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A BEHAVIORAL THEORY OF HUMAN CAPITAL INTEGRATION

Jesper Christensen

A BEHAVIORAL THEORY OF HUMAN CAPITAL INTEGRATION

PhD School in Economics and Management

PhD Series 04.2018

CBS  **COPENHAGEN BUSINESS SCHOOL**
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A BEHAVIORAL THEORY OF HUMAN CAPITAL INTEGRATION

A PHD THESIS BY

JESPER CHRISTENSEN

NOVEMBER 27, 2017

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ABSTRACT

Human capital – the stock of knowledge and abilities possessed by employees – is consistently touted as an integral part of firm survival and success in dynamic environments. Managers must regularly decide how to allocate employees among competing tasks and projects to optimize the utilization of available knowledge, as well as select and implement the required structural mechanisms to support employees as they combine their knowledge to address complex problems on behalf of the firm. The principal motivation of this thesis is to explore how the effectiveness of particular aspects of organizational design in fostering the integration and use of human capital is bounded by individual cognitive limitations that may lead employees to deviate from expected behavior, both individually and in collaboration.

The thesis consists of three research papers relying on comprehensive longitudinal project data from a global manufacturing company to investigate the integration of human capital and attendant consequences for firm performance. The first paper measures cognitive load as an outcome of managerial choices on employee allocation, and examines how cognitive load impacts employee choices on the distribution of working time among competing requirements. The second paper builds on these insights to explore how individuals adapt their information processing behavior in team settings based on cognitive load and the observed behavior of other team members, as well as how these adaptive processes and differences in cognitive load aggregate to impact team performance. The third paper investigates geographical and psychological distance between interdependent employees as important organizational design parameters that determine employee behavior and information use, both separately and in conjunction with one another.

The overarching contribution of the thesis is to demonstrate, through the combination of psychological and organizational theory, how the ability of firms to properly activate and apply the knowledge held by their employees is fundamentally contingent on the interplay of cognitive limitations and managerial choices on organizational design. Common to the findings in this thesis is their immediate applicability in managerial and organizational settings as recommendations on how to allocate employees between competing uses. In sum, therefore, the thesis sketches the contours of a behavioral theory of human capital integration.

SAMMENFATNING

Human kapital – den viden og de evner, som virksomhedens medarbejdere besidder – fremhæves ofte som en afgørende forudsætning for virksomheders overlevelse og succes i en dynamisk verden. Ledere må løbende beslutte, hvordan medarbejdere bedst allokeres blandt opgaver og projekter, således at den samlede viden udnyttes bedst muligt. De må samtidig sikre, at de nødvendige strukturer implementeres for at bidrage til medarbejdernes fælles håndtering af komplekse opgaver på vegne af virksomheden. Denne afhandling har til hensigt at afdække, hvorledes effektiviteten af de valgte strukturer afhænger af medarbejdernes kognitive begrænsninger, som ofte betyder, at medarbejdere afviger fra forventet adfærd, både individuelt og i grupper.

Afhandlingen består af tre forskningsartikler, som bygger på omfangsrige tidsseriedata fra en global produktions- og udviklingsvirksomhed. Disse data anvendes til at undersøge, hvordan human kapital bringes i anvendelse og derigennem påvirker virksomhedens resultater. Den første artikel måler kognitiv belastning som resultat af ledelsesmæssige beslutninger om allokering af medarbejdere og undersøger på denne baggrund, hvordan kognitiv belastning påvirker medarbejders fordeling af arbejdsindsats blandt forskellige opgaver og konkurrerende krav. Den anden artikel bygger på disse indsigter idet den undersøger, hvordan medarbejdere tilpasser deres anvendelse og deling af information i grupper på baggrund af kognitiv belastning og andre gruppemedlemmers adfærd. Det undersøges desuden, hvordan disse gensidige tilpasninger og forskelle i belastning påvirker gruppens samlede resultat. Den tredje artikel undersøger, hvordan geografisk og psykologisk afstand mellem medarbejdere er vigtige organisatoriske parametre, som i fællesskab påvirker medarbejderkognition og evnen til at anvende tilgængelig information.

