CHAPTER 3

Multitasking Behavior

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Introduction

This chapter does not attempt to furnish an overview of multitasking research in every scientific discipline. Rather, we highlight the importance of multitasking in the cognitive and information sciences and the need for further research on multitasking, particularly within the context of information behavior.

Why are we interested in multitasking? Why is multitasking an important theoretical and practical phenomenon for the cognitive and information sciences, and particularly for theories and models of information behavior? Multitasking has no doubt always been an essential human behavior. However, unlike earlier research on microanalyses of brain and memory structure/capacity (Miller, 1956), multitasking pushes brain and memory research into a more global consideration of human existence. Reasons for our increased interest in the phenomenon are society's heightened interest in security concerns, the evolution of a workplace with workers now required to perform tasks formerly performed by others, and above all the pervasiveness of communication devices in both work and leisure activities.

Citations to multitasking research in the cognitive sciences have recently appeared in the popular press. The ubiquity of digital devices such as mobile phones, messaging devices, video games, and desktop and laptop computers has helped create the impression that today's young people behave differently from previous generations in their simultaneous use of multiple devices, with the result that attention is diverted from the task at hand (Scott, 2006). In response to the numerous published studies indicating the negative effects of telephone use on automobile driver performance (Strayer & Johnston, 2001), many local and state governments have adopted laws to curtail this kind of multitasking behavior. Employers and organizational behaviorists are also concerned about multitasking in work environments, in part because of the proliferation of information devices (Holstein, 2006). They ask questions such as: How can we keep employees focused? (Hafner, 2005). Citing former Microsoft Vice President Linda Stone's (2006) phrase "continuous partial attention," *New York Times* columnist Thomas L. Friedman (2006) labels our multitasking age "The Age of Interruption."

However, we start by considering multitasking as a human ability; the ability to handle the competing demands of multiple tasks. A task is defined as "a distinct work activity carried out for a distinct purpose" (Cascio, 1978, p. 133). Multitasking can be defined narrowly or broadly. For example, is multitasking the human ability to deal with more than one task at the same time, or is multitasking actually the ability to switch quickly from one task to the next in a rapid sequence of tasks? We here define multitasking broadly. Waller (1997, p. 225) states that "individual-level multitasking processes involve a person's allocation of his or her own scarce cognitive resources among several tasks and the moderating impact of task elements, task processes, and task resources on individual multiple-task performance."

Multitasking occurs at different levels of human behavior, including the individual and group levels (Waller, 1997). When humans multitask, they work on two or more tasks and switch between those tasks, either as individuals or within groups (Waller, 1997). Multitasking and task switching are mechanisms that help humans deal with the complex environment in which they live. People often switch among different types of tasks such as talking on the telephone, computing, reading, and information seeking. There is a growing and crucial need to extend our understanding of multitasking behavior, particularly within the context of cognitive and information behavior.

In spite of the importance of multitasking in the cognitive sciences, until recently the field of information science devoted limited attention to understanding multitasking within the context of the field's research issues and problems. Previous *ARIST* chapters on information behavior touched only parenthetically on multitasking (e.g., multitasking will increase as a result of increased collaboration in the work environment [Foster, 2006]; see also, Courtright's [2007] chapter on information use environments; Davenport [2002] on distributed cognition; Finholt [2002] on the organization of work; Garcia, Dawes, Kohne, Miller, and Groschwitz [2006] on the workplace and technological change; Jones [2007] on management of tasks; Rogers [2004] on human–computer interaction [HCI]; and Vakkari [2003] on task-based information searching).

However, recently, multitasking research has grown in theoretical and practical significance for information scientists. Multitasking is emerging as a fundamental process that underpins information behavior. As with other information science concepts, such as relevance, uncertainty, or feedback, multitasking is now an important and complex concept that is crucial if we are to understand information behavior fully.

The purpose of this chapter is to develop a framework for clarifying the relationship between information behavior and multitasking. Because cognitive science research affects information behavior studies, we first outline multitasking concepts and models within the cognitive sciences, broadly defined.

Cognitive Sciences

Various cognitively oriented fields regard multitasking as an important element of their theories and models to explain cognitive behaviors. In this section we explore the nature of multitasking from the perspectives of cognitive science, communication studies, human factors, human–computer interaction, and organizational behavior. We examine the contribution each field has made to our understanding of multitasking.

Cognitive Science

Cognitive scientists have for decades studied many aspects of multitasking or task switching (Carlson & Sohn, 2000; Miyata & Norman, 1986). The growing complexity of the global information environment means that people are increasingly engaged in multitasking and task-switching behaviors. But only now is this research being applied. Many interactive technologies still do not provide effective support for managing multitasking behaviors (Wickens, 1992).

