Circles of Influence: How do you arrange 200 Performance Shaping Factors?

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SUMMARY

The Circles of Influence model is a method of organising Performance Shaping Factors that encourages the user to consider the bi-directional way in which many variables might interact to influence human performance. The model is presented as a tool to aid Ergonomics and Human Factors practitioners when undertaking activities such as project and task scoping, requirements capture, risk assessment, and Human Reliability Assessment.

KEYWORDS

Performance Shaping Factors, EHFA, Model, Method, Nuclear, Human Reliability, Tool, UX

Introduction

We often have a hard time understanding and explaining Ergonomics and Human Factors (E&HF) because there are so many facets to the discipline. Have you ever considered how many unique topics, subjects, domains, or E&HF areas of concern there are? You may have encountered a number of different models, or taxonomic breakdowns of E&HF through HF Integration (HFI) methodologies, or in the way the subject matter is sub-divided in books and other written material.

As E&HF professionals, we aim to optimise human capability, error probability and well-being through applied consideration of all the factors that may influence human performance – often referred to as Performance Shaping Factors (PSF). There are a number of good sources for prompts to consider a broad variety of PSFs, often centred around keywords such as Task/Process, People/Person, Equipment/Tools and Environment.

Would you be surprised if it was suggested to you that there are at least 200 PSFs that we might consider when undertaking a HF assessment? How are we supposed to remember and apply or consider all of those factors? Why would we?

This paper sets out a model of organising human factors, in the context of identifying PSFs, that encourages the practitioner to think about the user experience and the variety of inter-related factors that may influence human performance.

HF Domains, Keywords & PSFs

There are a large number of sources from which the breadth of human PSFs may be derived. Human related factors are commonly categorised or broken down taxonomically into domains, disciplines knowledge areas, topics or subjects. For example, Figure 1 provides a visualisation of the HF domains and technical guides available from UK Ministry of Defence (MOD) publications.

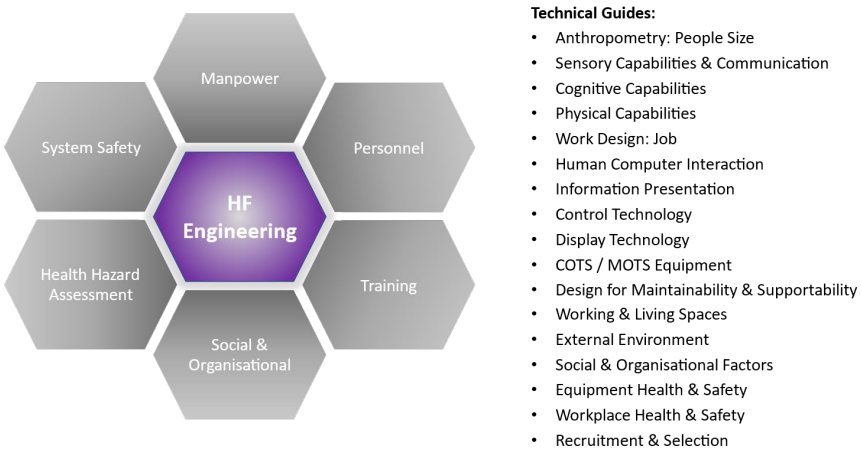

Figure 1: HF Domains and Technical Areas (UK MOD)

The PSFs presented within the Circles of Influence model have been derived from a variety of sources including textbooks, papers, technical guides, corporate guidance and manuals, standards and web sites. Those deemed to be most relevant and instructive have been identified within the References section.

Whilst these sources of HF related information are all of equal merit in their own right, the various lists of HF domains and PSFs are often incomplete (as they have been tailored to a specific purpose) and do not illustrate the relationships that exist between them. It was the author's ambition to collate as many PSFs as possible into an arrangement that would provide a single reference point that is applicable and useful to any context that requires HF assessment and the consideration of a broad range of potential human performance shaping factors.

