Practicing What We Preach: The Performance Shaping Factors of Human Factors Practitioners

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SUMMARY

The severity of performance shaping factors on human factors (HF) practitioners from safety critical industries in the United Kingdom (UK) is examined. Based on a Human Factors Analysis and Classification System (HFACS) survey, 32 HF practitioners reported that organisational influences were the most disruptive encountered PSF with the vocation ($p < 0.01$), compared with supervisory and workplace pre-condition factors. Follow-up semi-structured interviews with 5 participants highlighted these organisational PSFs could be attributed to the misperception of the HF role and value within organisational structures, contributing to the perception of HF receiving insufficient budgetary and organisational priority. Furthermore, participants viewed these PSFs to be significantly detrimental to their own well-being and to both the current and prospective health of discipline. Recommendations to address these issues are discussed.

KEYWORDS

Human Factors Practitioners, Performance Shaping Factors, Mixed Method Approach

Introduction

When Human Factors (HF) practitioners investigate the safety of a system the evaluation of external influences on human operators is crucial. Often referred to as Performance Shaping Factors (PSFs) (Kirwan, 1994), organisational, environmental and lifestyle considerations can significantly impact safety outcomes (Shorrock & Kirwan, 2002). PSFs are usually considered in primary and secondary users where failure to meet standards is observed, either through errors or violations. Shappell & Wiegmann (2000) defined errors as unintentional mistakes and violations are intentional breaks from rules or process. Organisational pressures and supervision issues are common forms of performance shaping factors (PSFs), which have been found to have contributed to problems in multiple safety critical domains including aviation (O'Hare, 2009; Chan & Li, 2021), nuclear power (Park et al., 2020), civil and military maritime (Gould et al., 2006). In many cases, the Human Factors Analysis and Classification System (HFACS) has been a valuable tool for HF practitioners in allowing the systematic identification, and hierarchical organisational ordering, of PSFs which contribute to a workplace environmental medium where human errors is more likely to occur (Shappell & Wiegmann, 2000). Concerning HF practitioners, decision errors could manifest as the misclassification of a system's respective risk, a skill-based error could be applying the wrong method, while a perceptual errors could be the failure to notice a safety issue during an observation. The persistent relevance of PSFs across safety critical domains make PSFs a good place to offer introspective view of the discipline, and may offer a good indication of the wider impact of PSFs on safety related disciplines.

Despite wide investigation of PSFs across safety critical industries, knowledge of HF practitioners PSF susceptibility remains elusive - a concern given that PSFs have been implicated in several high-profile accidents. These include the HF practitioner workload pressures of the 2006 Royal Air

Force Nimrod crash, as well as the financial priorities during the development of the Boeing 737 Max which resulted in several hundred fatalities. For example, the Haddon-Cave report (2008) of the respective Nimrod crash makes reference to high workloads of the HF professionals who delivered a sup-standard level of safety assurance being partly responsible for the accident. Similarly, the report highlights the commercial pressures the HF practitioners faced from their company. Together, these pressures present as forms of organisational and supervisory PSFs which undermined the essential safety assurance work that was undertaken. More recent evidence from the two Boeing 737 MAX accidents corroborate the view that commercial pressures continue to override the importance of HF practitioner safety assurance work (Department of Justice, 2021).

This paper investigates the frequency, impact and resulting severity of PSFs on HF practitioners from safety critical industries in the United Kingdom (UK) - Civil Aviation, Military Aviation, Other Defence, Maritime, Rail, Nuclear, Chemicals, Oil and Gas, and Information Technology. The research consisted of a mixed method design based on HFACS structured survey responses from, and follow-up interviews with, HF practitioners involved in the design and assurance of safety critical systems.

Method

Participants

Thirty-two HF practitioners took part in the survey, with follow-up interviews being scheduled with 5 survey respondents. Seventeen participants were chartered HF practitioners (53%). The average HF experience of the sample was 15.78 years (SD = 10.54, Min = 1, Max = 35)). Sample demographics are provided in Table 1.

