ORGANIZATIONAL ROUTINES AND ADAPTABILITY

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ABSTRACT

Organizational routines are ubiquitous stores of knowledge in organizations. Although routines enable consistent performance on tasks over time, routines might hinder adaptability by promoting inertia and rigidity. In this dissertation, I develop how routines could facilitate adaptation in organizations and foster successful performance on novel tasks. I argue that teams are changed in the process of using routines. I develop and test theory arguing that routines can facilitate the development of transactive memory systems (TMS), collective systems for encoding, storing, and sharing knowledge. I propose that routines provide a structure within which team members can learn about one another's skills. Thus, routines can build a team's TMS, which can improve performance on novel tasks. I use a mixed-methods design to both develop and to test theory. In Study 1, I performed 30 semi-structured interviews with United States Marine Corps officers. Based on interview findings, I hypothesize that teams that use routines will develop stronger transactive memory systems than teams that do not. Consequently, I hypothesize that teams that use routines will perform better on novel tasks due to the TMS they have developed. In Study 2, I developed a laboratory study in the cybersecurity context to test the hypotheses. Two hundred and thirteen participants in 71 teams were randomly assigned to perform a task with a routine or without a routine, and then perform a novel task. Results provide evidence to support the hypotheses.

Keywords: organizational routines, adaptability, organizational learning, transactive memory systems, novel tasks, cybersecurity

INTRODUCTION

Routines are ubiquitous in organizations. As interdependent, repeated patterns of collective action, routines enable consistent organizational performance over time (Cohen & Bacdayan, 1994; Cyert & March, 1963). Routines store organizational memory and capability (Dosi, Nelson, & Winter, 2001; Winter, 2000, 2003). Routines, however, have been associated with rigidity and inertia (Aldrich & Ruef, 2006; Gilbert, 2005; Haas & Hansen, 2005; Schulz, 2008; Sydow, Schreyögg, & Koch, 2009; Vermeulen, Van Den Bosch, & Volberda, 2007). Because a routine is designed to accomplish a specific task, it is not clear whether existing routines can continue to enable performance when tasks change. Indeed, existing routines could be maladaptive with respect to performance on novel tasks.

Recent research illustrates a puzzle about the relationship between routines and adaptation to novel tasks. If routines engender inertia in organizations, a reasonable conclusion would be that organizations that rely on routines – where a substantial proportion of work in the organization is governed by routines – would perform poorly on novel tasks. However, scholars (Bechky & Okhuysen, 2011; Schakel, van Fenema, & Faraj, 2016; Yi, Knudsen, & Becker, 2016) show that even in highly routinized contexts (e.g., law enforcement teams), workers can employ techniques that leverage existing routines, such as recombination, to complete novel tasks. These studies illustrate how routines could change or be switched.

In this dissertation, I offer another explanation for how routines could facilitate adaptation in organizations. Previous research (Feldman, 2000; Feldman & Pentland, 2003) emphasizes the role that workers play in intentionally or unintentionally changing routines. Instead, I focus on how using routines can change teams themselves. I develop and test theory arguing that the use of routines can facilitate the development of transactive memory systems

(Ren & Argote, 2011; Wegner, Giuliano, Hertel, & Ickes, 1985; Wegner, 1987). A transactive memory system (TMS) is a collective system for encoding, storing, and sharing knowledge, commonly known as "knowledge of who knows what." I argue that routines provide a structure within which team members learn about each other's skills. Thus, the use of routines can build a team's TMS, which can improve performance on novel tasks.

I use a mixed-methods design to develop and to test theory about the relationship between routines and TMS. In Study 1, I performed 30 semi-structured interviews with active-duty United States Marine Corps officers. The Marine Corps has a reputation for innovation among the US military services[1] and a substantial portion of work in the Marine Corps is governed by routines, making it a credible context within which to investigate the relationship between routines and TMS. Based on interview findings, I hypothesize that a team's repeated use of a routine will yield a more developed transactive memory system, relative to a team that has worked together but did not use a routine. I also hypothesize that a team using a routine will perform better on a novel task that differs from the one for which the routine was designed, and that the effect of the routine on performance will be mediated by transactive memory. In Study 2, I test these hypotheses in a laboratory study where teams of three complete two cybersecurity tasks, manipulating whether or not teams use a routine on an initial task, and then examining their TMS strength and performance on a novel task.

This dissertation contributes to theory in several ways. First, I extend the literature on organizational routines (Becker, 2004; Pentland & Hærem, 2015) by showing that routines can enable an organization's response to novel tasks, due to their role in developing TMS. Second, I contribute to the microfoundations movement in strategy research (Felin, Foss, Heimeriks, &

[1] For example, see this popular press article: https://www.huffingtonpost.com/steve-blank/how-the-marine-corps-buil_b_12897698.html

Madsen, 2012; Foss & Pedersen, 2016) by demonstrating that routines can develop TMS, which can serve as a source of competitive advantage in organizations (Argote & Ren, 2012). Third, I extend the literature on transactive memory systems by showing that organizational routines can serve as antecedents to TMS development (Ren & Argote, 2011).

ORGANIZATIONAL ROUTINES AND NOVEL TASKS

Routines are interdependent, repeated patterns of action (Cohen & Bacdayan, 1994; Feldman & Pentland, 2003; Gersick & Hackman, 1990; Pentland & Hærem, 2015). Originating from research on standard operating procedures and habits (Cyert & March, 1963; March & Simon, 1958), routines are repeated over time, involve multiple actors, contain recognizable patterns, and have interdependent components. Routines can be found in many different contexts (see Pentland & Hærem, 2015, for a review) and are a ubiquitous aspect of organizing behavior (Weick, 1979). Routines have been proposed as organizational genes (Nelson & Winter, 1982). They carry the organization's past task experience and yield consistent performance outcomes for a given task (Hodgson, 2008).

Workers in organizations, however, frequently need to perform novel tasks that differ from tasks they normally perform. It is not clear whether existing routines enable or constrain an organization's response to novel tasks. In fact, routines might inhibit the response to novel tasks by leading to path dependency, inertia, and a lack of willingness to explore alternatives (Gilbert, 2005).

Prior research examining organizational routines offers several explanations for how routines relate to an organization's ability to react to change. The dynamic capabilities literature suggests that meta-routines embedded in top management can help organizations cope with change by modifying the organization's existing resources, including by changing routines. Top managers enact meta-routines designed to change the organization's processes or other resources. These can be thought of as search or improvement routines, and organizational leadership initiates them (Eisenhardt & Martin, 2000; Kaplan, 2015; Zollo & Winter, 2002).

The routine dynamics literature argues that routines themselves are generative systems (Feldman, 2000; Feldman & Pentland, 2003). A routine has both ostensive and performative aspects. The ostensive aspect of a routine is the impression of the routine held by the actors; it is what individuals perceive the routine to be. The performative aspect is how the routine is enacted by members of the organization. The ostensive aspect constrains the performative aspect by providing a guideline for how the routine should be enacted, but the actual routine performances can diverge from the ostensive aspect. Repeated performances of the same routine are different. These repeated performances give rise to variations of the routine's enactment that are then instantiated into the routine's ostensive component. Through this process, the routine changes as it is used.

Although the meta-routines suggested by the dynamic capabilities literature provide an explanation for how organizations can respond to change in general, the literature is not intended to explain performance for a focal novel task. Rather, dynamic capabilities explain how organizations themselves can change or reorient in response to environmental conditions. Thus, the literature provides limited insight into how workers perform novel tasks.

The routine dynamics literature suggests that routines become agents of their own evolution, but does not answer the question of direction: it does not predict whether routine updating will be beneficial or detrimental for task performance, or under what circumstances. Also, this literature does not directly address performance on novel tasks. The dynamics of routine change may be motivated by changing task conditions, or it may occur naturally through repeated routine performances.

I argue that examining the relationship between existing routines and the processes of teams that use them can illuminate how routines could facilitate adaptation to novel tasks. To investigate this explanation, I first perform a qualitative study to develop theory on how teams are affected by the use of routines. Taking a grounded theory approach, I performed semi-structured interviews with United States Marine Corps officers. The Marine Corps is an appropriate context to investigate these questions for several reasons. The Marine Corps, like many military organizations, is governed by routines. In the Marine Corps, many capabilities are formalized in standard operating procedures (SOPs), formal regulations, and tactics, techniques, and procedures (TTPs). These constitute explicit routines (March & Simon, 1958). Other routines are tacit, such as the routine a supporting unit uses to plan and coordinate meetings (Nelson & Winter, 1982). These routines are difficult-to-articulate. Sometimes routine performances strictly adhere to the formal or official procedure, but often routine performances deviate from the ostensive concept of the routine (Feldman & Pentland, 2003).

The Marine Corps also has a strong reputation for adaptation in the face of novel tasks. The Marine Corps serves as the United States military's force in readiness. By definition, the situations in which Marines find themselves are new, as Marine units are commonly deployed to new conflict areas where the scope of the tasks are poorly understood. And due to the nature of the tasks Marines face, adaptation is a necessity. As one officer stated in an interview, "That's what combat is all about, right? No plan is ever fully executed, you're always adapting" [Interview 7].

STUDY 1

Research Setting

Method

To investigate the relationship between routines and team processes, I take a grounded theory approach. I performed semi-structured interviews with United States Marine Corps officers (Kvale & Brinkmann, 2009; Patton, 2002). Qualitative methods, like interviews, are appropriate for this study, which is aimed at generating explanations for how routines influence performance. I use findings from interviews to develop theoretical mechanisms for how routines relate to team processes to predict novel task performance (Edmondson & McManus, 2007). I sought to follow best practices in qualitative research to increase transparency of my data collection and analysis (Aguinis & Solarino, 2019). Thirty interviews have been conducted, and data collection is complete.

Participants. Marine Corps officers were selected as the population of interest as officers lead Marine units in the execution of routines. Officers are also involved in routine development.[2] Officers interviewed came from both combat and supporting career fields (11 combat arms, 19 supporting functions): no screening criteria were used. Officers were recruited via email through a snowball sampling procedure at a US west coast university operated by the US Defense Department, where the officers were graduate students. The author had previously been affiliated with the university and was granted access to interview officers. Despite having

[2] The US military has two rank structures: one structure for officers and one for enlisted personnel. Officers are concerned with leadership and management, whereas enlisted personnel are charged with task execution. Sampling only officers may bias findings if officers have little experience actually performing tasks. The risk of such a bias is mitigated in the sample, because 20 of the 30 officers had prior enlisted experience. That is, they first served as enlisted Marines before becoming officers. As such, they have experience with both task planning, as well as with task execution.

acquired general knowledge about the Marine Corps and the military while previously working at the university, the author had no prior military experience and cannot be considered an insider to the Marine Corps. Participant ranks ranged from first lieutenant to major, making these participants early- to mid-career officers actively involved in planning and executing operations. Four participants were female, and 26 participants were male. Twenty participants had prior enlisted experience. Twenty-eight participants reported the year they joined the Marine Corps, and the average length of time in service was 17 years.

Procedure. The author performed semi-structured interviews along with a collaborator on other projects about the Marines Corps. The author was introduced as a researcher external to the university where the interviews were conducted, but who had a previous affiliation. Thirty interviews were conducted between fall 2016 and fall 2017. Interviews were performed in three waves, and 28 interviews were conducted in person, while two were conducted by telephone. Interviews lasted between 30-90 minutes, were audio recorded, and were later transcribed. Interviews began with a prepared protocol designed to elicit personnel experiences regarding the use of routines in the Marine Corps, along with reflections of general experiences about career progression. The interviewers then probed for more information or experiences based on participant responses. The participants provided retrospective descriptions of leading and working with Marines to solve novel tasks. There were no unexpected opportunities, challenges, or events during the course of the research.

Data Analysis. The interview transcripts comprised 391 pages and 245,597 words. The author performed iterative coding of the transcripts after each collection wave. Coding was guided by seeking to understand the relationship between routines and performing novel tasks. The author reviewed each transcript and used an open coding process, followed by axial coding to aggregate codes into themes (Corbin & Strauss, 2008). After the third interview wave, the author judged that the saturation point had been reached and no new themes were coming from the data. Theoretical saturation was judged after open coding failed to yield new codes and axial coding failed to yield new themes. In total, 81 codes emerged. The codes were aggregated into higher-level codes and then into themes. Three general themes emerged: the use of routines in the Marine Corps, the relationship between routines and team processes, and the relationship between transactive memory and novel task performance. Within these themes, 8 sub-themes emerged.

Findings

I first describe whether and how participants described routines in the Marine Corps context. Then, I describe how routines influence team processes in the Marine Corps.

Routines in the United States Marine Corps

Routines are ubiquitous in the Marine Corps. Marine Corps routines are often instantiated in artifacts (Pentland & Feldman, 2008), and they take the form of standard operating procedures (SOPs), manuals, or tactics, techniques, and procedures (TTPs). When asked about the routines that govern their day-to-day work, respondents cited specific manuals and procedures by name, such as “OPNAV 3710” [Naval Air Training and Operating Procedures Standardization General Flight and Operating Instructions], “ANTTP” [Air Naval Tactics Techniques and Procedures], or the “ATAF” [All Tools Accounted For]. This pattern was consistent across both combat and non-combat fields. Participants emphasized how routines are released as parts of artifacts, and these artifacts play a substantial role in how Marines interpret and use routines. For example, one amphibious assault vehicle officer noted:

> The Marine Corps obviously as a whole releases publications covering how we conduct warfare, how we do certain tasks, the infantry has I think four different

> manuals probably each three or four hundred pages that govern how to dig a fighting hole, everything. I mean it's very, we're very programmed [Interview 8]

Multiple participants reflected on the length and growth of these artifacts. A heavy lift helicopter pilot reported:

> the SOPs can be huge. I'm talking 700-800 pages, they're just full of stuff. So it's not that one guy writes this thing right? Everyone kind of writes their own stuff, and it sort of comes together, and of course nobody actually ever sits down with a piece of paper and starts writing, fortunately. The reason they're 700 or 800 pages is because they used to be 20 pages and somebody added a little bit, and now they're 800 pages. The staff veterinarian needs to write something up about what we're gonna do for, you know, wild dogs or whatever. It's all in there. [Interview 5]

Routine artifacts grow in length as individuals contribute their areas of expertise. SOPs are meant to be "catch-alls," where if Marines encounter a problem, they find the procedure for how to resolve it in an SOP. Indeed, when asking Marines about whether they encounter problems they have never faced before, many initially respond no, and that all problems they face have a programmed response.

In the Marine Corps, routines are used as a source of capability and as a store of knowledge, consistent with prior theorizing regarding their role in organizations (e.g., Cyert & March, 1963; Nelson & Winter, 1982). Routines, particularly in the form of artifacts, like manuals or SOPs, serve as a key means for personnel to accomplish tasks (Pentland & Feldman, 2008). Supply officers rely on SOPs to issue equipment and gear to personnel. Armor officers rely on SOPs to maintain their vehicles and develop combat tactics. Pilots use SOPs to start and fly aircraft. Maintenance officers use SOPs to diagnose and solve technical issues with vehicles and equipment. Across all career fields, routines are sources of capability and knowledge.

Much of the time, these routines are rigid. They are difficult to change, and Marines claim to follow routines to the letter. Participants noted few differences between administrative and combat career fields in the degree to which they follow routines. For example, a supply officer noted: “I would say that the action that you take in the field that are administrative in nature are, there’s an expectation that the organization mirrors those very closely” [Interview 2] When combat arms participants discussed rigidity of routines, they emphasized the dangerous nature of their work. A logistics officer was deployed to Iraq and needed to organize supply convoys between coalition bases. He had subordinate convoy commanders who sought to contravene the standard operating procedure, which dictated that they ride behind the first vehicle of the convoy so that command and control could be maintained if the convoy struck an improvised explosive device (IED):

> So they would always say, ‘I’m riding first vehicle. If anyone’s gonna miss [seeing] an IED, it’s me.’ So one of them I really had an issue, because he was being overwhelmed with that. I said, ‘Look, you’re convoy commander, you’re not the IED hunter. You have to train your subordinates to…do that. You, you have a big burden you’re carrying in your heart, you’re conscious about it, you don’t want anybody to get [hit], you don’t wanna miss [seeing] it, but that’s just the trust because there’s a company commander who’s delegated that to you and then a battalion commander who’s delegated that to you, so you have to let somebody do the looking for you cause you have to manage all the communications and the rest of the convoy.’[Interview 15]

The logistics officer sought to enforce the standard operating procedure with his subordinate convoy commanders. His rationale was around safety – if the convoy commander remained unharmed during an IED attack, the commander could organize a defense and communications to minimize additional harm to the convoy. If the commander was incapacitated during an attack, due to contravening the SOP by riding in the first vehicle, the safety of the convoy itself would be compromised.

Although many routines are explicit – and codified in artifacts – some routines participants described were not codified (Nelson & Winter, 1982). Talking about his prior experience as an enlisted Marine, one participant noted:

> There are these unwritten rules of formations, like if the Gunny says to be there at 7 o'clock, you know, then the staff sergeant is gonna say to be there at 6:45, and then the sergeant is gonna say to be there at 6:30, and even without that instruction, the organization kind of does that. There's this unwritten rule that especially if you're lower ranking, that you show up early to everything and you kind of wait around until something happens. [Interview 2]

This routine for assembling for formation is not explicit. The explicit order is for Marines to assemble at 7 o'clock. However, the tacit understanding of how to execute this routine is for Marines to arrive much earlier, and the more junior the Marine, the earlier they must arrive. In this vignette, the understanding of what to do comes from the explicit routine, but the actual performance is not identical to the explicit – an idea in line with the ostensive/performative aspects of routines from the routine dynamics literature (Feldman, 2000).

How are routines created in the Marine Corps? Some procedures are standard across the Marine Corps and given to units by the larger command structure. Some units develop their own operating procedures or manuals – particularly higher-level commands responsible for many subordinate units. In describing how his unit created SOPs, one participant reported:

> Typically, I'll reach out to a peer or another unit…cause you know, you can look who got inspected last time. 'Hey you guys got inspected, do you guys have a voting program? Can I, can I get it? Do you have a shared drive that I can go on and just kind of look what you guys do?' So I think you know, outside of an academic setting, plagiarism runs rampant in the Marine Corps…whether that's an order, it's a Powerpoint to go to the field, you know very, very rarely do you actually create anything from scratch per se, it's like 'Hey you've done it before, give me what you've got.' And then you tailor that document to fit your particular circumstance. [Interview 22]

When units create SOPs, they closely follow existing routines in that domain. In the words of another Marine, there is "[a] lot of plagiarism, no pride in ownership" [Interview 5]. Marines look at examples of existing SOPs to generate new SOPs. This is consistent with prior work on how templates can enable intra-organizational knowledge transfer (Jensen & Szulanski, 2007).