Afhandlingen bidrager med afsæt i psykologisk og organisatorisk teori ved at påvise, hvorledes virksomheders evne til at anvende og udnytte medarbejderes viden er grundlæggende betinget af samspillet mellem medarbejderes kognitive begrænsninger og ledelsens beslutninger med hensyn til organisatorisk struktur og allokering. Fælles for afhandlingens konklusioner er, at de omsættes til konkrete anvisninger af, hvordan medarbejdere bedst allokeres under en række forudsætninger. Således bidrager afhandlingen til udviklingen af en adfærdsbetinget teori om allokeringen af medarbejderressourcer i virksomheder.

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Jesper Christensen

Copenhagen, November 2017

CONTENTS

PREFACE		i
CHAPTER 1	<i>A behavioral theory of human capital integration: An introduction</i>	1
CHAPTER 2	<i>Valuable to whom? A theory of individual allocation of effort under cognitive load</i>	21
CHAPTER 3	<i>Carrying the load: Effects of team cognitive load on team performance</i>	55
CHAPTER 4	<i>So close, yet so far: The interdependence of geographical and psychological distance in collaboration</i>	90
CHAPTER 5	<i>Conclusion</i>	118
REFERENCES		

CHAPTER 1

A BEHAVIORAL THEORY OF HUMAN CAPITAL INTEGRATION:

AN INTRODUCTION

1.1 PURPOSE OF THE RESEARCH

This thesis investigates the integration of human capital in organizations. Human capital is defined as the knowledge and abilities of individual employees (Ployhart and Moliterno, 2011). Integration denotes the process of combining human capital through particular organizational structures and mechanisms to ensure the matching of tasks and relevant knowledge, and to foster the combination and amplification of individual abilities and insights (Barki and Pinsonneault, 2005; Turkulainen and Ketokivi, 2012).

Integration mechanisms range from centralization and formalization (Pugh et al., 1968) to cross-functional teams, integrator roles, and information systems (Adler, 1995; Galbraith, 1973; Van de Ven, Delbecq, and Koenig, 1976). These are differentiated primarily according to their information processing capacity (Tushman and Nadler, 1978), which describes the extent to which they enable individuals to process and combine more and more complex information (Makhija and Ganesh, 1997; Puranam, Singh, and Chaudhuri, 2009). To the extent that selected mechanisms succeed in fostering integration, the organization is expected to reap collaborative benefits without sacrificing the advantages of specialization, and without incurring added costs from conflict, inefficient communication, and sub-optimizing behavior (Chen, Mattioda and Daugherty, 2007; Swink, Narasimhan, and Wang, 2007).

In past literature, integration has often been considered an intended strategy, where the degree of integration (and its correlation with performance) is assessed in terms of the presence of integration mechanisms (Gerwin and Barrowman, 2002; Gattiker and Goodhue, 2004). More recently, scholars have acknowledged that the implementation of such “*infrastructural enablers*” (Swink and Schoenherr, 2015: 71) does not equate to effective integration. Accordingly, calls have been made for research into *achieved* integration (Pagell, 2004; Turkulainen and Ketokivi, 2012); that is, the extent to which the implementation of particular organizational design choices and structural mechanisms ensure efficient coordination among individuals and units, with sufficient information being shared, processed and applied without unnecessary costs or undue pursuit of functional agendas (Barki and Pinsonneault, 2005; Pagell, 2004; Swink and Schoenherr, 2015).

This thesis contributes to this transition from a structural contingency perspective to real assessments of the process of integration (cf. Turner and Makhija, 2012; Puranam, Raveendran, and Knudsen, 2012). It begins from the observation that the decisional logic inherent in organizational information processing theory - in terms of how to match integration mechanisms to complexity and informational asymmetry - does not account for emerging insights on the behavioral nature of integration (Enz and Lambert, 2015; Frankel and Mollenkopf, 2015; Stolze, Murfield, and Esper, 2015). These insights include the emphasis on individuals as the engines of information processing (Turner and Makhija, 2012; Puranam et al., 2012) with cognitive and perceptive differences (Cronin and Weingart, 2007; Weingart, Todorova, and Cronin, 2008). The established logic ignores how cognitive and behavioral elements determine - and introduce variation in - the effective information processing capacity of the structural mechanisms in which individuals are embedded, and it therefore provides a partial and potentially spurious account of organizational outcomes (Frankel and Mollenkopf, 2015). Indeed, mechanisms have often been conceptualized as though *they* have the ability to process information (Turner and Makhija, 2012). Attention to the behavioral aspects of integration theory represents an opportunity to expand its explanatory power and practical applicability (Van de Ven, Ganco, and Hinings, 2013).