One of the most commonly used images relating to HF, particularly in the context of HFI, is illustrated in Figure 2. Such images have been widely presented and have endured as they clearly visualise the inter-relationships between core HF related domains. Expanded and more complex versions of this arrangement can be found throughout HF related literature.

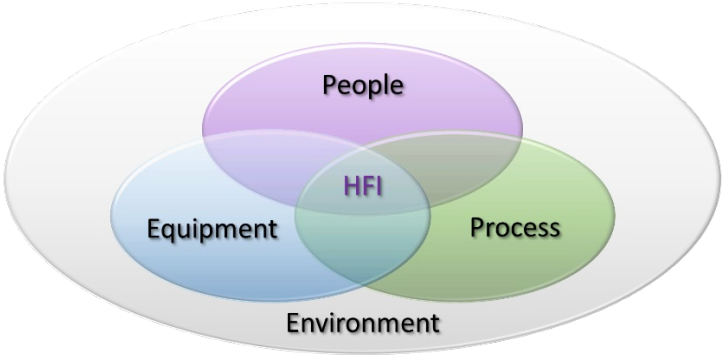

Figure 2: Visualisation of HF domains in support of Human Factors Integration.

It is acknowledged therefore that in many respects, the Circles of Influence model is no different, and indeed an adaptation of existing methods, expanding upon the concept of the human being at the centre of a complex system of factors that influence performance. The intention of the model is to:

- Provide a comprehensive list of PSFs in a single reference image.

- Encourage the consideration of how different PSFs and systemic elements influence each other.

The Circles of Influence Model

The model is based around the premise that User Experience (UX), or the Usability of a system (and therefore the potential for error) is influenced by the physical and mental attributes of the user, which influence, and can be influenced by their physiological, biological and psychological processes, which both influence, and are influenced by the way they perceive and respond to both engineered and socially organised systems, in the context of their working environment, made up of physical (real-world forces) and socio-cultural conditions.

This is a complex and difficult arrangement of inter-related factors to hold in mind, which is therefore visualised in Figure 3 below.