Routines and Transactive Memory Systems

In this section, I describe how the use of routines by Marine Corps teams influences team processes. I find that routines facilitate transactive memory system development (Ren & Argote, 2011; Wegner, 1987). A transactive memory system (TMS) is a shared system for encoding, storing, and sharing knowledge. It is colloquially known as "knowledge of who knows what." A TMS consists of (1) knowledge stored in individuals on a team, and (2) a set of transactive processes to encode, store, and retrieve that knowledge (Ren & Argote, 2011; Wegner, Giuliano, Hertel, & Ickes, 1985). A key finding in prior research on TMS is that a team's TMS develops over time through interaction (e.g., Liang et al., 1995). I find that routines play a role in structuring how team members interact, which strengthens TMS development.

Skill Development. A transactive memory system develops when members of a team have a shared awareness of one another's skills, knowledge, and abilities (Bunderson, 2003; Littlepage & Mueller, 1997; Ren & Argote, 2011). A primary function of routines in the Marine Corps is to build individual task knowledge. Having a foundation of individual task knowledge enables development of team-level transactive memory, as well as enabling successful responses to novel tasks. Individual skills have a clear link to novel task performance; it does the organization no good for individuals to develop new ideas but lack the means (e.g., knowledge) with which to execute them. A maintenance officer emphasized repetition to build knowledge, arguing that the knowledge gained through repeating tasks is useful to provide a foundation for future task performance:

> So, the Marine Corps is really good on building repetition. That's why you can see a lot of Marines are – some of us are very methodical. Because they teach us

> terms like SAFE: security, avenues of approach, fields of fire, entrenchment. They teach us many different acronyms. BAMCIS [Begin planning, Arrange reconnaissance, Make reconnaissance, Complete the plan, Issue the order, Supervise]. Begin to plan, all of these things. So in the field, MCT [Marine Combat Training] – those are things that we develop repetitiously. We do those things so we know, when we get into the basics we can move off of that towards innovation. But you need to have the ground set for that. If you don't have that down, you get killed. [Interview 3]

The acronyms the maintenance officer uses are not limited to basic training. The acronyms reflect routines that are used throughout the Marine Corps in actual operations. The routines serve the purpose of training Marines to develop foundational individual skills.

Accurate Expertise Recognition. Repeated use of routines by Marine Corps teams enables Marines to recognize each other's expertise (Bunderson, 2003; Littlepage & Silbiger, 1992). TMS readily forms in work teams with relatively short interaction times (e.g., Liang, Moreland, & Argote, 1995). I find that Marines report that using routines can make their perceptions of expertise more accurate.

When Marines perform routines, their individual task performances become visible to fellow Marines. By performing their roles or subtasks within a routine, Marines demonstrate skill (or lack of skill) in a knowledge domain. Routines are performed repeatedly by the same members of a team over time. The repetitive nature of routines helps to solidify a transactive memory system. An example from a Marine armor officer illustrates how.

The officer (Interview 27) was a former armor platoon commander. In this role, he commanded four tanks and approximately 16 Marines. One of his duties was to assign Marines to positions in the tank: driver, loader, gunner, and commander. To a certain extent, which Marine occupies which position is determined by rank – for example, all commander slots are filled by the platoon leader or non-commissioned officers. However, the officer had discretion with whom to assign to the loader and driver positions. Talking about drivers in particular, he described specific task knowledge that drivers must possess:

> What are you looking for, for…specifically…a driver…? One, someone [that] can listen, take orders, right? When you say turn left, they actually turn left. You would think that's common sense, and that a 18-, 19-year-old human being would understand the difference between left and right. You would be shocked. So you look for [the] basic things. And then you start looking for you know, when they see a, a dip in the road or a wadi, right, there's a procedure for how to take a tank down there where you can keep the main gun stabilized and not jolt the entire tank around. It's called an S-turn, right? [Interview 27]

When asked how he determined when Marines possessed these skills, the officer emphasized that it was through observations over time. He emphasized that it was over time and over repeated task performances. Specifically, when he wanted to evaluate a Marine, he only did so after three opportunities for the Marine to complete a driving task.

> I try to follow the, the three is a trend, right? So I wanna ride with a, a marine about three times and in between each talking to him right? This is what I'm seeing, is this what's going on, right? [Interview 27]

Thus, the officer performed an evaluation with multiple steps. First, the officer had a clear idea of what skills the driver needed. These skills were, in part, given by the routines used in the armor community. Thus, from the routine, the officer understood the tasks that the driver needed to be able to complete. Second, the officer had the Marine drive multiple times, performing a routine multiple times. This allowed the officer to develop an accurate assessment of the Marine's skills. The officer viewed it as necessary to observe multiple performances, stating: "I don't do the one and done kind of idea" [Interview 27]. This idea was echoed by a supply officer, who stated: "one snapshot in time can't give you the whole picture of a Marine" [Interview 29]. The evaluation period does not need to be long, but the armor officer emphasized that it had to be over time.

> A lieutenant after about a two-week period, I could probably tell you if he's gonna hack it or not in the Marine Corps, or in the armor community. Just understanding their, the way they, they deal with the tasks that I give them. The way they communicate. Those are key indicators in how an officer's gonna perform either in the Marine Corps or in the tank community. And that's over time as well. Even the guys that, you know, we would drop out of armor officer basic course, we never went off one impression. He always, they always got three different shots to do something correctly. [Interview 27]

Officers were reluctant to make any determinations about a Marine's skill on a task until they had observed the Marine performing the task multiple times. This could be done explicitly through rotation through roles specified by the routine. An aviation maintenance officer described how training is conducted on AV-8B Harrier jets. In performing training on jet engine maintenance, he reported an explicit process of rotation:

> we built up, tear down Harrier jet engines, like the new ones, the old ones, the gas turbine starters…each section [of] the engine, like one person would be in charge. They would tell, you know, their crew, like 'You get the tools, you read the pub, you do this,' you know, and you'd direct it and alright, done with that section of the engine, next guy takes over. [Interview 16]

Marines would rotate through leading maintenance on the different components of the engine. In doing so, all participants could evaluate one another's performance and calibrate their perceptions of that Marine's skills. Recognition of an individual Marine's expertise occurs over time through repeated use of routines: "you know I've had the pleasure of somebody recognizing a skillset that I have and letting me run with that and even funneling more people to come my direction for that skillset" [Interview 12]. The performance of the routine over time uncovers knowledge, and moreover, it allows the team to have an accurate perception of expertise (Austin, 2003; Brandon & Hollingshead, 2004) because multiple routine performances allow the team to calibrate their assessment of a particular individual's skill.

Thus, when Marines perform routines, fellow Marines learn what skills each possesses. To generalize more broadly, the fact that routines are repeated over time allows workers to calibrate their perception of others' skills. One task performance may not be sufficient to understand another an others' skill. Multiple opportunities to observe task performance leads to more accurate perceptions of others' abilities.

The process I describe, where Marines learn each other's skills through repeated use of routines, is consistent with the task-expertise-person (TEP) concept (Brandon & Hollingshead, 2004). A TEP is the basic unit in a transactive memory system. It consists of a task (e.g., submitting a financial compliance report) that is linked to specific expertise (e.g., accounting) and a specific individual within whom the knowledge resides (e.g., an accountant). A routine provides a partial TEP unit – T-E. The routine provides the tasks that need to be completed along with the expertise needed to complete the tasks, but the routine does not indicate the particular individual assigned. The linking of tasks to expertise (T-E) is analogous to a role.

Role Structure. I find that another way in which routines provide a means to develop transactive memory is in their structure. Routines contain role assignments (Cyert & March, 1963). That is, the routine includes not just the sub-tasks that need to be completed to accomplish a goal, but also the individual roles responsible for those sub-tasks. The routine either explicitly provides or implies a natural distribution of roles for a given goal, provided by the sub-tasks contained within the routine. This natural role division can play a role in developing TMS. For example, when participant 27 described the process of learning about tank crewmember skills, the skills in question are delineated by a procedure that explains which tasks each member of the crew will perform. This is an explicit representation of roles and tasks assigned to those roles. Such role assignments can create cognitive interdependence (Brandon & Hollingshead, 2004) and can facilitate TMS development (Pearsall, Ellis, & Bell, 2010).

A logistics officer described how he would approach building a procedure to respond to a humanitarian crisis, a task for which the Marine Corps is not designed, but with which the Marine Corps is often tasked. The officer described building a "mission essential task list" and finding any previous documents or publications used by other units who had performed a similar task in the past. He described including subject matter experts in the development process, and he emphasized the importance of roles. When developing procedures, he stated: "we wanna build our TTPs [tactics, techniques, and procedures] around what that subject matter expert plans to do, because the S3, the S4, the S6 role should all be supporting that role" [Interview 2]. S3, S4, and S6 refer to staff officer roles in a headquarters unit, and each number corresponds to a specialty – 3 refers to the operations section, 4 refers to logistics, and 6 refers to signals. Each of these roles has responsibility over a certain set of tasks. For example, the S4 officer would be in charge of transporting personnel and materiel, and the S6 officer would oversee communications and communications equipment. When building procedures, Marines explicitly consider roles and link them to tasks, which facilitates TMS development by focusing attention on individual Marines' performance in the tasks for that role. In this way, the routine provides a framework for a transactive memory system, which can develop into a TMS after the observation of repeated routine performances.

Coordination. Routines can provide benefits in addition to recognizing task expertise. Repeated use of routines can help build tacit coordination. The benefits of tacit coordination are not from building or learning task knowledge, but from the ability to work well with teammates. Coordination is an essential element of a developed TMS (Lewis, 2003; Liang et al., 1995). Marines reflected on their experiences in initial entry training, in particular, on basic training. An important skill that Marines learn in basic training is drill, where Marines synchronize their movements to act (march, hand movements, etc.) in unison. One logistics officer recalled how difficult it was to learn:

> I remember them trying to teach us how to march. Drill. Of course, I had no idea what I was doing. I never, I remember walking, so putting your left foot in front of your right and trying to march. But my arms were swinging with my legs which is awkward. And because I didn't know what they were doing. [Interview 13]

Throughout boot camp, Marines learn how to perform drill, as it is one of the mechanisms by which drill instructors teach recruits to instantly obey orders while coordinating with others. The logistics officer felt that the process of learning drill was beneficial for teaching Marines how to coordinate:

> I've placed a lot of value in, in drill. As simple as it sounds, as elementary as it sounds, you have the unit, and that's the unit equivalent to team, the unit functioning together as one. [Interview 13]

Other Marines reported similar types of collective exercises, which have the characteristics of routines. The activities are repeated over time, they involve multiple Marines, and they accomplish a task. An infantry officer described these exercises as a type:

> you would have a physical challenge that you would have to, you would have to complete and you have to complete this challenge with a group of, of, of peers in your platoon right? So there would be some sort of funky looking, a set of tires, a log, and you had to move all the tires over to this other log without touching these spots on the ground. And the only way to do that is that you had to work with members of your platoon and you had to discuss, 'Hey how are we gonna solve this problem?' [Interview 12]

The purpose of such exercises is not to teach task knowledge. Most people know how to move a tire. Having the group move a set of tires to a log without touching certain spots on the ground requires that group members coordinate. Knowing how to move a set of tires from one log to another is unlikely to valuable in combat. However, these exercises serve a function in teaching coordinating skills, which is important to TMS development. Moreover, the exercises teach Marines to trust one another:

> And that's the foundation [the] Marine Corps operates on, the fact that I could trust, I could trust the guy left and right to do their job, you know, that's the basic foundation the Marine Corps work on, so if I can't trust other staff section to do their job or if the CO [commanding officer] can't trust me to do my basic logistics function, then it's bad. [Interview 12]

Using routines can build both trust and coordination among Marines. And both trust and coordination are indicators of a developed TMS (Lewis, 2003).

Summary. Three characteristics of routines facilitate the development of TMS. First, the routine is repeated and performed similarly, providing for multiple opportunities to calibrate an assessment of an others' skills. Second, the routine contains role assignments, which creates cognitive interdependence, focuses worker attention on skills needed for particular roles, and provides a framework within which a TMS can develop. Third, a routine involves multiple actors who perform interdependent tasks. The repeated performance of interdependent tasks by multiple actors engenders trust in members' skills and expertise. By specifying how members interact, the routine also fosters coordination. Thus, routines foster development of an understanding of members' skills and expertise, a trust in that expertise, an assignment to roles based on that expertise and coordination of distributed expertise. That is, routines provide teams with an opportunity to develop a transactive memory system.

Hypothesis 1: Teams trained with a routine will develop a stronger transactive memory system than teams that do not train on a routine.

TMS and Novel Tasks

Novel tasks are common in the Marine Corps. When Marines describe novel tasks, however, they tend to be similar to tasks they have seen in the past or tasks that have been performed by other units. Thus, novel tasks are novel to the focal Marine or group of Marines. For example, a logistics officer described a novel task at her first unit after training:

> So when I was a lieutenant and I checked into the first battalion I went to, and about maybe two weeks into it, [they] said okay, we're going to have 300 reservists from MARFORRES [US Marine Corps Reserve] check in, and at the time I'm saying 'Huh, I only had one day of reserve administration in admin school, like what am I supposed to do?' The prior battalions who had deployed did not have, were not augmented with a reserve, like that many Marines. They may have one or two, but not 300, which...ended up being half the battalion that deployed with us. So out of 700 whatever, almost 800 Marines, you know, 300 to 350 of them were all reserves. So there was no, when I checked into the unit, yes, there was no SOP [standard operating procedure] of how do you know, how do you check them in? What are you supposed to do? That I had to figure out on my own. [Interview 20]

This task was novel to the officer. The task may have also been novel to the unit, as no standard operating procedure was available. The task was new in the sense that it had not been done before and there was no immediately available information to use to perform the task. However, the task was in the same knowledge domain of tasks that the officer had performed previously. From prior research, there are reasons to believe that both routines and TMS can improve performance on novel tasks. For example, routines provide cognitive interdependence (Brandon & Hollingshead, 2004), which can improve team creativity (Gilson & Shalley, 2004). Additionally, prior research has described the general benefits of a developed TMS on new tasks (Lewis, Lange, & Gillis, 2005).

I describe specific mechanisms by which routines and TMS improve performance on novel tasks: access to resources, coordination and trust, and retraining.

Access to Resources. When Marine Corps teams have developed a strong TMS, there are benefits for performance on novel tasks. Novel tasks often require resources that Marines do not have on hand (Srivastava & Gnyawali, 2011). For example, Marines frequently describe seeking templates or existing artifacts to solve novel tasks more quickly. As a supply officer explained:

> So going back to the example I gave you about the trucks, like I know who to call if my stuff breaks down, for example…[S]o then how do we get the Marines to the next spot? So there's like different rules about where you can and can't put Marines, you know, in tactical vehicles. Like you can't make them ride in the back on the highway without flak and Kevlar. What else? Like, figuring out that food and water situation, like I know who to get food and water from, it's just a matter of like, making sure I remember all that stuff, combining that knowledge that came from different places, and then putting it together into a solid plan. But it's not a formal SOP, it's just problem solving I think. It's, it's, it's just taking, you know, things that are kind of established and using them to fit your, your problem. Like a puzzle almost. [Interview 20]

TMS manifests here as knowledge of whom to go to for help. In this example, the supply officer highlighted that he knew whom to call for resources: for broken-down vehicles, for food, and for water. He describes the process of solving a novel task as combining existing knowledge he possessed into a solution. Critically, he does not describe the process as developing a new routine (or standard operating procedure), but simply problem solving.

Marines describe themselves as performing a shared mission, that the tasks they perform are in the service of the organization's overall mission. Marines are focused on the infantry Marine, even officers who are not in the infantry. For example, a pilot described the Marine Corp's emphasis as: "So in the Marine Corps, it's all about the troop, it's all about the grunt, his fight, so you know, everything is there to support the ground Marine, the infantry Marine" [Interview 1]. Marines see their mission as shared, and they also see the resources they have to accomplish the mission as shared: "And I say pooling because we're pooling resources and we're pooling networks and pooling relationships. And in order for us to pool that, we have to get them together face to face" [Interview 3]. TMS allows Marines to access the shared resources they need to accomplish novel tasks, by providing a structure within which to perform search for resources.

Coordination of Distributed Expertise and Resources. I previously discussed how using existing routines can facilitate TMS development, in part, by facilitating coordination among

Marines. Strong coordination is an indicator that a TMS has developed (Lewis, 2003; Liang et al., 1995). Coordination is also an important capability for responding to novel tasks (Faraj & Xiao, 2006). An armor officer described the benefits:

> But that stuff takes time too, you know, you gotta build relationships within a unit for implicit communication, stuff like that to happen. I mean I had staff NCOs [non-commissioned officers], senior enlisted people, who after we worked together for eight, nine, ten months, they would have ten tasks done before I even tasked them with it, because they already knew what was coming down. That's the type of implicit communication that I'm talking about. [Interview 7]

TMS thus benefits Marines when they solve tasks by improving problem recognition – in this example, non-commissioned officers (NCOs) could anticipate new tasks that the commander, the armor officer, would delegate. This was not explicit. Rather, the NCOs, based on their experience working with their commander, already knew what needed to be done, and the commander trusted them to act without direct orders.

Trust in Expertise. When a Marine team has developed a TMS, there are also benefits for team trust. Team members are more likely to trust one another to complete sub-tasks. A logistics officer who was based in Okinawa described the difficulty he faced in planning an exercise for an infantry battalion. The exercise was in Thailand, but several vehicles he needed to complete the exercise were being transported by cargo ship. Before delivery, the ship carrying the vehicles ran aground, and the officer no longer had access to them. He quickly generated a solution to the problem by repurposing vehicles belonging to another battalion and transporting them to the exercise site. The other battalion trusted the officer with their equipment, and the officer trusted the other battalion to make their equipment available. Trust in expertise on both sides enabled the officer to perform a novel task. Thus, the officer's solution was successful, in part, because he was able to rely on other members of the organization to successfully execute established routines: "These experts said these are the timelines, I trust them, you know, you trust them, and then these are the procedures that I put in place. You're going to get this exercise gearset [equipment] by this first exercise, you'll be okay. Everything works out and then well after that, it's just competence" [Interview 10]. Additionally, the officer was successful because he was able to obtain resources from the other battalion.

