SIGNAL DETECTION THEORY
AND THE ASSESSMENT OF
SITUATIONAL AWARENESS

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Introduction

Having accurate and up-to-date situational awareness (SA) is crucial in military operations. To determine the extent to which our C2 systems and training processes are affecting people’s SA, we need to carry out proper assessments through human-in-the-loop experimentation. Moreover, we require methods and metrics that enable us to quantify the extent to which SA is accurate, complete and up-to-speed with the evolving situation, both within individuals and across teams. This paper presents and discusses a technique for SA assessment based on the principles and methods of Signal Detection Theory.

Signal Detection Theory

Signal Detection Theory (SDT) is a mathematically-grounded framework for modeling and analyzing perceptual processes. It describes the task of perceptual discrimination as one of distinguishing between two types of stimulus, signals and noise. For example, a radar observer’s task is to detect relevant ‘blips’ (signals) whilst ignoring or rejecting other, irrelevant stimuli (noise). Aside from the physical properties of the stimuli and the context of observation, the theory posits two key factors determining an observer’s performance on such a task:

(i) the observer’s inherent sensitivity in being able to discriminate the true signals from the non-signals;
(ii) the observer’s strategy for handling uncertain stimuli that require a more explicit judgement based on the amount of perceptual evidence the observer feels is present: in other words, the setting of the observer’s response criterion (or bias) when it comes to ambiguous stimuli.

SDT thus recognises that individuals are not merely passive receivers of stimuli or data. When confronted with uncertainty, they also become engaged in the conscious process of deciding whether what they perceive signifies one thing rather than another [1].

SDT and SA Probes

How can the SDT approach be used to assess SA? A common way to evaluate SA is to “probe” subjects’ perceptions and understanding by eliciting their responses to pertinent questions about the situation. One notable probe technique is the use of multiple-choice questions, responses to which may be quickly evaluated against a known ground truth. This method is embodied in the Situation Awareness Global Assessment Technique, for example [2]. Typically, probe response data are assessed using some kind of hit rate: the proportion of probes for which the subject selected the correct answer. While this seems an obvious statistic to use in terms of face validity, on its own it is an inadequate index of SA accuracy as a hit rate does not disclose a subject’s false perceptions or false beliefs about the situation. In addition, hit rate...
alone fails to provide a full picture of the subject’s cognition as it confounds sensitivity and response bias [3]. Hit rate can vary widely due to response bias effects. Discriminating between subjects’ actual sensitivity on the one hand and judgement strategy in uncertainty on the other could therefore be valuable for understanding patterns in people’s situation assessments.

**True/False Probes**
To complement the SDT framework, we have begun exploring the use of *true/false probes* to assess SA in C2 experimentation. A true/false probe is a description of some aspect of the situation, a description which may or may not in fact be true. The description is presented to an individual who must indicate (to the best of his or her awareness) whether it is true or false. For example:

“A column of enemy tanks is now leaving the city.” True [ ] False [ ]

The subjects’ correct and incorrect responses naturally fit the outcome categories of hit, miss, false alarm and correct rejection that are the basis of analysis in SDT (Fig 1).

![Contingency table showing the four possible outcomes of a true/false probe response, depending on type of probe (true or false) and the response made (“true” or “false”).](image)

**Results from C2 Experimentation**
To date we have used this technique in a small number of C2 experiments, including JFCOM’s second Limited Objective Experiment (LOE 2). The paper will give details of the procedures used as well as illustrative examples of the kind of results that have been obtained. It will also discuss the pros and cons of the technique and note some specific lessons learned from these initial applications. For example, while applying SDT analysis to true/false SA probe results yields sensitivity and bias statistics that can give insights into subjects’ SA, we have also found that combining these with subjective self-ratings gives a fuller picture. We can conclude at this point that SDT appears to lend itself to the analysis of certain aspects of SA using true/false probes, and potentially may be valuable tool for SA assessment. However, there are some outstanding issues requiring further research.

**References**