Cognitive psychologists have an extensive research literature on multitasking, concurrent information processing, task switching (Burgess, 2000; Pashler, 2000), and sequential actions (Carlson & Sohn, 2000) at the microsecond level. Complex task switching can include three phases: desire to task switch, task switch, and switching back to a previous task. The finding that multitasking over different types of tasks can reduce productivity (Rubinstein, Meyer, & Evans, 2001) is further supported by the single channel theory, which suggests that the ability of humans to perform concurrent mental operations is limited by the capacity of a central mechanism (Schweickert & Boggs, 1984). A major understanding from cognitive science research has to do with both the positive and negative aspects of multitasking. Rubinstein et al. (2001) found that multitasking between different types of tasks can reduce productivity. Wickens (1992), on the other hand, suggests that *time sharing* allows the simultaneous performance of multiple tasks and *time swapping* allows the sequential performance of tasks.

Psychologists have also identified differences between prioritized and unprioritized multitasking situations (Ishizaka, Marshall, & Conte, 2001) and a model of group multitasking behavior (Waller, 1997). Aasman (1995) and Just, Carpenter, Keller, Emery, Zajac, and Thulborn

(2001) analyzed multitasking and dual tasking during driving. Hunt and Joslyn (2000) identified characteristics of individuals who do well in situations characterized by multitasking and decision making under considerable time pressure. Bainbridge (2002) described processes underlying human multitasking behaviors in complex task situations. Lee and Taatgen (2002) argued that multitasking behaviors can be best understood as a product of skill acquisition.

Grady, Springer, Hongwanishkul, McIntosh, and Winocur (2006) noted a “seesaw imbalance” in multitasking and aging; when we are younger there is a seesaw balance between two regions in the brain’s frontal lobes. Tasks that require concentration evoke high activity in the dorsolateral prefrontal cortex, while tasks not related to the central task (such as monitoring one’s surroundings) evoke low-level activity in the medial frontal and parietal regions of the brain. Seesaw imbalance occurs in older adults who find it difficult to inhibit distracting information, including interference from other tasks; thus for older people activity in the dorsolateral prefrontal cortex decreases while the medial frontal and parietal regions show less activity for focusing on the task. For aging effects on attentional control in multitasking, see Bherer, Kramer, Peterson, Colcombe, Erickson, and Becic (2005), and for aging effects on multitasking in employment, see Taylor, O’Hara, Mumenthaler, Rosen, and Yesavage (2005).

The Stroop effect in psychology denotes interference in a time-task experiment due to an incongruence between the semantic meaning of a test word and some other factor—for example, the word “blue” printed in a different color—slowing reaction times and increasing errors. In multitasking time-reaction experiments, the Stroop-like interference from the other task(s) in spite of preparation is perplexing (Meiran, 2000), requiring new research methods (neuroimaging, electrophysiology, etc.) in the important areas of study of the effects of aging (Mayr, 2001), brain damage (Keele & Rafal, 2000), and individual differences in function (Miyake, Friedman, Emerson, Witzki, Howerter, & Wagner, 2000). On the other hand, Meyer, Glass, Mueller, Seymour, and Kieras (2001) and Glass, Schumacher, Lauber, Zurbriggen, Gmeindl, Kieras, et al. (2000) did not find that degradation in performance during multitasking for people less than 70 years of age was due to decreased “hardware” functionality.

Task Switching

Task switching has been recognized as an important element of multitasking. Monsell (2003) reviews the notion of task switching in cognitive science research, which began with Jerslid (1927) but developed into a full paradigm only in the mid-1990s (Rogers & Monsell, 1995). Because it sees multitasking as switching from one task to another in rapid succession rather than the concurrent performance of two or more tasks, cognitive science research focuses on the costs to the individual of switching tasks compared to non-switch or task-repetition trials.

In experiments for deriving switching costs, subjects are asked to perform alternating different tasks so that their response times can be measured. When compared to non-switch or task-repetition trials, subjects performing switching trials take longer and make more errors. These switching costs can be reduced if the subjects are allowed to prepare for the task (Allport, Styles, & Hsieh, 1994; Meiran, 1996; Rogers & Monsell, 1995), but the costs cannot be reduced to zero—residual costs remain (De Jong, 2000; Kimberg, Aguirre, & D'Espisito, 2000; Sohn, Ursu, Anderson, Stenger, & Carter, 2000). Furthermore, even when the task switching occurs only once at the beginning of the trial and is subsequently eliminated, the single task switch at the beginning creates long-term mixing costs (mixing costs may capture executive control functioning processes in the experiment) (Rubin & Meiran, 2005).

Meyer and colleagues describe the executive control processes and cognitive architecture involved in rapid task sequencing/switching during multitasking in Rubinstein et al. (2001). Executive control provides a supervisory function controlling other perceptual/motor and cognitive processes when switching from one task to another. The three theories of executive control processes are:

1. The attention-to-action (ATA) model (Norman & Shallice, 1986), which envisages three subcomponents: action schemas, contention scheduling, and a supervisory attentional system.
2. The frontal-lobe executive (FLE) model (Duncan, 1986), which also envisages three subcomponents: goal lists, means–ends analysis procedures, and action structures.
3. The strategic response-deferment (SRD) model (Meyer & Kieras, 1997a, 1997b), which envisages three sets of production rules governing: Task 1 responses to stimulus, Task 2 responses to second stimulus, and executive process rules that obey task priorities allowing Task 2 responses to be stored temporarily in working memory until Task 1 priority is completed.