Retraining. The process of developing TMS has additional benefits for adaptation. Rather than treating Marines' skills as fixed, officers describe how developing TMS can guide training. An aviation maintenance officer illustrates this process:

> I think any human being wants to be cared for and you know, you want to be told when you're not doing well. I know I do. You know, now I can fix my deficiencies, and I think that's an important part of…being a Marine too is being able to give feedback and…grow your people instead of just kind of selling them off and getting rid of them. That's one thing [in] the Marine Corps we do, we call them leadership challenges. You know, it's like, 'Hey, so and so is horrible at fixing that airplane.' You know, let's get him or her up to speed, let's train them and teach them instead of just making them go work at the chow hall or you know, send them elsewhere. It's like no, let's, let's get them up to speed. [Interview 23]

The process of developing TMS, through observation of routine performances, uncovers Marine skills. But the process does not stop with the discovery of skills. Marines not only know who is good at what, but who is bad at what, and upon learning who is bad at what, Marines have the opportunity to take remedial action and train deficient Marines to be able to perform tasks. This benefits novel task performance by improving the general level of skill in a Marine Corps team, as well as increasing the pool of resources (e.g., knowledge) teams can use to address tasks.

FIGURE 1 ABOUT HERE

Summary. Figure 1 displays the theoretical framework. In summary, when Marine Corps teams use routines, the teams develop a transactive memory system, which benefits performance on novel tasks. To generalize the findings, TMS benefits novel task performance in several ways. First, with a TMS, workers know whom to go to for key resources (e.g., information, materials, equipment) needed to solve novel tasks. Second, TMS improves workers' ability to tacitly coordinate distributed resources and expertise. Third, TMS facilitates trust in expertise and skills between workers. Fourth, work teams can use a developed TMS to retrain deficient workers and improve the team's overall level of skill.

Hypothesis 2: Routines enable teams to adapt to new tasks: Teams that trained with a routine on one task will perform better on a new task than teams not trained with a routine.

Hypothesis 3: TMS mediates the relationship between the use of a routine and performance on a new task.

Boundary Conditions

Two types of boundary conditions may bear on the strength of the predicted effects. The first is task characteristics. An important consideration is the extent to which the novel task relates to the knowledge the organization already possesses. A TMS will benefit novel task performance more strongly (H3) when the novel task relates to existing tasks, that is, the novel task is not a radical innovation distant from the organization's existing tasks (Madjar, Greenberg, & Chen, 2011). However, it is not clear how much this boundary condition limits the generalizability of the theory. Organizations typically encounter novel tasks that relate to their existing capabilities – indeed, it is from their existing capabilities that many problems are generated in the first place. For example, a common task is attempting to improve production efficiency, or to create a new product. Both tasks are new to the organization, but they rely on the organization's existing stock of knowledge. I expect that when novel tasks are closer to existing tasks, the relationship between a TMS and novel task performance will be the strongest.

A second boundary centers around characteristics of the team. Routines will facilitate TMS formation (H1) the strongest in circumstance where sub-task performances are visible to all team members (Carter, Carter, & DeChurch, 2018). That is, for TMS to develop, it is necessary for members to acquire an understanding of each other's' skills and expertise. For routines to build TMS, sub-tasks should be performed so that other members can either observe the sub-task being performed or can observe the results of that sub-task. When sub-task performances are not visible, for example, in a distributed team where members rarely interact in person and may not see the product of each other's' work, I expect the relationship between routines and TMS to be weaker or to diminish.

Another team characteristic boundary condition is around stable team membership. I expect the relationship between routines and TMS to be stronger when teams have stable membership, as member turnover can disrupt a team's TMS (Lewis, Belliveau, Herndon, & Keller, 2007). However, given that TMS can develop quickly (Liang et al., 1995), when teams use routines under conditions of personnel turnover, I expect teams using routines to build TMS more quickly than teams not using routines. Indeed, there is evidence that routines can buffer organizations from the effects of turnover (Rao & Argote, 2006; Ton & Huckman, 2008).

Additional Findings

Analysis of the transcripts yielded some additional themes that play a role in how Marine Corps personnel use routines and approach novel tasks. In this section, I describe three contextual factors that influence how Marines approach task performances. These factors are important for understanding the Marine Corps context, and they are opportunities for future research.

Shared Identity

Identity in the Marine Corps. What is the Marine Corps identity? What makes a Marine a Marine? In coding the transcripts, identity emerged as an explanation for why Marines feel the need to follow routines, at least most of the time. This concept of identity follows work on social identity, which refers to an individual's perception of oneness with a group (Ashforth & Mael, 1989). Marine identities shape how Marines interact with routines and their propensity for adaptation.

Marines describe themselves as the best in the world. Marines are highly committed to the ideals of the Marine Corps and to accomplishing its mission. When discussing why they chose to join the Marine Corps, many Marines discussed their perception of the Marine Corps as the toughest of the US military services, the most elite, and the greatest challenge. Participants described recruiters and recruiting materials as emphasizing the challenge entailed in becoming a Marine, and participants who had served in recruiting functions also described how the screening approach they took selected for recruits who demonstrated an appetite for challenge.

Marines take great pride in their elite status when compared to other military services, and particularly in how the Marine Corps has achieved that status in the face of perceived resource deficiencies. The Marine Corps' is the smallest of the military services and has a commensurately smaller budget than the others. Multiple Marines described challenges they faced in acquiring parts or equipment, with some even describing thefts they committed from other services in order to acquire needed equipment. Marines use the phrases "drug deal" and "beg, borrow, and steal" to describe the acquisition of equipment, supplies, or personnel outside of conventional channels.

"Every Marine is a rifleman." The most important element of the Marine Corps identity is that "every Marine is a rifleman." This phrase, used nearly universally by participants, reflects the idea that all Marines, regardless of career field, are at their core rifle Marines. The Marine Corps is designed as an infantry combat-oriented organization, where the full effort of the organization is designed to support close combat by infantry Marines. And all Marines receive the same core training on infantry skills and tactics to a greater degree than the other US military services.

Consequently, Marine personnel identify as riflemen (or rifle Marines). This is the case even for those Marines who are not actively serving in a ground element; the preeminence of the rifleman is paramount. As one Marine said, “So in the Marine Corps, it’s all about the troop, it’s all about the grunt, his fight, so you know everything is there to support the ground Marine, the infantry Marine.” Thus, the identity of being a rifle Marine was not always meant literally, but was meant to described something shared between Marines irrespective of career field or specialty – the identity binds Marines together by providing a set of common skills and common values.

This sentiment was echoed by a pilot, who described how the emphasis on ground combat focused their attention and motivation on a single purpose. The pilot noted: “we always know we’re there to support you, and we never, I never lose focus on that, and most pilots never lose focus on that. And I’ll tell you most operators focus on we’re there for the infantryman and his fight.”

Officers used language of sharedness to describe their commitment to the ground Marine and “his fight.” This shared identity across Marines, even who were not rifle platoon commanders, creates to a shared commitment to the organization and to its mission, as well as to a feeling of *esprit de corps*, as another Marine noted: “[e]very single Marine is trained as a rifleman. And that connects us with the guys on the ground. And they put us through all that pain for a long time to reach back that when we’re making decisions while we’re sitting at our desks at a computer, just know that there’s another Marine eating dirt.”

Mission Accomplishment. By emphasizing the Marine on the ground, officers also emphasized accomplishing the mission. Performing the mission, whatever mission that may be, is paramount in the Marine Corps. Participants described how all concerns or problems were always viewed from the perspective of the mission, and that if officers had to decide between accomplishing the mission and Marine welfare (or any other issue), the mission would come first.

Part of Marine Corps identity is a feeling of professionalism around always completing the mission, above all else. When thinking about the mission, Marines perceive it as winning the infantryman's fight. The infantry focus of the Marine Corps focuses the organization's attention around a single purpose; all other tasks are subordinate to and support winning ground combat. Marines perceive one another as riflemen, and this shared identity across Marines leads to commitment to one another, and therefore to the mission: "I think – like – I think it is a commitment. And everyone has to be committed in order to get the mission accomplished, whether you're tired, whether you're – you know – your brother's keeper. And the commitment is not to the organization, it's to each other."

To accomplish the mission, Marines go to extraordinary lengths. When Marines encounter obstacles, they are willing to circumvent rules and routines and engage in unethical behavior in the service of the mission. Theft was reported: "I got something to get done. I'm not gonna let a rule stop me feeding my Marines, but, and if I gotta steal, I'll steal. You call it stealing, I'll call it – you got stuff there that I need, well give it to me, I'll take it." There is frequent concern that individual and unit performance is not at levels needed to support the mission, and that if an individual Marine fails to adapt or fails to solve a problem, other Marines on the ground will die. This fear of failing to accomplish the mission is a substantial motivator, and Marines view it as a responsibility to one another to fulfill expectations.

Identity creation and reinforcement. How is this identity built and reinforced? The first step is through the Marine Corps' recruiting mechanism. Marine recruiters perpetuate Marine Corps values of honor, courage, and commitment, and identify recruits who they belief exemplify these values. Marines talked about the Marine Corps' "propaganda machine": "what really got me interested in the Marine corps was, I would assume movies." Marine Corps identity is shown to the public via mass media, and recruiters do their best to demonstrate the values from popular culture. One Marine described how he chose the Marine Corps because when he visited the recruiting office, the recruiters had just returned from physical training – no other service, in his mind, lived its identity like the Marine Corps.

It is not just the selection mechanism that perpetuates Marine Corps identity. Identity is forged in basic training. Prior work has examined how total institutions like basic training break down individual identity and replace it with the identity of the organization (e.g., Zurcher, 1967). A key aspect of building identity in the Marine Corps is through collective punishment. Marines are expected to succeed or fail as a unit, and when they fail, all members of the unit share in punishment. Some Marines express some uneasiness that this type of collective punishment borders on the unethical:

> "And you're never gonna see somebody stand up and say, hey hazing is a good thing. Hazing develops cohesiveness and loyalty, and it does. Shared hardship, it's where Marine Corps bootcamp goes so far, that's where our model works so well. There's that shared hardship commonality. And I'll tell you the only initiation rite a Marine has to go through to be a Marine is boot camp. They call it initiation, not hazing, and fair enough."

However, even in recognizing the border between initiation and hazing, Marines recognize the value of shared hardship in basic training leading to strong collective identity. Part of Marine identity is toughness, and Marines take pride that their basic training is more difficult than the other services, and that Marine recruits suffer more.

Moreover, the type of training that Marines complete differs from other military services. All Marine Corps officers, regardless of career field (e.g., infantry, legal, aviation), attend The Basic School (TBS), a 28-week course that teaches newly-commissioned Marine Corps officers the basic skills needed to lead a rifle platoon. The rifle platoon is the smallest unit an infantry officer would command, comprising approximately 40-50 Marines and tasked with ground combat missions. All Marine officers attend TBS immediately after commissioning and TBS serves as the first training center for new officers. In fact, Marine officers do not receive their career field assignments until the end of TBS – officers are ranked in order of merit based on their performance at TBS, and this ranked list is used to assign officers to military occupational specialties.

Once Marines leave training and arrive in "the Fleet," or operational units, their identity is reinforced in multiple ways. The first is through the use of routines as a collective. Routines not only serve as a means for unit members to learn others' skills and specialties, but also as a means to reinforce identity – the idea that Marines succeed or fail as a unit continues into operational units.

> "You know that if you allow somebody else to either suffer in silence or take a heavy burden on their own, it's just gonna drag the rest of the team down, so most times in the most of the shops and sections I've been in, you reach out to that peer, that superior, that junior, whoever it is, you reach out to them and say, 'Hey look, I see you dealing with this, what can we do to fix it?'"

In performing routines as collectives, Marines reinforce their shared identity as riflemen and also their commitment to accomplishing the mission.

Another way Marines reinforce identity is through reading. The Marine Corps

Commandant, since the late 1980s, has promulgated a reading list of books and other publications for Marines to read. This list is divided into specific titles for the different ranks. These titles are designed to teach Marines about the history of the Marine Corps and the history of warfare, and in reading them, the organization reinforces identity as infantrymen. There is variance in the degree to which Marines actually do the reading – there is little enforcement and accountability – but Marines are motivated to read through the example of their leaders and out of a desire for personal improvement:

> "So that means working out to a point that you're physically uncomfortable, that means reading ancillary material that talks about Marine Corps history or leadership, these are the things that you have to take some sort of initiative in yourself to say in order to be the best that I can be as a leader of Marines"

Organizational processes like basic training, utilization of routines, and reading reinforce Marine collective identity. Marine identity is oriented around an infantry focus and a focus on the mission. Marines see themselves as riflemen and all activities in the organization are organized around supporting mission accomplishment for ground Marines.

Mission Accomplishment and Adaptation

A focus on mission accomplishment is an outcome of Marine identity. Marines, in their focus and identification with riflemen, believe that their activities must be oriented around mission accomplishment. Marines view a failure to accomplish a mission as a failure to support ground Marines – which could lead to unnecessary deaths. The relentless desire to accomplish the mission at all costs and through whatever means possible, as a result of Marine identity, is a key means through which the Marine Corps remains adaptive to new problems.

In what ways does the emphasis on mission accomplishment facilitate adaptation? There are at least three reasons that emerge from the interviews. First, the desire to accomplish the mission increases Marines' motivation. Marines report feeling responsibility to one another in order to accomplish this mission. This extended to all aspects of life in the Marine Corps, as one Marine explained:

> "It was mission accomplishment. You were a group. You took care of each other. If you got drunk and passed out and left on the road, no one was gonna go, they were gonna take care of you, you weren't gonna get in trouble because you were part of that group. Call it mafia, call it good old boys club, and there's a lot of actual value I see in that type of organization."

This commitment to other members of the organization, feeling of mission accomplishment, and focus on the rifleman as the prototypical Marine motivates Marines to solve problems. When facing new problems, Marines describe feeling a responsibility to solve the problem as quickly as possible to minimize the harm to ground Marines. This means Marines take on larger burdens on themselves in the attempt to accomplish the mission:

> "Well you always give help, you're not gonna just say "we all have the same load, let's go as slow as the slowest person" No, we're gonna lighten the slowest person's load and get them to go as fast as they possibly can even if it means we're carrying a crushing load and they're carrying a smaller load. If we need to succeed together and we don't help you out, we're gonna fail together."

The emphasis on mission accomplishment increases Marine motivation, particularly as it pertains to developing solutions to new problems. Marines are more likely to expend extra effort, to take greater burdens on themselves, and to be motivated to finding new solutions due to the emphasis on accomplishing the ground mission as a core part of their identity.

Second, the desire to accomplish a mission changes how Marines perceive problems. When discussing mission accomplishment, Marines frequently note that combat is a non-routine task, and that any plan or process for approaching a combat mission will require adaptation of existing plans. An amphibious assault vehicle officer described how when drilling his Marines, he would develop set procedures to be enacted depending on stimuli in combat. If the unit took artillery fire, there was a procedure in place to move the vehicles away from each other so they did not bunch up. He admitted that this plan would probably change in an actual combat situation.

By viewing their task through the lens of mission accomplishment, Marines saw new problems differently. Rather than continue to use the same processes that did not apply to new problems, the Marine mantra is “adapt and overcome.” Indeed, Marines saw themselves as adaptors – in seeing the mission as uncertain and changing, in order to accomplish the mission, Marines themselves needed to be flexible and to change their processes. Marines see opportunities for adaptation.

Third, mission accomplishment facilitates experimentation and rule-breaking. Marines see as part of their identity accomplishing the mission – and supporting ground Marines. This motivates them and also makes them see opportunities for adaptation when they encounter new problems. This is facilitated by experimentation and rule-breaking. Marines, in seeking to accomplish the mission, are more willing to break rules to get work done.

One logistics officer described his experience in Afghanistan. While working at the main base for Marine Corps operations in Afghanistan, he was tasked with ensuring the base’s physical infrastructure was operational at all times. At one point, the base experienced a power outage. This threatened all operations in Afghanistan, as the command post and communications functions were not operational when power was out. He immediately led his team to diagnose the problem and to solve it. This was a new problem for him and although there were routines in place to guide certain repairs, the officer explicitly disregarded SOPs and directed his team to do all needed to solve the problem:

> “For some reason like, this [thing] wasn’t working and it was knocking out power to actually the headquarters where the general was at, and we were, I mean I was like on a call all the time and I had an Army electrician working for me, and we were working non-stop just to get this panel, because the panel distributes

> electricity to the buildings, and uh, I mean he did something. He was doing dangerous things that were totally outside of the SOP. I mean he was working by himself, and I mean, I probably could have got in trouble for letting him do stuff like that, but at that time, my only concern was – I mean obviously safety – but getting power to the building, because the command center kind of controlled the operations that were going around for the Marines in Afghanistan"

A pilot described the process a squadron's commanding officer used to maximize mission accomplishment. Marine Corps helicopters ferry personnel and equipment from naval vessels to land to support bases and operations. Because these helicopters fly over water, Marine Corps rules require them to include a piece of equipment called a helo emergency flotation system (HEFS). In the event of a water landing, this equipment automatically inflates air-filled bags so that the aircraft does not sink.

This equipment did not work well, from the perspective of the commanders and pilots. In adapting to mission needs to carry more personnel and equipment via airlift, a commanding officer removed this piece of equipment:

> "Great idea if they worked. So eventually, through disuse and corrosion and what have you, eventually it just became hundreds of pounds of helicopter bags on the side that didn't do anything because no one would know if they even worked, and if they had to test them they didn't work. So one of the COs [commanding officers] said, hey we're taking those off the helicopter. Why? Because if you're making me carry an extra 400 pounds off of a limited power aircraft, that's 2 or 3 Marines I can't get in the zone because I don't have enough power to slide off the ship and settle, because I'm so full and now you're taking away 500 pounds of carrying capability."

This commanding officer had a mission to accomplish and saw the need for adaptation in order to increase his capacity. He was motivated to accomplish the mission, saw the opportunity for change, and was thereby motivated to experiment and break the rules to accomplish the mission. Ultimately, this CO was removed from command for breaking the rules in this way, but this example still illustrates how adaptation can manifest as a result of existing operating routines and rules and identity.

Knowledge and Routine Recombination

A second mechanism that emerged from the interviews is the role of routines in knowledge recombination (Kogut & Zander, 1992). Nelson and Winter argue "[i]nnovations in organizational routine similarly consist, in large part, of new combinations of existing routines" (1982, pp. 130-131). Organizations regularly recombine knowledge as a means of generating new ideas.

Findings from the interviews suggest Marine Corps personnel recombine components of existing routines when developing solutions to new problems. One officer was stationed in Afghanistan working on the staff for the overall Marine Corps logistics chief based in Afghanistan. In this capacity, he worked with a team of personnel to develop and execute plans around the transportation of equipment and supplies. This officer was stationed in Afghanistan when the Marine Corps' mission was winding down.