Table 1: HF practitioner sample demographics

	N	%
Employer		
Government	12	38
Industry	18	56
Self-Employed	2	6
Sector		
Military (Other)	9	28
Civil Aviation	8	25
Military Aviation	5	16
Nuclear	3	9
Medical	2	6
Rail	2	6
Maritime	1	3
Chemical, Oil and Gas	1	3
Information Technology	1	3
Chartership Status		
Chartered	17	53
Working Towards	11	34
Not Interested	4	13
Tenure, Mean (SD)	15.78 (10.54)	

Survey Development

A novel HFACS orientated survey was developed to quantitatively capture the relevance PSFs on HF practitioner work. Thirty-nine PSFs were developed based on Error Producing Conditions (EPCs) from Human Error Assessment and reduction Technique (HEART) (Stanton et al., 2017). For example, the EPC *"An impoverished quality of information conveyed in procedures and person-person interaction"* became *"Human Factors related performance requirements of systems are unclear"*. Subsequently, 39 PSFs were grouped according to the three highest levels of the HFACS hierarchical taxonomy: *Organisational Influences*, *Supervisory Factors*, and *Pre-conditions for Unsafe Acts*. Arrangement of the 39 PSF's within this framework is shown in Table 2. Participants were presented a *frequency* and *impact* questions for each PSF - *"To what extent does this factor impact your day-to-day work usually?"* and *"If applicable, to what extent has this factor impacted your work at its most extreme?"*. Both questions used a 1-5 Likert scale (low = 1 / high = 5) with *impact* questions also including a not applicable option (scored as zero). Furthermore, a *severity* score was calculated for each PSF by multiplying its respective frequency and impact scores.

Interview Procedure

A semi-structured interview approach was adopted to: (1), expand upon participant survey responses (2) identify HF PSFs which were not captured in the developed HF PSF survey, and, (3) identify possible remedial measures. Particular care was taken to avoid leading questions, and the interviewer had extensive experience of conducting research interviews. All interviews were conducted on Microsoft Teams and ran for approximately one-hour.

Data Analysis

Since data exhibited parametric properties, one-way repeated measures ANOVA procedures were performed. In cases where sphericity could not be confirmed a Greenhouse-Geiser correction was applied. To check for differences in PSF severity scores between HFACS top-level categories, and between lower order HFACS categories within each top-level category. Only descriptive analyses are presented for participant *frequency* and *impact* ratings.

Transcribed interview recordings were analysed with thematic analysis based upon Braun & Clarke's guidance (2006). The data was first coded bottom-up, identifying themes that appeared naturally in the data. Themes were then grouped top-down using the categories provided by the HFACS model.

Results

HFACS Survey

Descriptive statistics for participants' frequency, impact and severity ratings to each PSF are presented in Table 2. Figure 1 show the mean severity scores to PSFs at top and lower HFAC levels. At the top level of HFACS, participants scored the severity of O*rganisational Influences* PSFs the highest (M = 9.60. SD: 2.15), followed by *Unsafe Supervision* (M = 7.53, SD = 3.96) and then *Preconditions for Unsafe Acts* (M = 7.04, SD: 2.74). A one-way ANOVA revealed a significant main effect for the 3 HFACS levels (F (2,62) = 8.271, $p < .001$, $\eta_p^2 = .21$). Bonferroni corrected post-hoc tests showed that the severity of O*rganisational Influences* PSFs was significantly greater than both *Preconditions for Unsafe Acts* (mean diff = 2.07, $p < .05$) *and Unsafe Supervision* (mean diff = 2.56, $p < .001$). The PSF severity difference between *Preconditions for Unsafe Acts* and *Unsafe Supervision* was not significant ($p = .99$).

The One-way ANOVA results for the lower-level HFACS categories found no significant differences for PSF severity within O*rganisational Influences* (F (1.52, 46.99) = 0.99, p = .075), *Preconditions for Unsafe Acts,* (F (1.38, 42.70) = .43, p = .579), or *Unsafe Supervision* (F (2,62) = 0.978, p = .382).

Table 2: Mean and standard deviation PSF frequency, impact and severity scores

HFACS Top-level	HFACS Lower-level	Scale Items (N)	Freq (low - high: 1-5)	Impact (low - high: 1-5, NA: 0)	Severity (low - high: 1-5)
Organisational Influence	Resource Management	8	3.07 (0.50)	2.78 (0.80)	8.69 (2.88)
	Organisational Climate	6	3.22 (0.58)	2.93 (0.82)	9.49 (3.11)
	Organisational Process	3	3.24 (0.69)	3.28 (1.07)	10.64 (4.08)
Preconditions for Unsafe Acts	Conditions of Operators	8	2.44 (0.54)	2.63 (0.69)	7.13 (2.81)
	Environment	4	2.71 (0.66)	2.57 (1.14)	7.32 (4.01)
	Personal Factors	2	2.44 (0.73)	2.56 (1.11)	6.67 (3.95)
Unsafe Supervision	Inappropriate Supervision	4	3.08 (0.76)	2.76 (1.36)	8.36 (5.05)
	Poor Operations Planning	3	2.58 (0.69)	2.67 (1.11)	7.21 (3.56)
	Ignored a Known Problem	1	2.59 (1.16)	2.59 (1.74)	7.03 (6.57)