The three models "incorporate separable subcomponents that enable task switching" (Rubinstein et al., 2001, p. 765).

Logan (2004) describes the role of working memory in executive control during task switching. Theories of working memory are summarized by Miyake and Shah (1999) and Baddeley, Chincotta, and Adlam (2001). Working memory has capacity limitations (Anderson, Reder, & Lebiere, 1996); and in task switching, information is lost from working memory due to either decay (Anderson, Reder, & Lebiere, 1996) or interference (Waugh & Norman, 1965). Evidence for these two theories is mixed (Nairne, 2002). Two proposals describe how long-term memory and working memory combine together during task switching: They may be joined together, with working memory the active part (Anderson, Reder, & Lebiere, 1996), or they may be separate but interactive (Baddeley & Logie, 1999; Kieras, Meyer, Mueller, & Seymour, 1999). Does cognitive reconfiguration during task switching emphasize working memory (i.e., changing goals and stimulus-response mapping rules) (Rubinstein et al., 2001) or does it emphasize working memory plus cognition system outside working memory (Logan & Gordon, 2001; Meiran, 2000)? (See also the two opposing theoretical proposals for explaining time costs [Monsell, 1996], emphasizing either the task processing level or the executive control level.)

Multitasking continues to be an important concept for cognitive scientists. The next section examines how multitasking is represented in communication studies' models and theories.

Communication Studies

Communication studies observe multitasking from a multi-channel or multi-media perspective. In multitasking, the user of one medium or channel may also be engaging with other media at the same time. This phenomenon attracts particular interest because of the prevalence of multitasking behavior among today's media-savvy young people, who engage with television, music listening devices, instant messaging, and the telephone while surfing the Internet (Waxman, 2006). Using the term Concurrent Media Exposure (CME) to identify multitasking, Holmes, Papper, Popovich, and Bloxham (2005) state that CME behavior was indicated by 96 percent of their studies' participants, constituting 30.7 percent of the participants' total media exposure per day.

Communication scholars are interested in the user's "engagement" vis-à-vis the following four elements: (1) medium (channel), (2) content (genre), (3) audience (incidence of media exposure, time spent with media, audience demographics), and (4) context (location, hour of day, day of the week, mode of exposure, life activity, episodic structure, primary and secondary attention). These four elements constitute two study perspectives: either a media/content and/or an audience/context-centered viewpoint (Holmes, Papper, Popovich, & Bloxham, 2006). The media/content viewpoint can, in turn, have either a media channel or media content emphasis. The channel emphasis is an attribute of the particular medium: Different media channels have different potentials to engage their audience; a content emphasis focuses on the content delivered by the medium. Different media are associated with different formats, such as passive versus interactive or short episodic duration versus long episodic duration (Holmes et al., 2006).

Although CME is controlled primarily by the audience/context dimension, it is also influenced by the medium/content. For example, the combination of TV and the Internet is the dominant CME pairing, with CME occurring during 80 percent of Internet exposure (Internet as primary task) but only 28.5 percent during TV exposure (TV as primary task). For CME, Holmes et al. (2006) distinguish between active and passive engagement on the part of the user. This is illustrated on the passive side by the user shopping in a mall with radio in the background, where engagement/attention is shared; on the active side is the restless attention-shifting behavior that takes place in multitasking activities that occur in parent–child interactions.

The next section of the chapter examines multitasking research within the field of human factors.

Human Factors

Multitasking in human factors research is of pivotal concern in creating cognitive models that allow a human operator to supervise, control, and act appropriately in multidimensional environments. In human factors, multitasking is "the ability to integrate, interleave, and perform multiple tasks and/or component subtasks of a larger complex task" (Salvucci, Kushleyeva, & Lee, 2004, p. 267). There are examples of cognitive architecture/modeling and multitasking for driving (Aasman, 1995; Salvucci, Boer, & Liu, 2001), piloting combat aircraft (Jones, Laird, Nielsen, Coulter, Kenny, & Koss, 1999), and air traffic control (Lee & Anderson, 2001). Chou and Funk (1990) have proposed a Cockpit Task Management (CTM) system. Cognitive modeling for multitasking has increasingly involved studying complex domains, with unified cognitive architectures such as ACT-R (Adaptive Control of Thought-Rational) (Anderson, Bothell, Bryne, Douglass, Lebiere, & Qin, 2004), EPIC (Executive Process/Interactive Control) (Meyer & Kieras, 1997a, 1997b), and Soar (Newell, 1990).

Human factors researchers are beginning to develop supervisory and control interfaces based on cognitive modeling or cognitive architecture. Anderson and his associates (Anderson & Lebiere, 1998; Anderson, Taatgen, & Byrne, 2005; Gerjets, Scheiter, & Schoor, 2003; Schoor, Gerjets, & Scheiter, 2003; Taatgen, 2005) propose a general executive control model based on the ACT-R cognitive architecture. They have explored this cognitive architecture model for both discrete (Byrne & Anderson, 2001; Meyer & Kieras, 1997a, 1997b; Sohn & Anderson, 2001) and continuous tasks (Kieras, Meyer, Ballas, & Lauber, 2000). But they have used customized executives for multitasking that are appropriate only for the particular human activity being considered, ranging from list memory to mathematical problem solving, to air traffic control (Salvucci, Boer, & Liu, 2001).