The officer and the other staff officers received an order from their commander, the logistics chief, to draw up a plan to remove all Marine Corps equipment from Afghanistan. By this time, the Marine Corps had been in Afghanistan for over ten years. As an expeditionary organization, designed for short rapid-response missions, the Marine Corps is not designed to fight a ground war for over a decade. Thus, there was no existing procedure for retrieving equipment during as part of the draw-down.

The commander suggested to the staff to "vent," or review, all existing Marine Corps doctrinal publications. The logistics officer on his staff elaborated: "What he did was he took several manuals and he took the MPF [Maritime Prepositioning Force] operations doctrine, he had all his staff study doctrine…he created a whole new procedure based on MPF operations based on his staff. He was the one the best example I've seen where he used something in existence and reverse engineered it into something that was useful." This was an explicit example of recombination: in order to solve a new task, the Marine Corps team examined existing routine artifacts in the organization and identified useful elements to create a new procedure. Thus, existing aided in novel task performance by serving as a resource base for knowledge recombination.

Another officer suggested this type of behavior was common: "Yeah, no, we're always gonna try and find the closest fit we can and start with that. A lot of plagiarism, no pride in ownership. And that's a good thing because it's tested and you know what you're getting." The officers go on to describe how these routines are modified while they are used; Marines rely on the knowledge stored in organizational routines and recombine components of old routines as a starting place to address new problems.

STUDY 2

To test these hypotheses, I developed a laboratory study to permit strict control over manipulations and to rule out confounding factors. For example, routines may originate from different sources. Organizations may design routines to solve particular tasks. Conversely, teams themselves may create a routine to solve a task. I hold these and other contextual variables constant in the laboratory to ensure that such confounds do not influence the results. Thus, I isolate the causal effect of routine use on TMS formation and subsequent novel task performance. In doing so, I follow prior research (Camerer & Weber, 2007) in proxying organizations and organizational teams in the laboratory. I also follow prior work (Cohen & Bacdayan, 1994; Wollersheim & Heimeriks, 2016) in examining organizational routines in the lab. The study paradigm is designed to capture the critical features of routine use in organizations in the laboratory. I validated the design and materials of the study in the context of US military cyber-protection teams, where I performed pilot studies during military exercises. Participants in the laboratory study are randomly assigned to condition. Thus, the study offers high internal validity and complements field studies on routines that have used qualitative and archival methods.

Context

To be consistent with the research context in Study 1, the empirical context for Study 2 is cyber-defense, an increasingly important problem for organizations. Both government organizations and private organizations have been subject to data breaches, phishing attacks, denial-of-service attacks, and other forms of cyber-attacks. Notably, the United States government's Office of Personnel Management, which manages the US security clearance process, reported in 2015 that 21.5 million records of background checks and other records of personally identifiable information were breached by unknown actors.

Organizations have started to establish security teams to identify and to mitigate such attacks. For example, the United States military has established cyberprotection teams (CPTs) in the different services tasked with monitoring and defending US military and government computer networks. Cyberdefense team members employ diagnostic and programming tools to aid them in the identification and mitigation of threats. Their work is highly interdependent and routinized; CPT members use both tacit and explicit routines in their day-to-day work. Private organizations commonly create computer security incident response teams (CSIRTs), where CSIRT personnel monitor company networks and systems to prevent, identify, and mitigate against threats.

I bring the cybersecurity context to the laboratory. In this study, participants at a mid-Atlantic university were informed they were the CSIRT for a fictitious manufacturing company called DayRep. Participants were informed that their task was to identify any instances of industrial espionage from company data. Participants worked in teams of three to complete two separate cyberdefense tasks, a phishing identification task and a social engineering identification task.

I validated the general study design through a pilot study using real-world teams. Using an online platform developed by a software engineering group at a mid-Atlantic university, I developed a training simulation for US military cyberprotection teams (CPTs). The simulation was based on a simulation used in regular training, and it asks team members to identify and mitigate attacks on a computer network. Team members were told they had been assigned to a United States military forward operating base in a fictitious country in which there is an active conflict. They were told they must detect threats on the base's computer networks and prepare a diagnostic report for their commanders. I performed pilot studies with US Army Reserve and US Air Force Reserve teams. During these pilots, I received feedback on task design, routine design, and contextual realism. I incorporated the feedback into the study design and modified the paradigm for civilian participants.

Study Design

Participants were recruited from a participant pool at a mid-Atlantic university. Participants were paid either $15 in cash for their participation or with course credit.[3] Groups of three participants entered the laboratory and were introduced to the study. The experimenter asked participants to sign consent forms and directed them to sit at individual computers that were arranged around a table. Each computer was logged into a Google account and each computer screen displayed the same shared Google Drive folder containing all the study materials. To minimize the possibility of experimenter demand effects, the experimental instructions and contextual information were delivered via documents contained within the Google Drive folder. Participants read that they were members of a computer incident security response team (CSIRT) for a large manufacturing company (fictitious) called DayRep. DayRep's source of competitive advantage was in the quality and novelty of its materials employed in production, and as such, DayRep was subject to industrial espionage. Participants read that their task was to identify computer security issues and that their team of three was assigned to a forensic investigation due to a suspected incident of industrial espionage.

Following the introduction to the task and context, participants completed cybersecurity training. Participants individually read through a six-page document designed to familiarize them with basic cybersecurity concepts, with an emphasis on phishing, spear phishing, and social

[3] The form of compensation did not affect any measures or results in the study.

engineering. Knowledge of these topics was important for completing the tasks. Participants then completed, individually, a survey with three questions on these topics to test their knowledge.[4]

Tasks. Following the training, participants completed two tasks as a team. The order of the tasks was counterbalanced, and participants completed an individual survey in between tasks. For each task, participants received 20 minutes. In one task ("Task A"), participants completed a phishing identification task. A phishing attack occurs when an attacker sends messages from a purported trusted source to a target so that the target will reveal sensitive information. To complete this task, participants were given information about five key employees at DayRep in different functions (e.g., legal, manufacturing, R&D). For each employee, participants received 15 emails the employee received, malware scans of the employee's computer before and after the suspected incident occurred, and an access log to DayRep's shared file server. Participants could have identified that a phishing attack took place based on review of these documents.

In the second task ("Task B"), participants completed a social engineering task. A social engineering attack occurs when an attacker directly impersonates a trusted source to obtain sensitive information from a target. Whereas phishing attacks are mostly electronic, social engineering attacks frequently occur through telephone calls. Participants received information about the same employees in Task A. For each employee, participants received 15 memos that the employee purportedly wrote to memorialize phone calls they had received, 15 emails that the employees had received, and an access log to DayRep's shared file server. Participants could have identified that a social engineering attack took place based on review of these documents.

[4] Performance on this survey was aggregated to the group level, and participant knowledge did not differ significantly ($t(69)=1.626$, $p=0.109$) between the routine ($M=0.767$, $SD=0.164$) and the non-routine conditions ($M=0.821$, $SD=0.111$). Similarly, participant knowledge did not differ ($t(69)=-1.328$), $p=0.188$) between the Task A order ($M=0.771$, $SD=0.154$) and the Task B order ($M=0.815$, $SD=0.128$).

For both tasks, participants worked as a team to complete the same deliverable. Participants were told that their deliverable was a set of six report logs. The first report log contained four questions for participants to answer about whether there was an intrusion into DayRep systems. The other five logs were focused on the individual employees and contained three questions about whether the employee in question was subject to an attack, whether the employee intentionally or unintentionally enabled an outside actor to access DayRep systems, and what files the employee accessed or transferred from the company file server. Thus, each participant team completed six report logs for each task, with a total of 38 questions answered across both tasks. The blank reports were provided to the teams as a Google Doc, and all participants edited the same document while working on the tasks. I developed the tasks to be the same in terms of the deliverable, so that they could be comparable, but the content of the tasks was such that the method used to complete Task A could not be directly applied to Task B, and vice versa. Additionally, I included individual reports for each employee so that some element of the task could be repeated.

Manipulations. Teams were randomly assigned to one of two conditions. In both conditions, teams were provided with information, in the form of their training packet, designed to aid them in identifying phishing and social engineering attacks. In the routine artifact condition, teams were given a written procedure to aid them with the first task. Recall that the tasks were counterbalanced, so half the teams started with Task A (Order Condition A) and half the teams started with Task B (Order Condition B). If the team was in the routine artifact condition, the team received a written procedure that provided instructions for completing the focal task (either Task A or Task B). Thus, there were two routine artifact documents. In the non-routine condition, teams were not provided with any additional information to complete the task. However, teams in both conditions had access to their training packet, which contained all the information they needed to identify threats for both tasks.

The routine artifact is a document with multiple components. First, the artifact included three distinct roles (e.g., Email Analysis, Malware Analysis, Server Analysis). Team members were randomly assigned to roles. Second, the artifact included steps that describe how the member in each role should process the data provided to the team, along with how to interact with the other roles. The artifact was oriented around completing one focal employee report. The teams were instructed to repeat the steps for each employee. Thus, I instantiated a routine – the artifact yielded a repeated, interdependent pattern of action. It is repeated because each team needed to complete the procedure five times, one for each employee. It is interdependent because the procedure provided information for how the roles should interact in the service of completing a joint task. It is a pattern of action because it produced a recognizable set of behaviors for both the individuals and for the team as a whole.

The artifact provided instructions to complete the first task the team faced, whether it was Task A or Task B. If the teams had applied the procedure to the second task, they would have found that the content knowledge contained within the procedure would not have applied. For example, the routine for Task B contained information directing a member to analyze the call memos; as call memos do not exist for Task A, the information could not have been applied. Some of the procedural knowledge (e.g., red-flagging suspicious documents) could have applied across both tasks, but the specific sequence of sub-tasks was not directly transferrable.

Measures

Performance. I measured performance in each work period based on the report logs teams submitted. Each set of reports contained 19 questions, with each question assigned a number of points depending on how much information was requested from participants. There is a "right" answer for each question, and I measure performance by the number of questions teams answer correctly. Two coders reviewed all report logs. For Task A performance, the average inter-rater reliability (r_{wg}) was 0.99, and reliability was acceptable (ICC2=0.96). For Task B performance, the average inter-rater reliability (r_{wg}) was 0.99, and reliability was acceptable (ICC2=0.98).

Transactive memory systems. TMS was measured twice, after the first task and after the second task. I measure transactive memory systems (TMS) using Lewis' (2003) and Austin's (2003) scales. Lewis' scale consists of 15 items, divided into three sub-scales: trust, specialization, and coordination. This scale is designed to determine indicators of transactive memory and is widely used in research. For the Lewis scale, after the first task, average inter-rater reliability (r_{wg}) was 0.89. ICC1, the extent to which individual responses are a function of membership in team, was 0.36, indicating a large effect. Intraclass correlation coefficient (ICC(2)) was 0.62. After the second task, average inter-rater reliability (r_{wg}) was 0.90. ICC1, the extent to which individual responses are a function of membership in team, was 0.28, indicating a large effect. Intraclass correlation coefficient (ICC(2)) was 0.54. The nature of the Austin scale does not permit reliability statistics.

I examined the validity of the Lewis scale as measured after the first task and after the second task. When measured after the first task, Cronbach's alpha for the Lewis scale was 0.86. A principal components analysis with promax rotation yielded four factors with factor loadings above 0.4. Two of the factors correspond to sub-scales of the Lewis scale: the specialization and coordination subscales, for which the items in the sub-scales were the only ones that loaded. The two other identified factors consisted of items from the trust in expertise and coordination sub-scales. A confirmatory factor analysis using structural equation modeling in STATA, based on the three sub-scales yielded acceptable loadings, except for the fourth item of the trust sub-scale. Dropping this item did not affect the results. The factor analysis for the Lewis scale as measured after the second task was the same as after the first task.

Austin's measure consists of four dimensions: knowledge stock, consensus, specialization, and accuracy. The measure consists of a series of questions for participants to self-report their expertise in pre-defined knowledge categories with Likert-type scales, and for participants to identify the experts for each of the knowledge categories specified by the researcher. The researcher than calculates the knowledge stock of each individual member based on their self-reported expertise. Next, the research calculates a measure of whether the group members had consensus about each others' expertise by identifying the uniquely identified experts for each skill category and determining the standard deviation of the number of experts identified. A greater score indicates greater consensus. The researcher measures specialization by counting the number of times an individual is identified as an expert in each skill and taking the standard deviation across skills. Higher values indicate more specialization. Finally, transactive memory accuracy is measured by tying together the identified expert scores and the self-reported expertise scores. For each team member, a score is computed whereby the member receives points based on their accuracy in perceiving the most expert member in each skill. Each focal member's scores are averaged across skills and then averaged across all team members to arrive at the final accuracy measure. Full details of the Austin measure are available in the Appendix.

Behavioral Specialization. I developed a behavioral measure of specialization, as specialization is an indicator that TMS has formed. All participants worked at computers that were signed into unique Google accounts, and they worked on the same Google Doc to complete the reports. An advantage of using a Google Doc and unique Google accounts is that I can identify each individual's contribution to the team deliverable. The team's deliverable consisted of answering questions in five report logs, one for each employee of the purported company. For each report log, there were three questions that corresponded to the knowledge categories instantiated by the materials provided to the participants and the routine. One question related to the written materials teams were provided (e.g., call logs, emails), one question related to the malware scan logs, and one question related to the server logs. Thus, there were five examples of each type of question for each of the team's tasks.

The routine was designed to yield knowledge specialization, based on the roles to which team members were assigned. I develop a measure of specialization by identifying which questions each individual team member answered in the report logs. For each team member, I count the number of questions answered in each knowledge category. I then calculate the standard deviation of contributions across the three knowledge categories to determine a given team member's degree of specialization. A higher standard deviation indicates greater specialization. This measure is averaged across team members to determine team-level specialization. Because this measure relies on team members contributing to the report logs, I only calculated this measure when teams provided at least one answer to an employee report log. For task 1, two teams did not provide sufficient responses. Additionally, for five teams, technical issues prevented identification of the specific members contributing to the logs. Thus, for task 1, 63 teams are measured. For task 2, two teams did not provide sufficient responses, and there were three teams with technical issues, for a total of 66 teams measured.

Routinization. I instantiated a routine with an artifact, but routine dynamics theory (Feldman, 2000; Pentland & Feldman, 2008) suggests an artifact may not yield an actual routine, or that it may yield a routine in a different form from what was intended. To address this concern, I use a survey measure to check whether the routine artifact manipulation had an effect on participant behavior. Immediately after the first task (where teams received the routine artifact or did not), participants completed a survey. Included in the survey were three questions designed to gauge whether teams used a routine (e.g., "Our team used a step-by-step procedure to accomplish the task"). The Cronbach's alpha for the scale was 0.64, in the acceptable range, and reliability was acceptable (ICC(1)=0.31, ICC(2)=0.57). This measure serves as a manipulation check.

Summary Statistics

Two hundred and thirteen participants in 71 three-person groups participated in the study. The average age in the sample was 23, 56% of the participants were female, and 27% of the sample identified as white. Thirty-six groups were randomly assigned to the routine condition, and 35 teams were randomly assigned to the non-routine condition. Thirty-seven teams were randomly assigned to the task order with Task A first, and 34 teams were randomly assigned to the task order with Task B first.

Table 1 about here

Summary statistics and correlations are displayed in Table 1. The routine condition was positively correlated with TMS, as measured by the Lewis scale, after both the first task and the second task. The order condition, represented in the table as a categorical variable coded as 1 for the Task A followed by Task B order, was negatively correlated with task 1 performance, and positively correlated with task 2 performance. TMS measured after task 1 was positively correlated with TMS after task 2 and task 1 performance, while TMS measured after task 2 was positively correlated with task 2 performance.

Manipulation Check

I tested whether the routine manipulation induced participants to behave in a more routinized manner. After participants completed the first task (irrespective of order), each participant answered three questions (e.g., "Our team used a step-by-step procedure to accomplish the task") on a 1-5 Likert-type scale designed to assess whether they used a routine. (see discussion of routinization in measures section). Teams in the routine condition ($M=9.509$, $SD=1.644$) reported they worked with a routine more than teams in the non-routine condition ($M=8.809$, $SD=1.547$), and this difference was marginally significant using a two-tailed test ($t(69)=-1.846$, $p=0.069$). An OLS regression predicting the survey results and including the routine condition and controlling for the order condition confirmed these results ($B(\text{routine})=0.706$, $p=0.066$).

Analytical Strategy

To test Hypothesis 1, I perform an OLS regression predicting TMS and controlling for order. A significant and positive effect of the routine manipulation on TMS, while controlling for order, would provide evidence for this hypothesis.

To test Hypothesis 2 and 3, I perform mediation analyses. Traditional approaches to mediation analysis, such as the stepwise regression approach (Baron & Kenny, 1986), require a direct effect of an independent variable on a dependent variable, do not permit the estimation of a mediated indirect effect, and have low power when compared to other approaches (Kenny & Judd, 2014). The Sobel test (Sobel, 1982) is an alternative approach, but the approach imposes a normality assumption on the product of two variables that is violated in most analyses.

Thus, I use a bootstrapping approach for testing mediations (Hayes, 2013; Preacher & Hayes, 2004). This approach draws confidence intervals around the size of the indirect effect. Some advantages of this approach include not imposing distribution assumptions on the data, not requiring a direct effect of the independent variable on the dependent variable, and having higher power than other mediation tests, especially for small samples (Kenny & Judd, 2014).

A significant and positive indirect effect of the routine manipulation on task 2 performance, via TMS and controlling for order, would provide support for Hypotheses 2 and 3.

Hypothesis 1 Results

The routine manipulation was given to participants prior to starting task 1. TMS was measured by survey immediately after task 1 using Lewis' (2003) scale. Teams in the routine condition (M=53.343, SD=7.316) reported higher levels of TMS than teams in the non-routine condition (M=47.533, SD=5.895), and this difference was statistically significant (t(69)=-3.709, p<.001). This provides initial support for Hypothesis 1.

Table 2 about here

As teams were not only subject to the routine manipulation, but also to different order conditions for the tasks, I performed an OLS regression to predict TMS by the routine manipulation and controlling for the order condition. Results are shown in column 1 of Table 2, indicating that the routine manipulation had a significant and positive effect on TMS after task 1 (β=5.858, p<0.001), providing support for Hypothesis 1.[5]

Although I anticipated that the manipulation would have the strongest effects immediately after teams worked together using the routine. I also investigated whether the routine manipulation had a lasting impact on team behavior. A positive and significant effect of the routine manipulation on TMS measured after task 2 would indicate there are lasting benefits of using a routine on a team's TMS. Teams in the routine condition (M=55.843, SD=7.065) reported higher levels of TMS after task 2 than teams in the non-routine condition (M=52.448, SD=5.526), and this difference was statistically significant (t(69)=-2.251, p=0.028). The

[5] These results are unchanged when regressing TMS on the routine condition, the order condition, and the interaction of the routine condition and order condition.

magnitude and significance of the effect diminished from task 1 to task 2, but that there was still a significant effect on TMS speaks to the strength of routines in building a strong TMS that persists over time. Column 2 of Table 2 displays results from an OLS regression predicting TMS after task 2 and controlling for order. I find the routine manipulation has a significant and positive effect on TMS measured during task 2 ($\beta=3.365$, $p=0.027$). Taken as a whole, I find strong evidence for Hypothesis 1, that teams trained on routines develop stronger transactive memory systems than teams not trained on routines.

