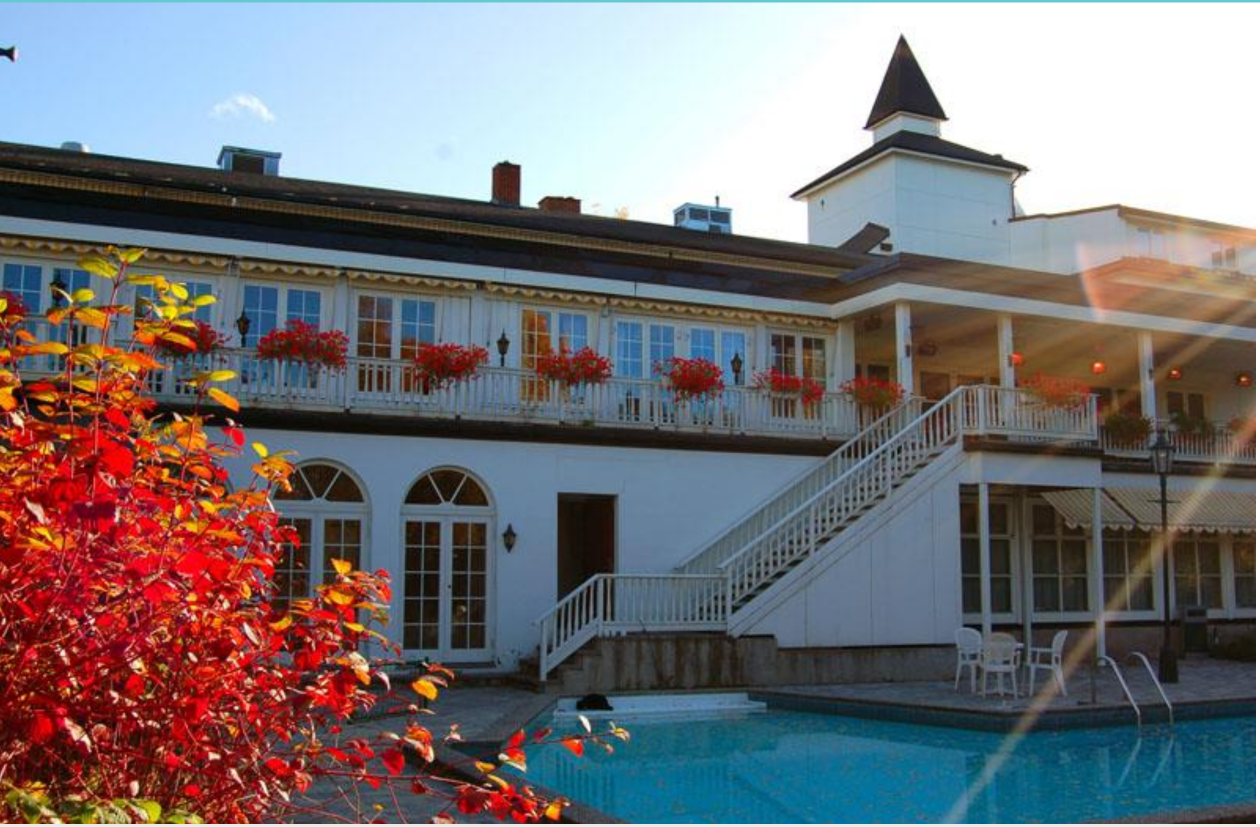
NES2015

Creating Sustainable Work-environments

Lillehammer, November 1.- 4.



