembering all information can have consequences for the course of the operation and the decisions that are to be made later. In particular impressive occurrences, such as sudden explosions, can cause the duty officer to not take in or remember other relevant information that is presented at the same time. Again this shows that one's cognitive capacity is limited and indeed influences the courses of action that are decided upon.

So, when being presented with many issues in a relatively short period of time, some issues are set aside and duty officers tend to make quick decisions without considering alternatives. This, however, appears to not always be the case. In some instances, duty officers that are faced with several tasks at the same time do take their time to reflect on the options they have before making a decision or giving any orders.

INCIDENT #3 – Fire at industrial plant
The duty officer is on his way to the fire, has gotten some updates, and suddenly the first crew manager anxiously tells him that there might be a fire near gas cylinders. Then, sudden explosions are reported and the first crew manager desperately asks the duty officer to scale up, but the latter is hesitant and does not really respond to this request: "Possibly I'll make it a very large fire".

INCIDENT #8 – Fire at kart track centre
The duty officer is confronted with possible asbestos and a request for a crane, which he both immediately acts upon. Then, it is noticed that one of the crews is positioned downwind in the midst of all smoke. The chief commanding officer and second duty officer suggest where to position them alternatively. The duty officer responds that he wants to leave it up to the crew itself and will consider it further sometime later if needed.

INCIDENT #9 – Fire at wood processing company
Several issues are presented: the fire might escalate; relief; and the fourth fire truck was not alarmed. The duty officer then learns that the crews cannot reach the upper part of the system safely where smoke is appearing as well. Together with the third crew manager he discusses how they can check on the fire in a safe manner and where to place the crane. This is a difficult matter, as they are not familiar with the wood processing system. Thereafter, the duty officer decides on an action plan.

Taking more time to consider options or postponing decisions especially applies to duty officers operating in an environment that requires some sort of expert knowledge or when they are operating in an environment they are not familiar with. In such instances, duty officers tend to take more time before making their decisions, even though they might experience the same pressure to respond as their colleagues who do decide and command immediately. Their lack of knowledge may hold them back from acting based on their first instinct and strengthen the need to deliberate their plan with others.

For similar reasons, duty officers appear to be hesitant to make a decision at all. It happens that duty officers are confronted with several issues and receive, unsolicited, suggestions from others on what to do. In such instances, duty officers tend to barely respond to such suggestions or dismiss them. As seen in incident #3 and #8, some make non-decisions in such circumstances: they present their statement as if it is a decision they have made, yet it somewhat avoids the issue that is presented to them. They more or less wave it aside by stating they will look into it after. By not making a decision they choose to play it safe and apply a wait and see approach: they 'decide' to accept the status quo, so they do not make a rash decision that might have negative consequences. It also confirms that duty officers, indeed, have a hard time processing and considering extra information or options when they already have a lot on

their mind. They either do not want to make rash decisions or do not want to deal with the issues concerned at that point in time.

It can be concluded that a confrontation with many tasks causes stress and a certain pressure to respond quickly. As a result, duty officers tend to make decisions immediately without any further deliberation and any suggestions that are proposed are either ignored or dismissed. Moreover, some issues are filtered out to overcome an overload. This shows that one's limited cognitive capacity indeed plays a role in decision-making. An exception can be observed in situations where certain expertise is needed. Then, duty officers seem to feel the need to discuss options and subsequently postpone making an actual decision, even though a lot of issues that need to be addressed have come to light.

5.2.2 Dealing with complex tasks

Incidents and tasks become complicated or complex once they involve, for instance, hazardous substances, specialist locations or buildings and terrains that have a complex structure. Moreover, incidents that are highly dynamic might prove to be complex as well, therefore demanding a lot of the duty officer's abilities.

As noted before, duty officers seem to be more hesitant to make decisions immediately when they are operating in an environment they are not familiar with or when they are confronted with issues that require expertise knowledge in order to fully comprehend the situation. Duty officers themselves do not necessarily have the knowledge needed to make the right decisions. This lack of knowledge makes it difficult to assess the situation and make the right decisions. In such situations, duty officers actively try to better understand the situation by regularly asking specialists for information. Specialists, in this sense, could be, for instance, a dangerous goods advisor, the company's duty officer or employees and owners of the company concerned. This expert information by itself causes cognitive load to increase, as it most likely is new to the duty officer and it takes a lot of mental effort for new information to be processed. To somewhat ease this burden, some duty officers request a simple version of the situation without all the slang so it is easier for them to understand: "I do know a little about it, but you obviously know more than I do […] So, for my understanding, it is a source with radiation, thus not an open source?" (#1; 20:41). This is essential for their sensemaking of the situation, which consequently can help them in making their decisions.

Yet, even if they have gained some knowledge on the situation and potential extra hazards that come with it, duty officers might still not be fully confident to make decisions instantly. Especially when it comes to decisions that directly involve the aspects that require a certain level of expertise. When one has just learned something new, one has not had enough time to familiarize oneself with the information. Different from dealing with issues that they are familiar with, duty officers are unable to recognize patterns when it comes to new and specialized issues. Consequently, they need their time to make a decision and there is the need to carefully consider the available options.