Hypothesis 2 and 3 Results

I use the PROCESS macro for SPSS (Hayes, 2013) to test the mediation of the routine manipulation on task 2 performance, through TMS. First, I test whether TMS measured after task 1 mediates the relationship between the routine manipulation and task 2 performance, controlling for the order condition and task 1 performance. I control for task 1 performance for two reasons: first, the team's performance on task 1 could reflect unobserved characteristics of the team that are important to include; second, although the teams were not informed of their performance on task 1, their perception of their performance on the task could have affected their performance on the second task. I use model 4 in the PROCESS macro, with Huber-White standard errors, and 50,000 percentile confidence intervals. I do not find a significant indirect effect of the routine manipulation on task 2 performance, through task 1 TMS ($\beta=-0.128$, 95% CI: -2.049, 1.369).

In the process of working on a novel task, a team discovers what knowledge each member possesses that applies to the new task, and thereby updates its TMS. I investigated whether task 2 TMS mediated the relationship between the routine manipulation and task 2 performance. Using model 4 in PROCESS, controlling for order and task 1 performance, using Huber-White standard errors, and 50,000 percentile confidence intervals, I do not find evidence of an indirect effect of the routine manipulation on task 2 performance through task 2 TMS (β=0.672, 95% CI: -0.163, 1.803).

Therefore, I investigated a serial mediation, whereby the routine manipulation affects task 2 performance through both task 1 TMS and task 2 TMS, sequentially. In this model, the routine manipulation affected the TMS built during task 1, which affected TMS built during task 2, which has subsequent effects on task 2 performance. Using model 6 in PROCESS, controlling for order and task 1 performance, using Huber-White standard errors, and 50,000 percentile confidence intervals, I find a significant indirect effect of the routine manipulation on task 2 performance, going through both task 1 and task 2 TMS (β=1.446, 95% CI: 0.063, 2.958). Figure 2 displays the serial mediation model with effects specified for the pathways of the mediation. This result provides evidence for Hypotheses 2 and 3, such that teams trained with routines performed better on novel tasks than teams not trained on routines, and the performance difference is explained by the TMS that the teams built in both task periods.

FIGURE 2 ABOUT HERE

Behavioral Specialization

The routine manipulation included role assignments, and as a part of creating a transactive memory system, the routine manipulation should have also induced team members to specialize in knowledge categories. Specialization is an indicator that a transactive memory system has formed. I use the behavioral specialization measure to further explore the effect of the routine manipulation on team behavior.

Hypothesis 1. First, I performed t-tests to examine whether the routine manipulation influenced specialization. During task 1, I find that teams in the routine condition were more specialized (M=1.166, SD=0.862) than teams in the non-routine condition (M=0.514, SD=0.349), and this difference was statistically significant ($t(62)=-3.965$, $p<.001$). During task 2, I find that teams in the routine condition were again more specialized (M=1.342, SD=0.753) than teams in the non-routine condition (M=0.526, SD=0.597), and this difference was statistically significant ($t(64)=-4.902$, $p<.001$). The magnitude of the difference increased from the first period ($\Delta=0.652$) to the second period ($\Delta=0.817$). To account for order effects, I performed regressions predicting specialization during task 1 and task 2, predicted by the routine manipulation and order. I find that the routine manipulation significantly increased the degree of specialization during both task 1 ($\beta=0.648$, $p<0.001$) and task 2 ($\beta=0.835$, $p<0.001$) (Table 2, Columns 3 and 4). These results provide additional evidence for Hypothesis 1, that routine use improves TMS.

Hypotheses 2 and 3. I investigate whether specialization mediates the effect of the routine manipulation on task 2 performance. First, I investigate specialization during task 1 as a mediator with the PROCESS macro for SPSS. Using model 4, Huber-White standard errors, 50,000 bootstrap confidence intervals, and controlling for order and task 1 performance, I do not find a significant indirect effect (95% CI: -0.203, 3.989), consistent with other results.

Next, I investigate the serial mediation, whereby there is an indirect effect of the routine manipulation on task 2 performance, going sequentially through task 1 specialization and task 2 specialization. Using model 6, Huber-White standard errors, 50,000 bootstrap confidence intervals, and controlling for order and task 1 performance, I find a significant serial mediation (95% CI: 0.001, 2.255). Thus, the routine manipulation increased specialization during both task 1 and task 2, which improved task 2 performance. This provides further evidence for Hypotheses 2 and 3.

Austin-style TMS

The previous analyses are performed with TMS as measured with Lewis' (2003) scale and the behavioral specialization measure. I also measured TMS with Austin's (2003) measure. Whereas Lewis' measure asks participants for their perceptions of TMS indicators (specialization, trust in expertise, coordination), the Austin-style measure directly measures TMS. The researcher specifies the knowledge categories needed for the team's task. Each participant then rates their own expertise in the knowledge categories and which member of their team is the most expert in the knowledge categories. From these ratings, four measures emerge. First, the team's total knowledge stock, as measured by self-reported assessments of own expertise. Second, the team's level of consensus on expertise. Third, the team's degree of knowledge specialization. Fourth, the team's accuracy in assessing each other's expertise. The measures are treated separately in analysis; there is no omnibus metric.

Table 3 about here

Hypothesis 1. First, I test hypothesis 1. I anticipate that the routine manipulation will increase a team's level of consensus, accuracy in assessing expertise, and knowledge specialization, as measured after the first task. I tested this with the OLS regressions shown in Table 4. In Table 4, I assess whether the routine manipulation affected the four measures of TMS, while controlling for order. I find that the routine manipulation significantly increased accuracy ($\beta=0.625$, $p<0.001$), consensus ($\beta=0.207$, $p<0.001$), and specialization ($\beta=0.289$, $p<0.001$) (columns 2-4), but not knowledge stock ($\beta=0.288$, $p=0.355$) (column 1). These results provide additional support for Hypothesis 1.[6]

[6] I performed four t-tests to test whether there is a difference on the dimensions of the Austin measure depending on the routine manipulation. I use a Bonferroni adjustment to lower the alpha value to 0.0125 to attain significance. Table A1 summarizes the results of the t-tests. I find that the routine manipulation had a significant effect on accuracy, consensus, and knowledge specialization, even with the lowered alpha value, providing evidence for Hypothesis 1.

I do not find that the routine manipulation influenced whether teams developed a stronger or weaker knowledge stock, despite theorizing that routines improve individual skill development. Due to time constraints in the laboratory context and the fact that most participants in the study were novices to the cybersecurity context, these results suggest a qualification to my theorizing about routines enabling individual skill development: routines may not enable skill development in very short time periods and where the users are novices.

Hypotheses 2 and 3. I use the PROCESS macro for SPSS. Using model 4, 50,000 bootstrap confidence intervals, and Huber-White standard errors, I estimate whether knowledge stock, consensus, accuracy, and specialization during task 1 have mediating effects of the routine manipulation on task 2 performance. I also control for order and for task 1 performance. I estimate these dimensions of TMS as separate variables, because the Austin measure is not meant to be aggregated into a single measure. I find that knowledge stock (95% CI: -0.874, 0.229), consensus (95% CI: -1.039, 1.602), and specialization (95% CI: -0.553, 1.828), and accuracy (95% CI: -1.039, 1.602) do not mediate the relationship between the routine manipulation and task 2 performance.

Turning now to the serial mediation, I investigated serial mediations for each of the dimensions of the Austin measure. Like the previous serial mediation, I control for order and for task 1 performance to examine whether TMS measured after task 1 and task 2 sequentially mediate the relationship between the routine manipulation and task 2 performance. I find that knowledge stock (95% CI: -0.359, 0.944), consensus (95% CI: -1.414, 0.519), and specialization (95% CI: -1.253, 0.203) do not mediate the relationship between the routine manipulation and task 2 performance. Accuracy (95% CI: 0.064, 3.433) does mediate the relationship between the routine manipulation and task 2 performance, providing support for Hypotheses 2 and 3 with the accuracy dimension of the Austin measure.

Taken as a whole, results with the Austin-style measure are consistent with results from the Lewis measure and the behavioral specialization measure for Hypothesis 1: the routine manipulation led to stronger TMS development than the non-routine manipulation for three dimensions of the Austin measure. For hypotheses 2 and 3, I find a significant indirect effect in a serial mediation analysis for the accuracy dimension of the Austin measure: accurate perceptions of expertise serially mediated the relationship between the routine manipulation and task 2 performance.

Robustness Checks and Additional Analysis

Baron and Kenny mediation. As described previously, I performed mediation analyses using bootstrapping to test Hypotheses 2 and 3. However, an advantage of the Baron and Kenny approach is that it permits the estimation of each "path" in the mediation. Thus, I performed a mediation analysis using the stepwise regression approach (Baron & Kenny, 1986), bearing in mind that this approach has lower power than the bootstrapping method.

Table 4 about here

I investigated the serial mediation, whereby the routine manipulation has sequential effects on task 1 and task 2 TMS, and then effects on task 2 performance.[7] Columns 1, 2, 3, 5, and 6 of Table 3 demonstrate this analysis. Like before, I do not find a direct effect of the routine manipulation on task 2 performance (β=-1.006, p=0.446, column 1) and I do find a significant effect of the routine manipulation on task 1 TMS (β=5.619, p<0.001, column 2) and task 2 TMS (β=3.253, p=0.031, column 3). In column 4, I find that task 1 TMS is a significant predictor of task 2 TMS (β=0.678, p<0.001), but that the routine manipulation is not (β=-0.555, p=0.637). In

[7] Further details on the mediation analysis can be found in the Appendix.

column 6, I find that only task 2 TMS significantly predicts task 2 performance (β=0.379, p<.05). These results are consistent with the mediation analysis performed with the bootstrapping approach and provide support for Hypotheses 1, 2, and 3.

Repeated Measures Analysis. Study 2's design involved teams performing two tasks in a counterbalanced order. In the main analysis, I accounted for order and found that the order of tasks did not influence results. I also wished to account for whether group characteristics or time influenced results. To test Hypothesis 1, I performed regressions predicting TMS and including the routine manipulation, time (or trials), and a manipulation by time interaction as predictors. To test Hypotheses 2 and 3, I performed a repeated measures analysis by performing regressions predicting performance and including the routine manipulation, time (or trials), and a manipulation by time interaction as predictors. I reshaped the data from wide to long format, and I replicated the mediations with the different measures of TMS. A significant mediation of TMS with the reshaped data would suggest that the routine manipulation increased TMS and performance irrespective of group characteristics.

TABLE 5 ABOUT HERE

To test Hypothesis 1, while accounting for time and its interaction with the manipulation, I performed the regressions shown in Table 5. The regressions confirm the previous analysis, such that the routine manipulation significantly increased TMS for the Lewis measure (β=5.809, p<0.001), the accuracy (β=0.622, p<0.001), consensus (β=0.208, p<0.001), and specialization (β=0.291, p<0.001) components of the Austin measure, and the behavioral specialization measure (β=0.617, p=0.001). This provides further support for Hypothesis 1.

To test Hypotheses 2 and 3, I used PROCESS. I tested each mediator separately, using model 4 in PROCESS, Huber-White standard errors, and 50,000 bootstrap confidence intervals.

For each mediation, I include the routine manipulation, time, and the manipulation by time interaction as predictors. For the Lewis TMS measure, I find a significant indirect effect of the routine manipulation on performance, going through TMS (95% CI: 0.831, 3.813). I also find significant indirect effects of the Austin accuracy measure (95% CI: 0.537, 2.746) and the behavioral specialization measure (95% CI: 0.384, 2.983), consistent with previous analyses. And consistent with the prior analysis, I do not find significant indirect effects for the Austin knowledge stock measure (95% CI: -0.248, 0.405), the Austin consensus measure (95% CI: -0.822, 1.358), and the Austin specialization measure (95% CI: -1.137, 0.901). Taken as a whole, I confirmed previous analyses and provide additional support for Hypotheses 2 and 3.

The Austin measure consists of four components. I also performed a parallel mediation analysis to determine whether there are simultaneous effects of the mediators on performance, controlling for time and the interaction of the manipulation with time. Using model 4 of PROCESS, Huber-White standard errors, and 50,000 bootstrap confidence intervals, I estimate the components of the Austin measure simultaneously and find significant mediations of consensus (95% CI: 0.987, 7.557), and accuracy (95% CI: 0.976, 4.277) in the predicted direction. However, I find a negative indirect effect of specialization (95% CI: -7.569, -1.182). This countervailing effect does not lead to a negative effect of TMS on performance, as the total indirect effect remains significant (95% CI: 0.380, 4.015). These results provide evidence for Hypotheses 2 and 3, but they also suggest that the relationship between routine use and TMS development may not be always be positive, and that future research should investigate the conditions under which countervailing effects like the one found here could strengthen or attenuate the relationship between routines and novel task performance.

Lewis subscale mediations

Although Lewis' (2003) scale is typically aggregated and used as a single measure, the three sub-scales of trust, specialization, and expertise reflect distinct indicators that may have separate effects on team performance. I examined whether the sub-scales separately mediate the relationship between the routine manipulation and team performance. I examined each sub-scale as a mediator in the same serial mediation approach used to test Hypotheses 2 and 3.

First, I examined the specialization sub-scale. Using the PROCESS macro for SPSS, I used model 6, controlling for task 1 performance and order, Huber-White standard errors, and 50,000 bootstrap confidence intervals. I find the specialization sub-scale does not mediate the relationship between the routine manipulation and team performance (B=1.015, 95% CI: -1.203, 3.06).

Next, I examined the trust sub-scale. Using the PROCESS macro for SPSS, I used model 6, controlling for task 1 performance and order, Huber-White standard errors, and 50,000 bootstrap confidence intervals. I find the trust sub-scale does not mediate the relationship between the routine manipulation and team performance (B=0.024, 95% CI: -0.379, 0.444).

Finally, I examined the coordination sub-scale. Using the PROCESS macro for SPSS, I used model 6, controlling for task 1 performance and order, Huber-White standard errors, and 50,000 bootstrap confidence intervals. I find the trust sub-scale does not mediate the relationship between the routine manipulation and team performance (B=0.392, 95% CI: -0.417, 1.297).

In sum, I find that the separate sub-scales of the Lewis (2003) TMS scale do not mediate the relationship between the routine manipulation and novel task performance. Only the complete scale as an aggregate measures is a significant mediator. This is consistent with the theoretical justification for aggregation and suggests it is the TMS construct itself driving the effects in the experiment rather than the indicators themselves. The indicators reflect TMS, but on their own do not have an effect; it is the construct that yields the effect.

Team Knowledge robustness

Team members completed a three-item survey to check their knowledge on cybersecurity concepts immediately after their individual training. This survey was used to verify that participants between conditions did not differ in their expertise, and I found no such difference in performance on the survey. Although participants were randomly assigned to teams and to condition, I wished to ensure that any baseline knowledge in cybersecurity concepts that participants held had no effects on the results. Thus, I entered the team-level variable reflecting performance on this survey as a control variable in the mediation analyses.

First, I examined the mediation analysis using Lewis' (2003) scale. When entered as a control in the PROCESS serial mediation, I find that the indirect effect of the routine manipulation on novel task performance, going through TMS, is no longer significant (B=1.371, 95% CI: -0.075, 2.817). However, when exploring this analysis more using a stepwise mediation approach, I find that TMS remains significant as a predictor of novel task performance (B=0.357, p=0.043) and that the manipulation is not significant (B=-0.485, p=0.719).

Next, I turn to Austin's measure. I performed serial mediation analyses for the four dimension of Austin's measure, including team knowledge as a control variable. Consistent with previous results, I find that knowledge stock (B=0.291, 95% CI: -0.370, 0.998), specialization (B=-0.395, 95% CI: -1.315, 0.408), and consensus (B=-0.303, 95% CI: -1.554, 0.962) are not significant mediators when accounting for team knowledge. However, accuracy (B=1.514, 95% CI: 0.034, 3.848) remains a significant mediator.

Finally, I examined the behavioral specialization measure. I entered group knowledge as a control variable in the serial mediation examining the mediating effect of behavioral specialization, and I find that behavioral specialization is not a significant mediator (B=0.709, 95% CI: -0.013, 2.229).

In summary, the inclusion of the group knowledge variable suggests that the degree to which team members possessed or acquired knowledge about cybersecurity concepts played a role in explaining the effect of the routine manipulation on novel task performance. Further research should account for or investigate how knowledge acquisition influences team dynamics.

Team identification

An alternative explanation for the effects I find is that the routine manipulation did not only induce TMS formation, but the formation of team identity. To rule out this alternative, I measured team identification after task 1 and after task 2 using an established 10-item scale (Ellemers, et al., 1999). Performing a serial mediation analysis in PROCESS with 50,000 bootstrap confidence intervals, model 6, Huber-White standard errors, and controlling for order and task 1 performance, I examine whether team identification mediates the relationship between the routine manipulation and novel task performance. I find that team identification does not mediate the relationship (B=0.386, 95% CI: -0.398, 1.479).

Additionally, I entered team identification (as measured after the first task) as a control variable in serial mediation analyses examining whether the different TMS measures mediate the relationship between the routine manipulation and novel task performance. I find that results are unaffected for the Lewis measure (B=1.169, 95% CI: 0.015, 2.350), Austin knowledge stock (B=0.121, 95% CI: -0.523, 0.739), and Austin accuracy (B=1.542, 95% CI: 0.181, 3.781). However, behavioral specialization (B=0.699, 95% CI: -0.020, 2.219), Austin consensus (B=-0.296, 95% CI: -1.511, 0.890), and Austin specialization (B=-0.339, 95% CI: -1.209, 0.405) no longer have significant indirect effects with analysis in PROCESS. However, when investigating these effects with stepwise mediation analyses, the results are unchanged from the prior analysis.

Survey measure of routinization

The manipulation check I used was a 3-item scale measured immediately after the first task to determine whether participants behaved in a routinized manner. As this measure captures the participants' perceptions of whether they worked in a routine manner, I chose to use this variable in a supplemental analysis. Specifically, I test whether this variable influences the degree to which participants developed transactive memory, and whether TMS mediates the relationship between perceptions of routinized behavior and novel task performance.