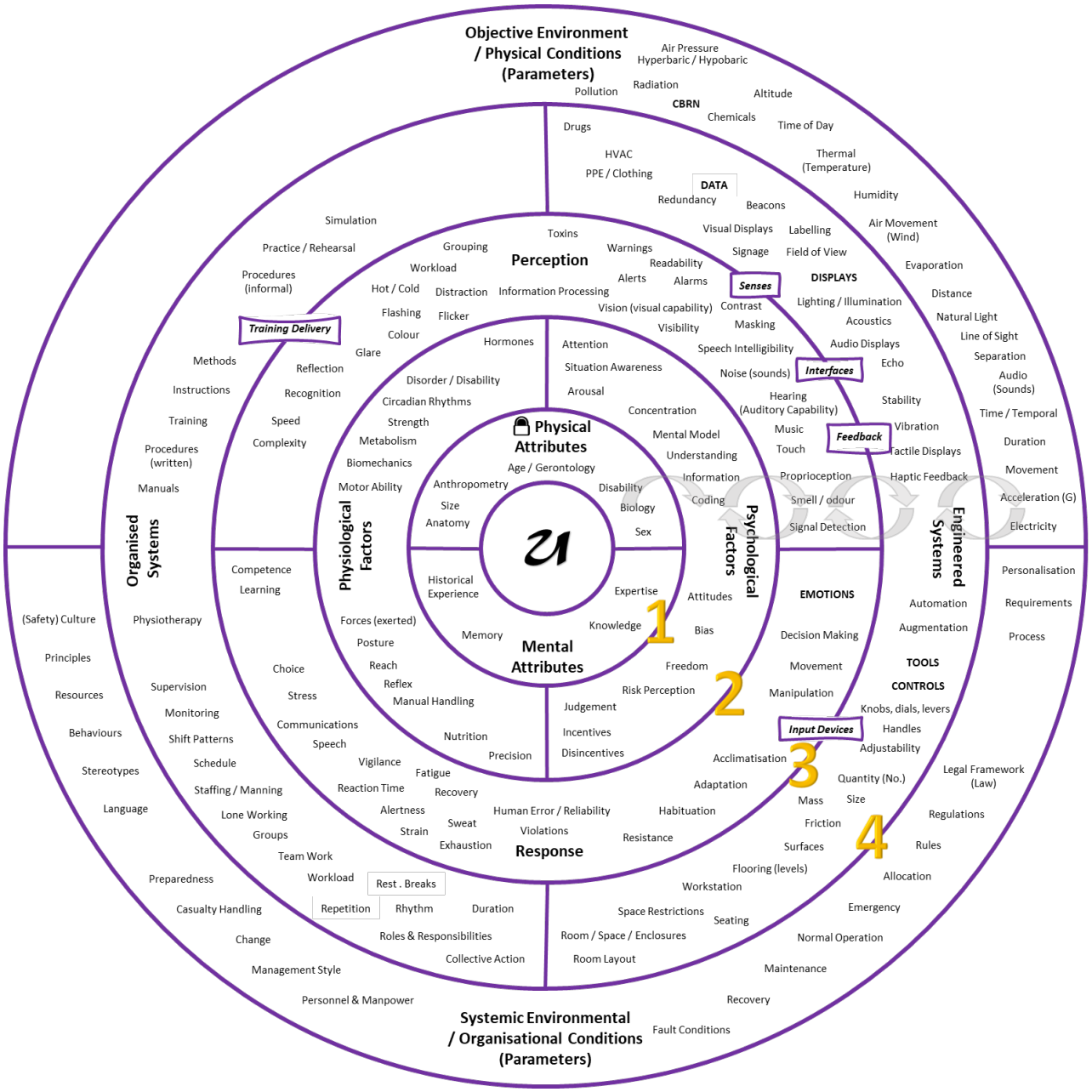

Figure 3: Circles of Influence Model

Model Layers & Influences

The model has been arranged as follows:

- **The Centre (U): Inner Circle / Layer 1:** The user or user group is at the centre of the model, and their primary attributes are divided into those of the mind (mental attributes) and the body (physical attributes). In the application of the model, it is considered that in the immediate context of task performance (in the present), the user has little control or influence over these factors. That is, people have little immediate control over, or ability to change their:
  - physical attributes such as gender, anthropometry, size or anatomy.
  - mental attributes such as their experiences, knowledge, memory capacity or expertise.
- **Layers 1 - 2:** A person's physical and mental attributes can have a significant influence over a variety of psychological and physiological factors, that in turn can influence their perception of, and response to the world.
- **Layers 2 - 3:** Physical, physiological and psychological factors can influence, and can be influenced by a person's ability to perceive and respond within a given context.
- **Layers 3 - 4:** Factors associated with perception and response can influence a person's interaction with Engineered and Organised Systems and vice versa.
- **Layers 4 - 5:** The performance of Engineered and Organised Systems both influence and are significantly influenced by broader environmental conditions and factors, whether physical, systemic or sociocultural.

Table 1 provides some examples of the bidirectional influences that exist between various PSFs. The table could never be exhaustive, and it should be noted that influences are not limited to binary relationships. A sequence of influences could exist spanning all layers that have a significant effect on user experience and performance. For example, the ambient environmental noise level will influence the design of an alarm system, which influences the way it is perceived and responded to, which in turn is dependent on the level of arousal, situation awareness and concentration of the user who has a specific level of knowledge and ability (based on their training) at that time.

Table 1: Examples of the bidirectional influences between PSFs.