INCIDENT #1 – Incident with radioactive substance
The duty officer learns that the radiation is minimal. A specialist from the company points out that they should quickly clean up the substance, which the dangerous goods advisor confirms considering potential spreading. The duty officer cautiously concludes he can order the company to start cleaning, which he does only after the dangerous goods advisor confirms that that is a good idea.

INCIDENT #2 – Gas leak
The crew manager explains that the explosion limit has dropped to 4% and suggests to explore the building to find the cause of the gas leak. The dangerous goods advisor, however, recommends to wait a little longer before going inside again and continue ventilating. The duty officer, then, accepts the latter's advice and orders the crew manager to ventilate some more.

INCIDENT #3 – Fire at industrial plant
The duty officer tries to learn more about the gas cylinders and directly states that they should try to cool them. He then checks with the company's duty officer whether it is possible to use a large container for this, who confirms. A while later he checks with one of the crew managers if it is possible to move the cylinders outside. Some moments later, the duty officer decides that a container should be arranged to cool the cylinders.

INCIDENT #9 – Fire at wood processing company
The fire seems to be under control again, so now the duty officer wants to find a way to get the remaining wood chips out of the pipes. He first gathers more information about the silo and then, in a small group of people from the fire service and the company, several possibilities are discussed as to how to achieve this. After a few minutes, the duty officer adopts a plan of action.

Duty officers, in such instances, are more reluctant to make decisions immediately, or at all. Hence, duty officers either take on a more wait-and-see approach, that is they wait until others come up with a plan or suggestions, or actively ask them for their opinion or approval before making a decision: "I really need the man from Stedin right now. […] I really need your advice guys" (#2; 17:39). Either way, the Plan Formulation phase is clearly present in the process that leads up to the eventual decision that is made – or command, in many cases.

Notably, duty officers themselves do not necessarily take part in the consideration of options in such circumstances. Often they do articulate what they think should be done, that is they express what the goal is, but do not specify how this should be achieved or executed. Again, the lack of expertise can explain why they tend to leave further refinement up to specialists. What becomes clear from this, is that specialized tasks prove to put a high burden on the duty officer's cognitive abilities. Despite this high load and additional pressure to act, they make time to work out a plan of action so they can eventually make an informed decision.

In practice this also means that there is more time between learning about an issue and making the decision as compared to the situations discussed in the foregoing.

In addition to such specialized incidents, incidents that involve complex sites or much uncertainty also cause a high task load on the duty officer. Again, such circumstances have as a consequence that duty officers are unsure of what they can do best. This makes their job more difficult.

INCIDENT #5 – Fire at multi-company building

For a while, the duty officer is trying to complete his picture of the building and its construction, yet a lot remains unclear. Then, the duty officer and crew managers notice that smoke is appearing from the ground floor of the building. The duty officer proposes they should shut down the sprinkler system and start ventilating. He outlines a plan and checks with the building manager what options they have to execute this plan. Thereafter, he decides on the final plan of action.

Making decisions when not having sufficient knowledge on the current situation or the location of the incident, increases the cognitive load one experiences. Hence, performing a task becomes more difficult when duty officers are uncertain of what is going on and what the setting is exactly. Duty officers, then, are dependent on the knowledge of others who are familiar with the situation to make any decisions. At such a time, they can come up with a plan, but they will need to ask whether it is possible to execute this plan and in what way this could be done. It is observed that duty officers actively search for validation and some guidance. The Plan Formulation phase, consequently, does occur in such circumstances.

Another effect is that making decisions takes a while longer in such circumstances. Instead of making a decision within a few seconds to a minute, it can take up to a few minutes before a final plan is decided upon. As opposed to situations where they have to deal with a large amount of issues, duty officers tend to take more time to outline a plan and decide upon a definite course of action. In most instances they also have more time to make their decision, as the incident is not developing quickly. Nevertheless, during escalation phases it can be observed too that more time is taken to choose a plan of action when operating in a more specialized environment. This possibly has to do with their lack of knowledge and the resulting insecurity, because of which they want to take their time to consult others.

Certainly there are instances where it might be very troublesome, or even impossible, to obtain more knowledge on the situation or where the duty officer does not make the effort to complete his picture, be it unconsciously. During such instances, the opposite occurs. When one thinks there is not a fair chance of obtaining more information or does not realize there is more to be known, one has no choice but to act based on the things that are acquainted. The

WYSIATI principle then obviously comes into play. There also is no use in trying to weigh several options, as one potentially does not have all information.

INCIDENT #6 – Explosion in medical centre

The duty officer has arrived at the site. The fact that the explosion was located in a medical centre is a point of attention, and on top of that not much is known about the incident. Because the duty officer has no clue about what has actually happened and cannot reach the crew manager who has more information, he cannot really formulate a plan and makes decisions based on what he hears and sees.