HFACS Interviews

One-hundred and fifty-three coded transcript "chunks" were identified. Chunks are referred to as "uninterrupted sections of text on the same topic". Chunks related to *Organisational Influences* PSFs were the most prevalent (N=141), compared with *Preconditions for Unsafe Acts* (N=8) and *Unsafe Acts* (N=4).

Organisations Influences

Within resource management, four areas were found to be of particular interest: workload and stress, competence and recruitment and retention. All but one of the interviewees stated that workload was one of the largest PSFs they routinely experienced, (P1) "*she was in tears about her workload*" and (P3) "*the fact they now have to try and do three years of work in 18 months*." Participant's HF advice being dismissed, as a source of stress, was a notable theme: (P3) "*It's just very frustrating when you're trying to fix it and you're just like banging your head against the wall*." and (P1) "*I felt people weren't listening".*

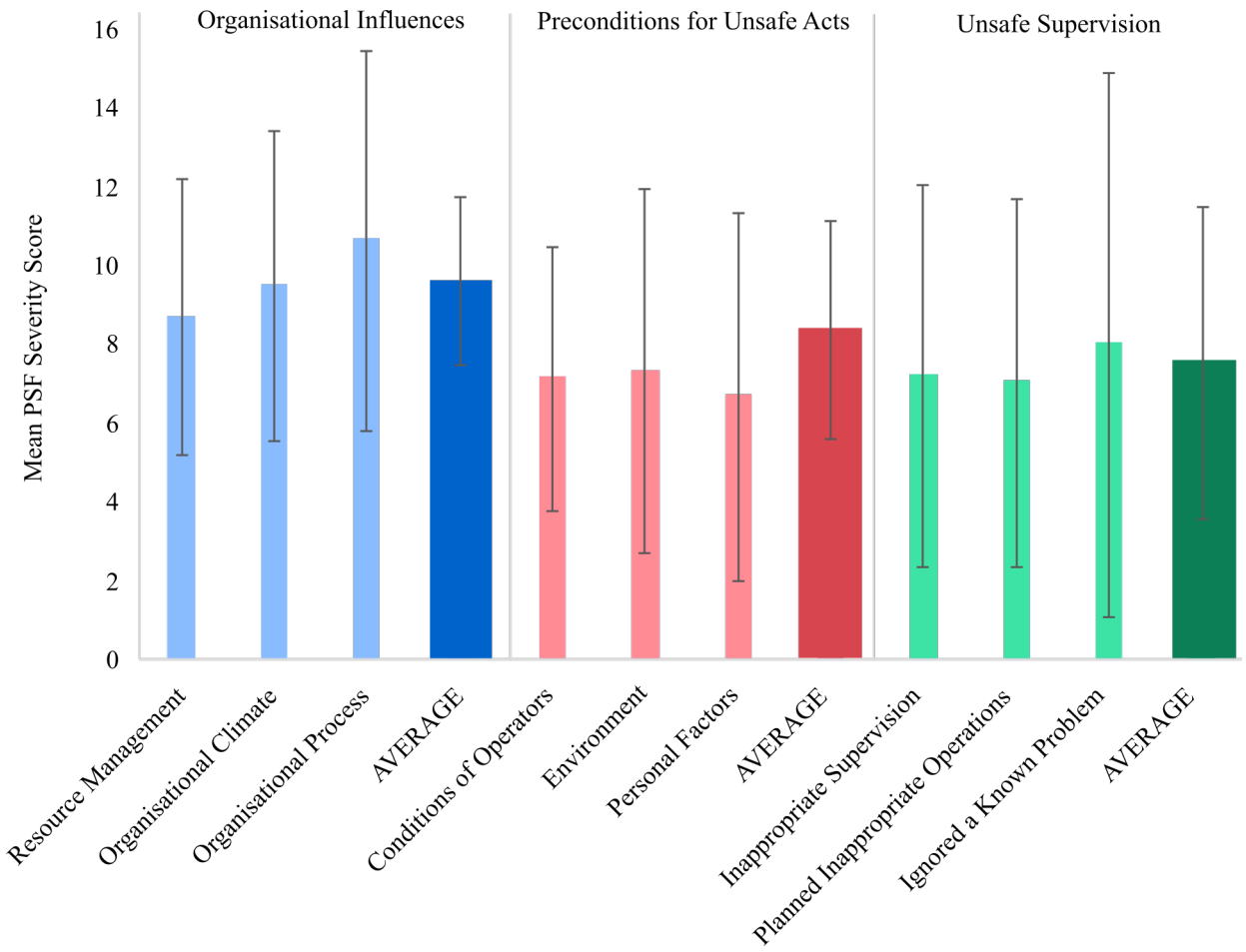

Figure 1: Mean HF practitioner severity ratings of PSFs grouped by higher and lower HFAC category. Error bars represent standard deviations.

Work stress was exacerbated by recruitment and retention issues, with turnover of HF staff, as a consequence of high workload: (P1) "*Turnover is extremely high because people come in and they think oh my god, and leave quite quick."* Work stress for HF practitioners was aggravated further by the perceived dearth of senior HF practitioners: (P4) *"Recruitment at the moment…to a large extent everywhere is competitive. We're all taking people off each other. There's only a kind of handful of organisations and [it's] hard to find the right people".* Likewise, the lack of a pipeline of HF professionals via undergraduate HF courses, and the requirement to take on unqualified undergraduate trainees. P4 offered "*there's a general shortage coming up*" given that "*there are fewer degree courses in the human factors profession*".

Interestingly, P2 suggested a recruitment specific HF issue could be that specific industries might have concerns about employing staff from a general HF background; (P2) *"There seems to be a bit of a stigma attached … I'm sure there's an element that people would be nervous about employing human factors resource if that resource didn't have any industry specific knowledge."* A recruitment related issue mentioned was that, within one organisation, the recruitment panel for a HF vacancy lacked any HF experience. The recruitment decision for the HF position was instead (P3) "*based purely on what you write on the paper, but the questions on the paper don't allow you to discuss the rationale… it's a very restrictive document to the point that these safety posts got rejected*". In another organisation, emphasis was appeared to be about recruiting anyone into the role rather than the right person: (P1) "[*quoting a hiring manager*] "*Just get somebody in, or*

