A Model for Mobile Performance Support Systems as Memory Compensation Tools

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Abstract
This article presents a memory compensation model that describes the process of using a mobile performance support system (mPSS) to support the function of the working memory. The model, drawn from information processing theory and cognitive load theory, describes the way in which information moves from the working, or short-term memory, to the long-term memory. Cognitive load theory proposes that the working memory can only process four to seven pieces of information at a time. The memory compensation model draws from the two theories to describe the role that mobile performance support systems play in combating information overload, as evidenced from electronic support systems used by cognitively impaired individuals. Further implications for human resource development include using the mPSS to promote inclusiveness in the workplace, with brain injured and older workers among the special populations that benefit from short-term memory compensation tools on the job. Further research includes expanding the model into a systems view of the organization, the individual, and the mPSS and best practices for developing applications for memory compensation.

Keywords: mobile performance support systems, working memory, cognitive load, information processing theory, information overload
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Introduction

The purpose of this article is to present a theoretical model for using mobile devices as mobile Performance Support Systems (mPSS) in the capacity of memory support tools. Memory support is the process of applying a strategy or tool to aid, enhance, or stand in for the working memory function in the human brain (Bäckman, & Dixon, 1992; Wade, 2001). Mobile Performance Support Systems (mPSS) are mobile devices or applications that aid performance of a task or job. mPSS are emerging as both communication devices and as job aids and electronic support systems. The discussion of how mPSS can aid in the support of memory will take place through the lens of three concepts: information overload, cognitive load theory, and information processing theory. This discussion will contribute to the current literature on mobile technology applications with a focus on how mobile technology, in addition to being a mode of connection, can aid in managing information overload caused by the large amount of data available by electronic means (Chen, Pedersen, & Murphy, 2011; Denton & Richard, 2012; Lee Zhuang, Yi Qiu, & Long Peng, 2011; Memmi, 2012). The rationale for creating a theoretical framework for implementing human resource development (HRD) programs of mobile technology is to inform the decision-making process in a way that allows organizations to choose efficient technology and aids in meeting organizational goals.

The intent of this article is three-fold. First, it will present the challenge of information overload, in which an individual receives more information than he can process (Denton & Richardson, 2012; Savolainen, 2007). Next, it will draw from cognitive psychology and its theories to examine how individuals process information. Finally, it will discuss Mobile Performance Support Systems as memory support tools, and the implications of the theory for HRD.

Performance Support

The history of performance support systems has evolved from job aids to hand-held electronic support systems, to mobile technology. Job aids include any tool that enables a worker to perform tasks and procedures (Rossett & Schafer, 2007). As computers and personal digital assistants (PDAs) became widely available, the Electronic Performance Support Systems (ePSS) became new tools, which served in the capacity of a job aid. ePSS are self-defined as electronic technologies that support performance (Rossett & Schafer, 2007). Gal and Nachmias (2008) define ePSS as integrating “learning and task performance into one single action by providing information and guidance during performance” (Gal & Nachmias, 2008). mPSS inherit the definitions and roles of the ePSS.

The role of the ePSS includes planning for tasks and assisting in the performance of tasks (Rossett & Schafer, 2007). ePSS also support training and development in a just-in-time framework (Bastiaens, 1999; Barker, van Shaik, & Famakinwa, 2007; Rossett & Schafer, 2007). Defining performance support is an important consideration in choosing mobile technology that will support HRD goals and aid in memory retention. The ubiquitous nature of mobile applications calls for some definition to distinguish performance support from applications that serve as tools, but are not related to task support. According to Rossett and Gautier-Downs (1991) the job aid (and by extension,
the ePSS, into which it evolved) has three roles: “to provide information, to support procedures, and to guide decision making” (p.8).

**Information Overload**

Information overload is a phrase used to describe the phenomenon of more data being presented to individuals than they can process, when the “the tie between information and human purpose has been severed” (Denton & Richardson, 2012, p. 86). Savolainen (2007) describes information overload as “a subjective experience of the insufficiency of time needed to make effective use of information resources available in specific situations” (p. 612). The problem of information overload is a matter of perception (Eppler & Mengis, 2004), therefore it is difficult to quantify the amount of digital data that might be problematic in a way that has meaning, and measurements in thousands to trillions of bytes often describe what becomes for many just background noise (Savolainen, 2007; Roman, 2010; Kook, Parente, & Verville, 2008). The data onslaught is comprised of not only information to be learned, but information that comes from media, business intelligence, entertainment, television, radio, the Internet, email, texts, cell phones, books, mp3s, and emerging media forms. Organizations produce their own data, some of which is relevant and necessary in the daily functioning of individuals.

