Distributed Cognition of a Navigational Instrument Display Task

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The information necessary for the performance of almost any everyday task is distributed across information perceived from the external world and information retrieved from the internal mind. These tasks are known as distributed cognitive tasks (Zhang & Norman, 1994). The external representations constructed from the information extracted from external objects (such as written symbols) and the internal representations in the mind (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.

In the aviation industry, there are a wide variety of navigational systems. However, there exists a set of very basic navigational instruments. These instruments are selectively tuned to transmitting radio stations on the ground. The received signals are then presented onto a display in the cockpit for the navigator to interpret. There is only so much information that a navigation instrument needs to display: azimuth or directional information, and distance information. However, the various instruments present these information differently and result in varying degrees of precision and efficiency as interpreted by the navigator.

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. Although these instruments are isomorphic and provide similar necessary information, they vary in their relative degree of directness and efficiency in their representation of scale information (Zhang & Norman, 1995). 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 navigator's behavior (Zhang, 1997). This research seeks to study the varying cognitive properties of the representations that such instruments produce. The specific assumption to be tested is that with the most direct system, scale information is maximally represented externally, resulting in higher efficiency, faster and more direct responses. An experiment was carried out to test this hypothesis on four sets of navigation instruments which are isomorphic to each other but have different degrees of directness.

The resulting behavior variance from the experiment indicates that some representations are more 'efficient' in extending the necessary information for a task. Although the different isomorphic representations result in varying initial levels of performance and learning curves, performances appear to converge after a sufficient period of learning.

An argument could be made for learning and practice to eliminate such a representational effect. However, further research need to be done in more complex and dynamic settings. The experimental task was a simple position-fixing task in a very controlled and calm environment. In an unpredictable and complex environment such as that of the cockpit of an aircraft, the representational effect could be more pronounced and a possible regression to initial performance levels should be studied. Another issue that is worth of further study is whether the converged performance after learning for different representations will diverge again under extreme conditions such as high cognitive workload and time pressure.

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