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Shifting visions of human performance improvement tools – Risks and potential outcomes

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ABSTRACT

The purpose of human performance improvement (HPI) tools is to guide and control human behaviour in operational settings in order to reduce the risk of errors inherent to operational activities and the conditions under which they are carried out. These tools are increasingly common in high-risk industries, but their systematisation raises several questions. This paper addresses the policies driving the implementation of these practices, their theoretical foundations, and the assumptions upon which these are based. It also reviews strategies used in the rollout and implementation of these practices. Our analysis reveals several potential weaknesses as well as a shift in the way HPI tools are promoted and deployed.

1. Introduction

Human performance improvement (HPI) tools are used in the nuclear industry and other sectors (petrochemicals, transport, healthcare, etc.) to reduce the risk of error inherent in human activity, as well as to limit risks inherent in contexts in which these activities are carried out, by implementing predetermined preventative individual and collective measures. These tools vary among industries and organisations (Wachter & Yorio, 2013a). In the nuclear sector, it is difficult to draw up an exhaustive list of all the HPI used by operators around the world. But there are more than fifteen different standard tools, recommended or prescribed to nuclear operators (INPO, 2006; DOE, 2009b): “task preview”; “job-site review”; “questioning attitude”; “stop when unsure”; “self-checking”; “procedure use and adherence”; “three-way communication”; “phonetic alphabet”; “place-keeping”; “do-not disturb sign”; “pre-job briefing”; “peer-checking”; “concurrent verification”; “independent verification”; “flagging”; “turn-over”; “post-job review”... For instance, French nuclear plants that use the HPI approach employ six standard tools: pre-job briefing (a short meeting, scheduled as close as possible to an intervention, to present the risk assessment conducted during the preparatory phase, as well as countermeasures); the two-minute rule (requiring workers to stop and observe their immediate work environment before beginning a task, to ensure an alert and critical mindset); self-checking (reading procedures or written instructions aloud and following the text with one’s finger); peer checking (using a buddy system to ensure one’s actions are always monitored by a peer);

effective communication (to ensure mutual understanding through clear, comprehensive transmission of oral information); and post-job review (a short meeting to capture direct feedback immediately after a job is completed).

Although these tools have a long track record and are being used increasingly, their systematic implementation raises several questions. Paradoxically, despite their widespread use and growing popularity, little research on them has been conducted in France by safety experts. The few studies devoted to them tend to fall into two camps: those conducted by organisations with a direct role in deploying these tools and a direct interest in promoting their adoption across different sectors (Jubert, 2018; Simonetto, 2020), and those conducted by researchers observing HPI tools in the context of more general studies, which tend simply to highlight the potential value of such tools alongside their limitations (Levy & Moulin, 2014; Le Coze & Fabre, 2017; Besnard et al., 2017).

The present study has two aims. First, it seeks to remedy the clear lack of debate over a set of practices that is currently being presented as a key lever for risk control by several French nuclear operators. To this end, we have carried out a bibliographical study which includes, in addition to scientific publications, standard reference documents and practical guides produced by or for operators, as well as other forms of grey literature. We looked at the way in which an organisation and its top management promote the application of these tools. We have chosen to refer only to documents in the public domain, most of which are accessible on the Internet.

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Second, this article seeks to give a balanced, dispassionate debate on HPI practices in a context characterised, both in France and internationally, by two opposing blocks: one believing that these practices have proven their value in multiple sectors of activity (Jubert, 2018; Kowalski & Summers, 2019; Simonetto, 2020; Watcher & Yorio, 2013a; Wachter and Yorio, 2013b), and the other, more sceptical, accusing the first group of promoting safety practices that lean far too heavily on behavioural approaches (Levy & Moulin, 2014; Hopkins, 2006). Between these two blocks, some authors choose a promising third path, relying on a very extensive empirical material. This leads them to have an interesting more balanced view (Skjerve and Axelsson, 2014; Oedewald et al., 2014).

To achieve this, as sociologists specialised in high-risk industries, particularly the nuclear sector, we won't focus on the tools alone, but place them in a broad system. Just as Laroche et al. (2018) argued about safety culture, human performance can indeed be understood as a "system" composed of three components: 1) the "idea" or "concept" of human performance, and associated theories and models; 2) "tools" and "practices" that are designed and promoted in the name of human performance and specifically discussed in this article; 3) "actors" who advocate and discuss the concepts and tools associated with the concept of human performance. Once again inspired by the work of Laroche et al. (2018), we can consider that these three components interact as follows: 1) the concept of human performance and associated ideas "equip" actors, through a "conventionalizing" process; the concept of human performance is thus a convention which provides a common ground for thinking and talking about safety issues; 2) this general concept of human performance is then translated into multiple concrete tools and practices, through an "engineering" process; 3) at last, these tools are diffused by and among actors, and specifically practitioners, through a "commodifying" process; regulators, consultants, academics, and other practitioners, "selling" them to managers and organisations in search of safety and human performance.

This paper results from this system analysis and is organised as follows. We begin by reviewing the history of the programmes at the origin of HPI practices in the nuclear sector and examine the risks inherent in these practices. We then analyse how these programmes have been adapted, promoted, and implemented in the nuclear industry in France. As a public institute specialised in nuclear safety and radiation protection, we are focusing our study on Électricité de France (EDF). It was the first company to deploy these tools and, as a result, the written sources available are the most numerous. In doing so, we show how the rhetoric around the implementation of these practices seems to distance them from the original principles at the heart of HPI. We go explaining what the risks are posed by this shift before closing with a review of potential future developments.

