Team Task Switching: A Conceptual Framework for Understanding Functional Work Shifts

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Modern work environments are technologically and socially rich, requiring individuals to manage multiple tasks that involve different technologies and varying degrees of interdependence. Individual and team performance hinge on functional work shifts that can involve changing tasks (multi-tasking), technologies (multi-tooling), and/or teammates (multi-teaming). We extend research on task switching to explain how the social and technological dimensions of tasks affect switch costs. The task switching literature identifies lateral shifts that occur when individuals change tasks. We also consider vertical switches that occur when individuals change from independent (i.e., working alone) to interdependent work (i.e., as part of a team) or from interdependent to independent work. We then integrate personological, social, task, and technological factors into one conceptual framework. Our framework lays the groundwork for understanding the effect of functional work shifts on task and team performance in modern-day work environments.

INTRODUCTION

As individuals respond to changing work demands, they are often required to switch their goal-directed efforts among different tasks, tools, and/or technologies. In addition, given the social complexity of modern-day organizations, at various times, individuals work alone, as members of a team, or as members of a larger system of multiple interdependent teams (i.e., a *multiteam system*; MTS; Mathieu, Marks, & Zaccaro, 2001). Switching attention among different tasks, tools, or teammates can deplete attentional resources and create additional cognitive processing demands. Such challenges may be magnified in contexts requiring individuals to regularly shift focus across multiple teams.

Research in human factors and cognitive psychology suggests interruptions to ongoing tasks can lead to performance decrements in the form of "*switch costs*" as individuals switch to an interrupting task and back again to an ongoing task (e.g., Trafton & Monk, 2007). However, the cognitive perspective on task switching does not yet provide a complete picture of the predictors of adaptive task switching, nor of the implications of maladaptive task switching, within environments where individuals switch among tasks that are independent as well as interdependent, and where interdependencies cross team boundaries.

In team and multiteam contexts, task switching is both an individual as well as a *social* phenomenon. Thus, the problem of team task switching sits at the intersection of two independent research literatures. The first is the literature on task switching within human factors and cognitive psychology (e.g., Allport & Wylie, 2000; Trafton & Monk, 2007; Wickens et al., 2013). The second is the literature on team effectiveness within social and industrial psychology and organizational behavior (DeShon, Kozlowski, Schmidt, Milner, & Wiechmann, 2004; Gersick & Hackman, 1990; McGrath, Arrow, & Berdahl, 2000). We integrate these literatures into a conceptual model of team task switching that explains the personological, social, task, and technological variables involved in team task switching. We begin by presenting an organizing taxonomy for classifying types of switches. Next, we propose a conceptual framework outlining how characteristics of the task, team, technology, and individual influence switching behaviors.

A Taxonomy of Team Task Switching

Figure 1 provides an organizing taxonomy for classifying types of switches encountered by individuals in modern-day work. Individuals make ***lateral shifts*** when they switch tasks, teams, or tools. Lateral shifts can be either singular or compound. A singular shift entails changes in one of the three elements (e.g., the individual switches from working on task A to task B). In contrast, a compound shift entails changes on two or more of the task, team and tool dimensions. For example, a compound task-team shift means the individual goes from working on task A with individuals X, Y, and Z to working on task B with individuals I, J, and K. The taxonomy also distinguishes ***vertical shifts***, which involve a shift in the level of interdependence (e.g., individual, single team, multiple teams) needed to complete a task. Vertical shifts can be either upward (e.g., working independently to working with a team) or downward (e.g., working with a team to working independently).

(a) Types of Lateral Shifts

	Shifting Involves a Change in:
Singular Shifts	
1	Task
2	Team
3	Tool
Compound Shifts	
4	Task + Team
5	Task + Tool
6	Team + Tool
7	Task + Team + Tool

(b) Types of Vertical Shifts

	Direction of Shift:
Upward Shifts	
1	Individual to Team
2	Team to MTS
3	Individual to MTS
Downward Shifts	
4	MTS to Team
5	Team to Individual
6	MTS to Individual

Figure 1. A taxonomy of team task switching across tasks, teams, tools, and systems. MTS = multiteam system.