Salvucci, Kushleyeva, and Lee (2004) provide a dedicated buffer supervising and controlling an automobile driver's goal set for multitasking, attached to the general executive. Driving a car is extremely complex and unpredictable; the higher level cognitive components maintain situation awareness, determine strategies for navigation, decide when to initiate and terminate maneuvers, and manage lower level cognitive components such as changing radio stations, conversations, and eating and drinking. Integrated driver cognitive models thus require "task prioritization and attention management to handle the multitasking nature of the driving task" (Salvucci, Boer, & Liu, 2001, p. 10).

Handheld devices provide unique challenges to user multitasking behavior. For a description of the special constraints of handheld devices (small screen size, slow processors, noisy physical environment, etc.), see Vaananen-Vainio-Mattila and Ruuska (2000). Nagata (2003) reports findings from a study that looks at multitasking while using a pocket PC (iPAQh3800). Following Preece, Rogers, and Benyon's (1994) definition of multitasking as alternating between tasks, Nagata (2003) looks at multitasking in terms of an interruption task resulting in a degradation of main task performance.

The next section outlines the role of multitasking in human–computer interaction studies.

Human–Computer Interaction Studies

The fundamentals of multitasking in human–computer interaction (HCI) studies are given by Tsukada, Okada, and Matsushita (1994), Card, Moran, and Newell (1983), and Preece et al. (1994). The issue of multitasking in HCI is approached via the concept of interruption. Interruptions are "unanticipated requests for switching between different tasks during multitasking" (McFarlane, 1997, p. 9). However, HCI differs slightly from cognitive science, which equates multitasking with task switching in repetitive tasks (see the cognitive science section of this chapter). In HCI, concurrent multitasking is acknowledged in the notion of the self being divided between internal (cognition) and external (observable behaviors) (Tsukada et al., 1994).

The information processing tasks that are internal to the person (cognition and perception) and external to the person (motor or actions) are different, creating a common situation in which a person can in fact be engaging concurrently in multiple tasks (Tsukada et al., 1994). A bottleneck may occur because people's external actions are undertaken in sequence (i.e., not concurrently) but tasks undergoing internal processing leading up to the action can in fact be performed concurrently or in parallel (McFarlane, 1997). Card et al. (1983) depict a model of two kinds of internal processing (perception and cognition) with only one motor processor for controlling external actions. Even in sequential actions, there can be an appearance of concurrent multitasking because external actions are defined as a series of 70 millisecond discrete actions that comprise all tasks, big or small. Thus, although motor actions are performed sequentially in chains of actions, the smallness of an action's discrete units means a task can be interrupted anywhere, at odd places, then returned to suddenly, giving the appearance of concurrent multitasking.

Relying on the idea that human actions are "discretizable," GOMS (Goals, Operators, Methods, and Selection rules) models have been developed (Card et al., 1983). A modification of the GOMS Model, called CPM-GOMS (Cognitive Perceptual Motor/Critical Path Method-GOMS), was created by John and Gray (1995) to model performance on subtasks and tasks. Chains of subtasks are scheduled on the three separate human processors (perception, cognition, and motor), each on a separate time track. The central idea is that people can do some things on one of the other processors while they are waiting to finish other things (McFarlane, 1997). The problem with multitasking on these parallel tracks is that people are interrupted and must return to the first task, often forgetting where they are in the subtask, which leads to wasted time and energy.

HCI research has focused on multitasking, task switching, interruptions and their effects on task performance, and on the ameliorative effects of interruptions on efficiency and safety. For example, research indicates a decrease in performance speed (Gillie & Broadbent, 1989; Kreifeldt & McCarthy, 1981) and observed differences in how people perform on interrupted tasks (Cabon, Coblentz, & Mollard, 1990) (for a review of the interruption and multitasking literature in HCI, see McFarlane, 2002). However, interruption of simple tasks has been found actually to increase performance efficiency (Brumistrov & Leonova, 2003; Speier, Valacich, & Vessey, 1997).

Information workers who engage in multitasking often suffer what is termed *prospective memory failure* when they return to a task. Prospective memory failure is the inability to remember the task that they must perform (Ellise & Kvavilashvili, 2000). Prospective memory failure has been shown to be a significant fact of life (Czerwinski & Horvitz, 2002; Dey & Abowd, 2000; Sellen, Louie, Harris, & Wilkins, 1996; Terry, 1988). Task interruptions at work are one of the most cited reasons for prospective memory failure (O'Connail & Frohlich, 1995). Accordingly, Card and Henderson (1987) propose a computer interface design to manage interruptions in multitasking and help people avoid prospective memory failure. McCrickard, Chewar, Somervell, and Ndiwalana (2003) propose a notification system, which they define as an interface used "in a divided-attention, multitasking situation," that delivers on time information to the user that is "parallel … extraneous or supplemental to a user's attention priority" (McCrickard et al., 2003, pp. 312, 315).