2. A brief history of human performance programmes

A. Recommendations from operators' associations and the International Atomic Energy Agency

The HPI tools used by a number of French nuclear operators originated during a period of reflection and formalisation that took place in the nuclear industry on an international scale in the late 1990 s and

focussed on the concept of 'human performance'. This movement received its initial impetus from two plant operator associations that defined the first guiding principles and produced the first conceptual and practical guides: INPO (1997; 2006)¹ and WANO (2002²; 2003).³ Human performance is a part of performance improvement which is defined as "the systematic process of determining desired performance, continually monitoring performance, discovering and analysing performance gaps, designing and developing effective interventions, implementing these interventions, and continually evaluating the results of improvement interventions within performance monitoring to ensure that the improvement process take place (IAEA, 2013, p. 5). Human performance tools are an important component of human performance improvement.

The approaches they proposed spread quickly, first among operators, particularly in North America and Europe, who used them to design and deploy their own programmes; second at the International Atomic Energy Agency, which then produced its own guidelines (IAEA, 2001; 2005; 2013); and finally, within regulatory authorities in some countries, including the United States (DOE, 2009a; 2009b) and Canada (CNSC, 2016). The deployment of these HPI tools was then consolidated in the sector via WANO peer reviews, during which operators visit their counterparts in order "to compare their operational performance against global standards of excellence".⁴ Similarly, via the OSART⁵ missions, the IAEA is looking into "How are human performance tools used in the field?".⁶

Each of these human performance focussed programmes was built on a series of observations shared across these organisations (Wachter and Yorio, 2013b). Primary among them was that, according to a figure cited regularly by operators and authorities worldwide, at least 80 % of identified safety events are due to human error,⁷ of which 20 % to 30 % (depending on the source) are attributable to individuals and 70 % to 80 % to organisational failures (INPO, 2006; DOE, 2009a).

Some authors (Watcher & Yorio, 2013a) have highlighted that three core principles may be identified in these programmes, and that these principles are still reflected in the positions of their successors and promoters today (Jubert, 2018; Simonetto, 2020).

- First, human error is inevitable because the mental, emotional and physical capacities of human beings are naturally limited.
- Second, error is unrelated to a worker's intrinsic worth or professionalism, as all workers, however skilled, experienced and disciplined they may be, are human and therefore fallible.

¹ The Institute of Nuclear Power Operations (INPO) is an organisation created in 1979 by the United States nuclear industry following recommendations issued by the Kemeny Commission after the Three Mile Island accident in 1979. INPO is also a member of the World Association of Nuclear Operators (WANO).

² The World Association of Nuclear Operators (WANO) is an international group of nuclear power plant operators dedicated to nuclear safety established in 1989 following the Chernobyl disaster to promote best practices and pool experiences.

³ Reference documents INPO (1997), WANO (2002; 2003) are not available on the Internet. They are discussed in a study Oedewald et al., (2014), to which we refer further on in this article. They are cited here for informational purposes.

⁴ e0cac459-76d4-48b5-a951-a754c8518024.pdf (wano.info).

⁵ OSART (Operational Safety Review Team) missions begin upon request from the Member State.

⁶ wnos.pdf (iaea.org).

⁷ This percentage is debatable in that it only makes sense if 'human factors' are juxtaposed with 'technical factors'. An approach more grounded in the human and social sciences, in which people and technology are inseparable, would make the case that all incidents and accidents can be traced back to human action, from the design of technical systems to their subsequent use and maintenance.

- Third, overall knowledge and understanding of the mechanisms responsible for errors is constantly improving, making errors increasingly predictable and preventable.

These core principles open up two perspectives for progress. The first follows recent developments in our knowledge of human behaviour, making advances possible in the channelling of risk related to ‘human factors’. Feedback and risk-prevention processes focussed on human factors are increasingly popular, with a growing enthusiasm for incorporating academic methodologies and analyses, such as James Reason’s work on the Chernobyl disaster (Reason, 1987; 1990; 1997).

The second has opened up as sectors have become more active in sharing feedback and experiences. The nuclear industry now frequently tends to look to the observations and practices of its neighbours in the military and aviation sectors, a trend visible in the literature (Maurino et al., 1995; Helmreich and Merritt, 1998) as well as in practical recommendations in the INPO guide (2006).

B. *The Institute of Nuclear Power Operations Reference Manual as an attempt to consolidate available knowledge*

The INPO Human Performance Reference Manual (2006) is a kind of reference framework for HPI programmes in the nuclear industry. It is an attempt from the early 2000s to consolidate available knowledge about error and human performance, geared toward practical use. Its goal was to ensure that individuals working on or near installations would be aware of potential pitfalls and, by identifying their warning signs, be able to employ various individual and collective strategies to protect themselves against them. To use the distinction drawn by Reason (1997), the aim is not only to limit the risk of ‘active failures’ in front-line activities, but also to control the risk of ‘latent conditions’ that might weaken the system.

The first key point addressed in the reference manual relates to individual behaviours, which underlie most active errors. The manual uses two distinct analytical models. The first, rooted in cognitive psychology, seeks to account for errors committed by individuals by examining their modes of cognitive functioning and the limits of their abilities (in terms of memory, learning, attention span, perception, reasoning, etc.), referring to the seminal works of Reason (1990), Rasmussen (1983; 1986) and Hollnagel (1998). The second draws on research in social psychology with the goal of understanding how the thoughts, emotions and behaviour of individuals may be affected by their interactions with other people in a team (with references to Helmreich’s work on aviation (Helmreich and Merritt, 1998; Helmreich et al., 1999) or by inaccurate social representations or cultural norms (with reference to Turner (1978) and Weick & Sutcliffe (2001), among others).