Laterally shifting tasks: Task switching. One element of lateral team task switching involves shifting among tasks – task switching. To better understand the effects of switching between tasks, we can draw from human factors literature focusing on interruptions to ongoing tasks, which can be viewed as an instantiation of task switching between two tasks (i.e., the ongoing task and an interrupting task). Here, cognitive mechanisms explain the ability to efficiently switch from one task to another (e.g., Trafton & Monk, 2007), and switch costs are explained in terms of task inertia (Allport & Wylie, 2000), cognitive tunneling (Jarmasz, Herdman, & Johannsdottir, 2005), and memory for task goals (Altmann & Trafton, 2002). Furthermore, the interruption literature describes the types of tasks that are particularly disruptive in a task switching scenario (e.g., Trafton & Monk, 2007), the amount of time required to return to the ongoing task following task switching (i.e., the "resumption lag"; Trafton & Monk, 2007), and remedial actions that may reduce switch costs (e.g., Brumby, Cox, Back, & Gould, 2013). Recent models of sequential task switching have explored task characteristics involved in switching from an ongoing task to one of *many* alternative tasks (Gutzwiller et al., 2014; Wickens et al., 2013).

Laterally shifting teammates: Multi-teaming. A second element of lateral team task switching requires individuals to shift attention across teams - multi-teaming. As indicated by their seminal article on multiteam membership (MTM; Mortensen, Woolley, & O'Leary, 2007), individuals in modern-day organizations are typically members of multiple teams at the same time. Hence, they are responsible to all of these teams and likely face differing demands, expectations, and constraints within each team.

The multi-teaming aspect of team task switching requires individuals to adjust to changes in teammates as they work on a given task. Even if tasks performed by a team are somewhat constant, the particular people one interfaces with to perform these tasks can change. We propose that that there are likely switch costs associated with moving between teams that may have different behavioral norms, interaction dynamics, etc. We consider the cognitive (e.g., DeChurch & Mesmer-Magnus, 2010), affective (e.g., Mortensen et al., 2007), motivational (e.g., Tajfel & Turner, 1979), and team composition (e.g., Cummings & Kiesler, 2005) mechanisms that may impact both the ability and motivation to switch between teams.

Laterally shifting tools: Multi-tooling. A third element of lateral team task switching involves shifting among tools - multi-tooling. Individuals use a variety of technological tools to complete work tasks. Often these tools have unique interfaces, learning curves, and best practices, placing unique cognitive and attentional demands on the user.

When forced to switch technology platforms, individuals are likely to experience cognitive interference from differences in the interface characteristics or requirements of the ongoing versus alternative tools. We consider cognitive mechanisms such as memory (e.g., Altmann & Trafton, 2002) and attention (e.g., Wickens, Hooey, Gore, Sebok, & Koenicke, 2009) that may impact the ability to efficiently switch between technological tools.

Vertical shifts. At times individuals work independently, at times they work in teams with other individuals, and at times they work within a larger system of teams. In short, individuals in modern-day organizations are part of MTSs.

MTSs consist of "two or more teams that interface directly and interdependently in response to environmental contingencies toward the accomplishment of collective goals" (Mathieu et al., 2001, p. 290). The MTS lens is useful for describing and explaining behavior and collective performance of loosely coupled teams working towards a common distal goal, but also focusing on proximal goals that may not always align perfectly with the distal goal (Marks, DeChurch, Mathieu, Panzer, & Alonso, 2005). It is therefore necessary for each team within an MTS to maintain internal coherence within a larger system.

Whereas in lateral shifts, team task switching factors revolve around aspects of the work itself (i.e., the task, the people, the tool), in vertical switches, the attributes of the entities that one works with when completing tasks are the primary focus.

Team Task Switching Factors as Sources of Inertia

Wickens and colleagues' (2013) research on cognitive factors suggest task switching behavior and performance is affected by (1) the extent to which a particular current task is "sticky" (i.e., high priority, easier to remain involved in, etc.) versus (2) the alternative task being "attractive" (i.e., higher priority, less difficulty, greater interest, etc.). We extend Wickens and colleagues' idea to include team and tool characteristics of lateral and vertical switches, and also use this framework to explain the inertia created by switches.

