Distributed Cognition of a Navigational Instrument Display Task

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Abstract

Distributed representation is a representational system that is composed of an integration and exchange of external and internal representational information in a seamless and interweaving manner. The performance of any everyday task utilizes perceptual information obtained from the external environment and internal information retrieved from one's memory. External representations constructed from information extracted from external objects (such as written symbols) and internal representations (such as schemas) dynamically integrate and interweave to result in a rich pattern of cognitive behavior. The principle of distributed representations is that a distributed cognitive task involves a system of distributed representations that consists of internal and external representations (Zhang & Norman, 1994, 1995). The task is neither exclusively dependent on internally nor exclusively dependent on externally processed information, but rather on the interaction of the two information spaces formed by the internal and external representations.

Even though different isomorphic representations may have a common underlying formal structure, the representation and distribution of the same information across the internal and external spaces can be different. The variant distributions of representational information result in producing alternate and occasionally contrasting behaviors. It would then be possible to observe the differing efficiencies of the representational systems. This representational effect is observed and studied over a series of experiments involving various navigational instruments from the aviation industry in a navigational task.

Cockpit information displays are examples of distributed representation systems. Navigational information in a cockpit information system can and is represented through a variety of isomorphic navigation instruments. Within the aviation industry, there exists a variety of navigational systems based on a set of key instruments. Although the navigational information displayed is similar, they vary in their relative degree of directness and efficiency in their representation of scale information (Stevens, 1946; Narens, 1981). The scale information of the orientation and distance dimensions in a cockpit information display is represented across internal and external representations and can dramatically affect the representational efficiency of the display and the pilot's behavior.

The experimental study compares the differing effects of a navigational task using three of the more prevalent navigation systems in use. A decomposition of the cognitive task into its core component levels identifies the representational properties responsible for the observed representational effect. The resulting variance in behavior in completing the task indicates which representation systems are more efficient, and thus which instruments are more 'direct' in producing such a representation system. Variance in behavior is measured through times for task completion and error rate.

A learning effect was observed for all three experimental conditions from repeated measures data. This dramatic and robust power curve of learning corresponds with the standard power law of practice. The data supported the hypothesis of a representational effect; performance differed in initial task completion times and the rate of observed learning between the three conditions. Task performance varied only minimally at the end of the experimental procedure. The performance convergence may be explained through practice from the learning period of the experiment.

The experimental results were consistent with the predictions of the distributed cognitive theory. The prediction was for representations to have a distributed space extending across the internal representational space and the external representational space, which was supported by the observed representational effect.

References

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