The second major point addressed in the reference manual concerns the management of organisations, which creates the context in which latent errors can occur. This issue is also addressed from two different perspectives: that of risk management, with a focus on Reason’s ‘Swiss cheese’ systemic accident model (1997), strongly influenced by the concept of ‘safety culture’⁸ (IAEA, 1991). The issue is subsequently approached from a more general perspective, with references ranging from the iconic principles of quality management, excellence and continuous improvement, to Schein’s academic research on leadership and organisational culture (Schein, 1992).

Our analysis of this INPO manual leads us to the conclusion that the HPI tools have, for main purpose, to operationalize and give a concrete form to the three major principles which have been set out in the approaches focused on “safety culture” after the Chernobyl accident (IAEA INSAG 4, 1991): a questioning attitude, a rigorous and prudent

⁸ ‘Safety culture’ has been the subject of much debate over the years, and we do not intend to elaborate on the subject here. For more information, see Fucks (2012), Santana (2016) and IRSN (2016).

approach, and necessary communication. But in the end, the proposed tools are actually very diverse.

First, they don’t have all the same origins and deployments. Some of them, such as secure communication or cross-checking practices, are for example directly derived from tools that were historically developed in the military sector, then in aviation, often cited as a reference in the benchmark (Maurino et al., 1995; Helmreich and Merritt, 1998). Other tools, such as “stop when unsure” or “procedure use and adherence”, are common to many high-risks sectors and industries. And a last tool as “questioning attitude” is very typical of nuclear industry.

Furthermore, all the tools don’t have the same goal. Some of them, such as “questioning attitude” or “self-checking” are mainly or strictly focused, for example, on the individual behaviours. Whereas other tools, such as “pre-job briefing”, “post-job review”, “turn-over” are designed to provide a response to organisational issues relating to the coordination of players.

Finally, in the INPO’ guide, tools don’t have the same status. Some tools, such as “task preview”, “job-site review”, “questioning attitude”, “stop when unsure”, “self-checking”, “procedure use and adherence”, “three-way communication” and “phonetic alphabet” are labelled as “fundamental”. But other tools, such as “place-keeping”, “do-not disturb sign”, “pre-job briefing”, “peer-checking”, “concurrent verification”, “independent verification”, “flagging”, “turn-over” or “post-job review”, are only labelled as “conditional” by INPO.

C. *Behaviourist programmes*

Reading the INPO reference manual, its behaviourist approach is clear: from the first words of its introduction—which sets the tone with a quote from Aristotle linking excellence to force of habit⁹—to the 274 occurrences of the word ‘behaviour’ in its 130 pages, not to mention multiple references to ‘reinforcing’ or ‘avoiding’ ‘good’ or ‘bad’ behaviours. The manual’s objective is clearly to help manage the behaviours of front-line workers, drawing on research with comparable ambitions in the field of psychology. The elements contained in the INPO manual are to a certain extent reflected in the IAEA document entitled ‘Managing Human Performance to Improve Nuclear Facility Operation’ (IAEA, 2013). While the first few pages of this Technical Report state that human performance improvement (HPI) must be integrated into a broader system (considering organisation, strategy, culture, etc.), the document then focuses on behaviour and ‘good practices in the use of HPI tools’¹⁰ (p. 2).

This behaviourist orientation, inspired most notably by Pavlov’s celebrated experiments, is based on theories developed from experiments initially carried out on animals and then extended to humans. This paradigm emerged in the United States in the early 20th century and is influential in the English-speaking world. It is built on the idea that individual behaviour can be conditioned, either through interactions with the individual’s environment or by reflexive responses to particular stimuli. Theorists working from this perspective take the view that behaviour is both predictable, in that it is governed by certain behavioural laws, and can be controlled using reinforcement, either negative (reprimanding or punishing undesirable behaviours) or positive (praising or rewarding desirable behaviours) (Skinner, 1969).

Close reading of the INPO guide reveals that its many references are not given the same weight. Behaviourism structures the approach, while

⁹ ‘We are what we repeatedly do. Excellence, then, is not an act but a habit.’ (INPO, 2006, p. 3).

¹⁰ HPI tools can also be found in another IAEA document devoted to ‘Behavioural Competencies of Employees in Nuclear Facilities’ (IAEA, 2020). This document is based on the INPO training manual (1997). It states that professionals must be competent in the use of ‘human performance tools such as self-checking, task review, situational awareness, three-way communication’ (p. 5).

the other authors, concepts and models—psycho-cognitive, psychosocial, systemic, managerial and cultural—are drawn in to add weight, detail and substance.

D. Epistemological tensions and contradictions

The analysis of the INPO manual reveals epistemological weakness. Specifically, compiling and combining multiple fields of knowledge and modelling approaches, while promising in practical terms, presents problems in that some of the disciplines and models to which the manual refers evolved—both historically and scientifically—in direct opposition to each other.

One epistemological incompatibility is between the ‘behaviourist’ and ‘cognitivist’ approaches. After a long period of dominance in psychology research in North America and Europe, behaviourism gradually waned starting in the late 1950s, when a competing paradigm known as cognitivism (Nicolas, 1998) emerged. Proponents of the latter accused their behaviourist colleagues of not sufficiently accounting for individual thought, particularly when it came to the influence of prior knowledge. It is therefore surprising, to say the least, to see work from these two schools of thought combined in the manual, which cites influential behaviourists specialised in general organisational management (Daniels, 1994) and industrial safety (Geller, 1998) alongside equally influential cognitivists working in nuclear safety (Reason, 1990; Rasmussen, 1986; Hollnagel, 1998), despite the fact that their respective models are barely compatible or even irreconcilable. As Karanikas and Zerguine (2024) point out, by combining different theories, ‘from a more pragmatic but still scholarly perspective [authors] collectively introduce unjustified generalisations, possibly unreasonable expectations, and occasional contradictions regarding conceptual, organisational, management, worker, and technology aspects’ (p. 8). The difficulty is that by focusing on psychological aspects, some of which are contradictory, other dimensions linked to safety and human performance are neglected.