In our conceptual framework of team task switching, ***inertia*** is created when stickiness factors stemming from the attributes of the ongoing task overpower attractiveness factors of alternative tasks. The relative stickiness and attractiveness of tasks stem from attributes of the task itself, characteristics of the entities one works with to complete those tasks (whether alone or within a team or MTS), and attributes of the tools used to complete the ongoing and alternative tasks. Individuals' ability, motivation, and performance when presented with a switch can be traced back to the sources of inertia.

Laterally-Induced Sources of Inertia

Task characteristics. As can be seen in the top half of Figure 2, attributes of the task may affect the lateral inertia between the "stickiness of the ongoing task" and the "attractiveness of the alternative task." Indeed, research suggests perceptions regarding task (1) difficulty, (2) interest, (3) importance, and (4) salience, have implications for an individual's ability and willingness to switch tasks (e.g., Gutzwiller et al., 2014). With regards to task difficulty, task switching research has demonstrated that individuals are more likely to switch to an easy task than a difficult task (e.g., Wickens et al., 2013), as individuals tend to avoid additional effort if it means their workload will increase and their performance may suffer (i.e., par hypothesis; Helson, 1949). One exception may be that an individual currently embroiled in a difficult task is less likely to want to switch to another task until the difficult task has been completed (Wickens et al., 2013). With regards to task interest, the extent to which individuals perceive an alternative task to be interesting can contribute greatly to their inclination to switch tasks. Indeed, research suggests individuals are more likely to switch to an interesting yet difficult task than a boring yet easy task (Wickens et al., 2013). With regards to task importance, individuals tend to prioritize tasks based on their level of importance; alternative tasks perceived to be more important than the ongoing task may prompt a greater willingness to switch. Finally, with regards to task salience, some tasks possess characteristics that attract one's attention more than others. For example, a flashing alert on a display may demand an operator's attention away from an ongoing task.

Team characteristics. As can be seen in the top half of Figure 2, characteristics of the team may also affect the lateral inertia between the "stickiness of the ongoing team" and the "attractiveness of the alternative team", including (1) shared cognition, (2) team affect, (3) collective efficacy/motivation, and (4) team composition. Shared cognition helps teams cope with changing conditions (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000). The cost of team switching is diminished if each team is structured such that there are standardized methods for accomplishing work (Zika-Viktorsson, Sundström, & Engwall, 2006), and predictable roles and responsibilities in each team context, thereby facilitating the development of compatible shared mental models within each team. When teams have a similar understanding of their environment, roles, and responsibilities, members are able to effectively function and adapt without explicit coordination (Cannon-Bowers & Salas, 2001).

Team affect characteristics, such as familiarity, trust, and cohesion, set the stage for positive working relationships across multiple teams (Mortensen et al., 2007). This creates a sense of collective efficacy among the team, likely improving the feasibility of team switching. Finally, team composition factors, such as differences in member expertise and team-relevant skill sets (e.g., social and task management skills) increase coordination costs within a given team (Cummings & Kiesler, 2005), thereby making an adaptive team switch more difficult and decreasing motivation to switch.

Tool characteristics. Characteristics of the tool may also affect stickiness and attractiveness values. For example, when users are accustomed to tool-specific techniques for accomplishing an ongoing task, switching tools may result in "tool interference" wherein techniques used in one tool may take time to drop below threshold and temporarily compete with activation of knowledge relevant to new tools used for an alternative task (Memory for Goals Model; Altmann & Trafton, 2002). Further, cognitive engineering models of attention allocation (e.g., the N-SEEV Model; Wickens et al., 2009) describe how individuals develop an expectation that particular pieces of information can be found within elements of a particular technology platform, or that they will have to store certain information using an external tool (e.g., a post-it note; Zhang & Norman, 1994). This expectation, among other factors, guides the individual's attention around various elements of the platform to retrieve information at critical points of task completion.

From a cognitive perspective, the mechanism that directs one's attention to critical pieces of information may be below the level of consciousness. This is important because if an individual must change technology platforms, critical information may no longer be available in expected locations, and the individual may not even be able to identify what information is missing prior to carrying out the task. Not only would the omission of expected information reduce the efficiency with which individuals are able to switch to a new task on an alternative platform, it could create a potentially dangerous situation for safety-critical situations.

