The 'new view' of human error. Origins, ambiguities, successes and critiques

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Abstract

Over the past two decades, the 'new view' has become a popular term in safety theory and practice. It has however also been criticised, provoking division and controversy. The aim of this article is to clarify the current situation. It describes the origins, ambiguities and successes of the 'new view' as well as the critiques formulated. The article begins by outlining the origins of this concept, in the 1980s and 1990s, from the cognitive (system) engineering (CSE) school initiated by Rasmussen, Hollnagel and Woods. This differed from Reason's approach to human error in this period. The article explains how Dekker, in the early 2000s, translates ideas from the CSE school to coin the term 'new view', while also developing, shortly after, an argument against Reason's legacy that was more radical and critical than his predecessors'. Secondly, the article describes the ambiguities associated with the term 'new view' because of the different programs that have derived from CSE (Resilience Engineering – RE then Safety II, Safety Differently, Theory of Graceful Extensibility). The text then identifies three programs by different thinkers (methodological, formal and critical) and Dekker's three eclectic versions of the 'new view'. Thirdly, the article discusses the success of the CSE and RE school, showing how it has strongly resonated with many practitioners outside the academic world. Fourthly, the objections raised within the field of human factors and system safety but also from different traditions (e.g., system safety engineering with Leveson, sociology of safety with Hopkins) are introduced, and discussed.

1. Introduction

Confronted, on the one hand, with an ever-increasing automation and use of computers in safety-critical systems such as air traffic control, aircraft cockpits and control rooms of nuclear power plants in the 1970s onwards, and, on the other hand, with a number of events (e.g., aircraft crashes, incidents in nuclear power plants), research on human error become a central topic in safety, in the last decades of the 20th century. It builds on disciplines such as cognitive psychology, engineering and system thinking, based on a mix of experimental and empirical data from various industries.

Given the importance of this topic for automation design, risk assessment, safety management and accident investigation, it has been thoroughly studied, discussed and debated over several decades, and different ideas, models and concepts have been proposed with both conceptual and practical implications over more than fifty years. Today, in an increasingly automated, digitalised and mediatised world reliant on screens, autonomous machines, algorithms and human-machine cooperation, research on human error remains as prevalent as ever.

In this area, the recent developments of the past two decades, characterised as the 'new view' of human error, have garnered both support (e.g., Read et al, 2021) and critiques (e.g., Cooper, 2022) from practitioners and academics. The term itself is divisive. From one point of view, drawing on several decades of different approaches in human error research, Read et al. wrote that these "*perspectives could also be seen to fit along a continuum between Dekker's (2006) 'old view' and 'new view' of human error*" (Read et al., 2021, 1035). Their interpretation is therefore highly positive in the sense that the '*new view*' is deemed analytically relevant. For these authors, it provides a lens to make sense of more than fifty years of developments in this domain. This is clearly highly supportive of the concept, endorsing its value both as a term and a conceptual proposition.

On the opposite side of the spectrum, Cooper asserts that "*there is no published, peer-reviewed empirical evidence to demonstrate whether or not any aspect of New-View's propositions are valid.*" (Cooper, 2022). He is highly critical and considers firstly that, despite all the support for the 'new view' from researchers and practitioners, it remains unclear how it differs fundamentally from the existing solutions. Secondly, he has claimed that it has yet to be shown empirically that it can be successfully applied to real life situations. He also discussed the ethical issues, considering the problem of introducing ideas without being able to prove their worth in operational contexts.

In these examples of positive or negative assessments of the 'new view', the authors present, compare, group or combine in different ways the ideas of a range of influential researchers such as Reason, Rasmussen, Hollnagel, Woods and Dekker (e.g., Swiss Cheese, Migration, Resilience Engineering, Safety II, Safety Differently). The aim of this article is to contribute to the current debate by clarifying this so-called 'new view' with the help of a historical and conceptual analysis. Indeed, this is not the first time these tensions have been expressed in the field of safety.

Against this background, this article serves to complement the earlier contributions in this journal in a dedicated special issue covering similar controversies (Roberts, Wears, 2019). It adds complementary insights to these publications in what is likely to remain an on-going debate in the field of safety, which is based on several competing research traditions with close relationships between theory and practice (Le Coze, 2019a, 2019b). Safety science research is not a socially, politically and epistemologically neutral arena (Haavik, 2021). The aim of this additional study is to contribute to describing and understanding the current confusion, and the associated controversies.

Following a methodological presentation, the origins of the 'new view' in cognitive system engineering (CSE) are explained. The following section unpacks the ambiguities associated with several developments in the CSE approach to human error in the past two decades. These first sections are followed by two more on the successes of and critiques of these developments. Finally, the article discusses their values and limitations.

2. Methodology

The methodological approach for this study consists in the systematic reading of texts (articles, books), tracking evolutions in thinking, in the developments and in the positions of the core authors on the topic of 'human error' (Reason, Rasmussen, Hollnagel, Woods, Dekker) over fifty years, from the 1970s to 2020. Drawing a line in history and choosing specific authors while leaving others in the background always involves some controversial and slightly arbitrary choices. For this article, it is considered that it was from the 1970s onwards that authors started to be heavily inspired by the burgeoning field of cognitive psychology to study 'human error'. Before this, cognitive psychology did not exist as an institutionalised discipline, and couldn't therefore constitute a background for the modern approach to this topic as we know it today. By the end of the 2010s, the key authors had been producing multiple contributions in this area for more than three to four decades through popular writings, to which other authors (and practitioners) across research traditions in safety have had time to discuss, incorporate, use or criticise. In other words, this fifty-year period is a relevant slice of history to clarify the 'new view' expression. It connects a more distant and a more recent past in the study of human error through developments explained in this article.

The choice of authors is also potentially controversial considering the vast number of scientists or researchers who have contributed over the past fifty years to the study of 'human error'. It necessarily leaves many important thinkers in the background. One rational for the selection of these five authors (Rasmussen, Reason, Hollnagel, Woods and Dekker) is their widely accepted influence in both theory and practice. Another reason is the tight and influential connections between these five authors, as found in their production (books, articles). Indeed, a close scrutiny of all their texts reveals how they create a tight network of ideas which develop through time and through the careful consideration of the others' writing. It is this dynamic that forms the backdrop of the 'new view' and constitutes its influence. This story starts fifty years ago with Rasmussen and Reason, who differed in their approach, followed by Hollnagel and Woods, then Dekker. This tight network of ideas deserves some unpacking.

This is how the notion of 'systematic reading' introduced above should be understood. All the authors' books (and articles) were read for this study, while proceeding with a chronological analysis combined with an awareness of the parallel developments by several authors over fifty years. These developments encompass the core themes of

cognition, error, causality and models of accident and safety. The fifty years of work by these authors constitute variations or alternative propositions on these core themes, which form the backbone of a systematic foray into this dense literature and support the interpretive process, inspired by epistemology (i.e., how knowledge is constructed). This analysis thus covers a large amount of material (hundreds of pages in the five authors' books and articles) that introduces numerous nuances, turning points, research programs, writing styles and intellectual trajectories, in evolving contexts. The earlier studies of Rasmussen and Reason provide a solid methodological, historical and conceptual background to which readers are referred when necessary (Le Coze, 2015, Larouzée, Le Coze, 2020).