First, I examined the mediation analysis using Lewis' (2003) scale. When entered as the independent variable in the PROCESS serial mediation, I find that the indirect effect of routine behavior on novel task performance, going through TMS, is significant (B=0.508, 95% CI: 0.033, 1.087).

Next, I turn to Austin's measure. I performed serial mediation analyses for the four dimension of Austin's measure, using the routinization measure as the independent variable. Consistent with previous results, I find that knowledge stock (B=0.243, 95% CI: 0.007, 0.649), accuracy (B=0.314, 0.021, 0.752) are significant mediators. However, I find that specialization (B=-0.032, 95% CI: -0.150, 0.049), and consensus (B=-0.032, 95% CI: -0.182, 0.093) are not significant mediators when accounting using the routinization measure as an independent variable.

Finally, I examined the behavioral specialization measure. I entered group knowledge as a control variable in the serial mediation examining the mediating effect of behavioral specialization, and I find that behavioral specialization is not a significant mediator (B=0.077, 95% CI: -0.067, 0.396).

DISCUSSION

In two studies, I develop theory and provide evidence on organizational routines and their relationship with adaptability. In Study 1, I performed interviews with 30 United States Marine Corps officers and developed theory arguing that organizational routines improve the development of a team's transactive memory system, and that due to transactive memory, teams using routines will perform better on novel tasks than teams that do not use routines. Specifically, I argue that routines improve team members' ability to recognize one another's expertise, provide a role structure that can develop into a TMS, and can improve tacit coordination. All of these factors lead to TMS formation. Consequently, a developed TMS can improve novel task performance by improving coordination of distributed expertise, improving access to resources, and improving team member trust in each other's expertise.

In Study 2, I developed a laboratory study and found evidence to support these hypotheses. Specifically, I find support for Hypothesis 1, such that teams using routines developed stronger transactive memory systems than teams that did not use routines. The significant difference between the routine and the non-routine condition on TMS persisted even after the teams performed a second task, suggesting that the benefits of routines in building TMS could persist over time. Although the data suggested some convergence between the conditions after the second task, the significant difference remained.

I also find support for Hypotheses 2 and 3, such that there was a significant indirect effect of the routine manipulation on novel task performance, mediated by TMS developed during task 1 and task 2. I find evidence for a serial mediation, whereby the routine manipulation affected TMS development while the team worked on the task for which the routine was designed, and consequently also affected TMS development while the team worked on the novel task. Thus, the TMS developed during the first task did not directly mediate novel task performance; rather, the TMS developed during the first task provided a platform upon which the teams reconfigured or updated their TMS during the novel task, which then improved performance.

My findings contribute to research in strategy, in particular, the micro-foundations movement (Foss & Pedersen, 2016). Micro-foundations research has emphasized individual managerial cognition. For example, Tripsas and Gavetti examine individual cognition at Polaroid and argue that existing capabilities and routines lead to search patterns that neglected digital technology (Tripsas & Gavetti, 2000). My findings suggest that scholars in strategy could learn from examining cognition at the group level. Transactive memory systems have been argued to be a micro-foundation for competitive advantage (Argote & Ren, 2012). My findings suggest that TMS can support competitive advantage by improving how organizational teams perform on novel tasks. Competitive advantage derived from TMS is not easily eroded or copied by other organizations. TMS is idiosyncratic to a particular group of individuals, and therefore, unless groups of individuals move to another organization (Groysberg & Lee, 2009), TMS cannot be transferred out of the focal organization.

My research also shows how routines, as an organizational capability, can change the teams that use them. Prior research in the routine dynamics tradition has emphasized how actors can change routines (Feldman, 2000; Feldman & Pentland, 2003). I contribute to research in organizational routines by demonstrating that the act of using a routine has lasting effects on team dynamics, and subsequent implications for team performance. Rather than applying only to the task for which the routine was designed, a routine can have performance implications for other tasks, due to how the routine structures team interaction and facilitates development of

TMS. Additionally, because I developed Study 2 to have two task orders, I also instantiated two different routines. Therefore, the benefits of routines for TMS development are not due to one particular routine but can be extended to routines more generally.

These findings contribute to research in organizational learning. Scholars have argued that organizations need some knowledge stock, or absorptive capacity, to integrate and transfer new knowledge (Cohen & Levinthal, 1990). As routines are a source of organizational capabilities (Nelson & Winter, 1982), one mechanism by which existing knowledge can lead to better integration of new knowledge and adaptation to novel tasks is through the formation of transactive memory systems. Additionally, my findings suggest organizational routines can be an antecedent to transactive memory systems (Argote & Guo, 2016). Prior research has shown that team interactions can promote TMS development (Liang et al., 1995). My results indicate that providing structure to team interactions, such as the structure embedded in a routine, can strengthen TMS development above and beyond only interaction time.

My findings complement simulation studies investigating the relationship between routines and TMS. Two studies (Miller, Choi, & Pentland, 2014; Miller, Pentland, & Choi, 2012) show that transactive memory improves routine execution, even for novel tasks, and that transactive memory can lead to the development of superior routines. My findings show that transactive memory can be an outcome of routine performances, suggesting a reciprocal relationship between TMS and routines (Argote & Guo, 2016). When teams use routines, they develop strong TMS. And with a strong TMS, teams can better execute and create routines.

More generally, this dissertation speaks to recent interest in organizational adaptability. Faced with rapidly changing technology and market conditions, organizations are grappling with the best way to structure themselves to remain adaptable under uncertain conditions. What are the optimal characteristics of organizational structure in a turbulent environment? Some organizations have responded by de-emphasizing formal structure. For example, the holacracy movement (Robertson, 2015) eliminates managers. Research in self-managing teams has emphasized the tradeoffs that teams face under conditions of self-management (Magpili & Pazos, 2018). My findings suggest that structure can be beneficial for adaptability by providing a means for team members to develop a TMS.

This dissertation has several strengths. First, I use a multi-method design to develop and to test theory. The semi-structured interviews performed in Study 1 have the advantage of providing contextual richness to theory generation that is grounded in how my phenomenon of interest unfolds in real-world organizations. The laboratory experiment performed in Study 2 has the advantage of strict control over performance conditions and random assignment to condition, permitting me to make causal claims. Although experimental designs are sometimes criticized for a lack of external validity, the combination of the qualitative evidence and the fact that the study paradigm was validated by real-world teams alleviates such concerns.

Second, I theorize about the relationship between routines and transactive memory systems. I use three different measures to examine this relationship: the Lewis (2003) scale, the Austin (2003) measure, and a behavioral measure of specialization. I find consistent results across all three different measures, such that routines contribute to aspects of TMS that predict performance on novel tasks. The fact that I find consistent results across three different measures implies that the results are not due to the characteristics of one particular measure, but might speak more generally about the TMS construct.

These studies have important limitations. First, Study 1 was performed in a military context. Despite important research in organization theory that has been performed in military organizations (e.g., Weick & Roberts, 1993), and calls to gain theoretical insights from military organizations (Augier, Knudsen, & McNab, 2014), this may pose a concern about generalizability. Moreover, the context in Study 2 is similar to those in high-reliability organizations, where the cost of failure is very high (Faraj & Xiao, 2006; Milosevic, Bass, & Combs, 2018). Future work should investigate routines and novel task performance in other organizational contexts.

Future work should also investigate whether the two boundary conditions I identify, task characteristics and team characteristics, influence the relationship between routines, TMS, and novel task performance. In Study 2, the novel task was in the same broad knowledge domain (e.g., cybersecurity) as the task for which the routine was designed. Do the benefits of routines in building TMS apply to novel tasks in different knowledge categories? Additionally, in Study 2, participants were collocated and worked on a task requiring some degree of interaction. Would these results hold when team members are geographically distributed? Prior research has shown that geographically distributed teams face coordination challenges (Espinosa, Slaughter, Kraut, & Herbsleb, 2007) which may make it difficult for teams to develop a TMS, and yet, a routine may be even more valuable for forming TMS in such teams, because routines may provide a means for team members to coordinate and share knowledge when they otherwise would not. This idea is analogous to the finding that routines buffer teams against the negative elements of team member turnover (Faraj & Xiao, 2006; Ton & Huckman, 2008).

CONCLUSION

Routines present a challenge and an opportunity for organizations. Routines store organizational knowledge and capabilities (Cyert & March, 1963; Nelson & Winter, 1982) and permit consistent performance on tasks over time. However, routines may also inhibit performance on novel tasks by introducing inertia and rigidity (Gilbert, 2005). A key challenge for organization design and strategy is to understand how best to structure an organization to yield sustainable competitive advantage in turbulent environments. This dissertation offers a complement to prior research on routines, which has emphasized how the actors who perform routines can change them (Feldman & Pentland, 2003).

Teams may change routines, but in using routines, teams themselves are changed. The process of using a repeated, interdependent pattern of action results in teams whose members have a better understanding of one another's skills and knowledge, or a transactive memory system. And the transactive memory system that develops from using a routine has performance benefits for novel tasks that are distinct from tasks for which the routine was originally designed. Thus, routines provide a means for organizations to use structure to solve the problem of how to adapt. Rather than being a hindrance to organizations in turbulent environments, storing knowledge in routines might yield sustainable competitive advantage.

TABLES AND FIGURES

Table 1: Pairwise Correlations and Summary Statistics

	Routine Condition	Order Condition A	Performance – Task 1	Performance – Task 2	Lewis TMS – Task 1	Lewis TMS – Task 2	Austin Knowledge Stock – Time 1	Austin Consensus – Task 1	Austin Specialization – Task 1	Austin Accuracy – Task 1	Austin Knowledge Stock – Task 2	Austin Consensus – Task 2	Austin Specialization – Task 2	Austin Accuracy – Task 2	Behavioral Specialization – Task 1	Behavioral Specialization – Task 2
Routine Condition	-															
Order Condition A	0.014	-														
Performance – Task 1	0.046	-0.264*	-													
Performance – Task 2	-0.046	0.471***	0.257*	-												
Lewis TMS – Task 1	0.408***	-0.247*	0.402***	-0.022	-											
Lewis TMS – Task 2	0.262*	0.173	0.131	0.304**	0.612***	-										
Austin Knowledge Stock – Time 1	0.107	-0.201	0.105	-0.179	0.420***	0.366**	-									
Austin Consensus – Time 1	0.419***	0.184	0.053	0.147	0.214	0.331**	0.141	-								
Austin Specialization – Time 1	0.402***	0.215	-0.029	0.151	0.164	0.326**	0.183	0.951***	-							
Austin Accuracy – Time 1	0.457***	-0.187	0.282*	0.010	0.538***	0.367**	0.555***	0.315**	0.342**	-						
Austin Knowledge Stock – Time 2	0.009	-0.267*	0.192	0.007	0.354**	0.282*	0.669***	0.137	0.153	0.512***	-					
Austin Consensus – Time 2	0.285*	0.164	0.011	0.039	0.115	0.234*	0.220	0.602***	0.579***	0.179	0.174	-				
Austin Specialization – Time 2	0.308**	0.169	-0.034	-0.003	0.162	0.256*	0.235*	0.587***	0.557***	0.193	0.172	0.965***	-			
Austin Accuracy – Time 2	0.315**	-0.094	0.237*	0.186	0.446***	0.544***	0.515***	0.362**	0.374**	0.735***	0.635***	0.409***	0.431***	-		
Behavioral Specialization – Time 1	0.448***	0.253*	0.329**	0.310*	0.176	0.160	-0.212	0.361**	0.336**	0.237	-0.135	0.262*	0.243	0.195	-	
Behavioral Specialization – Time 2	0.523***	0.379**	-0.057	0.382**	0.117	0.369**	-0.065	0.281*	0.299*	0.256*	-0.099	0.169	0.179	0.300*	0.572***	-
N = 71; * p<.05, **p<.01, ***p<.001																

Table 2: OLS regressions predicting TMS

	(1) TMS – Task 1	(2) TMS – Task 2	(3) Behavioral Specialization – Task 1	(4) Behavioral Specialization – Task 2
Routine Condition	5.858*** (1.515)	3.365* (1.492)	0.648*** (0.159)	0.835*** (0.148)
Order Condition A	-3.600* (1.525)	2.198 (1.526)	0.356* (0.158)	0.618*** (0.147)
Constant	49.385*** (1.257)	51.317*** (1.376)	0.325** (0.105)	0.199 (0.107)
N	71	71	63	66
R-sq	0.229	0.097	0.262	0.429
Robust standard errors in parentheses; *p<.05, **p<.01, ***p<.001				

Table 3: Regression results for Austin-style TMS measure

	(1) Knowledge Stock	(2) Accuracy	(3) Consensus	(4) Specialization
Routine Condition	0.288 (0.309)	0.625*** (0.144)	0.207*** (0.053)	0.289*** (0.078)
Order Condition A	-0.534 (0.313)	-0.264 (0.143)	0.088 (0.054)	0.151 (0.079)
Constant	8.503*** (0.314)	2.694*** (0.122)	0.491*** (0.051)	1.033*** (0.076)
N	71	71	71	71
R-Sq	0.053	0.246	0.208	0.205
Robust standard errors in parentheses; *p<.05, **p<.01, ***p<.001				

Table 4: Stepwise Regression Serial Mediation Analysis, Routine Manipulation, TMS, and Task 2 performance

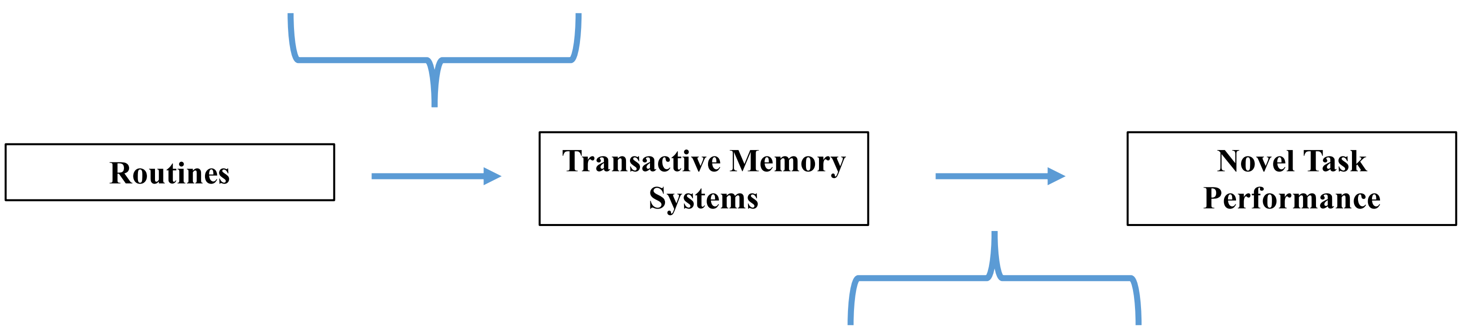
	(1) Performance – Task 2	(2) TMS – Task 1	(3) TMS – Task 2	(4) TMS – Task 2	(5) Performance – Task 2	(6) Performance – Task 2
Routine Condition	-1.006 (1.313)	5.619*** (1.419)	3.253** (1.475)	-0.555 (1.170)	-0.878 (1.394)	-0.667 (1.374)
TMS – Task 1				0.678*** (0.101)	-0.023 (0.144)	-0.280 (0.203)
TMS – Task 2						0.379** (0.188)
Order Condition A	8.095*** (1.440)	-2.309 (1.447)	2.806* (1.611)	4.372*** (1.448)	8.042*** (1.552)	6.381*** (1.819)
Performance – Task 1	0.505*** (0.158)	0.427*** (0.143)	0.201 (0.137)	-0.088 (0.098)	0.515*** (0.165)	0.548*** (0.149)
Constant	4.469* (2.502)	44.305*** (2.154)	48.921*** (2.357)	18.902*** (5.949)	5.477 (7.355)	-1.702 (6.252)
N	71	71	71	71	71	71
R-Sq	0.384	0.338	0.126	0.492	0.384	0.448
Robust standard errors in parentheses; *p<.10, **p<.05, ***p<.01						

Table 5: Hypothesis 1 Results accounting for Time

	(1) TMS (Lewis)	(2) Knowledge Stock (Austin)	(3) Accuracy (Austin)	(4) Consensus (Austin)	(5) Specialization (Austin)	(6) Specialization (Behavioral)
Routine Condition	5.809*** (1.562)	0.281 (0.315)	0.622*** (0.146)	0.208*** (0.054)	0.291*** (0.079)	0.618*** (0.174)
Time	4.924*** (1.371)	0.733* (0.332)	0.153 (0.164)	0.006 (0.051)	-0.027 (0.081)	-0.235 (0.169)
Routine x Time	-2.609 (2.206)	-0.256 (0.455)	-0.164 (0.221)	-0.072 (0.077)	-0.067 (0.115)	-0.057 (0.261)
Constant	47.533*** (0.996)	8.229*** (0.229)	2.559*** (0.111)	0.537*** (0.035)	1.111*** (0.055)	1.111*** (0.110)
N	142	142	142	142	142	129
R-Sq	0.171	0.054	0.152	0.134	0.134	0.165
Robust standard errors in parentheses, results unchanged when group-cluster standard errors used *p<.05, **p<.01, ***p<.001						