Finally, when using highly automated systems, automation reliance (Lee & See, 2004) could factor in to one's ability to efficiently and effectively switch to a new technology platform. As individuals interact with automation to carry out a task, they develop a task representation that includes elements of the task that are "allocated" to the technology. The automated functions are not practiced by the operator and thus do not become a prominent part of their task or tool mental model. When tools vary in the extent to which the expected automated functions are available, the operator must shift their mental model to better represent how the task is carried out using the new technology platform.

Personal characteristics. Personal characteristics may directly affect ability and willingness to switch, but also may moderate the relationship between the forces of inertia created by task, team, and tool stickiness and attractiveness factors and the willingness and ability to switch. For example, research suggests that multi-tasking ability is predictive of task switching ability and performance, and polychronicity is predictive of one's motivation to switch among tasks and one's satisfaction with jobs that require such task switching (Fahr, 2011; Kaff, 2004; König, Buhner, & Murling, 2005). When there is a mismatch between multi-tasking role requirements and multi-tasking preference, worker anxiety, stress, and discontentment arise (Sanderson, 2012), which increase employee tendency toward work withdrawal and turnover. Further, multi-tasking ability likely moderates the relationship between these forces of inertia and ability to switch, in that confidence in multi-tasking will tip the scales in favor of task switching. Similarly, polychronicity likely moderates the relationship between these forces of inertia and willingness to switch, in that preference to multi-task will tip the scales in favor of motivation to switch.

Vertically-Induced Sources of Inertia

The bottom half of Figure 2 details vertically-induced sources of inertia created by traversing levels and entities of an MTS. Prior research provides three functional mechanisms that characterize MTS entities with which individuals work: behavioral factors, motivational properties, and cognitive states (Zaccaro, Marks, & DeChurch, 2012). As was the case for laterally-induced sources of inertia, these vertically-induced sources of inertia can be understood as a differential between "stickiness factors" of an ongoing entity and "attractiveness factors" of an alternative entity. For example, when making a vertical shift from a team task to an individual task, the collective efficacy of the team is a motivational stickiness factor, and the self-efficacy of the individual is an attractiveness factor of the alternative task. If an individual is not confident in the team (i.e., low collective efficacy), but is confident in his/her own abilities (i.e., high self-efficacy), the downshift will be easier (i.e., lower inertia) than if the individual is confident in the team (i.e., high collective efficacy) and less confident in him/herself (i.e., low self-efficacy).

Behavioral factors. Upward team task switches entail increases in interdependence and require the individual to give up some control/autonomy and to rely heavily on the efforts of teammates. Upward switches are generally against the current, and entail a behavioral coordination cost as each new teammate becomes a new relationship to be managed. As such, coordination costs are exponential.

With each additional teammate comes a need to anticipate not only one's interactions with that teammate, but also the quality of interactions among one's teammates. For example, if A is teammates with B and C, then A must consider not only his or her relationship with B and C, but also B and C's relationship with one another. The formula expressing the coordination costs as a function of the number of teammates, *N*, is N(N-1)/2 (the Law of *N*-Squared: Krackhardt, 1994). Further, coordination difficulty increases with the number of members involved. Independent work and work within small teams requires less complex/formal coordination than work within larger teams and MTSs. As the number of members whose work must be coordinated increases, members must engage in more formal communication and coordination processes.

Motivational properties. The presence of others may either enhance or inhibit motivation to team task switch depending on alternative task difficulty and novelty. According to social facilitation theory, the presence of others is arousing, and this arousal raises motivation and performance when working on simple or common tasks, but inhibits it on more difficult or novel tasks. In upward shifts where the alternative task is well learned, the arousing presence of others can boost motivation. On the other hand, if the alternative task is not well-learned, the presence of others will harm performance on an upward shift (Blascovich, Mendes, Hunter, & Salomon, 1999). Furthermore, when one is tasked with working on novel or difficult tasks, the need for communication and coordination depletes needed cognitive resources and suppresses motivation to engage in such task shifts.