The next section explores the nature of multitasking within organizational behavior research.

Organizational Behavior

Current interest concerning multitasking behavior is reflected in three general areas of the organizational behavior literature: individual differences or preferences that motivate multitasking behavior, the relationships between multitasking behavior and a variety of individuals' work-related outcomes, and multiple-task performance at the group level of analysis. Although some work on multitasking behavior across a wide range of organizations can be found in other organization-focused literatures such as management science (e.g., Eppen, Gould, Schmidt, Moore, & Weatherford, 1998), labor economics, economic history, and occupational health (e.g., multitasking in French automobile firms [Gorgeu & Mathieu, 2005], among Dutch farm women [Bock, 2004], and in nineteenth-century Australian banks [Seltzer, 2000]), this section focuses on work published in core organizational behavior and applied psychology outlets.

It has been suggested that task environments have become more complex and workers' preferences have also changed in favor of greater task variety and more challenging work environments (Lindbeck & Snower, 2000). It thus seems reasonable to conclude that, in general, individuals are creating, encountering, and accepting more multitasking situations at work. Some workers succeed and even thrive in such environments but others do not cope well with task-juggling, experiencing instead increased levels of stress and stress-related injury and illness (Robinson & Smallman, 2006). As performance differences linked to multitasking behavior become more consequential to individuals and organizations, researchers have begun exploring the antecedents of multitasking behavior. This research eschews cognitive psychology's focus on the cognitive mechanisms of multitasking or the cognitive capability to multitask in favor of an emphasis on personality and preference.

Research on time urgency and multitasking is one such area of inquiry. Time urgency is a relatively stable individual difference variable and a subcomponent of the Type A behavior pattern (Conte, Landy, & Mathieu, 1995; Conte, Mathieu, & Landy, 1998; Landy, Rastegary, Thayer, & Colvin, 1991; Rastegary & Landy, 1993). Time urgency, like the Type A behavior pattern, has been associated with several health problems (Conte, Mathieu, & Landy, 1998). Time-urgent individuals carefully attend to the passage of time; they perceive time as their enemy and set themselves in opposition to it (Price, 1982; Waller, Conte, Gibson, & Carpenter, 2001). Time urgency is associated with time-related task strategies such as multitasking; time-urgent individuals are chronically hurried due to their tendency to schedule more activities than fit into the time available (Friedman & Roseman, 1974).

The issue of polychronicity has received slightly more attention in organizational behavior literature than time urgency, although the two concepts are closely related. Originally construed—along with monochronicity—as a characteristic of cultures (Hall, 1983), polychronicity in the organizational behavior literature refers chiefly to "the extent to which people (1) prefer to be engaged in two or more tasks or events simultaneously and are actually so engaged (the preference strongly implying the behavior and vice versa), and (2) believe their preference is the best way to do things" Bluedorn (2002, p. 51). Bluedorn cites significant positive relationships between polychronicity and extraversion (Lieberman & Rosenthal, 2001), favorable inclination toward change, tolerance for ambiguity, formal education, striving for achievement, impatience and irritability, and frequency of lateness and absenteeism (Bluedorn, 2002).

Other research focuses on the role of polychronicity in workers' outcomes in specific contexts. Slocumbe and Bluedorn (1999) found that the congruence between individuals' levels of polychronicity and amount of polychronicity they perceived in their workplaces to be positively related to (1) the individuals' organizational commitment, (2) their perceived performance, and (3) their perceptions of performance evaluation fairness. Similarly, Hecht and Allen's (2005) field study found that the fit between an individual's preference to engage in polychronic behavior and the opportunities to do so afforded by his or her work context significantly predicted worker well being (i.e., satisfaction, affect, self-efficacy, and psychological strain); however, these findings did not appear in data from their laboratory study of students. And, although Bluedorn (2002) found a negative relationship between the level of polychronicity and stress among dentists, he found no relationship between polychronicity and outcomes for other dental office workers. Additionally, in a study of delivery drivers, Francis-Smythe and Robertson (2003) found a significant positive influence of polychronicity on job-related well being. It would seem that at least for some types of work contexts, multitasking (polychronic) workers are "happy" workers. In sum, this area of research provides evidence of both positive and negative effects of multitasking behavior on workers' outcomes.

An additional and specific area of the organizational behavior literature addresses tensions between work and family roles, again providing evidence of both positive and negative influences of multitasking on workers. Research in this area generally conceptualizes multitasking as the switching by an individual between work-related and family-related roles. Ruderman, Ohlott, Panzer, and King (2002) found that managerial women with multiple life roles (job and non-job roles) successfully transferred their non-job multitasking skills to their work environments, ultimately enhancing their leadership qualities at work. This research provides support for the more general theory of work–family enrichment, which suggests "experiences in one role (can) improve the quality of life in the other role" (Greenhouse & Powell, 2006, p. 72). However, in a study based on data collected from 2,109 respondents, Voydanoff (2005) found that work–family multitasking (i.e., bringing work home and job contacts at home) were positively related to work–family conflict and perceived stress.