INCIDENT #17 – Fire at house

The duty officer has arrived at the site and asks the first crew manager for his picture of the situation. Based on this information, the duty officer gives the first commands. The following commands are also directly based on the signals he receives from the crews. He has not taken his time to walk around the site and gain a better picture of the incident himself, nor does he take his time to consider a plan of action.

Duty officers, then, operate based on the things they do already know of the situation. They tend to be hesitant to make rigorous decisions, but smaller and less complex ones are made without further reflection. Acting based on what they see and hear also means that they do not necessarily operate proactively in uncertain circumstances. Rather, they have a reactive attitude, meaning that they wait until they have more information on which they can build their plan. In fact, when duty officers do not have a concrete picture of the situation, they more or less have no other choice than to trust the judgement and signals of others in making their decisions.

In short, duty officers that are confronted with relatively difficult tasks, that is specialized, complex or uncertain circumstances, tend to avoid recognition-primed decision-making. Instead, they actively search for other opinions and suggestion by people who do have the expertise needed in that specific situation. This also means they take more time to decide. Rather than skipping the formulation of a plan and the consideration of potential courses of action, they willingly use the knowledge of others to outline the best fitting plan. However, when they do not have access to sufficient information on the situation or do not take the time to gain a complete picture, they are left no other choice than to act intuitively and react to the signals they receive from others.

5.2.3 Looking for support

It has already been noted that duty officers seek for support when operating in a specialized or unfamiliar environment, as they do not have the required know-how. Sometimes, however, duty officers do not instantly have access to the knowledge of, for instance, a dangerous goods advisor or other experts. In such instances, a duty officer still actively tries to find support by others who can be reached.

INCIDENT #1 – Incident with radioactive substance
The duty officer seems to be unsure as to how he should handle the situation. He has made some small decisions, but seems kind of lost. He then asks one of the crew managers what else they can do at this moment, who subsequently does a suggestion. The duty officer immediately agrees.

INCIDENT #2 – Gas leak
The duty officer contacts the chief commanding officer on the phone, explaining the situation and his plan to ventilate the building. He is unsure about how to do this and tells the chief commanding officer the options he has in mind. Several times he expresses he just wants to brainstorm and hear his view on the matter, as he is afraid to make the wrong decision.

Experiencing high cognitive load seems to strengthen the need for a support system in any shape or form. This is mainly caused by insecurity that results from the specialized task a duty officer might be confronted with. When not having an expert to consult and discuss with, duty officers try to find this support by others. In such instances, they do not long for expert advice, but rather they look for confirmation and second opinions so they can feel slightly more certain that they make the right choice: "I just wanted to discuss this with you, to check whether I oversee something or can I approach this in a simpler way. Because if I do nothing and it says 'boom', then I did the wrong thing" (#2; 17:58).

Besides asking for advice on a specific action plan, support is also desired in a more general way. In some occasions, duty officers ask for support as a preliminary action when they anticipate the incident might become too much for them to handle on their own.

INCIDENT #4 – Fire at school
A while ago, the duty officer learned that the fire has spread to the cavity wall and is asked to come and see it for himself. In the meantime the emergency centre asks whether he can miss one of the fire trucks, which the duty officer denies immediately. He then walks up to one of the crew managers who explains the issue they have with the cavity wall. Both men subsequently discuss two options they have to extinguish the fire inside the wall, after which the duty officer decides what the plan should be.

INCIDENT #7 – Fire at multi-company building
Soon the duty officer has noticed that the site is too complex for him to handle the overall incident by himself. He then asks the emergency centre to alarm a second duty officer. He then asks the second duty officer to take over control at one side of the building, so he can focus on the other side.

Seeking help by their support system, then, is a way to anticipate potential high cognitive load. When asking help from an extra duty officer or a chief commanding officer, duty officers can delegate some tasks and responsibilities to them in order to relieve themselves from extra burden. Most tasks that are delegated are indeed smaller tasks that do not necessarily have to do with the incident itself, such as taking care of the media or informing other actors like Salvage. Handing over these tasks, and thus the authority to make associated decisions, can relieve the duty officer, so he can focus on other issues at hand or on guiding the overall operation. Timely asking for support can therefore reduce the cognitive load a duty officer experiences during an incident.

It can be concluded that, in general, duty officers are not afraid to ask for help. In some instances it is a matter of needing a push in order for them to feel confident enough to make a final decision, whereas in other cases they anticipate the chance that they might feel overloaded. Either way, looking for support is a way to reduce the load one experiences. As a consequence, regularly duty officers do not make all decisions fully on their own.

5.3 Making decisions under low cognitive load

When operating under high pressure can cause duty officers to act based on intuition, the opposite might occur when dealing with less demanding circumstances. It is foreseen that when experiencing low cognitive load, duty officers tend to make their decisions in a reflective manner. In the opposite of high cognitive load, low cognitive load is recognized by a small amount of tasks that a duty officer is confronted with simultaneously or tasks that are relatively simple by nature. Both are discussed in the following paragraph.