Another factor affecting motivation to team task switch is the social attachment among teammates. Research on MTSs suggests that switching from the individual to the team may be easier (cognitively, attentionally, and motivationally) than switching from a team to an MTS task. The prospect of switching from individual to team-based work fulfills the individual's innate drive to affiliate and to form social groups (Baumeister & Leary, 1995), which can bolster motivation to upshift to team tasks. However, the development of identity/attachment at the team-level may conspire to make upshifts to MTS work less appealing, as these other teams may be construed as "outgroups" (Tajfel & Turner, 1979). Thus, switching from the team to the MTS may incur a motivational decrement.

Cognitive states. Shared cognition is a critical determinant of team and MTS performance (DeChurch & Mesmer-Magnus, 2010; Murase, Carter, DeChurch, & Marks, 2014), as it provides members with the cognitive knowledge base to understand and anticipate other members' needs and actions without engaging in extensive communication. Shared cognition becomes extremely important when individuals must work together during "quick coordination" tasks (e.g, safety-critical events; Resick, Murase, Randall, & DeChurch, 2014).

As team task switches require coordination with more individuals/teams, opportunities for cognitive disparities and associated coordination difficulties increase. For example, workers at different geographical locations have different work environments and task requirements, leading to potentially different cognitive models for how to coordinate activities with one another. As a result, coordination difficulties are more likely to occur at these boundary points rather than when workers are operating in the same environment with similar cognitive models. Thus, disparity in cognitive models increases as coordination with upward task shifts is required.

Conceptual Framework of Team Task Switching

Figure 2 illustrates our conceptual framework of team task switching and related stickiness and attractiveness factors, as well as inertia forces. We also include individual difference variables that moderate relationships between factors. The framework details individuals' ability and motivation to switch as key intervening mechanisms that lead to adaptive team task switching. This model, grounded in the robust literatures of performance adaptation (e.g., Baard, Rench, & Kozlowski, 2014), cognitive task switching (e.g., Wickens et al., 2013), multiteam membership (e.g., Mortensen et al., 2007), and multi-tooling (e.g., Trafton & Monk, 2007), can be used to ground empirical research and agent-based models of task switching performance.

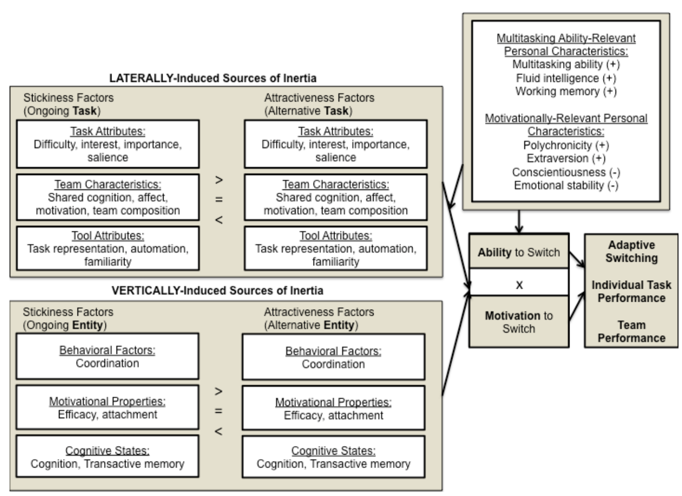

Figure 2. Conceptual framework of team task switching.

DISCUSSION

Previous models of task switching revolve around task and individual factors that affect work efficiency as individuals move from task to task throughout their workday. However, individuals not only accomplish tasks individually using one technological tool, they do so as members of multiple teams using a variety of technologies. Our conceptual framework of team task switching lays out a framework of vertical and lateral shifts, the sources of inertia, and the mediators and moderators that determine adaptive switching in today's complicated work environments. This model affords a comprehensive understanding of how individuals adapt to dynamic, environmentally-triggered performance demands requiring them to change tasks, teams, and technologies, and shift back and forth between personal, team, and system goals. Our framework will be useful for investigating task switching in any modern-day organization facing complex collaborative challenges, such as NASA space exploration, large scientific consortia (e.g., CERN), cybersecurity teams, healthcare systems, and the military. Furthermore, findings could then be leveraged to develop system-wide interventions that increase overall work efficiency and resilience in safety-critical systems.

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