Another epistemological tension arises from the heavy criticism that has been levelled against behaviourist theories by members of other fields in the human and social sciences. Behaviourists have been broadly critiqued for relying on reductive and rigid explanations for human behaviour, as well as for their express desire to condition individuals in ways that some sociologists have compared to the conditioning of animals (Crozier & Friedberg, 1977).

3. Inherent risks in the use of human performance tools

A. Monocausality in risk prevention and experience feedback perspective

A first risk of focussing risk prevention and feedback initiatives on front-line workers, becomes apparent when the INPO manual is read in parallel with an analysis that Hopkins (2006) published around the time the INPO manual was released. Hopkins’s analysis does not focus on human performance programmes in the nuclear sector, but on relatively comparable ‘behaviour-based safety’ programmes developed around the same time in the oil and gas industries. While the latter are less structured and employ fewer theoretical and conceptual tools than the former, they have two important features in common.

The first of these relates, once again, to the fundamental mindset behind these programmes that ‘human factors’ are the main cause of failures and that controlling human behaviour is the next and possibly the final frontier to be crossed in safety, as shown in the image below (Fig. 1), which was inspired by a graphic in a manual written for the oil and gas industry (Step Change Group, 2000) and reproduced by Hopkins (2006).¹¹

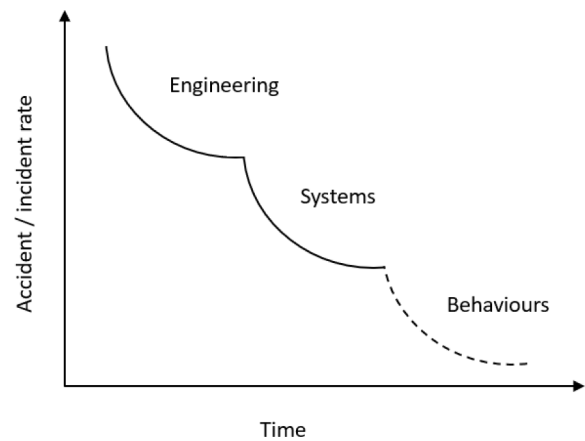


Fig. 1. The three ages of safety, cited in Hopkins (2006).

The second commonality is the types of practical countermeasures recommended to limit risks of error. For example, Hopkins cites the so-called SLAM approach (as in Stop, Look, Assess, Manage¹²), which echoes the principles underpinning some of the HPI tools, such as the pre-job briefing and the two-minute rule.

As early as 2006, Hopkins warned of a danger in this type of programme, arguing that if its proponents believed that safety would improve through approaches to risk prevention centred on the behaviours of front-line workers, they would also be tempted, in the event of an accident, to assume that those behaviours were its cause. Hopkins inferred that by assuming monocausal blame, they would be committing a major error in reasoning. In contrast, and in keeping with the then-recent work of Reason (1997), certain safety specialists at the time were calling for a much more systemic and therefore multi-causal approach to accident analyses and risk prevention.

By the same token, Rollenhagen (2010) identified this type of ‘unbalanced’ approach of safety management regarding ‘safety culture’: asking if this concept couldn’t become an ‘excuse’ for not thinking or rethinking design of technology or organisation. In the case of human performance as in the case of safety culture, this excessive focus on behaviours is not necessarily deliberate. But it risks diverting attention from other issues, at the expense of technological or organisational improvements. Moreover, this focus on behaviours could be even more tempting, given that technological or organisational changes are often long, complex and costly to implement.

B. The risk of blame

The second risk revealed upon reading the INPO manual (2006) is the risk that blame will fall on workers perceived to exhibit undesirable behaviours. In line with Reason’s (1997) work, the guide reminds us that the question of blame is a complex and delicate one. On the one hand, the INPO guide begins by explaining, in its section on management, that open communication about safety issues and possible errors is one of the best defences against problematic events, for two reasons. The first is that open communication avoids entering a ‘vicious cycle of blame’ and an accompanying culture of secrecy, in which individuals who believe their mistakes will be punished will tend to withhold information, as a result of which latent organisational shortcomings will not be corrected. Conversely, in an open, fair environment, problems are more likely to be brought to light and corrected. The second is that open communication

¹¹ This diagram was highly successful and circulated widely among operators, demonstrating the porosity of industrial sectors.

¹² The SLAM approach is based on four simple actions: ‘Stop—Engage your mind before your hands; Look—At the workplace and find the hazards; Assess—The effects of the hazards on people, property and the environment; Manage—With effective controls and advise others’ (2006, p. 590).

also makes individuals more responsible for their actions and more proactive in finding solutions to any problems they encounter: they understand they are allowed to make mistakes and will therefore seek assistance more easily in the event of difficulties. On the other hand, however, the INPO manual stresses the limits of this open, understanding and non-punitive approach to mistakes. It claims that the approach would conflict with the practical need to determine the degree of responsibility of the individuals involved in an incident or accident. From this point of view, the INPO guide is fully in line with Reason (1997) who “admits that a “no-blame culture is neither feasible nor desirable” (Reason, 1997, p. 195), an organization must be willing to examine how it assigns blame and punishment in order to create the more positive “just culture” that Reason proposes” (Coan, 2002, p. 235).

