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Analysis of Multi-dimensional Cognitive Processes

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The complexity of human cognition necessitates a reduction from a high level process (e.g., memory, perception, imagery, or attention) using a simplified model. Ideally, the methodology employed to study a particular component should be simple enough that the results can be trusted, yet complex enough to study the true nature of the substrate. The multinomial model developed by Riefer and Batchelder (1988) strikes this balance and hence is utilized extensively in the study of many cognitive functions. This methodology can be readily appreciated by exploring its application to the study of human memory. A typical recognition memory experiment involves a study phase and a test phase. The study phase may involve the presentation of a word list for a subject to remember and the test phase may involve the presentation of the words from that study list in addition to new distracter words. The subject is instructed to respond "old" or "new" to each word. If a subject says "old" when presented with a word from the study list, many questions arise regarding the experience of the subject. How strong is this memory in a range of none to absolute? Did the subject forget the word from the study phase and simply guess "old"? During data analysis, it is necessary to separate parameters that describe true memory strength and guessing. The multinomial model not only dissociates these parameters, but enables the study of multiple dimensions involved in a cognitive process.

We have investigated an alternative model which can be used to analyze cognitive processing. This signal detection theory (SDT) model has different underlying assumptions than the multinomial model and uses more detailed triple judgment confidence ratings to quantify the experience of the observer. It is important to extract all the information that a subject has to offer about a particular experience in the interest of developing the most accurate model of mental function. We have developed novel techniques for evaluating these multiple, conjoint rating scale data. To explore the accuracy of the SDT model as compared to the accuracy of the multinomial model, we conducted a source memory experiment and analyzed the results using both models. This type of experiment is appropriate as a multi-dimensional process as it involves both old-new recognition memory and memory for source.

During the study phase of the experiment, we presented subjects (Ss) with words from two lists using different presentation methods. Words from the first list were presented visually as anagrams which the Ss solved and

words from the second list were heard as well as presented visually. During the test phase, we presented the words from the study phase in addition to new words and instructed Ss to give a triple judgment corresponding to confidence anagram, confidence heard, and confidence new for each word. The resulting data were analyzed using the multinomial model developed by Batchelder and Riefer (1990) and the SDT model developed by Slotnick et al. (1996). The parameters derived from these models and the assumptions underlying these models were compared and contrasted. Both models result in comparable parameters that describe memory strength under neutral bias conditions, but these memory strength parameters derived using the multinomial model were not independent of bias. Using a chi-square goodness-of-fit test, we show that the SDT model is more representative of the data. These results indicate that the SDT model is a better predictor of the data than the multinomial model and henceforth should be considered in the analysis of multi-dimensional analysis of cognitive operations.

In addition to studying the results of source memory experiments, this methodology can be applied to other cognitive paradigms with multiple dimensions. For example, we are currently exploring the application of the SDT model in the study of the distinction between explicit and implicit memory and in the study of the distinction between shape and color in illusory conjunctions. The SDT model is a powerful means with which to quantify the multi-dimensional complexities of the human mind.

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