NES Nordic Ergonomics Society

Norsk Miljøpsykologisk Nettverk

NEHF Norwegian Society of Ergonomics and Human Factors

Høgskolen i Lillehammer
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www.nes2015.no

Creating Sustainable Work-environments

Proceedings of NES2015

Nordic Ergonomics Society 47th Annual Conference

01 – 04 November 2015, Lillehammer, Norway

Editors:

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Reidulf G. Watten

Publisher:

NEHF (Norwegian society for Ergonomics and Human Factors)

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Strandveien 55
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ISBN 978-82-995747-5-4

Human Error: Causality and the confusion of normative and descriptive accounts of performance

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That human errors can cause accidents is a core assumption of classical safety management systems, which aims to reduce the occurrence and consequences of human errors. This paper will present two interconnected lines of arguments that are contrary to the classical assumptions of causality and focus on human error. First it identifies challenges to the assumed causal connection between human error and accidents by discussing selection bias, lack of statistical contrasts between accidents and non-accidents with respect to human error and accidents, as well as the challenge of causal inferences for N=1 cases. The second line of arguments involves the conflation of normative and descriptive accounts of performance and how this hinders a structured and scientific approach to system performance. The paper ends with three principles that require a pre-hoc identification of behaviours that deviate from performance standards. This approach hopefully allows for practitioner acceptance of performance standards, a just evaluation of performance, as well as enabling proactive safety management by requiring that errors be identified prior to performance.

Keywords: Human Error, Causality, Accident Analysis, Hume´s Law

1. Introduction

A general definition of human error that encompasses most other definitions from the human factors community have been defined by Strauch (2002, p. 21) as "*an action or decision that results in one or more unintended negative outcomes*". A common claim in human factors literature follows the general form of "*human error caused xx% of accidents*". Examples of these claims can be given as "*most of the preventable incidents involved human error*" (Cooper, Newbower, Long & McPeek, 1978, p. 39), "*Studies of offshore and maritime incidents (accidents and near-misses) show that 80% or more involve human error*" (Rothblum, et al.,, 2002, p. i). Further, in a recent book Dhillon (2007) sums up existing transportation research and shows data that approximately 70 to 90% of transportation accidents in the four major transport domains (aviation, sea, rail and road transport) are the result of human error. In other words, the fallibility of human behaviour and decision-making are seen as a liability and as a cause of a majority of accidents in the majority of industrial, service or manufacturing sectors (Hollnagel, 2013).

The last decade a number of challenges to the concept of human error has been presented. These challenges involve the fact that human error is usually identified in hindsight (Shorrock, 2013), that the identification of all errors depends on a performance standard (Dekker, 2006; Shorrock, 2013) and that failing to identify a technical failure leads to claims that humans have caused the occurrence despite the lack of evidence (Dekker, 2006). Investigations of complex socio-technical systems have shown human errors can be seen as normal (Perrow, 1999) and that a system should be designed to absorb the consequences of these errors (Reason, 1997).

This paper will focus on two arguments that question the causal connection between the concept human error and accidents. The first is an evaluation of the possibility of making causal inferences based upon the available data of human errors and accidents. The second argument is that the use of human error as a cause represents a conflation and confusion of normative and causal accounts of phenomena.

2. Causality in Social Science

Modern theory regarding inferring causality from observations are to a large extent informed by Hume (1748/2007) and the *problem of induction,* which involves the lack of justification for drawing general arguments from experience-data. The reason is that any set of observed instances cannot be known to be a *complete set* of instances (*i.e.* we cannot know that what we have observed is the totality of facts). Hence, extracting "general valid statements" from experience becomes a logical fallacy because claims cannot be both empirical (based upon specific observed instances of a phenomenon) *and* still be general in the meaning that a statement is correct without reference to time or context (Krausz, 1986). Thus, the idea that we can derive general knowledge form experiential data is defunct and fraught with logical fallacies. This becomes a particular problem for applied sciences like Human Factors.

2.1. Impossibility of causal Inference from single cases

Accidents in socio-technical systems are all exceptional to the extent that they consist of a combination of contributing factors that are unique to that incident. In the strictest sense, the inference of causality from single events (such as accidents) is impossible, as the situation does not allow for experimental manipulation of the involved factors (Shadish *et al.*, 2001). Similarly, single-case studies do not allow for the identification of empirical regularities (e.g. cannot even support a weak probabilistic account of causality) because this would require multiple observations in order to ascertain empirical data patterns.