The relevance of the concept of information overload for HRD is in the context of how it affects individual performance. According to Eppler and Mengis (2004), more information is helpful in decision-making until a certain point, which they describe as an “inverted U-curve.” Information hits a saturation point and more information increases the stress level of the worker and negatively affects the decision-making process. Too many choices make it difficult to hone in on one particular solution. Eppler and Mengis (2004) make the connection between information overload and reduced performance, and propose that five factors cause of information overload: “personal factors, information characteristics, task and process parameters, organizational design, and information technology” (p. 332). To summarize, these factors work together in the individual experiencing information overload, as attitudes, perceptions, and environmental conditions influence how the individual deals with the quality and quantity of information within the context of the organization, the technology available, and the requirements of task performed (Eppler & Mengis, 2004).

Savolainen (2007) looks at information overload from the perspective of information and library science and concentrates on how individuals filter information. The literature review discusses ways in which individuals cope with information, a problem found in the literature that predates the Internet and new media. One coping strategy includes ignoring information, or withdrawing. The push-pull concept in another coping strategy, in which information is either pulled from sources through searching or is “pushed” through individualized and filtered by the user, such as email filters or RSS feeds that retrieve only information of interest to the user (p. 613).

Savolainen (2007) suggested that a combination of methods is appropriate to filter information and the challenge is managing when to use a particular strategy. The author conducted semi-structured interviews with a group of environmental activists who expressed similar ideas about how they personally filter information. The strategies used by the subjects mirrored the existing concepts of withdrawing and the push-pull method. One limitation of the study is generalizability, in that the subjects were young, with an
average age under-40 cohort, with the majority college educated. His findings support the idea that the amount of information confronting individuals daily requires some sort of strategy to break down and organize that information.

Theoretical Framework: Cognitive Theories

Technology developments moved the discussion of electronic support systems to mobile learning. Recent peer-reviewed literature focuses on mobile technology in the capacity of training and development through mobile learning (Cochrane, 2011; Elias, 2011; Franklin, 2011; Kearney, Schuck, Burden, & Aubusson, 2012; Miangah, & Nezarat, 2012; Rismark & Solvberg, 2012). A gap exists in HRD literature regarding how mobile phones take on the role of mPSS, independent of formal learning, which is structured (McGuire & Gubbins, 2010) and consists of a prescribed curriculum with determined outcomes (Tynjälä, 2008).

The Mobile Performance Support System model proposed in this article will draw from cognitive psychology, which attempts to describe how the brain handles information (Ruisel, 2010). The intake system in the human mind, according to cognitive psychology, is the working memory, or short-term memory, which theoretically can only hold small amounts of information as it processes it for storage in the long-term memory, which is believed to be limitless in capacity (Miller, 1956; Sweller, Ayres, & Kalyuga, n.d.). The working memory functions as a processor, a filter, and a sorting system. Miller (1956) was the first to describe the concept of working memory. Unlike behaviorism, according to Ruisel (2010), cognitive psychology relies less on the idea of the environment to influence the thinking process and more on the role of the human mind as an information processor.

Information Processing Theory

Information Processing Theory (IPT) is a framework based in cognitive psychology. It sees the human brain as a “natural information processing system” (Sweller, Ayres, & Kalyuga, n.d., p. 3). Gagne and Driscoll (1988) developed a model of information processing in the context of instructional design and learning that consists of two functions: executive control and expectancies. Executive control is the function in which the individual controls how information is input into the processing cycle. Expectancies are the information output, or outcomes, when speaking in terms of learning theory. In their model, the short-term memory moves information into long-term storage. The long-term memory reciprocates by supplying information used by the working memory to interpret meaning in information processing. Although the theory speaks of the human mind in computer-like terms, the human personality and human experience influence the way in which information is interpreted and stored (Gagne & Driscoll, 1988; Humphreys & Revelle, 1984; McInerney, 2005; Ruisel, 2010).

Cognitive Load Theory

Cognitive Load is a theory that also has roots in cognitive psychology. The idea of cognitive load theory, developed by Sweller (1988), is that the limitations of the working memory to process large amounts of information call for a design of information input that works with the bottlenecking effect of the working memory coming into the human mind. Cognitive Load theory is popular in instructional design to support the idea
of chunking, or breaking down learning material into bits small enough for the working memory to process (chunking, 2006). The idea is that these small chunks of information move efficiently into the long-term memory. Miller (1956) proposed that the human brain could process about seven pieces, “plus or minus two” of information at one time (p. 81). Other theories (Cowen, 2001) suggest smaller numbers, but the overall consensus is that there is a constriction of data coming in, which is difficult in the learning environment and in a data-rich society. Chen, Pedersen, and Murphy (2011) state that three “causal factors” that determine the particular cognitive load capacity of an individual are “mental load, mental effort, and performance” (p. 3). Mental load refers to the “task and environmental demands” required by a task. Mental effort refers to the “cognitive capacity” required by a particular task (p. 3). Mental load and mental effort working together, determine the performance level of the individual in a particular task (Chen, Pedersen, & Murphy, 2011, p. 3).