Several authors have highlighted the need for a more detailed understanding of interdepartmental

integration based on micro-level data (Griffin and Hauser, 1996; Malhotra and Sharma, 2002; Oliva and Watson, 2011). Attempts to empirically validate the traditional information processing perspective and its implications for organizational design have met with limited success (Capon, Farley and Hoenig, 1990; Drazin and Van de Ven, 1985; Puranam et al., 2012). This has been ascribed to equifinal performance of competing organizational designs (Gresov and Drazin, 1997) and inertia in structural change (Hannan and Freeman, 1977; Meyer and Scott, 1983), but the dominant explanation has become the difficulty of adequately capturing intervening variables that determine the relationship between high-level structural choices and performance (Abell, Felin, and Foss, 2008; Puranam et al., 2015; Siggelkow and Rivkin, 2009). Adding to these concerns, Premkumar, Ramamurthy, and Saunders (2005: 261) argue that the concept of fit between organizational information processing needs and the information processing capabilities of structures and mechanisms is “*an elusive concept for empirical research [for which] operationalization and empirical testing with an appropriate statistical procedure is still a major issue*”. In doing so, they echo the concern of Galbraith and Nathanson (1979: 266) that “*the concept of fit [...] lacks the precise definition needed to test and recognize whether an organization has it or not*”.

Delving into the black box of integration employing a behavioral lens is therefore critically important so as to allow scholars to understand the more granular context within which individual behaviors and actions take place (Foss, 2011). Indeed, “*studying how individuals act is important, because theoretical work in the behavioral tradition may otherwise invoke decision rules that only have weak empirical support*” (Billinger, Stieglitz, and Schumacher, 2013: 95). By demonstrating how the information processing capacity (and hence the integration potential) of different mechanisms is fundamentally bounded along certain behavioral dimensions, I hope to temper the view that integration efforts are inherently beneficial to performance, and instead lay the groundwork for a model of integration that explains the contingent value of integration mechanisms and sketches the contours of a behavioral theory of integration (Gavetti and Warglien, 2015; Kretschmer and Puranam, 2008; Postrel, 2002; Turkulainen and Ketokivi, 2013).

The remainder of this introductory chapter describes the rationale and structure of the thesis. First, the nature of the integration challenge, and the decisional logic governing the selection of appropriate integration

mechanisms, is described. Second, the theoretical perspective employed in the thesis is introduced. Finally, the empirical foundation of the thesis is described and the three research chapters are presented.

1.2 THEORETICAL CONTEXT

This thesis defines organizations as coordination systems (March and Simon, 1958; Okhuysen and Bechky, 2009) that orchestrate the differentiation and integration of specialized tasks (Faraj and Xiao, 2006; Kretschmer and Puranam, 2008). Differentiation is defined as the ‘*segmentation of the organizational system into subsystems*’ (Lawrence and Lorsch, 1967: 4). Differentiated units address distinct tasks and environments, and hence differ in structural characteristics, work processes, information requirements, and the knowledge and skills of their members (Gulati, Lawrence and Puranam, 2005; March and Simon, 1993). Differentiation enables specialization, which improves unit-level productivity by enhancing returns to individual knowledge (Grant, 1996; Jacobides and Winter, 2005) and economizing on bounded rationality (Connor and Prahalad, 1996; Ethiraj and Levinthal, 2004; Langlois, 1990). As the level of differentiation changes, the degree and nature of interdependence among differentiated tasks change accordingly (Simon, 1991; Thompson, 1967; Van de Ven et al., 1976). When wholly modular interfaces between tasks are not available (Sanchez and Mahoney, 1996; Srikanth and Puranam, 2014), firms need to integrate activities and outputs of differentiated units (Glouberman and Mintzberg, 2001; Scott and Davis, 2007).