However, according to Hopkins (2006), regardless of the intention of behavioural safety advocates, their approach is inevitably associated, in practice, with a tendency to blame workers adopting unsafe behaviours. Still in line with Hopkins, it can be pointed out that not all HPI tools present the same degree of risk. First, the risk is higher for tools focused on individuals, such as “self-checking” or “stop when ensure”, than for organisational tools, as “pre-job briefing” or “post-job briefing”, for example. In the latter case, in the event of an error, if blame is still to be attributed, it will be to the work group as a whole or even to the organisation. An evolution can be noted in the IAEA technical report (2013). While most HPI tools are aimed at reducing individual errors, some of them are presented as being focused on eliminating organisational weaknesses (p. 16).

4. Origins and development of EDF’s human performance project

We are now going to analyse the way in which the discourses of the promoters of HPI tools have evolved over time through a documentary analysis of a large French company: EDF. We have focused on this company because it began implementing HPI tools in 2006, and numerous written sources are in the public domain.

A. Initial alignment with recommendations from the Institute of Nuclear Power Operations

Against the backdrop of a powerful international dynamic initiated and structured by INPO (2006) and WANO (2006), EDF in 2006 became the first French nuclear operator to launch its own ‘Human Performance’ project (EDF, 2013) and introduce its own HPI tools.¹³ To give impetus to and explain its approach to its target audiences, EDF published two booklets within a few months of each other. The first, intended for field workers, presents HPI tools as practices to enhance reliability (EDF, 2006). The second, intended for managers, explains how to support implementation of this new approach (EDF, 2007). Examination of these booklets reveals that EDF’s project at that time closely aligned with INPO recommendations.

It develops the idea of identifying error precursors, described as ‘error-prone situations’, whether relating to the requirements of the task or to constraints in terms of organisation, the work environment, the intrinsic limits of human nature, or the specific abilities of a particular individual. The error-prone situations listed by EDF closely resemble the typical risk precursors defined by INPO: time pressure (urgency); excessive or inadequate self-confidence; habitual, routine activity; a lack of experience (first time on the job); unclear roles and functions; changes to schedules or working conditions; a recent change to a procedure; high-impact or high-risk activities; an irreversible action required as part of the work; extended, laborious activity generating significant fatigue and stress; complex activity involving multiple participants (such

¹³ The French name of the HPI tools could be translated as “practices to ensure reliable interventions”.

as supervising an apprentice); frequent interruptions; and inattention.

After listing these main error-prone situations, EDF presents the six HPI tools available to prevent them: the pre-job briefing, the two-minute rule, self-checking, peer checking, effective communication, and the post-job briefing. The way in which EDF presents these tools is also similar to the INPO standard. EDF begins by explaining *what* each entails and the procedure for *how* it must be implemented. It then describes the purpose and meaning of each tool from a teleological angle, explaining *why* it must be implemented. Lastly, EDF specifies in which contexts and therefore *when* the tool is relevant, implying that the tools are not intended to be used systematically and automatically, but adaptively and selectively depending on the specific circumstances of the work, which is once again consistent with the recommendations in the INPO guide.

B. Shift from conditional to automatic use of human performance improvement

The project to implement HPI quickly received support from the highest echelons of EDF, which set out to roll out and systematise their use. In accordance with INPO recommendations, the tools were introduced through an extensive programme that included classroom, simulator and onsite training for the entire staff. The initiative concerned all nuclear power plants, all disciplines and workers at all levels. The training was initially required for EDF employees only, but soon extended to workers and supervisors among EDF contractors.

Top management’s support for HPI soon brought a change in discourse regarding its conditions of use, as evidenced by a 2009 report by the Inspector General for Nuclear Safety and Radiation Protection (IGSNR). He called for these practices to become ‘second nature’:

I believe in the effectiveness of these practices; they have proven their worth in other industries, and I have used them myself in my previous roles.¹⁴ I encourage all stakeholders, EDF employees and contractors to embrace them so they become second nature, like speaking a language. (IGSNR, 2009, p. 13).

After seven years trialling its Human Performance project, EDF conducted a review and determined that the results were positive enough for the project to be permanently adopted as a programme, beginning in 2012 (EDF, 2013; Moreau, 2012). The Nuclear Generation Division then undertook a quantitative analysis of their effects, exercising the customary precautions in interpreting the data. Its analysis highlighted with satisfaction a number of ‘visible results’ in terms of safety:

There has been a marked decrease in the number of reactor trips since 2008. Two-thirds of this reduction is attributable to a reduction in Human Factor causes. We have seen an equivalent decrease in Events Significant for Safety resulting from human error, with the number divided by a factor of three between 2007 and 2010. The results in 2013 were even better, with no human performance-related reactor trips. In the social sciences, it is difficult to establish direct causal links, due to the large number of interdependent variables. Nevertheless, this statistical approach is a useful indicator, especially as exact equivalents are found in experiments in other countries (EDF, 2014).

At the same time, an even more pronounced change was taking place in the division’s attitude towards understanding and using HPI tools:

French culture places more emphasis on an actor’s skills and understanding of the situation than on implementing standardised reflex practices. Consequently, it takes a great deal of time and energy to persuade workers that it is not enough simply to understand and want to change their behaviours and habits. Rather, they must also learn to monitor and control their mechanisms of action that are largely automatic. This change is primarily

¹⁴ Note that all Inspectors General have come from a similar background: former senior officers who have served in the French Navy and, more specifically, aboard nuclear submarines.

collective. It requires constant managerial efforts that strike the right balance between enforcing rules and conveying meaning to workers (EDF, 2014).

C. A shift towards a more behavioural and procedural approach to safety

These statements reveal changing attitudes about HPI tools, compared to when they were first deployed. They show the emergence of a different vision of the working human and a different model of safety.