5.3.1 Dealing with a limited amount of tasks simultaneously

Although incident command can be highly dynamic with many developments occurring in a short period of time, this is not always the case. When one is situated in relatively calm conditions, that is when there are not as much issues to tackle, one probably does not experience much pressure to act quickly. Indeed, in some instances it can be observed that duty officers take their time to assess the situation and discuss possibilities when they do not have a lot on their mind or when the situation seems to be under control and the pressure is off. With regard to the mental effort that needs to be put into rational decision-making, it makes sense that generally one is willing to spend more time on considering the available options when the pressure is not as great; there is relatively more mental capacity left.

INCIDENT #4 – Fire at school
The duty officer has just arrived at the incident and starts to walk around the site, while asking the crew managers for information on the status of the fire. The crew managers are in the lead, as the duty officer uses swarming. Then, the issue of where to position the crane comes up. The duty officer calmly discusses this with the first crew manager, considering the two options they have, after which he makes a decision.

INCIDENT #7 – Fire at multi-company building
The fire is extinguished and the duty officer has scaled down; the pressure is off. Then, smoke development is noticed and a crew manager suggests ventilation. Together they discuss what to do, after which the duty officer also turns to Salvage for their opinion on the matter. Minutes later, a decision is made on how to ventilate.

INCIDENT #9 – Fire at wood processing company
The duty officer has applied a swarming technique, which means the first crew manager has been in charge and the duty officer can focus on getting a better picture of the situation. Together they discuss how they should arrange the water supply, weighing several options on where to position the water supply truck before making a final decision. Thereafter, the duty officer, chief commanding officer and crew manager thoroughly discuss how they can try best to extinguish the fire.

Low-pressure instances in terms of only a few issues to handle often occur at the end of the operation when the fire, or whatever else was going on, is finally under control or solved completely. It makes sense that people act less hastily when the pressure is off and therefore are more considerate of their decisions. Low cognitive load in the middle of an operation is less common. During most incidents duty officers have a lot on their plate when operating in the heat of the moment. Nevertheless, in the few moments they do not, it seems as if they do not feel the pressure to respond quickly and actually take more time to consider what to do. This means that more time is taken out for decisions and the Plan Formulation can be observed explicitly. This shows that when having to deal with not as many tasks, duty officers are willing to put more effort into making a decision. Likewise, they are able to use the extra cognitive capacity and effort that is needed to do this.

This does, however, depend on the circumstances. In some cases duty officers have less issues to worry about and deal with, yet they still do not make the effort to thoroughly discuss a plan of action or several options to achieve an objective.

INCIDENT #7 – Fire at multi-company building
The duty officer has assigned the backside of the site to the second duty officer. Consequently, the duty officer only has to interfere with the frontside and thus has a lot less on his mind than he did when he first arrived. He then expresses he expects to have sufficient water and decides to put the extra water truck on stand-by. Shortly after he continues organizing the positions of the trucks and he does not attempt to outline a plan of action to tackle the issue of unknown compartments within the building.

The main difference between the latter and former three examples is that in the latter case the duty officer had to deal with a remarkably high cognitive load before it decreased after the second duty officer's arrival. It might be that the duty officer still experienced some kind of pressure to act quickly and therefore did not take the time to go through the Plan Formulation phase.

It can be concluded that duty officers, in general, take more time to formulate a plan and make a decision when they are not dealing with many issues simultaneously. They seem to feel less pressure to respond immediately. Yet, when they operated under high cognitive load only shortly before, duty officers tend to still be caught up in their more rapid way of making decisions and are not bothered to consider decisions more profoundly.

5.3.2 Dealing with simple tasks

In the opposite of specialist incidents or duties, duty officers also have to deal with simpler tasks. Simple tasks are for instance the arrangement of relief, breathing apparatus or catering. This is because they involve a routine procedure. As the process for such matters is already

thought through and known to the people involved, it is expected that duty officers make their decisions quickly.

Indeed, it can be observed that in general duty officers tend to take only little time for making a decision. Rather than taking some time to figure out how to approach the issue, they immediately respond to the issue presented. Decisions that concern routine tasks or procedures, therefore, seem much easier to make than decisions that have to do, for instance, with the way a fire that is located in a complex building or system should be approached. In such instances duty officers do not need to outline a procedure or course of action; the procedures are in place already, so the only thing left to do for the duty officer is to decide that these processes should be activated. This also closely relates to pattern recognition as referred to in RPD. From previous experiences duty officers learned when to activate one of these procedures, something they can almost directly implement in the current situation when they have made they assessment.

INCIDENT #4 – Fire at school
The operation has been going on for a while now and the duty officer is wondering how much longer it will take. He then decides that some food and beverages should be arranged for the crews and orders the PC-LOG to take care of this.

INCIDENT #16 – Fire at abandoned office building
One of the crew managers has expressed that there is a chance the fire will escalate. He then notifies the duty officer that there is a need for more breathing apparatus, as their current supply is not sufficient. The duty officer immediately answers he will take care of that and gives his orders a few seconds later.