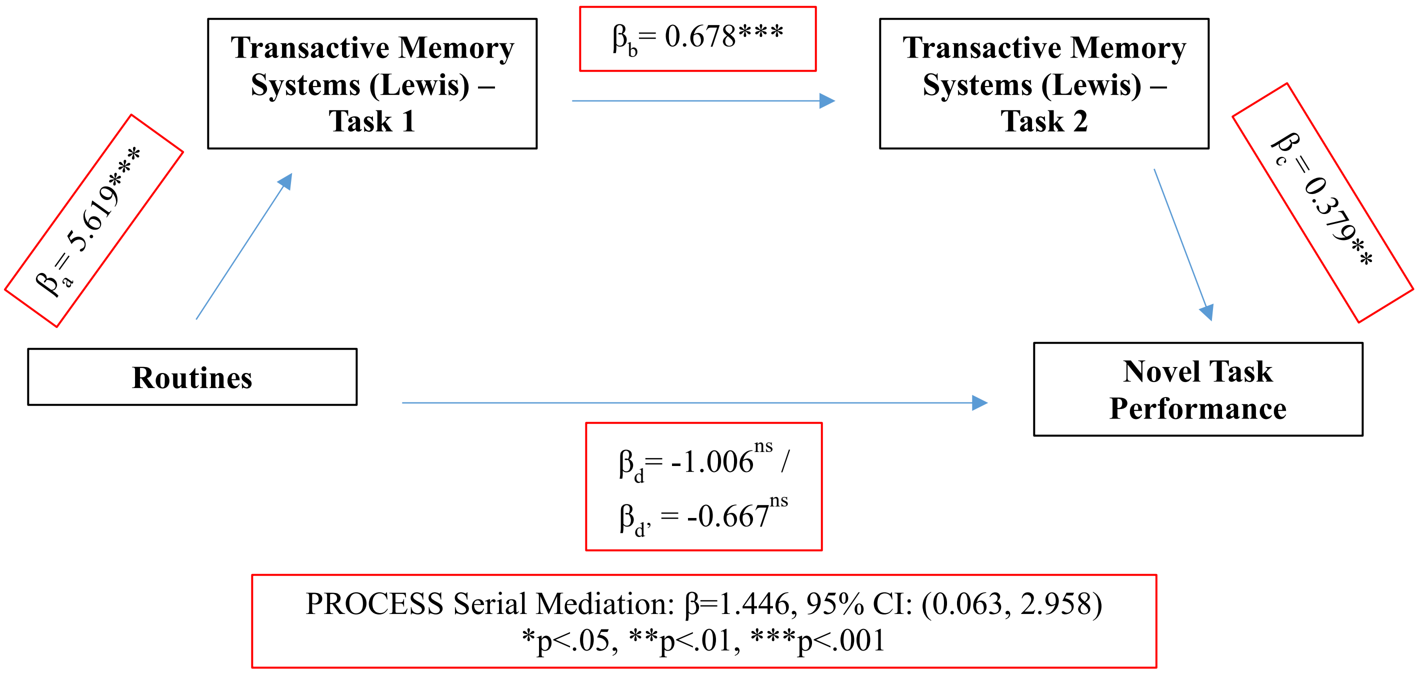
Figure 1: Theoretical Framework

Mechanism to Build TMS	Concept	Quote
Skill Development	Routines provide a platform to build individual task knowledge	*We do those things so we know, when we get into the basics we can move off of that towards innovation. But you need to have the ground set for that. If you don't have that down, you get killed. [Interview 3]*
Accurate Expertise Recognition	The repeated nature of routines enables accurate expertise recognition	*Even the guys that, you know, we would drop out of armor officer basic course, we never went off one impression. He always, they always got three different shots to do something correctly. [Interview 27]*
Role Structure	The role structure contained in a routine provides a distribution of expertise that creates cognitive interdependence	*: "we wanna build our TTPs [tactics, techniques, and procedures] around what that subject matter expert plans to do, because the S3, the S4, the S6 role should all be supporting that role" [Interview 2]*
Coordination	Repeated use of routines enables team coordination	*And that's the foundation [the] Marine Corps operates on, the fact that I could trust, I could trust the guy left and right to do their job, you know, that's the basic foundation the Marine Corps work on, so if I can't trust other staff section to do their job or if the CO [commanding officer] can't trust me to do my basic logistics function, then it's bad. [Interview 12]*



Mechanism to Perform on Novel Tasks	Concept	Quote
Access to Resources	TMS gives members awareness of location of expertise	*So going back to the example I gave you about the trucks, like I know who to call if my stuff breaks down, for example. [Interview 20]*
Coordination of Expertise & Resources	TMS enables coordination of expertise and resources to perform on novel tasks	*I mean I had staff NCOs [non-commissioned officers], senior enlisted people, who after we worked together for eight, nine, ten months, they would have ten tasks done before I even tasked them with it, because they already knew what was coming down. [Interview 7]*
Trust in Expertise	TMS enables trust in expertise and contributions of other members	*: "These experts said these are the timelines, I trust them, you know, you trust them, and then these are the procedures that I put in place. You're going to get this exercise gearset [equipment] by this first exercise, you'll be okay. [Interview 10]*
Retraining	TMS enables identifying deficiencies in member skills for retraining and future performance	*You know, it's like, 'Hey, so and so is horrible at fixing that airplane.' You know, let's get him or her up to speed, let's train them and teach them instead of just making them go work at the chow hall or you know, send them elsewhere. [Interview 23]*

Figure 2: Serial Mediation Model – Routine Manipulation, TMS, and Novel Task Performance



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APPENDIX A

Interview protocol

This protocol was administered to each interview participant and served as a starting point for the conversation.

1) How did you join the Marine Corps? What were your first impressions when you were first learning about the Marine Corps? How did you first hear about it?
2) What values were you taught when you joined the Marine Corps?
3) Tell me about your bootcamp experience. Can you give some examples of procedures or routines that you learned?
4) What makes the Marine Corps what it is?
5) Are you encouraged to experiment? Is adaptability valued for promotions?
6) What are the role of reading lists in the Marine Corps?
7) How would you describe being a Marine?
8) How would you characterize the USMC as an organization?
9) What role does adaptability play at the individual or unit level? Is it encouraged?
10) How would you characterize Marine Corps in the MC? Can you give an example?
11) What does the Marine Corps teach about teamwork? What does the Marine Corps teach about values?

APPENDIX B

Phishing Task Routine Artifact

Incident Response Playbook

Suspected Phishing Attack
This document is an incident playbook prepared by DayRep CSIRT for investigation and remediation of a suspected phishing attack. This playbook will prepare your team for determining whether a phishing attack occurred and how to investigate it.

<u>Role Assignments</u>
Each of you has been assigned a role in the analysis. In order to complete the steps in the playbook, you should stay in your assigned roles.

Role 1 – Email Analysis
The team member assigned to this role should perform an analysis of all provided emails to determine whether the user was subject to a phishing attack.

Role 2 – Malware Analysis
The team member assigned to this role should perform before and after analysis of users' malware scan logs to determine whether the user suffered a malware infection.

Role 3 – Server Analysis
The team member assigned to this role should perform an analysis of the server logs to determine whether external parties gained access to DayRep systems.

<u>Playbook</u>

Employee Analysis

0. Before analyzing employees, as a team, discuss the order in which you will go through the employees. Be sure that you understand each others' roles.

For all steps, perform each step for each employees' records. That is, start with one employee and continue perform all the steps listed below. Then, continue to the next employee.

1. *Email analysis* member should go through the employee's emails and identify whether there is evidence for a phishing attack. Refer to your training documents to determine whether an email constitutes a phishing attack.
    a. If you suspect an email could be a phishing attack, flag it for subsequent group discussion

2. *Malware analysis* member should go through the employee's before and after malware scans and determine whether there was an increase in malware on the computer. Refer to your training documents for information on how to read a malware scan log.

a. Flag egregious infestations for subsequent group discussion and note file or program names

3. *Server analysis* member should go through the server log and determine whether any external parties accessed the server. Refer to your training documents for information on how to read a server log

a. Flag external access for subsequent group discussion.

4. **As a team,** bring together any information you flagged together for a discussion

5. Each member should discuss all of the information they flagged

6. In a group discussion, determine whether the user was compromised by an attack and whether they are linked to an external actor. As part of your process, answer the following:

a. Was this user subject to a phishing attack? Provide evidence.

b. If this user was subject to a phishing attack, did the user enable an external party to access DayRep systems? If so, what was the file or program name they used? Provide evidence.

c. If the external party gained access, what files did they access and/or transfer? Provide evidence.

7. Fill out the report log for the employee

8. Repeat for all employees

APPENDIX C

Social Engineering Routine Artifact

Incident Response Playbook

Suspected Social Engineering Attack
This document is an incident playbook prepared by DayRep CSIRT for investigation and remediation of a suspected social engineering attack. This playbook will prepare your team for determining whether a social engineering attack occurred and how to investigate it.

<u>Role Assignments</u>
Each of you has been assigned a role in the analysis. In order to complete the steps in the playbook, you should stay in your assigned roles.

Role 1 – Call Analysis
The team member assigned to this role should perform an analysis of all provided call memos to determine whether the user was subject to a social engineering attack.

Role 2 – Email Analysis
The team member assigned to this role should perform an analysis of all provided emails to determine whether the user was subject to a social engineering attack.

Role 3 – Server Analysis
The team member assigned to this role should perform an analysis of the server logs to determine whether external parties gained access to DayRep systems.

<u>**Playbook**</u>

Employee Analysis

0. Before analyzing employees, as a team, discuss the order in which you will go through the employees. Be sure that you understand each others' roles.

For all steps, perform each step for each employees' records. That is, start with one employee and continue perform all the steps listed below. Then, continue to the next employee.

1. *Call analysis* member should go through the employee's call memos and identify whether there is evidence for a social engineering attack. Refer to your training documents to determine whether a call constitutes a social engineering attack.
    a. If you suspect a call could be a social engineering attack, flag it for subsequent group discussion

2. *Email analysis* member should go through the employee's emails and identify whether there is evidence for a social engineering attack. Refer to your training documents to determine whether an email constitutes a social engineering attack.

a. If you suspect an email could be a social engineering attack, flag it for subsequent group discussion

3. *Server analysis* member should go through the server log and determine whether any external parties accessed the server. Refer to your training documents for information on how to read a server log

a. Flag external access for subsequent group discussion.

4. **As a team,** bring together any information you flagged together for a discussion

5. Each member should discuss all of the information they flagged

6. In a group discussion, determine whether the user was compromised by an attack and whether they are linked to an external actor. As part of your process, answer the following:

a. Was this user subject to a social engineering attack? Provide evidence.

b. If this user was subject to a social engineering attack, did the user enable an external party to access DayRep systems? If so, what was the file or program name they used? Provide evidence.

c. If the external party gained access, what files did they access and/or transfer? Provide evidence.

7. Fill out the report log for the employee

8. Repeat for all employees

APPENDIX D

Examples of incoming and outgoing emails for the phishing and social engineering tasks provided to participants

Emails received by Laurie Kendrick (Finance)

Email 1

Laurie Kendrick

From:	**mariadellis@dayrep.com**
To:	**laurieskendrick@dayrep.com**
Subject:	**Budget meeting**
Attachments:	**invite.ics; projections.xlsx**

Hey Laurie,

It's time to schedule the quarterly budget meeting for Q4 of this year. Can you please look over the attached spreadsheet and correct and update the projections and then see if you make the meeting time in the calendar invite?

Thanks,
Maria

Email 2

Laurie Kendrick

From:	**clayasmith@dayrep.com**
To:	**laurieskendrick@dayrep.com**
Subject:	**Payments/reconciliation**
Attachments:	**reconciliation.xlsx**

Laurie –

We really need to reconcile the payments with the invoices from this quarter. The accounting team is losing it because they're convinced our books aren't balanced. I need you to delegate one of your team to this and make it a top priority.

Clay

Email 3

Laurie Kendrick

From: **contact@codecademy.com**
To: **laurieskendrick@dayrep.com**
Subject: **What we're learning next: React.js, Sass, and more**
Attachments:

Hi lkendrick,

We're expanding the courses we offer on Codecademy and want to give you a preview. What's been on your coding list? These are the courses we're most excited about sharing in the **next two months**.

Upcoming Courses

Deploy a Website. Learn to launch your own site, totally from scratch, using tools working developers do – including Github and Heroku.

Learn Sass. So you've covered CSS. What's next? Sass is an intermediate CSS framework that's required knowledge for anyone working in Front-End development.

Learn ReactJS. React was developed by Facebook to create the interfaces for Facebook and Instagram. It's super powerful, and also really popular with the startup crowd.

More Pro Content. We're working overtime to increase the quantity of projects and quizzes on the site, and improve quality across the board. Keep an eye out for new and upgraded Codecademy Pro offerings.

We hope you're as excited as we are! In the meantime, get back to coding!

*These emails were **sent** from Harold Stoltenberg (Corporate Communications) and are listed in chronological order.*
Email 1

Harold Stoltenberg

From:	**haroldsstoltenberg@dayrep.com**
To:	**hr@dayrep.com**
Subject:	**Health insurance??**
Attachments:	**None**

Hi –

I had some issues registering for health insurance (I think I registered after the enrollment period ended). Who do I talk to about this? I had to pay list price for my medication yesterday (IT WILL BANKRUPT ME!!!!).

Harold

Email 2

Harold Stoltenberg

From:	**haroldsstoltenberg@dayrep.com**
To:	**jackdarby@gmail.com**
Subject:	**KHS reunion**
Attachments:	**None**

You going?

Email 3

Harold Stoltenberg

From:	**haroldsstoltenberg@dayrep.com**
To:	**franciscocgibbs@dayrep.com**
Subject:	**finance update?**
Attachments:	**example.docx**

Hey Francisco –

I need an update on some numbers for the annual report. See attached. I'm concernd that table 2 is off (by an order of magnitude).

Harold

APPENDIX E

Example of malware scan log provided to participants

Malwarebytes
www.malwarebytes.com

-Log Details-
Scan Date: 9/1/18
Scan Time: 3:12 PM
Log File: afecd29a-b1f0-11e8-b039-94de904a4f55.json

-Software Information-
Version: 3.5.1.2522
Components Version: 1.0.441
Update Package Version: 1.0.6673
License: Corporate

-System Information-
OS: Windows 10 (Build 17134.228)
CPU: x64
File System: NTFS
User: LSternLStern

-Scan Summary-
Scan Type: Threat Scan
Scan Initiated By: Manual
Result: Completed
Objects Scanned: 327634
Threats Detected: 4
Time Elapsed: 15 min, 3 sec

-Scan Options-
Memory: Enabled
Startup: Enabled
Filesystem: Enabled
Archives: Enabled
Rootkits: Disabled
Heuristics: Enabled
PUP: Detect
PUM: Detect

-Scan Details-
Process: 0
(No malicious items detected)

Module: 0
(No malicious items detected)

Registry Key: 2
PUP.Optional.IFEO, HKLM\SOFTWARE\MICROSOFT\WINDOWS NT\CURRENTVERSION\IMAGE FILE EXECUTION OPTIONS\STEAM.EXE, In Quarantine, [7100], [239347],1.0.6329
PUP.Optional.IFEO, HKLM\SOFTWARE\WOW6432NODE\MICROSOFT\WINDOWS NT\CURRENTVERSION\IMAGE FILE EXECUTION OPTIONS\STEAM.EXE, In Quarantine, [7100], [239347],1.0.6329

Registry Value: 2
PUP.Optional.IFEO, HKLM\SOFTWARE\MICROSOFT\WINDOWS NT\CURRENTVERSION\IMAGE FILE EXECUTION OPTIONS\STEAM.EXE|DEBUGGER, In Quarantine, [7100], [239347],1.0.6329
PUP.Optional.IFEO, HKLM\SOFTWARE\WOW6432NODE\MICROSOFT\WINDOWS NT\CURRENTVERSION\IMAGE FILE EXECUTION OPTIONS\STEAM.EXE|DEBUGGER, In Quarantine, [7100], [239347],1.0.6329

Registry Data: 0
(No malicious items detected)

Data Stream: 0
(No malicious items detected)

Folder: 0
(No malicious items detected)

File: 0
(No malicious items detected)

Physical Sector: 0
(No malicious items detected)

WMI: 0
(No malicious items detected)

(end)

APPENDIX F

Example of server log provided to participants

10.131.0.1 [2/Oct/2018:03:47:21 GET /robots.txt HTTP/1.1 404
10.130.2.1 [2/Oct/2018:03:47:26 GET /home.php HTTP/1.1 302
10.131.0.1 [2/Oct/2018:03:47:27 GET /login.php HTTP/1.1 200
10.128.2.1 [2/Oct/2018:04:56:01 GET / HTTP/1.1 302
10.128.2.1 [2/Oct/2018:04:56:02 GET /login.php HTTP/1.1 200
10.128.2.1 [2/Oct/2018:04:56:02 GET /css/bootstrap.min.css HTTP/1.1 200
10.131.0.1 [2/Oct/2018:04:56:02 GET /css/font-awesome.min.css HTTP/1.1
200
10.131.0.1 [2/Oct/2018:04:56:03 GET /css/main.css HTTP/1.1 200
10.128.2.1 [2/Oct/2018:04:56:03 GET /css/style.css HTTP/1.1 200
10.130.2.1 [2/Oct/2018:04:56:03 GET /css/normalize.css HTTP/1.1 200
10.130.21.6 [2/Oct/2018:04:56:03 GET /files/finance/fin_position_Q1.pdf
HTTP/1.1 200
10.130.2.1 [2/Oct/2018:04:56:03 GET /js/vendor/modernizr-2.8.3.min.js
HTTP/1.1 200
10.130.21.1 [2/Oct/2018:05:45:03 GET /files/info/reports/Q2.pdf HTTP/1.1 200
10.130.2.1 [2/Oct/2018:04:56:03 GET /js/vendor/jquery-1.12.0.min.js HTTP/1.1
200
10.128.2.1 [2/Oct/2018:04:56:04 GET /bootstrap-3.3.7/js/bootstrap.min.js
HTTP/1.1 200
10.128.2.1 [2/Oct/2018:04:56:06 GET /fonts/fontawesome-
webfont.woff2?v=4.6.3 HTTP/1.1 200
10.128.2.1 [2/Oct/2018:04:56:29 GET /login.php HTTP/1.1 200
10.130.2.1 [2/Oct/2018:04:56:29 GET /img/ruet.png HTTP/1.1 200
10.131.0.1 [2/Oct/2018:04:56:32 GET /sign.php HTTP/1.1 200
10.131.0.1 [2/Oct/2018:04:56:51 POST /action.php HTTP/1.1 302
10.130.2.1 [2/Oct/2018:04:56:53 GET /login.php HTTP/1.1 200
10.130.2.1 [2/Oct/2018:04:57:00 POST /process.php HTTP/1.1 302
10.130.21.5 [2/Oct/2018:04:57:00 GET /files/rd/budget.xlsx HTTP/1.1 200
10.130.2.1 [2/Oct/2018:04:57:01 GET /home.php HTTP/1.1 200
10.130.2.1 [2/Oct/2018:04:57:01 GET /bootstrap-3.3.7/js/bootstrap.js HTTP/1.1
200
10.128.2.1 [2/Oct/2018:04:57:01 GET /js/vendor/moment.min.js HTTP/1.1
200
10.130.2.1 [2/Oct/2018:04:58:00 GET
/contestproblem.php?name=RUET%20OJ%20TLE%20Testing%20Contest HTTP/1.1
200
10.130.2.1 [2/Oct/2018:04:58:07 GET /details.php?id=35 HTTP/1.1 200
10.130.2.1 [2/Oct/2018:04:58:17 GET
/contestproblem.php?name=RUET%20OJ%20TLE%20Testing%20Contest HTTP/1.1
200

10.130.2.1 [2/Oct/2018:04:58:19 GET /details.php?id=33 HTTP/1.1 200
10.130.2.1 [2/Oct/2018:04:58:37 GET
/contestproblem.php?name=RUET%20OJ%20TLE%20Testing%20Contest HTTP/1.1
200
10.130.2.1 [2/Oct/2018:04:58:40 GET /details.php?id=34 HTTP/1.1 200
10.131.0.1 [2/Oct/2018:04:59:28 GET
/contestproblem.php?name=RUET%20OJ%20TLE%20Testing%20Contest HTTP/1.1
200
10.131.0.1 [2/Oct/2018:04:59:31 GET /details.php?id=36 HTTP/1.1 200
10.131.0.1 [2/Oct/2018:05:00:19 GET
/contestproblem.php?name=RUET%20OJ%20TLE%20Testing%20Contest HTTP/1.1
200
10.131.0.1 [2/Oct/2018:05:00:25 GET /details.php?id=37 HTTP/1.1 200
10.131.21.3 [2/Oct/2018:06:04:25 GET /files/legal/brief234.pdf HTTP/1.1 200
10.130.2.1 [2/Oct/2018:07:16:13 GET /contest.php HTTP/1.1 302
10.131.0.1 [2/Oct/2018:07:16:14 GET /login.php HTTP/1.1 200
10.128.2.1 [2/Oct/2018:08:16:00 GET / HTTP/1.1 302
10.130.21.2 [2/Oct/2018:08:16:01 GET /files/archive/prod_logs.zip HTTP/1.1 200
10.130.2.1 [2/Oct/2018:08:16:01 GET /login.php HTTP/1.1 200
10.130.2.1 [2/Oct/2018:08:16:02 GET /fonts/fontawesome-
webfont.woff2?v=4.6.3 HTTP/1.1 200
10.130.2.1 [2/Oct/2018:08:16:04 POST /process.php HTTP/1.1 302
10.130.2.1 [2/Oct/2018:08:16:05 GET /home.php HTTP/1.1 200
10.130.21.4 [2/Oct/2018:08:16:05 GET /files/prod/process2.pdf HTTP/1.1 200
10.131.0.1 [2/Oct/2018:08:16:05 GET /bootstrap-3.3.7/js/bootstrap.js HTTP/1.1
200
10.130.2.1 [2/Oct/2018:08:16:09 GET /compiler.php HTTP/1.1 200
10.130.2.1 [2/Oct/2018:08:16:13 GET /home.php HTTP/1.1 200

APPENDIX G

Report document template completed by participants in both tasks

Scenario I -- Report Logs

Instructions: Your task is to fill out the six logs in this document, one overall report and five separate reports for each of the employees. ***You will only be evaluated on what is written in this document, so you should try to answer as many questions as possible.***

You may put "N/A" an an answer to any question

1) Final Report Log I

This is the final report you will submit to the CEO, along with the individual report logs you complete.