otherwise we'll lose the budget". And in the safety environment that is really not good enough because you are putting people's lives at risk.".

Participants voiced issues concerning organisational climate that were not unique to HF professionals. One participant (P1) simply stated that their organisation "*lacked a safety culture*", while another other (P3) implied a lack of a safety culture by stating "*people are quite scared to speak up at the moment*". However, organisational climate issues that were unique to HF partitioners included processes for signalling HF work demands. Correspondingly, one participant reported that the HF role in their organisation was unclear outside of the HF staff (P5) "*I've been called, everything from HR [Human Resources] specialist to a CRM [Crew Resource Management] specialist*." and (P4) "*there's a perception that human factors is a nice to have.*" Relatedly, participants reported unreasonable challenge to their assessments, where stakeholders would argue against HF recommendations or concerns: (P1) "*I was sometimes made to doubt myself. I remember having a conversation with the site manager and him saying in quite a patronising manner… "Have you not worked in manufacturing before?" That makes you start doubting yourself, doesn't it*?"

The conflict of commercial and safety priorities within organisations were keenly felt by participants. One participant perceived their organisational processes to be designed to protect the company from a legal perspective rather than to implement and disseminate HF findings: (P1) "*because it's legal privilege but we're never gonna learn if we can't talk about incidents and talk about what happened…those lessons were not exploited".* The conflict was substantial enough for one participant to carefully consider their self-written objectives. (P5) *"It's related to whether I get my bonus…Now a lot of my goals could be shut down because of fear from commercial or branding... But if I'm to do the right thing by safety and get my goals I have to do [safety related work], but I'm not gonna reach my goals if commercial win. So what? Which one is it? What do you want me to do?"*

Unsafe Supervision Influences

Two individuals discussed poor management of HF, with both referring to managers above the HF team leader level. The first comment (P1), related to earlier resource management issues, is that senior managers failed to acknowledge resource and competency issues and would not support hiring action to resolve those problems. The second comment (P5) referred to a lack of strategy after a competent manager moved on and was replaced with an individual less concerned with HF, "*…then we didn't really have a manager we had a head of safety, if I was dead honest. It did fall apart from there because there wasn't a decent strategy*."

