Performance in manual process control
– mediation of time pressure and practice effects
by the structure of control behaviour

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Abstract

An explanation of how practice and time pressure may affect performance in
dynamic control tasks is offered in the Contextual Control Model (COCOM,
Hollnegel, 1993): Performance depends on the orderliness of operator behaviour, i.e.
how well control actions are planned in advance. Whether an operator can develop
proper plans to guide his/her control actions depends on a number of contextual
factors, e.g. the subjectively available time (which is decreased by time pressure) and
the familiarity with the task (which increases with practice). COCOM further
predicts that due to recurring patterns of actions, the structure of a sequence of
systematically chosen control actions will be more regular than actions taken in a
trial-and-error fashion without a guiding plan, which will show more random
patterns.

The predictions of COCOM were tested in an experiment with 40 participants who
manually controlled five parameters in a process control simulation. While earlier
studies of COCOM relied on subjective ratings to assess orderliness, we examined
the regularity of the structure of control actions with $\text{emc}_{\text{dp}}$, an objective measure of
regularity which is based on information theory (Röttger, Klostermann & Manzey,
2007). Results show that both performance and the amount of regularity in the
operator behaviour increase with practice and decrease under time pressure, and that
regularity of control actions mediates practice and time pressure effects on
performance. These are the first objective data to yield empirical support to
COCOM’s predictions regarding time pressure and practice effects on operator
behaviour.

Introduction

In order to optimize the design of human-machine systems, it is necessary to predict,
and thus to understand how operators act in various situations that may arise while
they are performing their tasks. A possible way to gain insight into the processes of
operator behaviour is to develop models of operators. Such models are often
developed from a theoretical perspective and have a rather small empirical basis. A

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