In the first booklet, published for workers (EDF, 2006), EDF had linked the use of HPI with the identification of certain risk situations. It had also relied on, to repeat the wording cited above, the ‘actor’s skills and understanding of the situation’ to identify risk situations and determine the appropriate HPI tools by asking ‘what, why, when and how’ questions in each such situation. In this respect, EDF’s approach was consistent with the INPO recommendations, which stipulated that HPI should not be required systematically and used mechanically but turned to on a case-by-case basis as needed (INPO, 2006). However, posters displayed more recently at the various nuclear power plants in the fleet send a different message, championing automatic, universal, and systematic application of HPI as an ‘automatic reflex’ (IGSNR, 2019). Workers and their managers are no longer expected to understand why, when, and how to use HPI as a tool, but to comply with these new ‘rules’ of behaviour in all locations and circumstances, like other compulsory workflows.

The shift in position is also visible in the annual reports from the IGSNR. In 2013, the Inspector General who had supported and seen the adoption of these practices a few years earlier (IGSNR, 2009) wrote of HPI tools and safety in a way that focussed far more on the organisational and collective dimension than on the behavioural and individual. He stressed the need to address ‘root causes’ and emphasised the benefits of the various ‘opportunities for listening and dialogue with workers, before and after the job, as well as at the start, during and at the end of unit shutdowns’ (IGSNR, 2013). Upstream, the two-minute rule and pre-job briefing, when coordinated with the risk analysis, facilitated effective job preparation and risk prevention. Downstream, post-job briefings, when coordinated with experience feedback, could help in detecting and reporting ‘weak signals’ (IGSNR, 2013). Reports produced by subsequent Inspectors General have shown a striking change of tone and register. One called on workers to show more ‘discipline’ in applying HPI and exhorted managers to demonstrate greater ‘commitment’ to upholding the approach and ‘intransigence’ when enforcing its application (IGSNR, 2016). Managers were also exhorted to aim towards HPI tools becoming used as an ‘automatic reflex’ (IGSNR, 2019). The current Inspector General likens the use of HPI to ‘a discipline’ (IGSNR, 2021).

5. Risks associated with the shift

This new orientation for HPI appears to deviate away from the recommendations in the INPO guide (2006) as well as EDF’s original project (2006; 2007). This type of move is not specific to EDF, but seems to be characteristic of high-risk industries which, in their quest for performance, see the control of human behaviour as a new source of improvement (Hopkins, 2006). In our opinion, whereas the initial project represented an opportunity to improve safety, the vision shift, if it is followed by action, opens up three kinds of risk.

A. Risks of managerial action weakening the risk control system

A first risk concerns upper management’s ability to weaken the balance and coordination of the various risk-prevention measures. As

early as 2006, Hopkins (2006) was concerned that senior leaders are the most at risk of missing key safety factors and making poor decisions based on misguided principles and unsuitable indicators.¹⁵ There is a likely cause for concern with recommendations that encourage to make HPI a mandatory routine. It is understandable that top managers would be tempted to conclude that their approach is correct when their chosen performance indicators are positive. But the defence-in-depth system appears to be weakened by an overly behavioural and monocausal approach to safety (Hopkins, 2006; Moreau, 2012), which can tend to take precedence over identifying, implementing, maintaining and improving other supplemental and alternative technical and organisational defensive barriers.

The second risk relates to lower level managers, who are expected to help with the rollout of HPI in their field inspections and observations (Hopkins, 2006; EDF, 2007). In the first presentations advocating for the deployment of the tools, they are expected to guide and support their team, promote, and encourage best practices, facilitate team members’ work, and coordinate dialogue between managers and the workers who report to them, reconciling their points of view. They are also expected to relay to their superiors any needs for technical or organisational improvements. At the same time, managers are also expected to remind their subordinates of the ‘requirements’ within their teams, make workers ‘understand’ and ‘comply with’ them, and participate in reporting and processing ‘non-conformities’ (EDF, 2007), all while remaining ‘positive’ and taking care not to view themselves or be perceived as ‘policemen’, to use a term employed in a practical guide cited by Hopkins (2006). In his view, however, this warning is futile. Hopkins considers that such a behaviour-centred programme will inevitably risk that managers become controlling and blame front-line workers. Among the possible harmful consequences, this approach can deter workers from reporting difficulties to their managers if they know they have every chance of being blamed for them.

B. Less visible factors in safety become obscured

According to Hopkins (2006), another drawback to programmes centred on worker behaviour is that they place too much emphasis on ‘observable’ behaviour, even making it one of their guiding principles, as confirmed by review of the 2006 INPO Manual (2006). Human performance improvement is designed with the intention—and in some cases a requirement—that workers visibly demonstrate their use of HPI with specific gestures, as shown in EDF’s training visuals (Moreau, 2012; EDF, 2018a). Recent efforts to create an HPI procedure seem to reinforce this expectation for observable behaviour by integrating it into evaluation processes (EDF, 2018b).

The problem with this approach is that, as Hopkins’s analysis (2006) reiterates, in line with Pidgeon and Turner’s work, ‘a way of seeing is always also a way of not seeing’ (Pidgeon and Turner (1997)). These programmes are liable to focus attention on observable behaviours to the exclusion of other less or even non-visible yet equally essential components of risk management. Two components in particular come to mind: other job skills (since the formal HPI safety tools are merely one resource among others) (Besnard et al., 2017) and other organisational defence barriers (Hopkins, 2006; Reason, 1997) that contribute to safety in general and the implementation of HPI in particular. It should be noted that the 2013 IGSNR report (2013) had identified this risk, stressing that front-line stakeholders and managers cannot always work without disturbances, for reasons often relating to the organisation.