Most work is accomplished in groups of people in organizations; some organizational behavior scholars have therefore investigated multitasking behaviors specifically in group settings. Waller (1996, 1997) suggested that groups, like individuals, can choose different task performance strategies such as time swapping (performing one task at a time, en masse), or time sharing (performing multiple tasks simultaneously by distributing tasks across different group members). Marks, Mathieu, and Zaccaro (2001, p. 356) have likewise conceptualized teams as "multitasking units that perform multiple processes simultaneously and sequentially to orchestrate goal-directed task work."

In subsequent empirical work, Wagner, Meyer, Humphrey, and Hollenbeck (2005) argue that the choice between simultaneous (time sharing) or sequential (time swapping) task performance strategies in teams produces equivocal results. They suggest that different combinations of individualistic and collectivistic action influence how much multitasking behavior occurs in teams, reflecting team members' ability to recognize the different tasks needing to be performed and allocating them across team members. A limited amount of work in organizational behavior has also investigated individual influence on team multitasking behaviors.

Waller, Giambatista, and Zellmer-Bruhn (1998) studied the influence of highly time-urgent individuals (as compared to other group members) on group-level multitasking in small groups working toward a strict deadline. They found that the presence of a highly time-urgent member depressed group multitasking behavior, ostensibly because these individuals were able to keep their groups focused on one primary task at a time and thus monitor progress toward the deadline. Other work in the area suggests that groups comprised of individuals who are time urgent and hold a goal-oriented future- (rather than past- or present-) time orientation are more likely than other groups to "cram" more work into an allotted amount of time and that they cope by engaging in multitasking behavior (Waller et al., 2001).

The organizational behavior literature on multitasking paints a rather equivocal picture of multitasking's outcomes for workers. On the one hand, being able to switch among various tasks is regarded as a way for workers to enjoy enriched jobs and avoid monotonous, repetitive tasks that lead to boredom and dissatisfaction. Creating multitasking work environments is seen by many organizations as an arrangement that allows workers to be more flexible and responsive to unpredictable external organizational environments (Whitfield, 2000).

On the other hand, research in this area also suggests that for some workers, multitasking leads to increased levels of stress and health-related problems. Several studies have found indications that individuals are differentially motivated to and/or capable of engaging in multitasking behavior. Future research in organizational behavior should improve our understanding by more deeply investigating at least three issues.

First and as previously mentioned, the issue of volition in multitasking contexts should be carefully addressed. What different behaviors occur when workers choose to multitask and regulate their own pace of work as compared with being placed in a job context that requires near-constant multitasking? Additionally, previous research indicates that information regarding deadlines and time pressure can significantly affect individuals' task-pacing efforts (Waller, Zellmer-Bruhn, & Giambatista, 2002). Does the interaction of pacing volition and deadline imposition influence individuals' multitasking behaviors? How does information regarding task priorities (Ishizaka et al., 2001) affect pacing and multitasking under such conditions?

Second, existing work on multitasking in terms of person-job fit should be augmented. What *types* of multitasking requirements seem to be better suited to which individuals? Finally, issues of training multitasking behavior at both individual and group levels should be addressed in the organizational behavior literature, drawing upon pertinent research in human performance, cognitive psychology, and other disciplines. If the choice of task performance strategies is equivocal (Wagner et al., 2005), then what cues trigger multitasking behavior in high-performing individuals and groups in complex, time-pressured, task-performance contexts? Notwithstanding existing predilection and ability, it is conceivable that the *timing* of multitasking behavior, in addition to simultaneous task performance itself, could be improved for some individuals and groups.

Summary

Overall, in the cognitive sciences we see the development of two major themes. The first is that multitasking is, more often than not, studied within cognitive science and its associate disciplines in terms of interruption; thus, it is defined as a behavior that decreases efficiency and wastes time. Secondly, research acknowledges that with the proliferation of communication and information devices, multitasking while using these devices is facilitated and probably increasing. Is multitasking a negative or positive side effect of the advance of communication technology? Is it a behavior that is more important to us than we know?

In the next section we examine how multitasking is understood within information science.

Information Science

Until recently, information science devoted little attention to understanding multitasking within the context of the research issues and problems of the field. Multitasking research is now growing in theoretical and practical importance in information behavior research. We next examine how multitasking informs research on the Web and information retrieval.

Web and Information Retrieval Studies

Recent studies suggest that users' searches may have multiple goals or topics and that they occur within the broader context of information-seeking behaviors (Spink, 2004; Spink, Ozmutlu, & Ozmutlu, 2002). People may pool their topics and interact with an information retrieval (IR) system on multiple related or unrelated topics. Overall, a user's single session with an IR system consists of seeking information on single or multiple topics and also switching among topics (Spink et al., 2002).

Spink, Bateman, and Greisdorf (1999) found respondents in a Web-based survey reporting multitasking searches.