Another facet of this study is the positive and negative reception of the recent developments in the study of errors, in the context of the 'new view'. To investigate these differing views, the analysis relies on the notion, and reality, of research traditions. It is not always straightforward to delineate clear-cut traditions - some can overlap, and groupings and distinctions can be controversial (Le Coze, 2019a). But the research traditions do effectively structure safety science since the engineering, psychological or sociological perspectives of safety necessarily differ, and traditions are largely built on such disciplines (and sometimes, their combination). In this article, the main traditions distinguished are human factors and system safety, system safety engineering and the sociology of safety. Selected writings of the core authors in these traditions are used, when available, as an indication of how ideas are received. Additionally, the domain of practitioners is considered as a specific space of reception, beyond academic traditions, reflected in the publication of practice-oriented (or consulting) types of books, but also in blogs, podcasts and websites.

This article heavily references published books, but this is not to deny the importance of scientific articles in this study. However, it is in books that one can find the most fully expressed ideas due to the format that they offer to their authors. Books also tend to reach a wider audience than scientific journals, especially when they are published with a target audience of practitioners in mind. The influence of the authors discussed in this article is also a result of the success of their books, which offer a less restrictive format than in scientific articles. For space reasons and readability, the article gives summaries of these books and reasonable shortcuts to ideas and contexts (for instance, changes in the authors' academic positions are not always mentioned), without altering the central concepts and important differentiations that help clarify the picture of the 'new view'. For this reason, the quotes have been carefully selected, but remain limited in number in order to cover fifty years of research within a reasonably-sized article. This historical and conceptual clarification enhances our ability to situate the diverse receptions of these various developments, ranging from success to critiques. Readers are invited to refer to referenced books and articles for further details if needed. The aim of this article is to stress the salient features that help provide analytical relevance while remaining readable. The descriptive sections proceed chronologically, following the systematic approach described above, by introducing Rasmussen (and Reason), Hollnagel, Woods, and finally Dekker.

3. Origins: cognitive system engineering (CSE)

The intellectual origins of the 'new view' lie in the field of cognitive (system) engineering (CSE). From the 1970s onwards, Rasmussen, Hollnagel and Woods developed ideas, concepts, notions and practices to support human-machine design (display, interface), human reliability assessment (HRA) and accident investigation. They were part of a growing community of researchers involved in similar problems around the world, mostly in the context of safety-critical systems due to the increase in computers and system complexity. For these purposes, they developed specific perspectives on cognition, human error, causality and accident and safety models. This history, from the 1970s through the 1990s, formed the basis of the 'new view' that was formulated in the early 2000s.

3.1. Rasmussen

Rasmussen was a leading figure of cognitive engineering in the context of a Danish nuclear project in Risøe (Rasmussen, 1969, 1984, Rasmussen, Jensen, 1974, Rasmussen, Lind, 1981), while other influential authors, such as Norman, hailed from the US (Norman, 1988). In the 1980s then 1990s, Rasmussen's ideas moved from an interest in human error to a broader sociotechnical view of the problem of safety and accident (Rasmussen, 1990, 1997). Based on an ecological view of cognition, anchored in the information processing analogy and the study of experts (Rasmussen, Jensen, 1974), he saw human error as an expression of intrinsic learning properties, self-adaptive properties of people expressing their degrees of freedom while performing their tasks.

Error needed therefore to be thoroughly contextualised, while introducing the subjective analyses of retrospective observers. Analyses of errors are normative judgments after the facts, which imply often implicit 'stop rules' that determine the depth and type of investigations following an event (Rasmussen, 1990). For Rasmussen, the combination of these adaptations (which he metaphorically compared to the Brownian movement) can lead to accidents when they migrate beyond the boundaries of safe performance (Rasmussen, 1997). To further elaborate this topic, he also drew up a vertical (control theoretic) sociotechnical view, supporting a graphical representation of accidents, Accimap (Rasmussen, 1997, Rasmussen, Svedung, 2000).

3.2. Reason's input to a theory of 'human error'

In the same period, from the 1970s onwards, but outside of the CSE framework, Reason developed his own approach to error, cognition, causality, and safety and accident models (Reason, Micielska, 1982, Reason, 1990, 1997). In fact, he and Rasmussen were closely connected but pursued two different programs on the same topics. A first main difference is that Reason took a taxonomic approach to human error (heavily based on Rasmussen's SRK cognitive model, Rasmussen, 1983) rather than an ecological one. While for Rasmussen, human error is the result of adaptive processes (and subjective retrospective analysis), for Reason, human errors are 'unsafe acts', differentiated by

cognitive categories (slips, lapses and mistakes) to which he adds the notion of violations.

A second difference is the safety and accident models, which Reason bases on the defence-in-depth (so called Swiss Cheese) model combined with the notions of latent/active failures, and sharp-end/blunt-end. Reason also made propositions on safety culture, and just culture. The differences between the two programs on causality, safety and accident are visible in Rasmussen's warning against what he calls the "*defence-in-depth*" fallacy. He considers that, due to the workers' self-adaptive properties, it is misleading to assume a total independence of the defences, and that several local adaptations can lead one onto a path towards accidents, without necessarily being noticed.[1] Another difference concerns the retrospective subjectivity of observers. For a more detailed presentation and comparison between these two authors, see Le Coze (2015) and Larouzée, Le Coze (2020).

3.3. Hollnagel and Woods

In the 1980s, Hollnagel (in Scandinavia) and Woods (in the US) developed their own perspectives on cognition, human error and safety and accident models in a CSE context originally created by Rasmussen (Hollnagel, Woods, 1983, Woods, Roth, 1988, Hollnagel, 1993, 1998, Woods, Johannesen, Cook, Sarter, 1994, Woods, 1988, 1990, 1993). The two authors are conceptually close, and their collaboration leads to the proposition of Joint Cognitive Systems (JCS) in the mid-2000 (Hollnagel, Woods, 2005, Hollnagel, Woods, 2006), a development that started in the early 1980s (Hollnagel, Woods, 1983). They shared two fundamental points that differentiated them within the field of CSE at the time.

The first of these points is that a cognitive system should be defined, described and studied as a functional coupling between humans and machines, and not as an addition of two different parts separately. This view has strong implications. For instance, it blurs a neat causal attribution in a case of failure. A failure cannot be attributed to one or the other, but to the functional coupling of the two. It is dependent on how the design of this coupling, its reliability and safety have been thought out (Woods, 1990, Hollnagel, 1992). It also radically challenges the principle of understanding cognition through fixed properties 'in the head' of individuals, devoid of context. This was argued by Neisser as a challenge to the mainstream burgeoning cognitive psychology of the 1970s (Neisser, 1976), of which he was one of the pioneers (Neisser, 1967).