Memory Compensation

The concept of ePSS is helpful for shifting the view of mobile phones from a personal communication device to a performance support system. ePSS are the electronic iterations of job aids (Rossett & Schafer, 2007). Gery (as cited by Cavenaugh, 2004), divides electronic performance support systems into three categories, intrinsic, extrinsic, and external support. Intrinsic support is inherent to the task in which the user is performing. Gery (1995) states that, when the user is engaged with intrinsic support, they “do not have the psychological awareness of being in software. They simply feel that they are just doing their work,” and the author continues to explain that extrinsic support is help from outside the system, such as “tips, cue cards, explanations, [and] checkers” (p. 51). External compensation strategies include the equivalent of performance support systems, whereas external support includes any learning, referencing, or job aids that occur outside the workflow (Rossett & Schafer, 2007).

Wade and Troy (2001) discuss the problem of memory aids in the context of support tools for brain-injured individuals. According to the authors, the role of internal memory compensation through “mnemonic strategies” does not suffice in the everyday working environment. The authors break memory aids into two categories, internal and external. Internal memory aids are built into the system, such as “an alarm sound acting as a reminder to switch off an appliance,” which contrasts with external aids, which requires that information should be entered from outside the system, such as “diaries, notebooks, lists, wall charts, and calendars” (p. 306).

Memory Compensation Model

Finding applications to aid in memory compensation is not difficult. Mobile devices, such as tablets and smartphones not only connect users to the Internet, but the number of applications available for download grows by hundreds of thousands (Quirolgico, Voas, & Kuhn, 2011). The model proposed in this paper is based within the framework of information processing theory and cognitive load theory. The mobile phone used in the capacity of an mPSS functions as a support system for the working memory. The individual receives input from the organization and other external sources. The information could be classified as formal or informal learning or data that needs to be retained. As the amount of information exceeds the capacity for working memory, the
individual uses the mPSS as a way to sort information, break it down into chunks, and turn that information into meaningful data that can be referenced, shared (collaborating), or acted upon (tasking).

Collaborating, referencing, and tasking are important outcomes in the context of organizational information and performance (Gery, 2002). From the top down, the model describes the way in which an individual takes in information from both an organization and the environment. Information overload affects performance when working memory reaches its capacity to process information and the ability of the individual to act on that information is compromised. When information exceeds the limits of the working memory, the mobile phone in the role of mobile performance support breaks information down into chunks and provides storage to increase the amount of new information that can be processed at any given time. This could be something simple, like a group of phone numbers, or a complex set of task instructions that need to be recorded on the spot.

The mobile device allows the information chunking to take place as the information comes in, much like in a formal learning situation, in which an instructional designer or teacher chunks the material before it is presented. The user can also sort the information into applications specifically designed for that information. The advantage of using a mobile device that has the capacity to run different applications is that the information can be sorted into categories that make it possible to put that information to use when the user retrieves it, allowing the user to push and pull information. For instance, contact information can be linked to social networking applications to collaborate with colleagues; it can be stored as reference material, or used to complete a task.

**Collaboration**

The Internet has enabled users to communicate and collaborate by bridging distances and time constraints. Synchronous and asynchronous workspaces exist online, in which users can share information and files, and use online applications in collaboration with other users. Mobile technology provides access to the same type of applications, but the limitations of the size and capacity to display information on smart phones and smaller tablets creates the need to design applications that break data and information into the type of manageable learning chunks that aid in learning and processing the information in the working memory (Alarcón, et al., 2006). This tends to funnel mobile collaboration into applications that interface like social media, and break collaboration into manageable chunks, through short messages and that may be kept for later reference or discarded. mPSS design can draw upon mobile technology’s strength as take-anywhere, just-in-time external performance support (Gal & Nachmias, 2008) that is not tied to a proprietary system. This is not only useful for communication and collaboration, but for storing and managing communications, which is valuable to users who have hit their information overload threshold, or for those with memory impairments.