2.2. Selection Bias and lack of contrasts between accidents and non-accidents

Another challenge is that the claims "human error have caused 80% of accidents" are based upon a selection of *only accidents*. When a sample is selected on the basis of characteristics of sampling units (such as people or events) it leads to *selection bias* which greatly reduce the validity of (causal) claims (Bareinboim & Pearl, 2012) simply because conclusions are restricted to the limited population from which the sample is drawn.

In the case of accidents – selecting only accidents to observe does not give answers to the importance of human error in accidents – primarily we have no grounds for comparing accidents with non-accidents. Table 1 below show the traditional description of the current knowledge, where human error is observed in 80% of accidents. The occurrence of human error in non-accidents/near misses is unknown.

Table 1. Cross-table indicating lack of information regarding near misses and human error

	Human error	Absence of human error	Sum
Accident	800	200	1000
Near miss	???	???	1000
Sum	???	???	2000

The lack of information on the relative involvement of human error in non-accidents hinders causal inferences to be made between human error and accidents. Also, there are very few (if any) studies that have compared accidents with near misses or successes with errors. Only recently have researchers argued that we need also to study the how's and why's of socio-technical systems ability to succeed in demanding situations (Hollnagel, 2013; see also Øvergård *et* al., 2015).

3. Conflating Normative and Descriptive Accounts of Performance

3.1. Descriptive and Normative Accounts of Performance

A descriptive account of performance describes what a system actually does (Vicente, 1999). The account must involve stating the components (nouns), the behaviours (verbs) and the interaction (relational terms) between these components. A description is a neutral representation of an event and should not include subjective judgements like ethical (right/wrong) or aesthetical (pretty/ugly) evaluations. Hence, descriptive accounts only contain the facts of some subject matter. This is both a limitation and strength.

On the other hand, a normative account of performance is a statement on how a system should behave (Vicente, 1999). The normative account involves the evaluation of an act or behaviour through the use of a performance standard (Shorrock, 2013). A normative account of performance of is a consists of three different elements – a) a *reference to an action*, b) an (often implicit) *reference to a performance standard* for evaluating the action, and c) a *subjective evaluation* of whether the act in question was compliant with the performance standard. Performance standards could be socially shared as in laws, regulations or represented by agreed standards such as the ISO 9241-210 (ISO, 2010) or they can be fully subjective as in matters of taste.

The outcome of an evaluation is dependent on the performance standard used. Any description of an act as an "error" implicitly uses a performance standard since any event that does not fulfil the requirements in the performance standard can be said to be "in error", "inadequate" or "faulty". The result is that *any success can be made into an error* by changing the performance standard.

3.2. Performance and Error: Independent Ontological Categories

The reference(s) are implicit when the behaviour or standards are not described in the argument. The effect of this is that by removing the description of what actually occurred we end up with an indirect, non-descriptive and normative claim that bears the guise of a causal explanation.

Hence, following the idea that any normative argument is a compound of different subject matters (actual acts, subjective evaluations and performance standards) that are of different ontological categories that occur at different places and with different goals, we can say that a normative evaluation of an event cannot be used as an explanation of that event since the normative argument involves subject matters (performance standards and subjective evaluations) that was *not present* during the occurrence of the act in question. Hence, a normative account has similarities to contra-factual reasoning – which is about something completely different than what actually happened (Dekker, 2004).

In this sense we can say that any normative evaluation of performance conflates normative and descriptive accounts. It, therefore, cannot be used as an explanation since a failure to comply with a performance standard is not sufficient to produce the event (unless compliance with the performance standard is the goal).

Illusory explanations. Explaining events using absent phenomena can be compared to wishful thinking in the regard that counter-factual arguments always can be brought to bear on any situation. Using counter-factual argumentation as in "*If the person had done something different the outcome might have been better/worse*" equates to building a legal case based upon an imaginary sequence of actions. This gives the comfort of an (illusory) explanation, rather than trying to explain the events that actually took place.