A second fundamental point linked to the first is a rejection of the mechanistic (or physicalist) view of machines that is applied to humans at the expense of a more adequate depiction of cognition (Hollnagel, 1984, 1988, Woods, 1987, 1988). This was a criticism of some of the prominent views and uses of the time. They objected to what they considered to be the 'machine-like' use of the information processing model in cognitive psychology, such as developed by Reason (and Rasmussen, to a certain extent,

[1] Snook then took up this idea in the concept of "*practical drift*" in his case study of friendly fire (Snook, 2000)

a point not developed here for space reasons, see Le Coze, 2015), but also used by engineers in design and human reliability assessment (Woods, 1990, Hollnagel, 1992). These two fundamental points also led both authors to raise some serious doubts about the concept of 'human error'.

Yet, despite these shared principles, Hollnagel and Woods had different research styles, and scientific productions. Hollnagel for instance took a long-term interest in developing methodologies for human reliability assessment (HRA) and accident investigation based on adequate models of cognition.[2] For this author, 'errors' are not distinguishable from success but are instead retrospective attributions by observers (Hollnagel, 1983). Cognition should be understood as a contextual and control problem, not as a sequential and information processing one (COCOM, Hollnagel, 1993).

Based on this idea, Hollnagel developed his own HRA methodology in the late 1990s, called CREAM (Hollnagel, 1998). This he followed with a second one in the early 2000s, called FRAM, due to his dissatisfaction with the first, which he considered to overly mimic the engineering mind set (Hollnagel, 2004). FRAM is based on the concept of performance variability leading to unexpected outcomes, which Hollnagel describes as resonance, in contrast to Reason's Swiss Cheese model (for a retrospective overview of FRAM and its developments since 2004, see Patriarca et al., 2020). This is highly compatible and almost identical to Rasmussen's "defence-in-depth fallacy" (but uses resonance instead of Brownian movement as a metaphor, Le Coze, 2015), although operationalised with HRA-type purposes in mind. But one could also argue that FRAM is no longer connected to HRA precisely because it is motivated by the limitations of HRA (i.e., mimicking engineering methods through linear causality and bimodal failure modes of machines).

The fundamental points behind Hollnagel's propositions were shared by Woods, who empirically studied cognition in context. He raised doubts and concerns about the possibility of studying cognition exclusively in laboratories, through experiments or based on a sequential and linear information-processing view, what he described as cognition '*in the head*'. Woods and his colleagues preferred for instance the notion of a distributed cognition (Woods et al, 1994, Woods, Cook, 1999), which conceptualises the complex interplay between screens, people and the world ('*cognition in the wild*' is also often considered to be a core contribution to and expression of distributed cognition, Hutchins, 2005). Based on this position, Woods and his colleagues conceptualised 'human error' as a mismatch in this triad (i.e. screens-tools, people, world) rather than an isolated event *'in the head'* of people. They were less methodologically oriented and

[2] Hollnagel contributed to the production of what has been called the second generation of human reliability assessment methods which includes a more sophisticated view of cognition, as a response to the call from the engineering community to provide more elaborate insights to this end (Dougherty, 1990, see Borings for a historical perspective of HRA, since Swain in the 1960s, Boring, 2012)

more ethnographically driven than Hollnagel, and built a discourse on errors based on their empirical observations and conceptualisation.[3]

They exploited insights from Rasmussen (e.g., people expertise, subjective analysis of human error in retrospect), and from Reason (e.g., defence in depth, latent causes, sharp/blunt end) and their own refinements and analyses, to propose a contrast between their propositions of a new approach and what they described as the conventional approach of human error. They started by acknowledging their predecessors and making clear that "*labelling actions and assessment as errors identifies a symptom, not a cause; the symptom should call forth a more in-depth investigation of how a system comprising people, organizations, and technologies both functions and malfunctions (Rasmussen et al, 1987; Reason, 1990; Hollnagel, 1993)*" (Woods et al, 1994, 3).

Woods and his colleagues made a series of points which can be summarised as follows (Woods et al, 1994). This new approach relies on the recognition of people's expertise in context by showing the distributed nature of cognition (1), problematising causal attribution retrospectively (2), revealing the complex goal conflicts faced by people in real life situations leading to operational trade-offs through local rationality (3), recommending practical design options for expert systems and interfaces (4), warning against a strategy consisting in tabulating errors as a preventive strategy (5), changing the way people's contribution at the sharp-end is understood (6), and situating them in the context of sharp end/blunt end and latent causes (7).

3.4. Dekker

In the early 2000s, Dekker turned the 'new approach' to human error versus the 'conventional' one into the 'new view' versus the 'old view' (Dekker, 2002a, b). He formulated the points (1) to (7) above into a more accessible opposition, visually contrasted in a table. He thus contributed to amplifying the distinction established by his predecessors and making it easily accessible (Dekker was a PhD student of Woods, and also Billings, a human factors scholar). In the 'old view', human error is the cause of many accidents, and the system in which people work is basically safe and success intrinsic.

The main threat to safety comes from the inherent unreliability of people, and as such progress can be made by protecting the system from unreliable humans through selection, proceduralisation, automation, training and discipline. By contrast, in the 'new view', human error is a symptom of trouble deeper inside the system and safety is not inherent. The systems themselves carry contradictions between the multiple goals that people must pursue simultaneously, they have to create safety. Dekker's manual of human error investigation concretely operationalises this background, and makes

[3] This ethnographic posture in the study of cognition makes Woods a proponent, in the US, along with Klein, of naturalistic decision-making - *NDM* (Klein, Woods, 1993).

accessible to investigators, in a practical way, decades of key insights on cognition by the CSE school through points (1) to (7) above (Dekker, 2002b).

But Dekker did not stop there. What started as a personal clarification and amplification of the new approach versus the conventional one became something else with a series of essays in the 2000s (Dekker, 2004, 2007, 2011) carrying a far more critical, philosophical and radical attack on Reason's ideas. While Woods and Hollnagel, following Rasmussen, acknowledged the value of Reason's contribution while questioning some of his insights, Dekker openly and clearly criticised Reason's entire program.

First, Dekker rejected the conceptualisation and lexicon used by Reason for human error. He considered terms such as 'unsafe acts', 'violation', 'latent failure' or 'mistakes' to carry overly negative connotations. "*Forget wrongdoing. Forget violations. Forget errors*" (Dekker, 2004, 39). For Dekker, Reason's conceptualisation is also wrong because it creates the idea that human errors objectively exist out there without considering the subjectivity of science, its constructed character.[4] In other words, 'errors' do not exist in the world, they are instead constructed by observers[5]. Second, the metaphor of '*defence-in-depth*', represented as holes, arrow and slices, is inadequate in accounting for the complexity of accidents. It is too linear, structural, mechanistic and simple.

To operate this radical move, Dekker relied in his essays on both philosophical ideas (ranging from system and complexity theory through radical empiricism and constructivism to postmodernism) and sociological ones (normalisation of deviance, practical drift). For this author, accidents are the result of a '*drift into failure*', which cannot be captured by the Swiss Cheese model. Although aimed specifically at Reason, Dekker's critical approach targeted the entire human factors and system safety (HF & SS) community, which he considered to be overly objectivist, experimental, dualist, reductionist and mathematical (Dekker, 2004).

He also targeted other established HF&SS notions in aviation: situation awareness (Hollnagel, Dekker, 2004), function allocation (Dekker, Woods, 2002) and procedures. Equally, also in the mid-2000s, Dekker critically revisited the concept of just culture as elaborated by Reason, an important addition and implication of his approach to human error (Dekker, 2007).[6] Overall, he developed an opposition between the two schools on the topic of human error, safety and accident within HF&SS, based on epistemological, philosophical and sociological inspirations.