It is also notable that for such matters the duty officer is not bothered to discuss the issue with others. This is probably also because it is not the question of how to solve the issue, but whether the solution should be activated or not. As a result, the load put on the duty officer's cognitive abilities is limited. Not having to consider how to execute a solution puts less pressure on the duty officer. Hence, low task load in terms of simple, routine tasks seems to cause duty officers to make their decisions intuitively. The procedure is already laid out for them and they are familiar with it, meaning that they do not have to put unnecessary effort into making the decision and thus can decide directly based on their intuition.

Although the arrangement of relief is also a standardized procedure, the run-up to the eventual decision is somewhat different. When it comes to relief, it is observed that often times several options are assessed. Other than with the matters of breathing apparatus or catering, for relief it should be decided who will replace whom. This requires some organization and strategic thinking of what approach fits best. Rather than blindly arranging relief based on how this was arranged during previous operations, some consideration is put into what crews should be relieved first and what the consequences might be for the overall operation.

INCIDENT #19 – Fire at restaurant
The operation has been going on for 1,5 hours now and both the duty officer and chief commanding officer think it is time for relief. They have a long discussion on how to arrange this; who should be relieved, when and by whom. Eventually it is decided that all fire trucks should be relieved, and directly after the relief procedure is started.

In such instances it can be noted that there is much more to arranging relief than just activating the procedure. It is not a complex task, but it does require the duty officer to take a moment to consider how they should approach the matter. Deciding on the 'how'-question thus takes a while and asks for a reflective approach. Nevertheless, the eventual decision on whether to start relief is mostly a reflexive one, assuming that the duty officer has a clear view on the crews and their current status.

Hence, it can be concluded that simple, routine tasks, in general, go hand in hand with a more reflexive approach by the duty officer. Routine tasks are more likely to be a matter of yes or no, rather than requiring the duty officer to outline the exact solution. As a result, duty officers immediately make their decision. As stated above, relief is somewhat of an exception, in that the 'how'-question should still be answered. Yet, deciding whether relief should be activated also is a reflexive rather than a reflective action.

5.5 The effects of low and high cognitive load on the overall operation

Until now it has become apparent that, generally speaking, the cognitive load experienced by duty officers is mostly high. Oftentimes they are dealing with either very complex circumstances or with a lot of issues at the same time – or both. In most cases the cognitive load they experience is high from the beginning onwards, though in some cases it only increases once the operation develops or when the incident escalates.

Two patterns can be recognized when it comes to this. First of all, duty officers sometimes deliberately arrange a large amount of actions and take on a lot of tasks at the same time. This mainly occurs at the beginning of the operation and, as a result, their cognitive load increases substantially. This also means that during the course of the operation the number of tasks gradually decreases, as most matters are arranged already.

Incident #7 provides a clear example. While on his way to the scene, the duty officer receives information on the incident and notices massive clouds of black smoke, which cause him to scale up immediately. Within ten minutes he arranges extra fire trucks, supporting vehicles like a crane and water supply system, and a second duty officer. Gradually all crews arrive on scene and the duty officer is busy positioning everyone and dividing tasks, while at

the same time trying to gain a better picture on the lay-out and contents of the building. The duty officer appears restless and in some instances he also raises his voice. Within fifteen minutes all assistance is arranged and the duty officer clearly calms down when the second duty officer arrives. From here on, cognitive load gradually reduces and only twenty minutes later the fire is mastered. Thereafter he is mostly concerned with smaller tasks like arranging logistics and downscaling. This is also noticeable in the duty officer's behaviour: he starts giving the crews compliments on their hard work, whereas before he frequently raised his voice.

What is evident from this incident, is that the deliberately high cognitive load the duty officer took upon himself has led to fairly fast and effective firefighting. Based on the signals the duty officer received from others and the cues he notices himself, he decided to better be safe than sorry and immediately made several decisions in order to scale up. By scaling up this quick the duty officer ensured having enough resources to contain the fire and by deploying a second duty officer he avoided extra task load. Hence, he did not have to worry about having insufficient resources later on, nor did he loose his oversight. Certainly, the arrival of the second duty officer was the major turning point; once the duty officer did no longer have to focus on both sides of the building, he seemingly became more at ease. It is noteworthy, though, that in the end the duty officer actually admits: "I scaled up a bit excessively, haha" (#7; 02:56). This shows that he probably would have made different decisions if he had taken some more time to consider what to do. Yet, despite the stress it might have caused and leaving aside whether the upscaling was excessive or not, the rapid decisions the duty officer made at the start caused the fire to be mastered relatively quickly and non-chaotically.

Taking on many tasks in the beginning of the operation, therefore, is also a way to minimize the task load later on in the operation. It should be noted, however, that this mainly goes for minimizing task load in terms of the amount of tasks. Depending on the incident, relatively simple tasks are often executed spread over the overall incident. This is because arranging breathing apparatus or catering can also be one of the many tasks the duty officer is concerned with and thus is not necessarily something that can be observed primarily after high task load has occurred.