Spink et al. (2002) show that IR searches often include multiple topics during a single search session. They found that multitasking information seeking and searching are common human behaviors. Many IR system users conduct information seeking and searching on both related and unrelated topics. In addition, Web or IR multitasking search sessions are longer than single topic sessions, with mean topics per Web search ranging from 1 to more than 10 topics and a mean of 2.1 topic changes per search session.

Recent studies have examined multitasking searching on the Excite and AlltheWeb.com Web search engines (Ozmutlu, Ozmutlu, & Spink, 2003, 2004). Ozmutlu et al. (2003) provided a detailed analysis of multitasking sessions on AlltheWeb.com. They found that almost one third of AlltheWeb.com users performed multitasking Web searching. Multitasking Web search sessions often included more than three topics per session; were longer in duration than regular searching sessions; and most of the topics in multitasking searches involved switching among general information, computers, and entertainment. Ozmutlu et al. (2004) found that one tenth of Excite users and one third of AlltheWeb.com users conducted multitasking searches. Multitasking Web search sessions were longer than regular search sessions in terms of queries per session and duration, with both Excite and AlltheWeb.com users searching for about three topics per multitasking session and submitting about four to five queries per topic.

Typical Web search sessions are two queries; some comprise three or more (Spink & Jansen, 2004). Spink, Park, Jansen, and Pedersen (2006) conducted two studies of multitasking during Web searching; a study of two-query search sessions on the AltaVista Web search engine and a study of three-or-more-query search sessions on the AltaVista Web search engine. They examined the degree of multitasking search and information task switching during the two sets of AltaVista Web search sessions. A sample of two-query and three-or-more-query sessions were filtered from AltaVista transaction logs from 2002 and qualitatively analyzed. Sessions ranged in duration from less than a minute to a few hours. Findings included: (1) 81 percent of two-query sessions included multiple topics, (2) 91 percent of three-or-more-query sessions included multiple topics, (3) there was a broad variety of topics in multitasking search sessions, and (4) three-or-more-query sessions sometimes contained frequent topic changes.

The next section explores how multitasking is viewed within information behavior studies.

Information Behavior Studies

Spink and Park (2005) studied both multitasking information and non-information behaviors by business consultants. Key findings included: (1) seeking information formed 10.5 percent of business consultant daily tasks, (2) information-seeking tasks occurred within multitasking and task switching sequences with computing and communication tasks, and (3) information-seeking tasks were often conducted to support or respond to communication or computing tasks. Spink and Park (2005) provided a model of multitasking and task switching during information behavior that included cognitive, cognitive style, and individual differences variables. Spink, Alvarado-Albertorio, Naragan, Brumfield, and Park (2007) investigated the multitasking information behaviors of public library users at the Brentwood and Wilkinsburg Public Libraries in Pittsburgh through diary questionnaires. Some 63.5 percent of the 96 library users engaged in multitasking information behaviors, with a mean of 2.5 topic changes and 2.8 topics per library visit. A major finding was that many people in libraries seek information on multiple topics and engage in multitasking behaviors.

Spink and Cole (2005, 2006a, 2006b) have argued that, when information is added into the mix, the concept and process of multitasking takes on an added layer of complexity. Information behavior may involve a combination of cognitive and physical actions, on dual or multiple tasks concurrently or sequentially, including switching between different information tasks. Cognitively, humans sequence their information tasks and information task switching at different levels of complexity and speed. They argue that people's information behaviors are embedded within multitasking information behaviors that occur when users juggle multiple topics during the same search session.

Spink and Cole (2005, 2006a, 2006b) highlight how humans cognitively coordinate their information-seeking behaviors with their interactive searching (human–system interaction) behaviors; this includes recognizing and making sense of and cognitively articulating an information problem or a gap in their knowledge. In other words, information seekers have to coordinate a number of factors, including their cognitive state, level of knowledge, and understanding of their information problem, into a coherent series of sustained activities that include seeking, searching, retrieving, and using information. We know that hand-eye coordination is a physiological process that humans develop from childhood. But how do humans learn the process of coordinating their information needs into coherent processes of human information seeking, searching, retrieving, and use behaviors?

Rather than seeing this as a negative, like driving while engaging in another task, within information behavior research (Just et al., 2001; Rubinstein et al., 2001) we see multitasking as an essential element of the information-behavior process that must be carefully examined, allowed for, and facilitated in the design of IR systems (Spink, Park, & Cole, 2006).

Conclusion and Further Research

What have we learned from our examination of the cognitive and information sciences view of multitasking? The cognitive sciences are moving forward with research on interruption behavior that decreases efficiency and wastes time and on the positive and negative effects of multitasking while using information and communication technology.

Multitasking has been found to be beneficial in only a few cases (Brumistrov & Leonova, 2003; Speier, Valacich, & Vessey, 1997). Research in cognitive science and human factors sees multitasking as having negative consequences (i.e., producing a slow-down in performance of a principal task and increased errors). Cognitive science research views multitasking in terms of task switching, which causes inefficiencies in performance because of the residual costs when one returns to the primary task after having performed a secondary task. Because it sees multitasking as switching from one task to another in rapid succession rather than the concurrent performance of two or more tasks, cognitive science's research focus is on the costs to the individual of switching tasks compared to non-switch or task-repetition trials.