[4] In the early 2000s, new tools were developed based on Reason's ideas, including a method to identify and count 'errors' (Wiegman, Shappell, 2003), which are susceptible to criticism regarding their ability to proceed 'objectively'. This is the idea behind Woods and his colleagues' objection (Woods et al., 1994), which was amplified in a more radical way by Dekker (Dekker, 2004).

[5] See Le Coze, 2012 for a constructivist research agenda in safety

[6] Later, Dekker and Nye contended that Reason's proposition to develop a practical tool to support 'just culture' is an 'algorithmic one', mistaking justice for the prescription of a rational decision-making process (Dekker, Nye, 2013).

For Dekker, there is on the one hand, a 'problematic' mainstream represented by Reason's work, and on the other, an alternative school based on CSE that has greater potential, especially if his propositions are followed (Dekker, 2004). Although these differences with CSE were already known in the 1990s and acknowledged by Reason (Reason, 1997), Dekker radicalised them, sharpening the divide. One can guess that Reason was offended by this extreme position as he simply chose not to mention Dekker in his update of his classic book '*Managing the risk of organisational accident',* published in 2016 (Reason, 2016). Although he discussed the ideas of classic CSE authors (i.e., Rasmussen, Hollnagel and Woods) in this book, he simply ignored Dekker in what can be understood as a dismissive gesture. He wrote "*I bitterly resist any attempt to proscribe the language of error*" (Reason, 2016, 103).

4. Ambiguities in the 'new view'

So far, the historical and conceptual narrative of this article has introduced several nuances spanning the 40 years of research on human error, safety and accident, from the 1970s to the early 2000s, introduced by different authors. It explains the origins of the 'new view' discourse, and how Dekker sharpened the divide between a mainstream and an alternative school. However, as we move further on in history from the mid-2000s to 2020, some ambiguities should be discussed, explained and clarified in order to keep track of the developing 'new view'. First, the concept of 'Resilience Engineering', and the concepts that followed such as 'Safety II', 'Safety Differently', 'Theory of Graceful Extensibility' should be introduced. Second, the eclectic conceptual and empirical background of Dekker's essays over the years should be explained and questioned.

4.1. Resilience Engineering & more

In the mid-2000s, Woods and Hollnagel (with Leveson, discussed later in this article in the 'Objections' section) edited a book on Resilience Engineering (Hollnagel, Woods, Leveson, 2006). The book was framed by Hollnagel and Woods, who both wrote the introductory chapters that situate, explain and shape the trajectory taken in the book. Hollnagel introduced his development of HRA through the FRAM approach, and the difference in accident models it implies, including most notably the Swiss Cheese model (Hollnagel, 2004, Hollnagel, 2006). Whereas Woods problematised the notion of trade-offs against multiple conflicting goals in organisations, which require tough decision-making, based on what he empirically observed in practice (Woods, 2003a, Woods, Hollnagel, 2006).

The notion of Resilience Engineering (RE) therefore encompasses all that was developed during the 1980s and 1990s by these CSE authors. Although Decker was not an editor of the book, he did introduce his ideas of '*drift into failure'* in a chapter, consistently with his writing elsewhere (Dekker, 2006). From a historical perspective, the terminology of RE instituted or officialised the school derived from CSE, making it more explicit in promoting a coherent alternative discourse on human error. It also included an

associated notion that had been gaining growing success across disciplines and domains: resilience.

Resilience is a transdisciplinary concept emphasising adaptive capabilities, but also the ability to bounce back after stresses, adversities and shocks. Considering the importance that CSE authors give to front-line people who compensate for design flaws, find solutions to work constraints and invent strategies to cope with complexity, this notion of resilience gives a sense of unity to the research of these three core authors.[7] However, they continued to develop their arguments independently in the subsequent years. Let us now discuss them briefly without making it too impenetrable.

Hollnagel emphasised the importance of what goes right with the notions of ETTO then Safety I/Safety II (SII) (Hollnagel, 2009, 2014). He then developed RAG (Resilience Assessment Grid) and further refined FRAM (Hollnagel, 2012). In connection with his research, he pursued this methodological orientation, contrasting it with a traditional approach, Safety I, which overly stresses the negative side of practices.[8] Woods expressed his formal ambition, beyond his ethnographic approach, with his Theory of Graceful Extensibility (TGE), inspired by the theoretical discourse on Complex Adaptive System and Resilience as an important notion to be defined (Woods, 2015, 2019, see Cook, Long, 2021 for an empirical illustration of TGE). Finally, Dekker continued to pursue his critical approach, this time targeting bureaucracy, and switching to the notion of Safety Differently (SD) with a more political inspiration of anarchism (Dekker, 2015, 2017).

So, behind the unity of CSE then RE, three different perspectives were pursued, one with a more methodological angle (Hollnagel, Safety I/II, FRAM), another with a formal ambition (Woods, TGE) and a third with a critical approach (Dekker, SD). In this context, the original content of the 'new view' in the early 2000s as formulated by Dekker and based on Woods' work (Dekker, 2002a) had now slightly evolved towards a greater differentiation in relation to the style, interest and orientation of the various authors (figure 1). This creates ambiguity of course but can also lead to confusion when readers lack the time to fully understand such conceptual nuances and developments. Moreover, there is another layer of ambiguity to be found when looking closely at the 'new view' as Dekker defines it. Indeed, three separate versions exist, revealing an eclectic empirical and conceptual background, to which the article now turns.

[7] One dissenting voice on the notion of resilience is Hale's argument that existing notions in the field such as safety culture or high reliability organisation cover similar issues, and that there is no need for a new term. See also a similar argument by Hopkins ten years later (2014). This author is introduced in the 'Critiques' section. For a parallel history of High Reliability Organisation (HRO) and Cognitive System Engineering (CSE) then Resilience Engineering (RE) with an explanation of the differences and commonalities, see Le Coze (2019c).

[8] There are also foundational and visual dimensions in Hollnagel's work but these are not developed in this article.

