1. Introduction

The U.S. Army Research Laboratory’s Human Research & Engineering Directorate (ARL HRED) has developed a modeling and analysis tool called Command, Control, and Communications: Techniques for the Reliable Assessment of Concept Execution (C3TRACE). C3TRACE outlines the flow of communications through the soldier command and control structure in proposed Future Force concepts. C3TRACE provides an environment for targeted evaluation of the effects of different configurations of soldiers and information technology on soldier and system performance. This tool provides the capability to represent any organizational level, the people assigned to that organization, the tasks and functions they will perform, and the communications patterns within and outside the organization, all as a function of the frequency, criticality, and quality of incoming information. C3TRACE can be used to identify communication bottlenecks, workload peaks, and decision-making vulnerabilities so that the combined effectiveness of a proposed configuration can be assessed and changes to the organizational structure or information technology design can be recommended.

Three main input categories are required to build a C3TRACE model, the organization structure (i.e., personnel), the functions and tasks that will be executed by the personnel (i.e., sequencing, decisions, and queues) and the communication events (messages incoming in the form of face to face, digital, voice, etc.). The output of the model includes operator performance and decision quality. Factors that affect decision quality include initial information quality, decay rate, and time since last update. Current ARL HRED research is aimed at providing a richer set of options to include soldier characteristics. Performance shaping factors (PSFs) consider individual operator characteristics such as aptitude level, length of service (i.e., experience), and age to mathematically describe how these operator attributes impact overall task execution time.

Experience and self-efficacy (i.e., confidence in one’s ability to do well) are currently being framed as a PSF for C3TRACE. An algorithm was developed that describes how self-efficacy and experience impact task execution time for high and low stress events. According to Bandura (1997), self-efficacy is positively correlated with performance and is also related to speed and accuracy of decision-making. There is extensive evidence that self-efficacy is associated with higher levels of motivation and performance for both civilian and military populations (e.g., Potosky, 2002). Further, the relationship between self-efficacy and performance is moderated by a multitude of factors, such as skill level and uncertainty. Individuals can fail to perform optimally even if they know what they are doing and have the skills necessary to do it. Skill can be over-ruled by self-doubt (Bandura, 1997). The stressfulness of a situation may also impact on the relationship between self-efficacy and performance.

2. Approach

The algorithm is based on theoretical models and previous research data collected at an Emergency Operations Center (EOC; See Cosenzo, Fatkin & Branscome, In Review). Data were collected at an EOC since it was a realistic high stress multitask environment and the flow of information is similar to the military environment. Soldiers have multiple responsibilities in an information-rich environment. The flow of information in an EOC has many similarities to that of a military tactical operations center (TOC) that can be modeled in C3TRACE. An incoming message is received and acknowledged. Once that message has been acknowledged it is then compared to information that is currently known. Depending on the type of information received, a decision must be made regarding the appropriate course of action and the action is then enabled.
Nineteen EOC operators completed a battery of stress and demographics measures. Data were collected over a period of three weeks for each operator. For each day of data collection, performance data and self-efficacy data were recorded. The performance measure was the time required for the operator to complete an emergency call. From the data collected at the EOC, an algorithm was developed. The algorithm incorporated three variables: 

- **Self-efficacy** - Operators were asked to rate (from 1-10, low-high) their level of confidence in their ability to do well,
- **Time in Current Position (Experience)** - Operators reported how long they have worked in their current position, and
- **Perceived Stressfulness of the Event (SRE)** - Operators were asked to rate the amount of stress they typically experience when taking various types of calls on a scale from 0 -100 (low to high stress). Experience (in years) was grouped into four categories, 1-5, 6-10, 11-15, and 20 and Above Years. Efficacy was grouped into two categories: 8.0 and above (high) or 6.0 and below (low). Dispatchers with 11 or more years of experience only reported high self-efficacy. This is a logical finding; the more experience individuals have in a job, the more confident they are in their ability to do well. To reflect this finding, when an individual has experience of 11 or more years, they will be automatically placed in the high self-efficacy group by C3TRACE. The decision events were grouped into two categories, high stress events and low stress events. Dispatchers reported stress levels, as measured by the SRE, for these events of 63.3 and 28.0, respectively. Various linear and non-linear functions were applied to the data to yield the best fitting equation. The relationship between self-efficacy and performance was non-linear and varied depending on experience and stressfulness of the event. For example, operators with low efficacy made decisions slower during high stress than low stress events. Interestingly, when experience was entered into the equation, more experienced operators with high efficacy made decisions slower during high stress events than the less experienced operators. For low stress events, the pattern of responses was highly variable.

### 3. Conclusions

Our research has shown that theory and experimental data can enhance the capabilities of modeling environments. We developed a mathematical performance shaping function for C3TRACE which showed how self-efficacy and experience moderate performance. Further research needs to be conducted to validate the algorithm before it is implemented in the tool.

### 4. References


### Author Biographies

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