The second pattern observed is that high cognitive load experienced due to complex or specialist incidents generally remains high over the course of the operation. In such circumstances, high cognitive load has nothing to do with escalation or unanticipated developments in the first place, but with a lack of expert knowledge. As stated before, it is noticeable that the duty officer's stress level decreases once he has a support system to fall back

on. Yet, the insecurity and lack of knowledge remains, which maintains a moderately high cognitive load.

In incident #9 it is noticeable that, before making decisions, the duty officer repeatedly asks his crew managers and people from the company for information on the wood processing system and confirmation. At one point, fire has been confirmed to be located somewhere in the system and the duty officer outlines a plan of action to close in the fire. He even expresses that the pressure is off, though still keeping in mind possible escalation. Then, suddenly smoke development is increasing and one of the crew managers suspects the fire has spread. The duty officer immediately gives several commands and scales up. Soon he realizes he does not have sufficient knowledge on how the system works and asks someone from the company for help again. A while later, the duty officer wants his crews to perform an extra check to see whether the fire is indeed extinguished. However, some employees interfere with the operation in an unsafe manner. This is an ongoing dilemma for the duty officer, as he does need their knowledge, but they have no experience in handling such incidents.

Specialist incidents seem to go hand in hand with an ongoing high cognitive load. Depending on the development of the incident this load can grow higher, but it never really becomes low until the incident is fully under control. The lack of knowledge and constant need for expertise cause decisions that concern a specialism to be made quite slowly, even if there might be no time to consider. It makes it difficult, if not impossible, for the duty officer to immediately decide on issues that regard the specialist field concerned. On top of that, they appear to be hesitant to make a decision without further deliberation. Hence, reflexive decision-making is barely apparent during such incidents, except when it concerns urgent matters, such as ensuring the crew's safety.

6. Discussion

A recurrent pattern that is found in this study is that incident command decision-making in general complies with a reflexive decision-making style rather than a reflective style. Generally speaking, duty officers tend to skip the Plan Formulation phase. As expected, this study demonstrates that duty officers, indeed, immediately turn to the Plan Execution phase after assessing the situation when having to deal with many issues within a short period of time. It also shows that the opposite occurs when it comes to handling a small amount of tasks. These findings are in line with previous research by Cohen-Hatton et al. (2015) and Klein (1993), amongst others. As Klein et al. (2010) showed in previous research, making reflexive decisions is a way to save time in the often rapidly developing situations duty officers deal with.

Moreover, duty officers might choose this approach to reduce the mental effort of making a decision (Evans, 2008). This way they can prevent themselves from becoming cognitively overloaded, which could otherwise cause them to oversee cues and make inadequate decisions. Following the same line of thinking, duty officers can take their time to rationally consider the available options when dealing with only a few tasks without risking an overload. These observations, then, can be referred back to the essence of the CLT: people only have a limited working memory capacity, which limits the amount of information one can process within a short period of time (van Merriënboer & Sweller, 2005). In this sense, it is difficult for someone to carefully consider the available options when being confronted with several issues within a short period of time, whereas low cognitive load enables us to deliberately reflect on our possibilities.

Similar to this conclusion, previous research demonstrated that when having to deal with complex tasks, duty officers turn to reflexive decision-making due to the large share of cognitive capacity that is taken up by such tasks (Nygren & White, 2002; Omodei et al., 2005). This differs from the findings presented in the current study. Indeed, duty officers tend to have a hard time dealing with complex issues. Yet, they do not make decisions based on their intuition, but generally seem to apply a reflective decision-making style. This is because novices, unlike experts, are unable to identify important features of the issues concerned and retrieve appropriate solutions based thereupon (Larkin, McDermott, Simon and Simon, 1980). Rather, novices start their problem-solving by identifying a goal and thereafter try to generate methods that can help achieve this goal. As novices do not have the necessary knowledge that facilitates them to act based on intuition, they are forced to put mental effort into considering the available options.

In a similar sense, McClean (1995, p. 97) concluded that "intuitive thinkers should also be subject-matter experts", as tacit knowledge ensures there is no need to consciously analyse available data elements. Also, the human brain tends to fill up knowledge gaps by itself based on previous experiences, which consequently facilitates reflexive decision-making (Hilbig et al., 2012). As duty officers might not have this previous experience or knowledge, this process is not likely to take place. This indicates that duty officers need an expert's input before they can make a decision when they are not familiar with the possibilities or do not know what to expect. It can thus be suggested that duty officers who do not possess the necessary knowledge are in fact unable to apply a reflexive decision-making style. Moreover, it is in line with other research that demonstrated that novel tasks strengthen people's search for information (Betsch, Haberstroh, Glöckner, Haar & Fiedler, 2001). This may explain why duty officers turn to others for support and why it takes more time for them to make a decision, even if they experience time pressure or other stressors.