1) Was there an intrusion into DayRep's systems?
(WRITE YES/NO)

2) If there was an intrusion, which employee was responsible for allowing external parties access?
(PROVIDE NAME)

3) How did the employee named in 2) allow external parties access? (PROVIDE NARRATIVE DESCRIPTION OF PROCESS AND ANY SOFTWARE OR ACCOUNT CREDENTIALS USED)

4) What files did the employee and/or the external party access? (PROVIDE FILE NAME FROM SERVER LOG)

2) Forensic Analysis Report Log

EMPLOYEE NAME: HAROLD STOLTENBERG

1) Was this user subject to an attack by a malicious actor? Provide evidence (e.g., email content, number, links, etc)
(WRITE YES/NO; PROVIDE DESCRIPTION OF HOW ATTACK OCCURRED)

2) If this user was subject to a malicious attack, did the user enable an external party to access DayRep systems or access DayRep files themselves? If so, what was the method used? Provide evidence (e.g., email number, call number, malware scan number, file/program name)
(WRITE YES/NO; PROVIDE NARRATIVE DESCRIPTION OF ATTACK; PROVIDE DESCRIPTION OF EVIDENCE)

3) Did the user access any files OR did the external party gained access to files? What files did they access and/or transfer? Provide evidence (e.g., server log entry)
(WRITE YES/NO; PROVIDE FILE NAME FROM SERVER LOG)

3) Forensic Analysis Report Log

EMPLOYEE NAME: JOSEPH PERRY

1) Was this user subject to an attack by a malicious actor? Provide evidence (e.g., email content, number, links, etc)
(WRITE YES/NO; PROVIDE DESCRIPTION OF HOW ATTACK OCCURRED)

2) If this user was subject to a malicious attack, did the user enable an external party to access DayRep systems or access DayRep files themselves? If so, what was the method used? Provide evidence (e.g., email number, call number, malware scan number, file/program name)
(WRITE YES/NO; PROVIDE NARRATIVE DESCRIPTION OF ATTACK; PROVIDE DESCRIPTION OF EVIDENCE)

3) Did the user access any files OR did the external party gained access to files? What files did they access and/or transfer? Provide evidence (e.g., server log entry)
(WRITE YES/NO; PROVIDE FILE NAME FROM SERVER LOG)

4) Forensic Analysis Report Log

EMPLOYEE NAME: LAURIE KENDRICK

1) Was this user subject to an attack by a malicious actor? Provide evidence (e.g., email content, number, links, etc)
(WRITE YES/NO; PROVIDE DESCRIPTION OF HOW ATTACK OCCURRED)

2) If this user was subject to a malicious attack, did the user enable an external party to access DayRep systems or access DayRep files themselves? If so, what was the method used? Provide evidence (e.g., email number, call number, malware scan number, file/program name)
(WRITE YES/NO; PROVIDE NARRATIVE DESCRIPTION OF ATTACK; PROVIDE DESCRIPTION OF EVIDENCE)

3) Did the user access any files OR did the external party gained access to files? What files did they access and/or transfer? Provide evidence (e.g., server log entry)
(WRITE YES/NO; PROVIDE FILE NAME FROM SERVER LOG)

5) Forensic Analysis Report Log

EMPLOYEE NAME: LORI STERN

1) Was this user subject to an attack by a malicious actor? Provide evidence (e.g., email content, number, links, etc)
(WRITE YES/NO; PROVIDE DESCRIPTION OF HOW ATTACK OCCURRED)

2) If this user was subject to a malicious attack, did the user enable an external party to access DayRep systems or access DayRep files themselves? If so, what was the method used? Provide evidence (e.g., email number, call number, malware scan number, file/program name)
(WRITE YES/NO; PROVIDE NARRATIVE DESCRIPTION OF ATTACK; PROVIDE DESCRIPTION OF EVIDENCE)

3) Did the user access any files OR did the external party gained access to files? What files did they access and/or transfer? Provide evidence (e.g., server log entry)
(WRITE YES/NO; PROVIDE FILE NAME FROM SERVER LOG)

6) Forensic Analysis Report Log

<u>EMPLOYEE NAME: STELLA BROWN</u>

1) Was this user subject to an attack by a malicious actor? Provide evidence (e.g., email content, number, links, etc)
(WRITE YES/NO; PROVIDE DESCRIPTION OF HOW ATTACK OCCURRED)

2) If this user was subject to a malicious attack, did the user enable an external party to access DayRep systems or access DayRep files themselves? If so, what was the method used? Provide evidence (e.g., email number, call number, malware scan number, file/program name)
(WRITE YES/NO; PROVIDE NARRATIVE DESCRIPTION OF ATTACK; PROVIDE DESCRIPTION OF EVIDENCE)

3) Did the user access any files OR did the external party gained access to files? What files did they access and/or transfer? Provide evidence (e.g., server log entry)
(WRITE YES/NO; PROVIDE FILE NAME FROM SERVER LOG)

APPENDIX H

Survey items for routinization manipulation check (1-5 Likert-type scale)

Please indicate the extent to which you agree or disagree with these statements:

Our team used a step-by-step procedure to accomplish the task

Our team used a repeated pattern of action to accomplish the task

Our team improvised a plan when accomplishing the task

APPENDIX I

Survey items for Lewis (2003) TMS scale (1-5 Likert-type scale)

Please indicate the extent to which you agree or disagree with these statements (1-5):

Each team member has specialized knowledge of some aspect of our project.
I have knowledge about an aspect of the project that no other team member has.
Different team members are responsible for expertise in different areas
The specialized knowledge of several different team members was needed to complete the project deliverables
I know which team members have expertise in specific areas

I was comfortable accepting procedural suggestions from other team members
I trusted that other members' knowledge about the project was credible
I was confident relying on the information that other team members brought to the discussion
When other members gave information, I wanted to double-check it for myself
I did not have much faith in other members' "expertise."

Our team worked together in a well-coordinated fashion
Our team had very few misunderstandings about what to do
Our team needed to backtrack and start over a lot
We accomplished the task smoothly and efficiently
There was much confusion about how we would accomplish the task

APPENDIX J

Survey items for Austin (2003) TMS measure

- For each skill/area of knowledge listed below, please select the answer that corresponds with your evaluation of your ability in that skill/area knowledge. (1-5)
    - Phishing email detection
    - Malware scan log analysis
    - Server log analysis
- For each area of skill/knowledge listed below, please select the answer that corresponds with the team member you believe is most knowledgeable about that particular skill or area.
    - Member A, Member B, Member C
    - On the skills listed above

APPENDIX K

Description of Austin-style TMS measure

Austin's measure consists of four dimensions: knowledge stock, consensus, specialization, and accuracy. The measure consists of a series of questions for participants to self-report their expertise in pre-defined knowledge categories with Likert-type scales, and for participants to identify the experts for each of the knowledge categories specified by the researcher. The researcher than calculates the knowledge stock of each individual member based on their self-reported expertise. Summing the individual knowledge stocks yields the group's knowledge stock. Next, the research calculates a measure of whether the group members had consensus about each others' expertise. For each skill, the researcher assigns a number for each unique identified expert. The most frequently identified expert is coded as 1, the next as 2, and so on. Then, for each skill the standard deviation is taken and then averaged across the skills. Finally, the measure is subtracted from 1, so that the final measure indicates more consensus if it is higher.

The researcher measures specialization by counting the number of times an individual is identified as an expert in each skill. Then, the researcher takes the standard deviation across skills, which is averaged across members. Higher values indicate more specialization.

Finally, transactive memory accuracy is measured by tying together the identified expert scores and the self-reported expertise scores. For each team member, a score is computed whereby the member receives points based on their accuracy in perceiving the most expert member in each skill. Thus, for each focal skill, the researcher assesses who the focal member identified as the most expert. Then, the focal member receives points based on the self-reported expertise of the identified expert in that skill. For each, if Member A selected Member B as the expert in Skill Y, and Member B reported an expertise value of 5 in Skill Y, Member A would receive a score of 5 for Skill Y. Each focal member's scores are averaged across skills and then averaged across all team members to arrive at the final accuracy measure.

APPENDIX L

Survey items for team identification (Ellemers, Kortekaas, & Ouwerkerk, 1999) (1-5 Likert-type scale)

Please indicate the extent to which you agree or disagree with these statements (1-5):
I think my team has little to be proud of
I feel good about my team
I have little respect for my team
I would rather not tell that I belong to this team
I identify with other members of my team
I am like other members of my team
My team is an important reflection of who I am
I would like to continue working with my team
I dislike being a member of my team
I would rather belong to another team

APPENDIX M

Table A1: T-test results for Austin-style TMS measure

	Routine Condition – Mean/SD	Non-Routine Condition – Mean/SD	T-Statistic	p-value	N
Knowledge Stock	8.509 (1.298)	8.229 (1.355)	-0.892	0.3758	36 routine/35 non-routine
Accuracy	3.181 (0.572)	2.559 (0.656)	-4.263	0.0001	36 routine/35 non-routine
Consensus	0.744 (0.247)	0.537 (0.206)	-3.842	0.0003	36 routine/35 non-routine
Specialization	1.402 (0.343)	1.111 (0.328)	-3.648	0.0005	36 routine/35 non-routine

APPENDIX N

As described previously, I performed mediation analyses using bootstrapping to test Hypotheses 2 and 3. However, an advantage of the Baron and Kenny approach is that it permits the estimation of each "path" in the mediation. Thus, I performed a mediation analysis using the stepwise regression approach (Baron & Kenny, 1986), bearing in mind that this approach has lower power than the bootstrapping method.

Table A2 shows the mediation analysis. First, I perform an analysis investigating whether the routine manipulation affected task 2 performance, mediated by TMS developed after task 1. Columns 1, 2, and 5 of Table A2 demonstrate this analysis. For all analyses, I include the order condition and task 1 performance as a control variable. In column 1, I find that the routine manipulation does not have a significant direct effect on task 2 performance (β=-1.006, p=n.s.). In column 2, I find that the routine manipulation has a significant effect on task 1 TMS (β=5.619, p<.001). And consistent with the previous mediation analysis, in column 4, I do not find evidence that task 1 TMS mediates any effect from the routine manipulation on task 2 performance.

Table A2: Stepwise Regressions for Mediation Analysis

	(1) Performance – Task 2	**(2) TMS – Task 1**	**(3) TMS – Task 2**	**(4) TMS – Task 2**	**(5) Performance – Task 2**	**(6) Performance – Task 2**
Routine Condition	-1.006 (1.313)	5.619*** (1.419)	3.253** (1.475)	-0.555 (1.170)	-0.878 (1.394)	-0.667 (1.374)
TMS – Task 1				0.678*** (0.101)	-0.023 (0.144)	-0.280 (0.203)
TMS – Task 2						0.379** (0.188)
Order Condition A	8.095*** (1.440)	-2.309 (1.447)	2.806* (1.611)	4.372*** (1.448)	8.042*** (1.552)	6.381*** (1.819)
Performance – Task 1	0.505*** (0.158)	0.427*** (0.143)	0.201 (0.137)	-0.088 (0.098)	0.515*** (0.165)	0.548*** (0.149)
Constant	4.469* (2.502)	44.305*** (2.154)	48.921*** (2.357)	18.902*** (5.949)	5.477 (7.355)	-1.702 (6.252)

N	71	71	71	71	71	71
R-Sq	0.384	0.338	0.126	0.492	0.384	0.448
Robust standard errors in parentheses; *p<.10, **p<.05, ***p<.01						

APPENDIX O

Repeated Measures Stepwise Regression Mediation Analysis

To test Hypotheses 2 and 3, I first performed stepwise regressions for each of the separate measures of TMS, six in total. These results are shown in Tables A3-A8. The Lewis TMS measure, the Austin accuracy measure, and the behavioral specialization measure are significant mediators of the effect of the routine manipulation on performance, indicated by their significance in column 3 of Tables A3, A5, and A8.

Table A3: Lewis TMS mediation accounting for time

	(1) Performance	(2) TMS (Lewis)	(3) Performance
Routine Condition	0.261 (1.402)	5.809*** (1.567)	-1.864 (1.296)
Time	3.257* (1.398)	4.924*** (1.081)	1.456 (1.278)
Routine x Time	-0.952 (2.171)	-2.609 (1.449)	0.003 (1.708)
TMS (Lewis)			0.366*** (0.099)
Constant	10.6*** (0.963)	47.533*** (0.999)	-6.787 (4.751)
N	142	142	142
R-Sq	0.047	0.171	0.178
Robust standard errors in parentheses, results unchanged when group-cluster standard errors used *p<.05, **p<.01, ***p<.001			

Table A4: Austin knowledge stock mediation accounting for time

	(1) Performance	(2) Knowledge Stock	(3) Performance
Routine Condition	0.261 (1.402)	0.281 (0.315)	0.204 (1.411)
Time	3.257* (1.398)	0.733* (0.332)	3.107* (1.419)
Routine x Time	-0.952 (2.171)	-0.256 (0.455)	-0.899 (2.185)
Knowledge Stock			0.205 (0.337)
Constant	10.6*** (0.963)	8.229*** (0.229)	8.914*** (2.854)
N	142	142	142
R-Sq	0.047	0.054	0.048
Robust standard errors in parentheses, results unchanged when group-cluster standard errors used *p<.05, **p<.01, ***p<.001			

Table A5: Austin accuracy mediation accounting for time

	(1) Performance	(2) Accuracy	(3) Performance
Routine Condition	0.261 (1.402)	0.622*** (0.146)	-1.251 (1.425)
Time	3.257* (1.398)	0.153 (0.164)	2.884* (1.379)
Routine x Time	-0.952 (2.171)	-0.164 (0.221)	-0.552 (2.118)
Accuracy			2.431*** (0.746)
Constant	10.6*** (0.963)	2.559*** (0.111)	4.379* (2.049)
N	142	142	142
R-Sq	0.047	0.152	0.105
Robust standard errors in parentheses, results unchanged when group-cluster standard errors used *p<.05, **p<.01, ***p<.001			

Table A6: Austin consensus mediation accounting for time

	(1) Performance	(2) Consensus	(3) Performance
Routine Condition	0.261 (1.402)	0.208*** (0.054)	-0.013 (1.505)
Time	3.257* (1.398)	0.006 (0.051)	3.249* (1.412)
Routine x Time	-0.952 (2.171)	-0.072 (0.077)	-0.856 (2.190)
Consensus			1.320 (2.531)
Constant	10.6*** (0.963)	0.537*** (0.035)	9.891*** (1.708)
N	142	142	142
R-Sq	0.047	0.134	0.049
Robust standard errors in parentheses, results unchanged when group-cluster standard errors used *p<.05, **p<.01, ***p<.001			

Table A7: Austin specialization mediation accounting for time

	(1) Performance	(2) Specialization	(3) Performance
Routine Condition	0.261 (1.402)	0.291*** (0.079)	0.343 (1.519)
Time	3.257* (1.398)	-0.027 (0.081)	3.249* (1.401)
Routine x Time	-0.952 (2.171)	-0.067 (0.115)	-0.971 (2.190)
Specialization			-0.282 (1.687)
Constant	10.6*** (0.963)	1.111*** (0.055)	10.913*** (2.128)
N	142	142	142
R-Sq	0.047	0.134	0.047
Robust standard errors in parentheses, results unchanged when group-cluster standard errors used *p<.05, **p<.01, ***p<.001			

Table A8: Behavioral specialization mediation accounting for time

	(1) Performance	(2) Behavioral Specialization	(3) Performance
Routine Condition	0.261 (1.402)	0.618*** (0.174)	-0.686 (1.505)
Time	3.257* (1.398)	-0.235 (0.169)	3.926** (1.499)
Routine x Time	-0.952 (2.171)	-0.057 (0.261)	-0.951 (2.157)
Behavioral Specialization			2.376** (0.768)
Constant	10.6*** (0.963)	1.111*** (0.110)	8.237*** (1.262)
N	142	129	129
R-Sq	0.047	0.165	0.124
Robust standard errors in parentheses, results unchanged when group-cluster standard errors used *p<.05, **p<.01, ***p<.001			