Model Layers	PSFs	Influence	PSFs
Layers 1 & 2	Gender, age, anthropometry	Influence ⇨	Attitudes, reach, metabolism
	Disability, knowledge, expertise	Influence ⇨	Posture, forces, understanding
Layers 2 & 3	Attitudes, biases	⇦ Influence ⇨	Stress, information processing
	Biomechanics, strength	⇦ Influence ⇨	Fatigue, movement
Layers 3 & 4	Visual capability	⇦ Influence ⇨	Visual display system
	Thermal sensitivity	⇦ Influence ⇨	Local working environment
	Perceived complexity	⇦ Influence ⇨	Training, procedures, supervision
	Physical response	⇦ Influence ⇨	Tools & equipment design
Layers 4 & 5	Audio/visual interfaces	⇦ Influence ⇨	Light, noise, stereotypes, language
	Shift patterns, workload	⇦ Influence ⇨	Culture, Personnel, Management

There are many different paths and combinations, therefore the model encourages the user to consider the bi-directional relationships between many PSFs, which is particularly important when deriving requirements in support of capability development (equipment or workplace design) or considering dependency in support of Human Reliability Analysis (HRA).

The full model places 200 individual PSFs into each of these layers, providing a structured framework with a significant array of PSFs to consider during E&HF related assessment.

PSF Arrangement

The positioning of the individual PSFs within the model is relatively arbitrary and any person wishing to use this method is at liberty to change and adapt the arrangement. In most cases the application of the PSFs to the specific layers is deemed to be intuitive, although in the process of distributing the PSFs and in iteratively developing the model the following should be noted:

- The guiding principle was to start by positioning each PSF as close to the centre of the model as possible. However, if any PSF can be influenced by others then it must be moved accordingly.
- Similar factors, or factors that are commonly considered together have been positioned close to each other.

Boundaries of Control

Two notional boundaries of control have been identified in relation to the model.

1. Layer 1 marks the boundary within which a person's physical and mental attributes cannot be changed (within the context of a given assessment).
2. Layer 3 marks the boundary within which any system designer has very little control. For example, it is only possible to predict or influence (and not control) how an operator may perceive and respond to any given system or context.

User Experience and Emotions

The model has been developed with the context of Capability Development and Safety Substantiation in mind, specifically within complex systems associated with high hazard industries. However, the method is applicable for use in the context of UX assessment, where a user's emotional state and response may be an important factor. Although we all spend our days existing in an emotional state (often many in parallel), emotions and the importance of emotions to human experience and behaviour are less commonly acknowledged or considered during HF assessments. However, in the context of UX and systems design, it is acknowledged that emotions play a significant role in the way operators perceive and interact with systems, and influence attitudes, motivations and behaviours. Although the model does not explicitly accommodate all human emotion, Table 2 provides a set of emotions that have been identified in the course of its development. The table is divided into two sides, those that are considered to have a notable effect on human attitudes and system performance that can be influenced by system design, and those less so. It is acknowledged that this classification is relatively arbitrary and has not been validated.

Table 2: Human Emotions

Influential Emotions		**Lesser Influential Feelings & Emotions**
Angry	Insecure	Amazed, Ashamed, Bitter, Depressed, Disdain, Disgusted, Embarrassed, Energetic, Envious, Foolish, Furious, Grieving, Hopeful, Hurt, Inadequate, Inspired, Jealous, Joy, Lonely, Lost, Loving, Miserable, Proud, Relieved, Resentful, Shocked, Silly, Stupid, Suspicious, Tense, Terrified, Trapped, Worthless.
Annoyed	Irritated	
Anxious	Motivated	
Bored	Nervous	
Comfortable	Overwhelmed	
Confused	Peaceful	
Content	Sad	
Determined	Satisfied	
Eager	Scared	
Excited	Self-conscious	
Frustrated	Uncomfortable	

Worried	Complacency	

Use Cases

Typically, when undertaking HF assessments, it is not practicable or necessary to either identify or consider so many different PSFs. However, within a (UK) regulatory framework that encourages the demonstration of a comprehensive, systematic and methodical approach to risk assessment (including the consideration of human factors), it is important to establish confidence that nothing that should reasonably be considered (within scope) has been inadvertently omitted.