Previous research indicated that reflexive decision-making is the result of high task complexity (e.g. Backs & Seljos, 1994; Nygren & White, 2002). The current study, while finding no proof for this statement, found that rather under some circumstances of low cognitive load duty officers tend to turn to reflexive decision-making. This holds true for low complexity tasks, that is routine tasks. A routine is "a learned behavioral solution, which comes to mind when a decision problem is encountered by the individual" (Betsch, 2005, p. 40). This implies that routines are known to be serving particular goals based on previous experience. When one is repeatedly confronted with such routine tasks, it even can become automatically instantiated when one encounters the particular issue. As routine fireground tasks such as arranging breathing apparatus are issues duty officers are taught and confronted with regularly since the beginning of their career, this explains why it is relatively easy for them to make an immediate decision. In addition, when being confronted with strong routine tasks, people tend to avoid new information on alternatives (Betsch et al., 2001). As Rieskamp and Hoffrage (2008) already indicated: reflecting on other options is not always considered worth the effort.

An obvious finding that emerged from the analysis is that duty officers sometimes fail to make a real decision or postpone making a decision by stating that they will look into it later. Van den Heuvel et al. (2012) previously indicated these two errors as *omission bias* and *choice deferral*, respectively. Such 'decisions' lead to inaction, as the Plan Execution phase is never reached. It seems common sense that people try to avoid making difficult decisions. In previous research it is demonstrated that a delay of action is a way of coping with the uncertainty of a

situation (Lipshitz & Strauss, 1997). Postponing a decision can be a strategy to win some time to gather additional information on the issue, so one can make a more informed decision.

Considering the time pressure that oftentimes goes hand in hand with incident command, it could be hypothesized that such biases in incident command decision-making are not likely to be the result of trying to win some time. Rather, so-called decision inertia in incident command seems to be the result of an acute sense of accountability (Eyre, Alison, Crego, & McLean, 2008). In this regard, it can be suggested that duty officers try to avoid the responsibility for a decision and the justification thereof afterwards by deciding to not make a real decision (yet), but rather a nondecision. Similarly, postponing a decision could be a way to avoid negative emotions like anticipated regret (Anderson, 2003).

Another interesting finding is that high cognitive load due to a large number of tasks gradually decreases over the course of the operation. In some instances dealing with a high load in the beginning of the operation even appears to be a deliberate choice made by the duty officer. It is therefore likely that duty officers do this to anticipate on potential developments, so they are prepared for possible setbacks, or to fasten the operation. One factor that might play a role in this process is the experience a duty officer has with the tasks that are presented. Klein and Weick (2000) concluded that experience is key for effective decision-making. Having a certain extent of expertise causes duty officers to be able to size up situations quickly, recognize patterns of how they should probably react and form expectations. This makes it possible, and easier, to make rapid decisions in order to anticipate the situation. Indeed, previous research demonstrated that proactive incident command leads to more efficient emergency response and minimizes negative outcomes (Yarmohammadian et al., 2013). It is possible, therefore, that the reactivity Rake and Njå (2009) related to time pressure and Lipshitz (1993) to uncertainty, then, also partly is the result of a lack of experience.

Considering the findings in relation to the hypotheses stated at the start of this study, it can be concluded that a notable divide exists within both hypotheses, which was not fully anticipated based on the existing theories on incident command decision-making. When considering the effects on decision-making style, high and low cognitive load cannot be held as a whole. This study demonstrates that the level of complexity and the amount of tasks have a somewhat different effect on an incident commander's decision-making style than expected. In addition, it also shows that the relationship between cognitive load and decision-making style is not as straightforward as might be suggested. Other factors, such as experience, tacit knowledge and decision biases also seem to have a substantial influence on the decisions (not) made on the

fireground. Yet, an important remark should be made with regards to these results. The current study does not statistically test the hypotheses for a correlation between cognitive load and decision-making, implying that no definite conclusions can be drawn on the significance of the results found.

Therefore, future research should focus on testing the correlation between cognitive load and decision-making style to add a quantitative dimension to the matter. Moreover, in previous research a lot of attention has been paid to the number of tasks and related time pressure incident commanders are confronted with during an operation. In comparison, the complexity of tasks and its influence on decision-making has been understudied. Because some notable observations are made in the current study regarding the complexity of tasks, more research is recommended to study this relationship in-depth and obtain more insights on how this relationship works. Additionally, it would be interesting to complement a study of real-time data with interviewing the duty officers concerned; a method applied previously by Cohen-Hatton et al. (2015). Consulting them can help with verifying the findings and is a way to obtain more detailed insights as to why a certain amount of cognitive load resulted in a particular decision-making style. This could also be helpful for gaining more insights in the role of expertise.

7. Conclusion and Practical Implications

The main objective of this thesis was to gain more insight into the relationship between cognitive load and incident command decision-making. The following research question was formulated to guide the study: *How does cognitive load influence fireground commanders' decision-making style?*

First of all, the results suggest that duty officers generally tend to turn to reflexive decision-making rather than reflective decision-making. It was found that high task load in terms of many simultaneous tasks in particular causes fireground commanders to apply a reflexive decision-making style, as it enables them to make their decisions more rapidly. On the other hand, it was also observed that the number of tasks does not make them decide intuitively when the complexity of these tasks is high, as it causes difficulty in terms of determining the right plan of action. Consequently, they need to ask others for help and making decisions takes a while longer. The first hypothesis, therefore, can only be partially accepted.