Although some cognitive science research indicates that there may be positive aspects to multitasking, the overall feeling is that further system design modifications are needed to protect against the negative effects of multitasking. A more nuanced view is possible if tasks are considered primary or secondary and requiring active or passive attention on the part of the user. An example of a primary-active task is a pilot engaged in active flying (e.g., steering) while monitoring safety-related alarm systems; an example of a secondary-passive task is listening to music while doing housework or studying for an exam. Although primary-active tasks are considered a positive form of multitasking that system design can augment, secondary-passive tasks and even secondary-active tasks (such as using a cell phone while driving) are considered impediments to the primary-active task of the user. This four-cell division of multitasking in cognitive science research between primary and secondary tasks and active and passive attention is revealingly expressed in a study of the differing placement of child-caring and housework by men and women (Michelson, 2005). The four-cell way of looking at multitasking also highlights the issue of imposed tasks versus voluntary multitasking, such as checking e-mail (secondary) while writing a business report (primary) for such beneficial reasons as resting the mind, collecting one's thoughts, or alleviating tedium—all of which serve to focus the mind when the user returns to the primary task.

Research on multitasking in organizational behavior focuses chiefly on developing a deeper understanding of the antecedents of multitasking behavior. Polychronicity seems to be the central variable of interest, for both individual and group-level multitasking behavior. Researchers are divided as to the positive and negative effects of workplace multitasking.

Many workers profess a preference for work environments that offer multitasking opportunities; however, many others report detrimental effects such as stress after working in demanding, multitasking-oriented settings. Finally, researchers report fairly consistent findings regarding the stress associated with multitasking connected to concurrent work–family demands.

Information behavior research, however, is developing the view that multitasking is an essential information behavior that enables us to adapt to our surroundings and survive. In other words, when we are engaged in performing a main task, communication devices facilitate a multitasking behavior that has always been present but becomes more obvious when we use these devices; that is, we constantly engage in a low-level scanning or monitoring of the environment. This low-level monitoring alerts us to danger and may set in motion other important information behavior phenomena that relate to human sensitivity and adaptation to both the social and physical environment in which we live (Spink & Cole, 2006a). This analysis provides hints of the importance of multitasking to human survival (Brumistrov & Leonova, 2003; Monsell, 2003; Speier, Valacich, & Vessey, 1997).

In addition, this chapter proposes that, both theoretically and practically, multitasking is an important concept for information behavior research. However, in the context of information behavior, multitasking is still largely under-researched. Task analysis in cognitive IR is a new arena of research. In spite of the new focus on tasks (Vakkari, Pennanen, & Serola, 2003), few information behavior models and theories take account of multitasking behaviors. Humans knowingly construct the information behavior-related processes that constitute our information behavior as a series of tasks. In the stop-and-go of everyday life, however, we are not in total control of how multiple tasks interact with each other; nor are we in control of how stages of an uncompleted task interact with or somehow become embedded in a task that is in focus at a given moment. Understanding and modeling multitasking information behaviors requires a greater understanding of the coordination and interplay among information seeking/foraging/sense-making, organizing, and use tasks.

We need to reconceptualize information behavior as the interplay of multitasking processes that require information coordinating behavior to work effectively (Spink, Park, Jansen, & Pedersen, 2006). Current information behavior models are also based on a single information task paradigm. But, information behaviors are often accomplished in complex fashion. Conceptualizing multitasking and coordination behaviors as suggested offers a relatively new, heuristic direction for information behavior research. The authors are currently conducting further studies to extend our understanding of the nature, patterns, and impacts of information behavior within a multitasking and coordinating framework. These include implications of multitasking in Web searching (Spink, Park, Jansen, & Pedersen, 2006) and also the development of new searching tools for more efficient IR system design (Spink & Cole, 2005).

Further research is being conducted to investigate the interplay between information and non-information tasks (Spink & Park, 2005). In particular, the concept of *information coordinating behavior* (ICB) is an important area of study for information science because it investigates how we intertwine tasks while sustaining momentum for completing individual tasks. The development of information behavior necessitates a theoretical and empirical explication of the important nature and role of information behaviors, including ICB. In information behavior, humans *coordinate* a number of elements, including their cognitive state, level of domain knowledge, and understanding of their information problem, into a coherent series of activities that may include seeking, searching, interactive browsing, retrieving, and constructing information.

Information seekers perform *interdependent activities* to achieve *goals* or solve problems. These activities may also require or create *resources* of various types. In this view, information seekers *coordinate information tasks* arising from dependencies that constrain how tasks can be performed. These dependencies may be inherent in the structure of the problem (e.g., components of a system may interact with each other, constraining the kinds of changes that can be made to a single component), or they may result from decomposition of the goal into activities or the assignment of activities to other actors and resources.

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