As a rhetorical game, assume that a situation where a car has driven off a road with 60 km/h speed limit and collided with a three. A non-normative description of the event could be something like this "*the car entered the turn in the road doing around 90 km/h. The car lost friction, slid sideways out of the road and hit a tree beside the road*". The latter argument describes the factual occurrences and connects the action with the outcome without making a normative evaluation of the action. In this case the facts are preserved without leaving room for impression or normative interpretations of the facts. The all too common arguments "human error caused the accident" or "the driver went too fast" does not add anything to the description of the event. The causal nature of the events is fully included in the descriptive account and no normative evaluation is needed to give an account of the events.

4. A Proactive Definition of Human Error

As noted by Strauch (2002) there is an understandable tendency to apply the knowledge of the accident *in hindsight* when we are trying to understand the decisions made by the involved operator(s). Information that one in hindsight knows was critical to successful performance is focused upon, while the operator´s point of view is ignored (or cannot be known). In this way, we create meaning where there were none for the operator. Hence we engage in contra-factual storytelling that are more about meaning making than science (Dekker, 2015).

So, should we stop using the term human error – as advocated by Shorrock (2013), or may the concept, which has drawn much interest and fruitful discussion in the past decade, still be usefully applied? To escape the dangers of hindsight, as well as the described fallacies of connecting normative and descriptive approaches to behaviour to make a seemingly causal argument, principles that lead to a proactive definition of human error is presented. The three principles are described below.

1. Only actions by the human operator that have been described in a company´s safety management system as unsafe *prior to an incident* and entered into the company´s training program can be called "Human Error".

In this way, the case of human error would amount to a deviation from known procedure which has been trained thoroughly. The classical reactive safety management approach of "reducing human errors" (an approach which is still much used) can be turned into something proactive by requiring that organisations must make explicit risk evaluations where they evaluate probable (and improbable) actions that a human operator can be expected to make. The identified errors should then be taken into the training and assessment systems of the organisations and operators should be trained in the proper handling of unexpected critical incidents where human error would be expected (Nazir, Manca & Kluge, 2013).

2. Naming an action as an error in hindsight is not allowed unless the action is specifically stated in the safety management system.

Following this requirement it is up to the safety management system and the associated training regime of the organisation to identify errors before they occur. By disallowing the use of evaluations in hindsight the investigators can then focus on the event itself instead of looking for (human) errors. Also this principle would allow us to appreciate Woods and colleagues´ definition of human error as an error only if the operator viewed the action "*at the time the act was committed or omitted*" (Woods *et al*., 1994, p. 2). Hence, by describing which type of acts that are seen as errors prior to events taking place we achieve three goals – 1) we can appreciate the operator´s viewpoints in evaluating 'novel' occurrences of human performance prior to accidents, 2) we achieve a level of organisational justice by pointing out which behaviours that would be seen as negligible - thus moving towards a just organisational culture (Dekker, 2006), and 3) we ensure *double-loop learning* where we in addition to evaluating performance also re-assesses the performance standards which is used to evaluate performance and goal-attainment (Argyris & Schön, 1978).

3. Descriptive and Normative accounts of performance should be presented separately.

Human factors specialists should attempt to keep description and evaluation of actions separately as a combination of these two often leads to illusory explanations. Similarly, when we make a normative evaluation/statement the performance standard should always be explicitly described and the exact deviation from that performance standard should be described and explained.

5. Conclusion

Recently Shorrock (2014) questioned, "*Is human error the handicap of Human Factors?*". I concur; somehow, we have seen a human factors concept being adopted outside the circles of human factors specialists, and 'human error' is often used by laypersons (and the media in particular) to identify "the cause" of an accident. This is strictly non-scientific as have been shown by the previous arguments. For human factors to remain scientific we need to avoid making use of simplistic 'common sense' statements that do not hold up to scientific scrutiny.

For singular events a descriptive account of the timeline of events and the involved components in combination with the admissible performance standards will suffice to get a full overview of the event. The addition of post-hoc causal statements will not add anything to the understanding or description of the event – besides letting us know something about the inferences made by an observer or evaluator of that event. Normative evaluations will always tell us more about the evaluator than about the event – simply because the act of evaluating will be based upon the ethics/aesthetics of the evaluator – and do not describe the performance as such.

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