The method has been developed with several specific use cases in mind. There are various reasons why a HF assessor might want to consider a blue-skies approach to identifying as many PSFs as possible relating to a given context. For example:

- **Project Scoping:** When the problem space is poorly defined, the HF assessor may wish to refer to a broad set of topics to ensure the full breadth of potentially relevant human factors have been considered.
- **Bid or Proposal Writing:** In response to a statement of work or initial scope of work, that requires the HF assessor to determine which human factors (and related activities) are most applicable to the given context.
- **Early Human Factors Assessment (EHFA):** EHFA is often undertaken at the start of a project to formally identify and capture the range of human-related concerns to be addressed.
- **HF Integration Planning:** Aligned with EHFA, a comprehensive consideration of all potential human related issues is necessary in support of identifying potential HF related risks, assumptions, issues, dependencies and opportunities (RAIDO).
- **Risk Assessment or Hazard Identification:** Consideration of a broad range of human factors and PSFs is beneficial in direct support to formal risk assessment.
- **Human Reliability Analysis (HRA):** The consideration of PSFs (or error producing conditions) and their interdependencies is a core aspect of HRA, both qualitative and quantitative.
- **Requirements capture:** Understanding the full range of human related concerns relating to the procurement or development of a new capability is essential when capturing human related system requirements. The model and set of PSFs presented within it provides a useful guide to prompt the consideration of how human performance may influence and be influenced by system design requirements.

Regardless of the specific application, within the context of HF assessment it is important to demonstrate that the approach taken is methodical, systematic and comprehensive. Any HF assessment process is made more robust where the assessor is able to demonstrate not only which factors have been deemed to be applicable, but also those factors that have been deemed not to be applicable (with justification).

Practical Application

At the time of writing (February 2024), the model has been established and relatively stable for a number of years. The Circles of Influence model was not developed in support of any particular programme of work and was not funded by any external organisation to meet any particular purpose. The model was created to be a useful reference point and tool in support of the activities (use cases) outlined above. The following modes of application have been implemented over several years of use.

Reference model

In its simplest guise, the Circles of Influence model is a useful reference point, or quick look-up diagram when considering HF in any given context. As noted, it is rarely necessary that a HF assessor is required to consider all and every potential PSF, but equally, a full and complete list can be hard to find, and it is often useful in support of a quick verification check.

Scoping & EHFA

The model has been used (although not formally documented) in the context of project scoping, and EHFA. The author has chaired a number of 'round table' discussions where the project context and role of the operator has been set out, and where necessary, broken down into smaller functional nodes. The project team (a small group of HF professionals) used the model as a vehicle to prompt conversations and determine what the key HF areas of concern might be. By way of example, it has been used to scope HF associated with 'Airspace Change', deep tunnelling / mining and high hazard hoist related operations.

In the context of project scoping and EHFA, the model was incorporated into a dynamic tool within the Microsoft Excel software application. The macro-enabled spreadsheet allows the user to dynamically select and highlight the PSFs of interest. There are three levels of highlighting, enabling a visualisation of three levels of PSF importance / priority (at the users' discretion). Once the exercise is complete, the spreadsheet (with notes) is saved as a record of decisions made and discussions held. Figure 4 is a screenshot of the application of the Excel-based tool.