C. Risks of opportunistic misinterpretation of the original goals

The third type of risk, identified in other sectors by Hopkins (2006)

¹⁵ Hopkins has addressed this issue in numerous publications. See in particular Hopkins (2000; 2008).

and Clarke (1999), concerns perverse side effects generated by a safety management system so heavily geared to demonstrating compliant behaviour. Within such a system, HPI is no longer viewed as primarily a practical fool-proofing aid to benefit front-line workers and field managers; it is viewed—perhaps increasingly—as a means of reassurance for managers. It enables them to showcase, particularly to their own internal and external oversight bodies and technical support entities, the way in which the much-vaunted ‘safety culture’ permeates their operations.

A similar issue is whether front-line workers, managers and service providers might, in turn, use HPI to their own advantage through a kind of ‘strategic compliance hacking’ (Merle, 2010). They might think it in their immediate interest to adopt the most zealous and ostentatious application of HPI at every opportunity, in an attempt to derive an advantage such as a promotion or a contract renewal, even at the cost of neglecting HPI’s original intent and sacrificing some of its benefits in terms of safety, security, radiation protection and quality.

There is also a risk that compliance will take precedence over intelligent, appropriate application of HPI to a particular set of circumstances. A compliance context might also encourage employees to develop ‘ritual’ activities (Hopkins, 2006) that serve a symbolic rather than genuinely practical purpose.¹⁶

6. From risk to opportunity: Areas for discussion

A. Inherent sources of division and shift to be overcome

Our analysis of HPI finds multiple sources of tension underlying these types of programmes that focus on the behaviour of front-line workers and managers. These tensions are inherent in HPI as it is an approach that mixes extremely diverse, and in some cases conflicting, human activity and safety models. The approach remains centred on human error, despite being integrated into more global risk management systems in which humans-at-work are a resource. And it is often ambiguous regarding how responsibility should be attributed in the event of an error or accident.

Tensions can also exist in the conditions in which HPI is deployed, which vary between organisations and evolve over time. Our analysis revealed a gradual shift in the way HPI has been presented and promoted. Although HPI was originally conceived as part of a much larger arsenal of ‘human and organisational’ tools (Merle, 2013), it gradually became a central approach to be applied rigidly and universally.

B. First improvement: Create conditions that encourage stakeholders to adopt human performance improvement

Although HPI has on occasion been sharply criticised (Lévy & Moulin, 2014), and the shift towards systematic implementation does present risks, HPI practices can positively affect safety provided that they have stakeholder buy-in. According to an in-depth comparative study of maintenance personnel at three nuclear power plants in Northern Europe, buy-in to this type of tool depends on three main factors (Skjerve and Axelsson, 2014; Oedewald et al., 2014).

The first is the *group environment*, encompassing attitudes about mistakes and trust, as well as the general culture of relationships between workers and managers and among co-workers.

The second factor is the *meaning* that these tools have in the eyes of employees, who will adopt and therefore use them only if they consider them useful and well-integrated into their work practices. Their use must be perceived as natural and justified, considering a task’s

complexity or rarity, as well as the level of risk in the situation.

The third and final factor concerns employees’ *freedom to choose* whether or not to use these tools, based on time pressure, the availability of the human, material and documentary resources necessary to their use, and the tools’ flexibility and ease of use.

In addition to the fact that it was conducted in the nuclear sector, the above research (Skjerve and Axelsson, 2014) has two other major benefits compared to the other studies already cited. The first is the richness of its empirical data, which combine both qualitative and quantitative data and cover three power plants with contrasting circumstances and dynamics. The second major benefit of the research is its more detailed approach, which centres on understanding and assessing the factors for buy-in and rejection, rather than making arguments for or against the programme. After anticipating and evaluating the factors that contribute to the robustness or fragility of HPI practices, the study’s authors come to identify two points that require particular vigilance (Oedewald et al., 2014).

The first is the workload entailed in deploying this type of programme and the concomitant risk of conflicting instructions and demotivation if there is not enough time for implementation. Some of the workers and managers interviewed for this research pointed to the sometimes time-consuming nature of these programmes, citing not only the time required to use the HPI tools in the field, but also the time needed for all the related organisational work: training staff in advance, observing and supporting them with the process in the field, and processing data obtained from subsequent feedback on the experience.

The second point of vigilance concerns the meaning given to these practices and their conditions of use. Interviewees were concerned about somewhat ‘inept’ or ‘naive’ applications of HPI methods, which could paradoxically distract workers from performing their jobs. They also considered some HPI tools to be better than others, with perceptions of their respective benefits varying between power plants, disciplines, teams, individuals, tasks, objectives, working conditions and countries. The study’s authors therefore insist on the need for flexibility when using these tools, so that their intended users see sense in adopting them.

C. Second improvement: Talk about work to improve safety

The final avenue for overcoming the tensions underlying HPI programmes is to create opportunities for dialogue. This proposal was among the ideas put forward by Hopkins himself (Hopkins, 2006). Although sceptical and sometimes even critical of HPI programmes, he did not reject them outright; in fact, he pondered the conditions for their success, which he defined to some extent as mirroring their conditions for failure. In his foreword (Hopkins, 2006), he includes a reminder that high-level managers play a crucial role in creating opportunities for communication about work practices and how the work is actively and collectively organised. He also stresses that local managers should, at their own levels, organise frequent meetings with workers to discuss safety and respond quickly to their suggestions and concerns.

It is worth noting that although some of the HPI tools, such as pre- and post-job briefings, encourage communication, discussion can also be stimulated by proposing that HPI serve as part of a broader set of tools available to stakeholders. Talking about safety issues in general can ultimately be beneficial. For example, such debate may challenge the status quo and reveal certain assumptions to be false. It may also increase stakeholders’ margin of manoeuvre, creating an enabling environment (Falzon, 2013) in which they can thrive. Lastly, discussions relating to situations at work and professional practices necessarily precede the development of a collective competency that, in turn, leads to effective performance. In particular, this dialogue, and even professional disputes (Clot, 2007), can help in constructing a common operational framework (Terresac and Chabaud, 1990) and shared representations of a situation.

