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A relationship between operator performance and arousal in assembly

Sandra Mattsson[a*], Åsa Fast-Berglund[a] and Peter Thorvald[b]

[a]*Chalmers University of Technology, Hörsalsvägen 7A, SE-41481 Gothenburg, Sweden*
[b]*Unversity of Skövde, Högskolevägen, SE-541 28 Skövde, Sweden*

* Corresponding author. Tel.: +4631-772 4446. *E-mail address:* sandra.mattsson@chalmers.se

Abstract

In order to meet the challenges of future complex systems, manufacturing companies need to better understand how social sustainability affects the operator. One way of studying this is to investigate the possible relationships between operator performance and emotion in an assembly experiment. 60 participants took part in an experiment to investigate the relationships between operator performance and objective and subjective arousal. Results showed a weak relationship between operator performance and objective arousal but no significant relationship was found between performance and subjective arousal. The relationships indicate that further studies on operator emotion could be important to better assembly performance. A tool for doing this might be the Qsensor used in this experiment (measure of objective arousal). More studies are needed to further investigate found relationship and if objective emotion measures can be used to predict performance at assembly workstations.

Keywords: Operator performance; arousal measurement, assembly; perceived view.

1. Introduction

A prerequisite for the success of modern manufacturing companies is the ability to produce as effectively as possible. This demands a high degree of flexibility and re-configurability of the production system [1], which introduces complexity to the systems. In these systems, human operators remain an invaluable resource; by being superior to robots at rapidly interpreting unplanned tasks and situations and handling flexibility and complexity [2, 3]. In recent years there has been an increased need for social sustainability research regarding operators' working conditions [4, 5]. Assembly operators are human beings with moods, emotions and subjective experiences that influence their communication, decisions, actions and motivations regarding both work and personal life [6]. If operators experience dissatisfaction and negative feelings towards their assembly work tasks, manufacturing companies face the risk of losing employees to competitors. Negative feelings such as boredom and under-stimulation affect operator performance [7]. To stay competitive and avoid costly personnel turnover as well as knowledge draining in the future, manufacturing companies therefore need to be mindful of the well-being and subjective emotions of their employees.

By studying *operator emotions* connected to the task or system it is possible to detect stress, anxiety and frustration among the operators, as well as boredom [8]. Individuals are also diverse and have different knowledge and skills in their work situation and will therefore often experience work-related stress when the work demand is not matched with their own abilities [9, 10].

To stay competitive and avoid costly personnel turnover as well as knowledge draining in the future, manufacturing companies need to be mindful of the well-being and subjective emotions of their employees. It is therefore important to study operator emotion in order to improve the working conditions, which can have positive impacts on performance. Previous performed experiments show that operator performance can be increased by introducing changes to the information presentation [10, 11]. In these

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experiments, information presentation was changed according to the operators' errors and perception of the situation.

This paper presents a correlation study of that experiment. The aim of this paper is to investigate if there are correlation relationships between operator performance and arousal. Operator emotion is studied by looking at subjective and objectively measured arousal.

1.1. Operator emotion

In traditional cognitive science, emotions were not seen as essential to human cognition and were in fact explicitly disregarded in the study of the human mind (e.g. [12]. However, in later years, and especially with the widening of the cognitive scope to include a more context aware view of human cognition, this disregard for emotions has been heavily criticized and emotions are now seen as a crucial element of human cognition (e.g. [13-15]). Damasio argues for a dichotomy of emotions and feelings where the former are closely coupled with the neurobiology of the brain as basic, conscious or unconscious and involuntary states such as hunger, fear or pain. He further argues that feelings are the phenomenological experiences of emotions [14].

When studying operators' emotions, understanding the nature of emotion and how it is assessed, is important. Individual difficulties in assessing and describing one's own emotions have been noted by many researchers [16]. These difficulties suggest that emotions lack distinct borders, which makes it hard for individuals to discriminate one emotion from another. However, subjects rarely explain one positive emotion without mentioning their experience of other positive emotions [17]. Posner et al., note that emotions are complex and have overlapping experiences [18], similar to the experience of colours where some colours look alike and are interrelated. This indicates correlations between different emotions which researchers address by dimensional models of affect [18].

Schlosberg divided emotion in a two-dimensional model, pleasantness-unpleasantness and attention-rejection by studying facial expressions of emotion [19]. Later, the dimensions were developed and remade into different models by different researchers, but with similar concepts [18]. Russell proposed a structured model of affect states [20], which included the two dimensions of emotion: arousal and valence. Smiling and laughing are behaviours related to valence described by bipolar adjectives such as happy/unhappy and pleasant/unpleasant. Arousal is portrayed in an individual's activity and alertness, galvanic skin response and by scales such as wide-awake/sleepy and excited/calm [21]. The dimensions are visualized in Figure 1 [18, 20] where arousal is on the vertical axis and valence on the horizontal axis. Arousal is depicted on a scale from aroused to not aroused or not engaged independent of whether the emotion is positive or not and valence is ranging from unpleasant to pleasant.

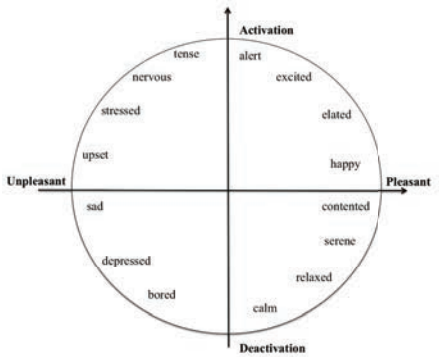

Fig. 1. Russell´s Circumplex Model of emotion [18].

Furthermore, some researchers argue that a third dimension is needed to describe affect [21, 22]. These researchers provide evidence that supports the three-dimensional model, which includes dominance in addition to the two dimensions stated above. Stamps tested both the two- and three-dimensional models of affect and results indicated that the three-dimensional version is the beneficial model for describing affect [22]. Mehrabian and Russel (1974) define dominance as to what extent an individual feels free to act or is unrestricted. Bipolar items such as autonomous/guided and in control/cared-for may be used to measure this concept. This variable is maybe not as obvious as the others. Whether someone is happy or aroused is easier to address and not as abstract as noticing when someone is feeling dominant.

In this study, SAM was used to measure the subjective experience of emotion (regarding arousal, valence and dominance). SAM is an assessment scale based on pictures that indicate the levels of arousal, valence and dominance. The assessment is based on an individual's affective reaction to stimuli. SAM was originally implemented as an interactive computer program, and was later expanded to include a paper-and-pencil (PPSAM) version for use in groups and mass screenings [23]. In this study, *subjective operator emotion* is measured using PPSAM self-ratings. Figure 2 illustrates the PPSAM used in the experiment. The figures represent the self-assessed valence (first row ranging from unhappy to happy), arousal (second row ranging from relaxed to excited) and dominance (third row ranging from little control to control).

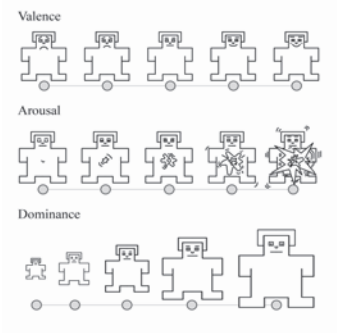

Fig. 2. The Self-Assessment Manikin (SAM) used in the experiment to measure the subjective emotion of valence (first row), arousal (second row) and dominance (third row). To the original figures, explanatory text in Swedish was added [23].