Second of all, it appeared that a small number of tasks results in a reflective decision-making style. Duty officers take more time before they decide, as they feel they have more time to consider what to do. However, this seems to not be the case when shortly before they operated under high cognitive load; then they appear to still be burdened with the preceding stress and continue making decisions in a reflexive manner. Besides that, simple, or routine, tasks, are also mainly made based on intuition. The arrangement of relief is an exception, as the implementation thereof still requires some strategic consideration and is not fully standardized. Just like the first hypothesis, therefore, the second hypothesis can only be justified partially.

Based on this qualitative study on incident command decision-making, it can be concluded that cognitive load seems to affect the way duty officers make decisions on the fireground; differences in cognitive load imply differences in decision-making style. This effect, however, is not two folded as the hypotheses suggested. Rather, it can be stated that dealing with a large number of tasks or routine tasks causes duty officers to turn to reflexive decision-making as a way of preventing cognitive overload and it is considered excessive to apply a reflective approach. Other than that, high cognitive load due to complexity of the task is found to force the duty officer to apply reflective decision-making. And lastly, having to deal with only a limited amount of tasks provides duty officers with more time, which they generally tend to use to reflect on the available options.

These outcomes have some implications for the practicalities involving incident command on the fireground. As has become clear throughout the data analysis, the intensity of the duty

officer's experienced cognitive load is visible in his behaviour, both physically and vocally. Other players in the field, like crew managers, chief commanding officers and supporting services, should be educated on how to recognize such cues. For instance by presenting them visualizations or video footage of duty officers in both high and low cognitive load instances. When they know how to identify high cognitive load, they are also more aware of its effects. This might stimulate them to help the duty officer out by taking over one or more tasks to release some of the burden or by not confronting him with extra information and tasks that might not be relevant.

However, the primary responsibility for dealing with cognitive load lies with the duty officers themselves. It is of importance that they are aware of the cognitive load they experience or potentially will experience later on in the operation, so they can blow the whistle when it might become too much to handle. Training sessions in the form of, for instance, simulations can help with this. Creating a higher awareness of potentially high cognitive load can also encourage duty officers to ask for help timely. Some people tend to rather not do this by nature, but it can make a substantial difference with regard to the success of the operation, even if it involves delegating only small tasks to others. Hence, it is important that they are stimulated to call for help.

Lastly, it is observed that the commands given by duty officers are not always clear to the people that need to execute them, especially when operating under high cognitive load. In order to prevent issues arising from such ambiguity, it is important that commanders are well aware of the way they give their commands. Again, training sessions and video footage can help educating duty officers on how to give commands most effectively.

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Annex I – Codebook

Incident

Date

Region

Upscaling

File

Timestamp	Observation	Analysis	Command phase	Level of Situational Awareness
xx:xx	Description of events	What signals are noticed? What signals are not noticed? What information is used to make a decision? Is contradictory information recognized?	Situation Assessment (SA): Cues	**Level 1:** Perception of elements: status, attributes and dynamics of specific elements (not connected)
		Are the surroundings observed? What assessments are communicated? What risks are perceived? What questions are asked? (about the situation and deployment) Does the duty officer distance oneself to zoom out?	Situation Assessment (SA): Assessment	**Level 2:** Comprehension of situation: significance of elements for goal (holistic / interrelated) (meaning of elements)
		What problems are presented to the duty officer? Are goals articulated? How many goals are set (simultaneously)?	Plan Formulation (PF): Goal Formulation	**Level 3:** Future projection: pattern recognition
		What expectations are articulated? Are expectations adapted? Are expectations checked? With what (and how many) disappointments is the duty officer confronted?	Plan Formulation (PF): Expectations	
		What possibilities are recognized? What options are articulated and considered? What suggestions are done by others to the duty officer? Are consequences of actions foreseen?	Plan Formulation (PF): Option Awareness	

	Time pressure: how long does it take to make a decision? What is yet unknown? Is there a need for extra information? What decision are made? Is there decided on extra support?	Plan Execution (PE): Decision
	Does the duty officer actively look / ask whether decisions are executed / effective? Are orders revised as a result of monitoring? Does the duty officer have an eye for his people (Crew manager/ relief)	Plan Execution (PE): Monitoring
	Directive or participative? Suggestive or authorative? What information does the duty officer share with the chief commanding officer or crew manager? What does the first contact with the duty officer look like? Is the plan of action shared? Does the duty officer listen to others? Non-verbal communication?	Plan Execution (PE): Communication
	Are tasks divided and is communicated who is responsible for what? Proactive or reactive upscaling? Are tasks delegated? Is there a need for multi-consultation? Is the organizational structure adjusted? Does the duty officer arrange support?	Plan Execution (PE): Organizing
	Stress or tranquillity? Formal or informal atmosphere? Positive or negative humour? How does the duty officer cope with disappointments? Do people recognize each other? Write down statements that reflect emotions	Emotions

		How many tasks does the duty officer set / is the duty officer presented with? What tasks does the duty officer set / is the duty officer presented with?	Cognitive Load	