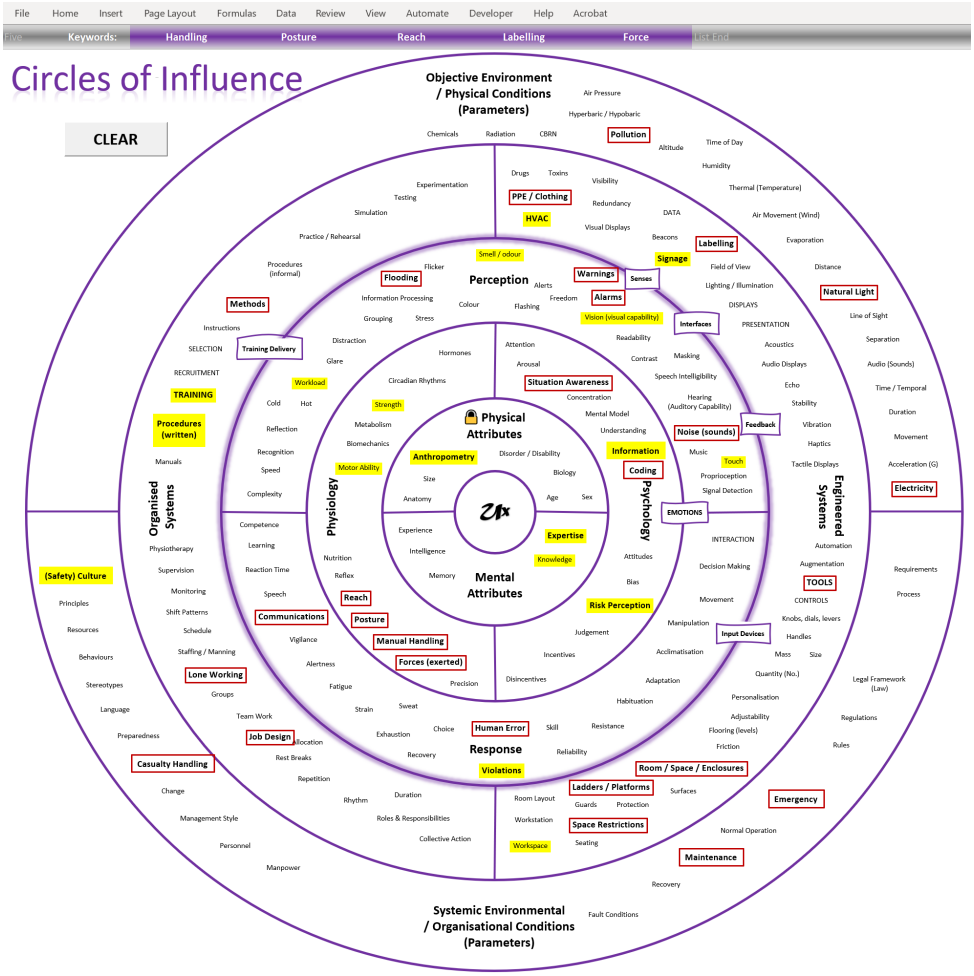

Figure 4: Example output from HF scoping exercise.

Limitations & Learning from Experience

It is acknowledged that in the application of such a model, as with any similar tool or technique (e.g. HAZID), the output is highly dependent on the individuals undertaking or supporting the assessment. Both the inputs and outputs can be very subjective, therefore scoping and analysis exercises often benefit from small multidisciplinary teams.

It was noted during practical application that it can be tempting to select a large number of PSFs, as it may be difficult to argue initially that PSFs are not applicable. A certain amount of discipline is required to refine the selected PSFs to only those that that will have a significant influence over human performance in a given context. The definition of what is 'significant' will vary from context to context. In practical terms, multiple 'passes' are performed where on the initial pass a high number of PSFs may be identified, then on successive passes they are de-prioritised or deemed to be less significant or out of scope.

The model was not originally envisioned to be used with groups, teams or crews in mind, although it may be applied in such contexts.

Conclusions

The Circles of Influence model was developed as an aid to enable HF practitioners to visualise and identify a broad range of PSFs that might be applicable to a given operation, task or exercise. Although not without limitations, it has proven to be a useful reference tool in the context of HF scoping and EHFA. The model is being shared freely with the HF community to be used and adapted for the benefit of all.

References

Although not referred to explicitly within the text, the following documents were used in the derivation of the full set of PSFs within the model.

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