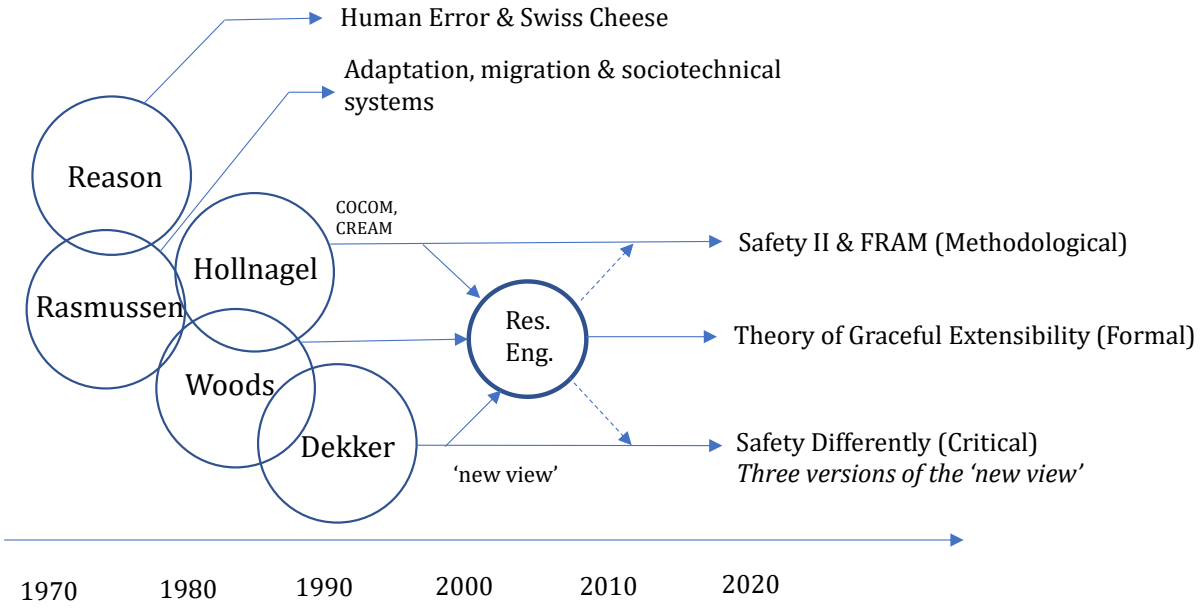

Figure 1. Reason and the authors of the CSE and RE school

4.2. Three versions of the 'new view' by Dekker

Let us remember that the 'new view' is Dekker's formulation of Woods and colleagues' distinction between the conventional and new approaches to human error research in the 1980s and early 1990s (Woods et al., 1994). But as noted in the description of Dekker's contribution, shortly after formulating the 'new view' (Dekker, 2002a), his program became more radical through an explicit rejection of Reason (Dekker, 2004, 2007, 2011). As such, this is a different 'new view', a second version. Indeed, when reading Woods and colleagues' work, Reason appears as part of their definition of the new approach, in contrast to what they describe as the conventional one. They do not appear to intend to criticise Reason, but rather to see him as an important contributor to a new understanding of errors more generally, to which they also contribute.[9]

It is a deliberate choice to stress either the complementarities or the divergences in writings. Both strategies are potentially valuable, depending on one's judgement as to the extent of the differences, and their consequences in relation to practical and theoretical purposes, and the various readerships (i.e., academics, practitioners). This choice is also, of course, embedded in the writing style and publication strategies of the authors. For Woods and his colleagues, the differences were acknowledged but not

[9] Clearly, Reason, at the time (the 1990s) established important and influential ideas (section 3.1): errors are intrinsic to cognition (one cannot decide not to make errors) (1), errors and performance are two sides of the same coin (2), errors are of different types (slips, lapses, mistakes, violations) (3), errors are linked to different aspects of cognition (attention, perception, memory, problem solving) (4), errors in accidents are 'active failures' of 'unsafe acts' triggered by 'latent conditions', represented by holes in a defense-in-depth visual (5), errors are not the cause of accidents, but triggered by deficiencies in the system ('error enforcing' conditions) (6), sharp end versus blunt end helps to address systemic properties (7), cognition cannot be changed but work situations, their design, can (8), incidents are limited and information about safety reactive (9). Overall, Reason is an important author who greatly clarified the notion of 'human error' in contrast to the simplistic views of the 1980s and 1990s. These ideas remain compatible with those of Woods et al. (1994), despite the differences initially established by Rasmussen (see sections 3.1 and 3.3) and by Hollnagel and Woods (section 3.3.). To emphasise common points or differences is a choice.

considered significant enough in the context of their publications at the time, in the mid-1990s, to exclude Reason from what they saw as a new approach. This was however clearly Dekker's intention, a few years later, in the early 2000s. So, based on this analysis, two versions of the 'new view' must be distinguished, one that is compatible with Reason, and a second that is an explicit rejection of Reason, as a representation of the mainstream.

As already mentioned, to develop his rejection of Reason, in this second version of the 'new view', Dekker borrowed from different backgrounds, mostly epistemological, philosophical and sociological. He used constructivism, radical empiricism, postmodernism, system and complexity philosophy for this purpose. His material came from the aviation and maritime industry, which are typical safety-critical areas (Dekker, 2004, 2011). A bit later however, with Safety Differently (Dekker, 2015, 2018), the intellectual stance became more political, with influences from anarchism (Scott, 2012). The tone was still critical, but his targets were no longer exclusively Reason (even though he was criticised this time from an 'anarchist' angle), but also behavioural based safety (BBS), Heinrich and Vision Zero. In doing so, Dekker also moved from safety-critical domains (e.g., aviation, maritime, healthcare) to look at occupational safety in other kinds of industries (e.g., retail, food & beverage). This is quite a different context, both intellectually and empirically and therefore constitutes a third version of the 'new view' (table 1), which is rarely mentioned nor described. Note that the critical tone increases from the first to the third, embracing ever more topics and issues.

Table 1. Three version of the 'new view'

First version of the 'new view' (late 1990s, early 2000s)	Formulates Woods' new approach ('*behind human error*') through an explicit opposition between an 'old' and 'new view', emphasising the complexity of human error, the value of understanding the contribution of people, and systemic reality of work (compatible with Reason)
Second version of the 'new view' (early 2000s, mid-2000s)	Radicalises the first version of the 'new view' by rejecting the mainstream represented by Reason's contribution and the HF&SS quantitative, experimental and objectivist approach of 'human error' with the help of postmodernism, radical empiricism, complexity philosophy and sociology
Third version of the 'new view' (mid-2010s)	Extends the second version of the new view by incorporating occupational safety (i.e. Heinrich, BBS or Vision Zero), by sensitising the second version to an anarchist discourse in order to build a critical perspective of bureaucracy (and applied to Reason's model)

	and by covering occupational safety sectors (retail, food & beverage)

4.3. Clarifying the 'new view'

This historical and conceptual retrospective review serves to clarify the 'new view'. The idea was derived from the CSE school of human error, accident and safety by Rasmussen, Hollnagel and Woods, which ran parallel to yet differed from Reason's conceptualisations in the 1970s through the 1990s. The 'new view' was formulated by Dekker in the early 2000s, who, as a student of Woods, promoted his ideas. This formulation helped amplify Woods and colleagues' message, making it more explicit. Shortly after, in the mid-2000s, Dekker proposed a more radical version of his 'new view' with a head-on criticism of Reason's legacy, who in his eyes represented the mainstream approach in HF & SS. This is the second version of the 'new view'.

Around the same time, in the mid-2000s, Resilience Engineering (RE) brought Woods, Hollnagel (and Dekker) together around their ideas derived from CSE. However, as time passed, these three authors rapidly followed their own programs, one more methodological with FRAM (following Cream) and SII (Hollnagel), another more formal with TGE (Woods) and the third more critical with SD (Dekker). By further expanding his ideas to include occupational safety, incorporating anarchist thoughts and targeting on other topics (BBS, Heinrich, Vision Zero), Dekker produced yet another version of the 'new view' (figure 1, table 1). This narrative covering around 50 years of research on human error can be visualised in figure 2.