Preconditions for Unsafe Acts

The physical environment was discussed as an issue by one participant (P4), who was concerned that because HF practitioners worked away from front line operational staff that this would contribute towards negative feeling or poor understanding of HF, "*I hear such a disconnect between the operation people going, oh, they don't care about us, something more to side. I spend my day in, day out, caring about people, but they don't see that*". While it may be impossible to always work physically near front line staff, and the participant recognised that, they were concerned that there were few opportunities, due to operational pressures and perceived additional effort from operational staff, to observe staff in safety critical jobs stating that, *"I need to see the operation to understand it, to feel it, to do the right thing. Like, you know, this brings us into work as done versus work as imagined".* The participant was concerned that the accuracy of their work may be

impacted, given that what they are told about operations potentially differs from how they are carried out.

Discussion

This study provides evidence HF practitioners are mostly confronted by PSFs that can be categorised as organisational influences according to the HFACS framework. This finding was supported by both the survey and interview data. In particular, the results suggest that a range of organisations PSF, in the form of resource, process and climate, which impede HF practitioner work. For example, the misperception of HF's role and value within organisations is a significant barrier to the quality of the safety work performed by HF practitioners – sometimes leading to the dismissal of HF recommendations. Resultingly, HF safety recommendations are not perceived as being well managed by HF practitioners, likely facilitated by higher managers possessing a poor understanding of HF. It can be considered that more holistic approaches are needed to convince individuals and organisations of the risks of overlooking HF input. Currently, this responsibility appears to be placed on individual, or small groups, or HF professional, and represents considerably aggravator of HF practitioner workload. Additional workload contributors included the difficulty recruiting qualified HF personnel. This corroborates research showing the impact of highly specialised individuals leaving a profession upon the elevation of workload on those remaining (Yan & Sun, 2022).

Resource management issues represented the most impairing PSFs within the survey and the interviews. This suggests the HF discipline is currently confronted with having greater demand than there is supply. Whilst beneficial at the individual level, it presents a difficultly to safety critical organisations where there are limits on financial and experience resource to meet HF requirements. The interviews raised that this issue may get worse as, in the UK at least, due to the absence of undergraduate HF relevant courses. Add to this the reticence suggested in interviews of employers hiring graduates and investing in training, due to the risk of them leaving. There is a clear risk of there being a much smaller pipeline into the discipline. With this in mind, if nothing is done by the discipline as a whole, workloads will continue to increase. Without an appropriate training pathway, the HF discipline may not be sustainable. This issue appears to be common across Science Technology Engineering and Mathematical (STEM) disciplines, particularly in defence given nationality requirements, as the UK is producing fewer specialists in these fields (Turner, 2022).

One area of concern within the organisational climate was how operational demands could outweigh the importance of HF safety work. Described as a constant battle between safety and commercial by one participant, that there is a concern that any criticism of safety could damage an organisations image. This was found in both commercial aviation and the medical industries. A recent report by the House of Commons Defence Committee (Defence Committee, 2022), following a review of integration activity, described the Ministry of Defence (MOD) as having a "cultural resistance to change or criticism". Although this was not directly in relation safety, it does suggest an organisational climate where the open constructive criticism needed in safety critical areas could be supressed.

Safety culture is often discussed in relation to safety critical industries and refers to the empowerment of employees within an organisation to prioritise safety (Choudhry et al., 2007). Safety culture was perhaps not expected to be discussed as impacting HF practitioners, who might be expected to be promoting it rather than be affected by it. Nevertheless, in the current study, HF practitioners have been impacted by their organisation's safety culture. It is damaging for HF

practitioners in two ways. Firstly, it makes reporting safety issues and having them addressed difficult. Secondly, it makes it difficult to identify HF safety issues as operators are less likely to spontaneously report issues, or to be open during engagement, for fear of blame.

HF practitioners are impacted by PSFs, and this impact is not limited to any single safety critical industry. The survey data provided several initial PSFs to examine, while the interview data has provided a rich picture of the impact of PSFs on HF practitioners professionally and psychologically. While this research did not explore the mitigating factors for PSFs, the extent to which PSFs effect HF practitioners involved in designing and assuring safety critical systems has been partly answered. The positive impact of increased awareness and support for HF by senior leaders should be considered by organisations seeking to reduce the impact of PSFs on HF practitioners.

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