¹⁶ Hopkins expressed this concern in the following terms: ‘This is not to say that the mini risk assessment strategy is necessarily successful. If it is not carefully managed it can rapidly degenerate into an ineffective ritual.’ (Hopkins, 2006, p. 590).

7. Conclusion

This analysis shows that human performance improvement tools have intrinsic weaknesses relating to both their foundations and their deployment's arguments. This assessment also describes a shift away from the intended application of HPI towards a more systematic, procedural use.

One possible interpretation of this shift would be to view it as a regression to a behavioural approach to safety, which was dominant in accident analysis (Promé-Visinoni, 2014) and prevention until more system-wide approaches emerged in the aftermath of the Three Mile Island (Perrow, 1984) and Chernobyl (Reason, 1997) accidents. Ultimately, although the behavioural model on which HPI tools are based is being challenged regularly and aggressively, it is nonetheless enduring in practice within organisations. The risk of regression should therefore never be discounted, and constant vigilance against it is essential (Hopkins, 2006).

An alternative interpretation of this shift—which unlike the first, has not yet been addressed in the literature and therefore deserves to be developed—is that it expresses a clash between two competing visions of safety: a 'controlled' vision, in which activities and behaviours must be standardised, and a 'managed' vision, in which stakeholders must be given the flexibility to adapt to the infinite variability of the situations they will face in their work (Cuvelier and Woods, 2019). Each vision has a different conception of risk and the role of workers.

The 'controlled' vision considers that risks can be identified in advance and defensive barriers can be put in place for each. It typically perceives human workers as a threat, since, through their mistakes, they can weaken and destabilise this defence system. To avoid errors, workers' actions must be tightly controlled by means of procedures, or even replaced by automated systems. This vision assumes that the characteristics of work situations are known in advance and that any inherent variability is only marginal—which may of course be the case in many configurations. But the temptation to control the 'human factor' most often leads to activities becoming hyper-scripted (Amalberti, 1998).

In the 'managed' vision, risks are instead considered to be emergent and generated by an unexpected combination of factors. Human workers are perceived as a robustness factor that can help to reduce uncertainty. They are assumed to be competent and to apply available knowledge and the resources available in the work environment when not executing predefined scripts. With their ability to adapt and innovate, workers are seen as assets to reliability, albeit fallible ones needing to be equipped with appropriate tools.

The 'controlled' and 'managed' visions are both found in the nuclear industry, where considerable efforts are made to control and manage safety. Controlled safety is 'safety born of rules, i.e., regulatory authorities, specifiers, organisers, designers, managers, etc. Conversely, managed safety is a form of knowledge based on the practices, actual experience and know-how of field workers' (Cuvelier and Woods, 2019, p. 47). Some tools seem to correspond more to one vision than the other. More than the tools, the visions changes that go with them bear the trace of the oscillation. The ways in which they were conceptualised and applied demonstrate constant oscillation between the two visions, blurring the boundaries of each.

This oscillation is first apparent in the initial design of human performance programmes, where tensions emerge between, on the one hand, the desire to equip and support front-line workers and managers by introducing tools and working conditions that would empower them to handle situations acknowledged to be complex and random (managed safety), and, on the other hand, an equally clear desire to supervise and constrain their behaviour by using tools to create reliability and reinforcement techniques to script a rather general—and, as such, insufficiently precise—set of principles (a questioning attitude, a prudent, meticulous approach and dependable communication) hitherto associated with 'safety culture' (IAEA, 1991) (controlled safety). Oscillation is

also apparent in the deployment's arguments of HPI practices with, on the one hand, the desire (initially, at least) to leave front-line workers and managers significant flexibility regarding where, when and how to use HPI tools (managed safety), and, on the other hand, an increasingly marked desire to turn HPI into a rule to be applied as an 'automatic reflex' (controlled safety). As neither vision can be considered fully adequate for assuring safety alone, the oscillation does not appear to pose a problem. On the other hand, what could stand for a risk to safety is a clear shift towards controlled vision.

Human performance improvement tools therefore hold a tension between the visions of academics and industrial associations, between the visions¹⁷ of different scientific approaches. In our opinion, the most notable tension is between work as imagined and work as done, or 'Work as Agreed' vs 'Work as Possible' (Karanikas, 2022). One is idealised by designers and regulators, who tend to marginalise the variability in work situations and view it as exceptional when field workers interpret guidelines appropriately. The other is based on an acknowledgement that real-life work situations, on closer inspection, are never strictly identical: they are subject to unavoidable contingencies and various requirements (relating to safety, radiation protection, production, quality, and more), forcing field workers to arbitrate and make adjustments (Stoessel, 2010).

As a next step, in line with initiatives already undertaken in other European countries (Skjerve and Axelsson, 2014; Oedewald et al., 2014), it might be useful to devise a more discriminating approach to HPI, understanding the nuances and the specific operational, organisational and cultural issues associated with each tool. In this way, and to go further in the analysis, our work must be completed by a field survey, based on interviews and observations, to better understand the way in which managerial visions are embodied in the reality of work.

CRedit authorship contribution statement

Ivanne Merle: Writing – original draft, Methodology, Investigation, Conceptualization. **Alexandre Largier:** Writing – original draft, Methodology, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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¹⁷ The more precise content of each of these visions and the effects of the tensions between them on performance could be the subject of future work.

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