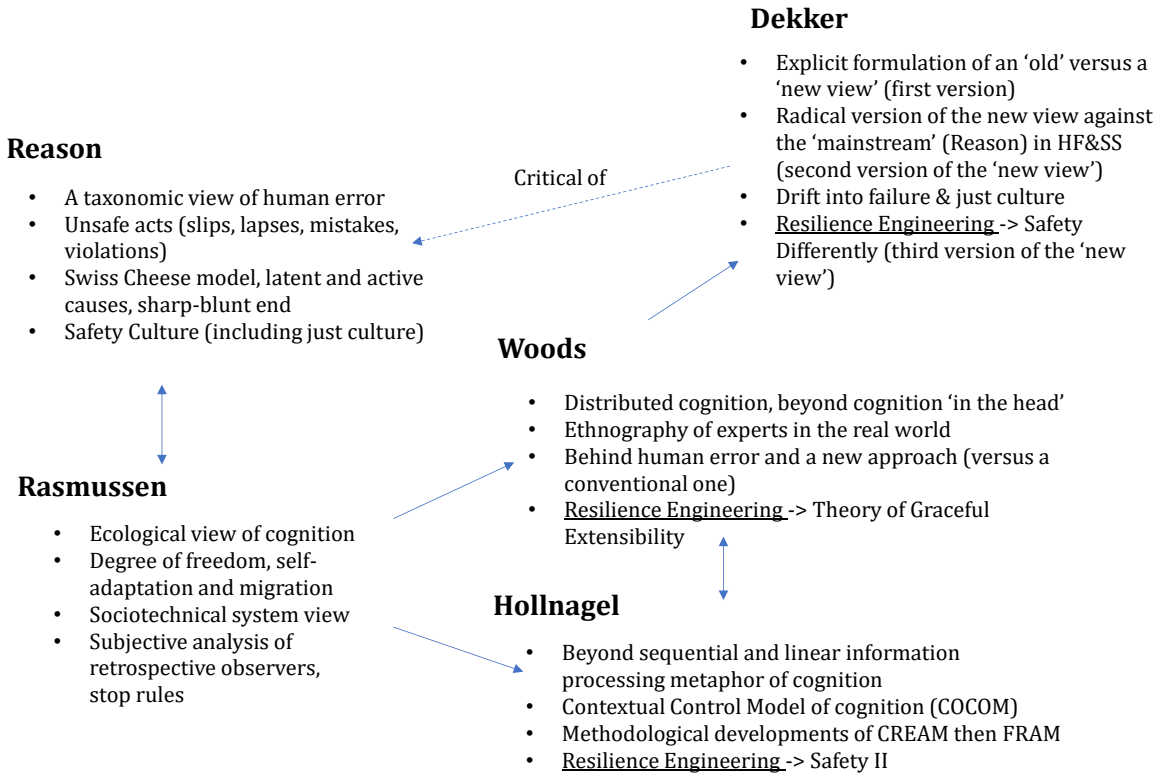

Figure 2. 'New view' origins and ambiguities

This nuanced, elaborate and complex picture is rarely acknowledged in the literature. One reason for this lies in the intense, highly productive pace of the authors and the diversity of concepts produced in a relatively short period of time. There has been no visible intention so far in the community to present the convolutions entailed for safety research. The thrust behind this intense production of books promoting different concepts is the professional market in safety which has exploded in the past two decades (Le Coze, 2019c). These books are written with practical readers in mind. But this is a source of confusion, and a challenge to the status of safety science research. The authors follow their own paths, amplifying differentiations without addressing, for instance, the compatibilities between these paths, nor the difficulties met by practical readers in keeping up.

With no answers to such questions, it is less surprising that there is room for misunderstanding, divisive receptions, and controversies. Are Woods and Hollnagel 'new view' authors? If so, what sort of 'new view' authors are they? The first, second or third, more critical, version of the 'new view'? Does Hollnagel endorse the idea of Safety Differently by Dekker? Do Hollnagel and Woods agree with Dekker's rejection of Reason's legacy?[10] Is Hollnagel also inspired by political ideas of anarchism, and what about Woods? Are Woods and Dekker happy with the FRAM methodology? Do Woods and Hollnagel agree about Dekker's critical rejection of a 'problematic' mainstream HF &SS? Do they agree with his critical tone about Reason's work? Does Dekker support Woods's formal agenda (based on complex adaptive system)? Does Resilience have the same meaning for the three authors? In the absence of such questions and clarifications, the 'new view' is often used as a term that aggregates with little differentiation the whole range of CSE and RE authors, with or without Reason (Read et al, 2021, Cooper, 2022) [11].

The retrospective review in this article shows that it is more prudent to avoid conflating these programs, so that the nuances remain evident for practical and theoretical purposes. The authors' ideas should not be mixed without taking into account their disagreements and agreements. As a result, the term '*CSE and RE school*' is used in preference to 'new view' in the next sections, unless other specified. CSE and RE appear to be the most common denominator of the authors, best reflecting their shared roots. With this in mind, the next section will discuss the successes and critiques, without aiming for exhaustivity. The aim is to illustrate a variety of divisive responses across

[10] The fact that Dekker's '*new view*' formulation is never mentioned in the narrative of Hollnagel and Woods in the mid-2000s is an indication (Hollnagel, Woods, Leveson, 2006, Hollnagel, 2004). Note that Woods and Cook wrote about what they presented as the '*new look*' of human error in the early 2000s, which incorporated Reason (Woods, Cook, 2004).

[11] In fact, some of these issues are found dotted across these authors' articles and books, but nothing is made very explicit. Not that it is an easy task, and not necessarily perceived as necessary when each author follows their own path, with operational purposes in mind, each with their own audience of practitioners, and academics.

practitioners and academics, and not to encompass the whole range of positive or negative reactions available.

5. Successes

Undeniably, and despite the confusion, the CSE and RE school has been influential in the past years. There has been strong interest on the academic front, demonstrated over the years by the many conferences and workshops held, and articles and books published since the mid-2000s (e.g., Hollnagel et al, 2008, Nemeth et al, 2008, Nemeth, Herrera, 2015, Read et al, 2021). The healthcare safety research community is quite receptive to these orientations with several volumes on 'resilient healthcare' (i.e., Hollnagel et al, 2011, Hollnagel et al, 2015). Another example is air traffic control with the Hindsight magazine published by Eurocontrol and edited by Shorrock, which brings together the practitioners and CSE and RE authors (i.e., Hollnagel, 2013, 2017, Dekker, 2013). It has always been at the heart of CSE and RE to deliberately target practice (and more generally, HF&SS, see Shorrock, Williams, 2018), as illustrated by the success of Reason (Reason, 1997, 2016).

Therefore, the CSE and RE school in general has been a source of inspiration for many practitioners who have found there some powerful means of thinking about human errors, people at work, and the complexity of the daily life of organisations. Strategically, discussing Reason's legacy has proven to be a valuable strategy for CSE and RE authors. By positioning their ideas in relation to Reason's influential models of error, safety and accidents, they help practitioners who are familiar with these models to think about their potential limitations. Hollnagel's classification is popular because of its affirmation of the need for new models, beyond the Swiss Cheese, when faced with increasing complexity (Hollnagel, 2004).