**Referencing**

Unlike collaboration, in which the mobile user is interacting with other users and adding, subtracting, or changing information, referencing refers to accessing data that is fixed and cannot be modified by the user (Gery, 2002). According to this study,
information available from online-accessible sources or stored within stand-alone software has the potential to contribute to information overload by connecting the user to the vast sources on the Internet. In the context of a performance support system, well-organized reference data allows the user to completely bypass using long-term memory to access stored information. A study of police officers in the United Kingdom found that mobile phone usage to access information reduced information overload, due to the ability of the officers to manage the information (Lindsey, Cooke, & Jackson, 2009).

**Tasking**

Task support is at the heart of performance support systems, which provide, guiding, coaching, and decision-making. (Gery, 2002; Rossett & Schafer, 2007). Performance support does not merely aid in task completion, it provides “valued information processes, or perspectives that target a need or task” (Rossett & Schafer, 2007). It is in this capacity that mPSS provide memory support, as well, as allow users to connect with information that walks through a process that may not be committed to long-term memory. Tasking may systematically involve collaboration and referencing (Gery, 2002). This systems view of performance support allows for mPSS to be integrated into tasks and processes within an organization (Cho, et al., 2011; Gery, 2002; Rossett & Schafer, 2007). mPSS allows the user to avoid information overload by focusing support on an individual task, through just-in-time training or performance support integrated into the application being accessed (Cole, Fischer, & Saltzman, 1997).

_Figure 2._ Model of mobile phones as performance support systems. Adapted from Gagne and Driscoll (1998), Valcke (2002), Chen, Pedersen, and Murphy (2011), and Gery (2002).
Development of the Model

The original idea of the model grew from an informal discussion about the use of mobile phones and devices in a study skills course geared specifically to students with acquired brain injuries (ABI), also referred to in some texts as traumatic brain injury (TBI). A white paper (Schwartz and Wild, n.d.) describes a program of the Military Health Program’s Computer/Electronic Accommodation Program (CAP), using the Pharos Cognit, a commercially available smart phone developed to support memory compensation in cognitively impaired individuals. In the CAP program, service men and veterans with TBI are given a two-fold system for memory compensation: a PDA and a curriculum set that trains the user in the use of the PDA with a curriculum that makes the user aware of the cognitive skills necessary to operate the PDA. Schwartz and Wild (n.d.) found that the program was much more cost effective using the mobile phone applications in both a learning capacity and as a kind of ePSS, than traditional rehabilitation.

The memory support model serves as a bridge from that concept to a look at ways, additional to brain injury, in which the ability of an individual to process incoming information might be compromised, such as the aging process and information overload, the main emphasis of this paper. Schwartz and Wild (n.d.) served as a catalyst for researching peer-reviewed literature on the subject of mobile phones as memory compensation tools. In looking at the literature, there are many useful models in describing memory and learning, as well as theories on mobile learning, but I did not uncover a specific model that describes using a mobile device as a way to compensate for working memory.

Implications for Human Resource Development (HRD)

Wade and Troy (2001) cite mobile phones as ideal memory support tools due to the growing ubiquitousness of the technology. It is that ubiquitousness that might allow HRD professionals to overlook the potential of mobile technology to solve specific information management problems. Many mobile phones in current use have the capacity to work as referencing, sharing, and tasking tools.

The multi-tasking nature of smart phones of mobile devices with the ability to run applications makes storage and retrieval of information possible, and the nature of the communication devices allows the user to not only reference information, but to connect that information with others and other applications in which the information may be acted upon, processed, or deleted. One possible way to implement a program supporting memory function in an organization would be to invest in the development of application suites that meet the needs of the organization and can be easily downloaded to smart phones or installed on mobile devices.

Another implication for HRD professionals is a question of inclusion. Individuals with short-term memory challenges, such as in the aftermath of brain trauma or in older workers, who may have mild to moderate short-term memory impairment, which may cause an otherwise functional individual the need to compensate with an external job aid. Barriers to the implementation of ePSS usage remain in current practice, such as cost, the digital divide. Among the reasons working-memory and memory compensation have important implications for HRD is that it is estimated that the number of military personnel with mild acquired brain injury numbered over 25,000 in 2010 alone (DOD,
This includes a large number of highly skilled workers potentially entering the civilian workforce that have cutting-edge technology skill sets and leadership experience. Older workers, an increasing percentage of the workforce, might also benefit from a performance support system that enhances the abilities of the working memory to process information. Retaining older workers who possess the tacit knowledge and experience is important in order to avoid reinventing the wheel, so to speak, each time a well-trained older worker retires and takes years of knowledge and procedure into retirement.

An expansion of this article will further explore expanding the model into a systems view of the organization, the individual, and the mPSS. More detailed analysis of memory problems and implications on the job is needed, as well as an exploration of barriers to implementing an mPSS program within an organization, including multiple platforms, cost, and user ability. Further areas of research include best practices for developing applications for memory compensation.
References