The language of unsafe acts, violations and failure established by Reason in the 1990s and criticised by Dekker, can carry several assumptions about practices that are at odds with what practitioners observe and experience. The complexity of real-life situations and organisations does not fit neatly for many into the depreciative terminology of 'unsafe acts'. This is captured in the works of the CSE and RE authors with their different styles, their propositions to shift or to complement the current lexicon, their methods and practical recommendations to give greater recognition to people's expertise (against a top-down, control approach), and by paying attention to the positive.

These ideas came at a time when the traditional ways of framing safety through compliance, incident reporting, errors, counting events and indicator-based management were being challenged, independently, by some practitioners or consultants (i.e., Smith, 2018, Marriott, 2019). For these reasons, there has been a particularly enthusiastic reception for these ideas, enabled by social media, blogs, websites and podcasts, with some authors providing practical translation, as with HOP (Human and Organisational Performance). HOP was developed and promoted in the US context by authors such as Conklin, who has experience as a senior advisor in Los Alamos Laboratory (Conklin, 2012, 2018). Considering his influence in practitioner

circles, Conklin may well have played a role in popularising and amplifying the notion of the 'new view'.

Note that Conklin's work is not a simple transfer, but an active translation, tailored for a specific audience of practitioners, with operational needs, to which this translation responds.[12] Another example of adaptation is found in Lloyd (Lloyd, 2020) who writes about a case of a HSE manager who described a shift in the language of and approach to safety management. This shift was found in changes in word use from '*accident'* to *'learning event*', from '*advisors'* to *'coaches*', from '*accident investigation'* to *'learning review*' and from '*audit'* to *'continuous improvement opportunities'*. Here, the continuity with the Dekker's language criticisms (about Reason's vocabulary) is obvious. By changing the words used to describe different practices, alternative paths are suggested. Yet, doubts have also been raised about the CSE and RE school, and we will now discuss these various critiques.

6. Critiques

One significant concern expressed by some is how such ideas, promoted as a reset of previous ways of dealing with safety, have the data to support their claims. Do they work? How different are they from a more traditional approach? How much of the old approach should be rejected, and how much of it retained? Without independent research to attest to the realities and extent to which these ideas can positively transform safety practices, answering such questions is difficult. The strongest opposing voices come from proponents of other ideas in safety who see themselves as targets of the CSE and RE school, such as Cooper (Cooper, 2022). Nevertheless, these concerns are legitimate.

Some researchers in HF&SS who can be identified with the mainstream as defined by Dekker have also been cautious. While the limitations of cognition as information processing "*in the head*" at the expense of a more distributed (or functional) description have been heard by many (i.e., Stanton et al, 2008), the more radical and critical assessment of established notions such as situation awareness (Dekker, 2004, Hollnagel, Dekker, 2004), function allocations (Dekker, Woods, 2002), errors (Dekker, 2002, 2004) or the 'Swiss Cheese' model (Dekker, 2004, Hollnagel, 2004) have been received more cautiously (i.e., on function allocation, Hancock et al., 2013; on situation awareness, Parasuraman et al., 2008, Endsley, 2015, on model classification, Reason, 2016, not to mention Reason's dismissive reception of Dekker's critiques).

An example of cautious incorporation is Harris's presentation of HF&SS in aviation (Harris, 2011). This is one safety-critical domain in which human factors have had a close relationship with industry over several decades, building sound practical and theoretical relationships through extensive research and funding, and contributing to the high level of safety achieved in this domain (along with engineering and regulation).

[12] This process of adaptation is quite interesting, it is not explained in this article but Conklin refers indiscriminately to both Reason and the authors of the CSE and RE school (Hollnagel, Dekker, Woods) in the references of his book (Conklin, 2012), to the first version of the 'new view' than the second or third.

This is precisely the type of mainstream that Dekker has in mind with his critique. So, has the critique been fruitful?

Harris's textbook covers the entire spectrum of human factors and remains clearly rooted, first, in the information processing view of cognition, second, in a taxonomic view of errors and third, in the Swiss Cheese model of accident and safety. Around this, the other core aspects of HF&SS in aviation are articulated. These include training, selection of workforce, workload, situation awareness, decision-making and crew resource management, but also human reliability assessment and function allocation design principles.

In line with the cautious reception found in the HF&SS literature, the core established methods and notions remain the building blocks in this domain, as found in this textbook. In other words, in aviation safety, the mainstream, Reason's model and its assumptions, still prevail. This picture, however, requires some nuance. Throughout his textbook, Harris systematically refers to the ideas of Hollnagel, Woods and Dekker on core topics (situation awareness, human error, function allocation, accident investigation). So, their contribution is acknowledged, but not strongly enough to '*throw the baby out with the bathwater*'.

This textbook provides an interesting example of a safety critical system that cautiously incorporates these insights, more as an opportunity for reflection, while remaining entrenched in the rationale of Reason's model. This is not a judgement about the value of these ideas (nor an opinion of HF&SS in aviation), it is an observation of the current situation where, throughout a textbook, such ideas have indeed managed to penetrate one safety-critical domain (see also, from within, Bergström et al., 2015).

Some authors who have also established a strong relationship with practice but from other research traditions have been cautiously appreciative of the notion. This is the case of Leveson with system safety engineering (Leveson, 2020), and Hopkins' sociology of safety (Hopkins, 2019). Although Leveson co-edited the first RE book to be published (Hollnagel, Woods, Leveson, 2006), a recent study from this author strongly challenges Hollnagel's approach of Safety II (Leveson, 2020) on several key aspects of its discourse: description of safety I ("*strawman"* argument), approach to causality (linear versus non-linear), use of analogies and meaning of vocabulary, conceptualisation of emergence and of complexity, classification of accident models and absence of empirical cases.

These are extensive problems, and it is beyond the scope of this article to discuss them. One central topic connecting many of them is the conceptualisation of complexity in relation to causality, emergence and analogies. Since SII (Hollnagel, 2014) is based on previous writings (Hollnagel, 2004, 2009), Leveson is criticising a much longer thread of developments, going back to the origins of RE, perhaps even some aspects of CSE, and Hollnagel's approach of HRA (Hollnagel, 1993, 1998). What propelled Leveson to co-edit the RE book with CSE authors in the mid-2000s (Hollnagel, Woods, Leveson, 2006) in the first place might have been their common view of what they considered to be the

limitations of Reason's model, with the help of Rasmussen. But their paths seem to have diverged later (Leveson, 2012).[13]

Hopkins is more critical of the 'anarchist view' of safety developed by Dekker (Dekker, 2018) than SII. As a sociologist with a strong expertise in high-risk systems (Hopkins, 2016), he is concerned about Dekker's message that rules can be made up by people themselves. In other words, and as a sociologist, he is concerned about the way a core notion such as bureaucracy is approached in safety critical systems contexts (Hopkins, 2019). Hopkins indeed stresses the importance of organisational structure, and of making sure that practices are collaboratively controlled through a mix of strong engineering input based on sound risk assessment and a sensitivity to real practices, what he describes as 'rule management' (Hopkins, 2011). It is difficult to imagine leaving people to decide for themselves in safety-critical systems such as aviation, offshore exploration or refining. Hopkins is closer to the mainstream HF&SS in this sense, as represented by Reasons' rationale (Harris, 2011).

Hopkins's normative sociology of safety is indeed compatible with the Swiss Cheese model metaphor (Hopkins, 2012). And this is not the first time that he has criticised the CSE and RE authors, he believes that they fail to explicitly acknowledge the contribution of the High Reliability Organisation (HRO) studies that cover and address similar problems (Hopkins, 2014). There are other critiques from the sociology of safety, for instance, of CSE and RE's rejection of the benefit of major accident investigations (Hayes, 2019). But there are also sociological compatibilities when, for instance, the standardisation and bureaucratisation of safety are combined into an analysis of the current organisational trends affecting practices (e.g., Almklov et al., 2014, Almklov, Antonsen, 2019), or when sociomaterial studies involve a reflection about human-machine interactions for which the joint cognitive engineering approach proves to be highly relevant (e.g., Haavik, 2013, 2019).

7. Discussion

One ambition of this article was to provide a background from which a clarified picture of the 'new view' can be obtained in a context of the controversies it sparks. What has been described as the CSE and RE school has incited enthusiastic responses from some, but it has also raised doubts among both practitioners and researchers. By proposing a historical and conceptual study of these ideas over several decades, this article builds a bigger picture to discuss both their values and their limitations. Based on this picture, it appears that a degree of nuance must be applied to the current situation.

The value of these developments is clearly visible in their ability to engage with practices, methodologically but also critically. They aim to be operational and to contribute to a different view of work and to the safety of front-line operators within the contemporary situation and its evolutions. Despite the varied reception across safety

[13] But there is a strong link between HF&SS and System Engineering Safety through Rasmussen's sociotechnical view of accident/safety (Waterson et al., 2017, Leveson, 2017).

critical domains as illustrated (e.g., aviation, healthcare), and beyond the confusion created by the diversity of developments that lack clarification, the material produced forms an interesting literature that undermines a simplistic view of human error and is now widely acknowledged across a range of industries.

It is also an interesting critique or counterpoint to the mainstream HF&SS discourse on human error as described in this article (without having to '*throw the baby out with the bathwater',* namely without the excess of a complete rejection). In this respect, another value of these developments lies in their attempts, in different ways (methodological, formal, critical), to elaborate principles (migration, resonance, drift into failure, graceful extensibility) to grasp the complex patterns of interactions which are behind unexpected and unwanted events as much as behind the production of safe performances.

Yet, several overlapping reservations can be formulated (beyond the HF&SS tradition) from the cautious receptions and critiques of researchers in system safety engineering and the sociology of safety. Of course, such reservations and critiques are expected when research traditions collide, often creating misunderstandings that are deeply entrenched in the goals, practices, assumptions and perspectives of the researchers involved (Le Coze, 2019a). These have also been about books written mainly for practitioners (rather than with researchers in mind) which are caught in the growing influence of social media, amplifying controversies beyond the academic world. It should be noted that blogs, podcasts and social networks, despite their value, can also contribute to polarising antagonisms, rather than promoting nuances. Although there are few studies available, it might make sense to incorporate the internet into the picture somehow. This is one downside of the otherwise valuable format and freedom that books tend to offer. Divergence can increase and confusion with it, as explained in this article.

From the patterns of critiques identified in this article, the intensification of the negative appraisals is possibly linked to two trends. The first trend is the growing popularity of the CSE and RE school over the years, which has started to impinge on the existing traditions in safety science research (e.g., behavioural based safety, system safety engineering, sociology of safety). This has triggered reactions by established authors in these traditions, who have dedicated time to unveiling the core problems in their eyes (e.g., Cooper on empirical validity, Leveson on rationale). The second trend is of a growing perception that authors are taking excessive critical positions, as in the case of Dekker's three stages of the 'new view'. The second and third versions (table 1) indeed successively and critically target human error and then bureaucracy. These versions are quite radical. Authors who disagree with such an excess either dismiss (e.g., Reason on human error), moderate (e.g., Harris on human factors) or deconstruct its logic (e.g., Hopkins on bureaucracy).

This situation is of course healthy from the point of the view of safety research. It shows that there is a diversity of conflicting perspectives, expressing the complexity of reality, and of the foundations of safety, as argued elsewhere (Le Coze et al, 2014). The opposite would be surprising, strange or, even worse, if it was the reflection of a lack of expertise in the field to elaborate on these issues, or of an unwillingness to tackle this complexity.

It is hoped that this article can help create bridges, where possible, between the traditions, or at least, help clarify the picture. In a complex world, no controversies would in practice mean no research. Out of the various concerns, two are interesting candidates for further exploration, clarification and discussion: complexity and bureaucracy. These topics illustrate some of the reservations that may be widely shared about the ability of the CSE and RE school to bring insights from other traditions into its rationale when venturing beyond the analysis of the work situations of mostly sharp-end actors. These two topics are also consistent with Haavik's suggestions as to how to broaden the debate in safety science research (Haavik, 2021).

Conclusion

The purpose of this article is to discuss the 'new view' and its divisive character by clarifying the picture and following up on earlier studies into the controversies in safety science research. By proceeding historically and conceptually, it shows that the 'new view' has its origins in the cognitive system engineering (CSE) school. This school offers a unique understanding of the topic of human error through a long thread of developments, over fifty years, involving several key authors (Rasmussen, Hollnagel, Woods, Dekker). Their scientific activity shows a diversity of ideas that follow different programs, producing a wealth of conceptual refinements (from migration to resonance, from trade-offs to theory of graceful extensibility, to name but a few).

In this context, the 'new view' was first formulated by Dekker in the early 2000s, when translating the CSE background work of Woods and colleagues. It also appears that the contours of Dekker's term 'new view' have evolved over time with no fixed, unique meaning. They developed in parallel to his eclectic thinking that evolved towards even greater levels of critical tone (from radical empiricism to anarchism). Three versions of the 'new view' are identified. Other notions that derive from the CSE school of human error, including Resilience Engineering (RE), also need to be contextualised to be understood as reflections of the authors' research styles and program orientations.

Some are more methodological (Hollnagel, FRAM, Safety II), more formal (Woods, Theory of Graceful Extensibility) or more critical (Dekker, Safety Differently). This historical perspective contributes to clarifying the current confusion, which is connected to the expansion of the safety market (and social media) fuelled by the practitioners' interest in reflective, useful and practical ideas. This dynamic and confusion partly explains the varied receptions of these ideas, from positive to more negative, several of which are identified in this article.

On the positive side, the novel ideas are thought to offer powerful insights. They challenge simplistic reasoning. They stress the importance of valuing, conceptualising and managing the expertise of front-line people. Their various angles enrich our understanding of the topic of human error, by remaining alert to its complexity and the importance of avoiding simplistic discourses, and of emphasising interactions, patterns and systems. On a more negative side, and beyond the issue of the current confusion, some of the propositions to move towards alternative safety practices based on these

ideas are not yet considered to be sufficiently tested, or empirically validated. Finally, their use of important notions such as complexity and bureaucracy are challenged by other research traditions such as system safety engineering and the sociology of safety. This points to further possible clarifications in the future.

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