THE NATURE OF THE INTEGRATION CHALLENGE

Drawing on research into formal planning and division of labour (e.g. Chandler, 1962; Taylor, 1916), early contributions on organizational design and integration developed an assumption of designability, i.e. that ‘*organizational systems could be articulated with enough specificity and precision to allow for individuals to fully complete the work*’ (Okhuysen and Bechky, 2009: 467) independent of the attributes of the individuals embedded in the system (Scott and Davis, 2007). In this tradition, research has developed important insights on the integration of employees and human capital (e.g. Hickson, Pugh and Pheysey, 1969; Lawrence and Lorsch, 1967). In particular, scholars have recognized the heterogeneity of task interdependencies (McCann

and Ferry, 1979; Thompson, 1967; Van de Ven et al., 1976) and the variation in informational asymmetry between units (Galbraith, 1973; Tushman and Nadler, 1978). These dimensions determine the level of requisite integration among units and, in turn, the mechanisms most appropriate for achieving integration (Lawrence and Lorsch, 1967; Ketokivi, Schroeder and Turkulainen, 2006).

The insight that interdependencies are heterogeneous builds on the observation that tasks differ in the extent to which “*value generated from performing each is different when the other task is performed versus when it is not*” (Puranam et al., 2012: 421). An extensive range of taxonomies of interdependence have been developed as the relevant literatures have progressed (e.g. Thompson, 1967; Van de Ven et al., 1976; McCann and Ferry, 1979; McCann and Galbraith, 1981; Burton and Obel, 1984), but a rigorous definition of interdependence has remained elusive, despite calls for the development of an interdependence construct (Puranam et al., 2012).

Drawing on the fundamental view of interdependence as the change in task value brought about by other tasks, scholars have devoted significant attention to the different ways in which tasks may be interdependent. For instance, tasks may be related either sequentially or reciprocally, depending on whether one or both of them serve as prerequisites for the other (Giachetti, 2006; Thompson, 1967; Van de Ven et al., 1976). Similarly, interdependence may involve the exchange of different types and amounts of resources and may occur at different frequencies (Crowston, 1994; McCann and Ferry, 1979). Whether interdependent tasks are temporally separated or take place in quick succession also has a significant impact on coordination (Adler, 1995; Schelling, 1960), as does the relationships and epistemic interdependencies among agents responsible for the relevant tasks (Levinthal and Warglien, 1999; Puranam et al., 2012). In sum, the nature and degree of task interdependence may vary along several dimensions with important consequences for the required mode and frequency of coordination. For instance, as tasks and units tend towards greater sequential (unilateral) or reciprocal (bilateral) dependence, the interaction frequency between units will increase along with the need to combine and process information on one or both sides of the relation through closer and more personal integration (e.g. mutual adjustment, Glouberman and Mintzberg, 2001), to economize on coordination costs (Williamson, 1985). Similarly, increasing task complexity and variability has been linked with greater

reliance on personal and group-based coordination mechanisms in place of structural and impersonal mechanisms (Faraj and Xiao, 2006; Perrow, 1967; Van de Ven et al., 1976).

Greater differentiation and specialization of individuals and units implies informational asymmetry (Tushman and Nadler, 1978). In short, individuals in separate units depend on and possess different stocks of knowledge and so they come to know and view the world differently (Brown and Eisenhardt, 1995; Dougherty, 1992). In terms of information, organizations are comprised of more or less diverse tasks, and the execution of each task draws on and creates information that is specific to its characteristics and local environment. With greater diversity, organizations face a greater disparity in the information and skills required to complete different tasks (Tushman and Nadler, 1978). In addition, every task in an organization is associated with a particular level of uncertainty that reflects the amount of new information that must be developed or acquired during execution (Galbraith, 1973; Premkumar et al., 2005). When firms become increasingly complex (e.g. more knowledge-intensive) or experience increasingly dynamic environments, they face greater uncertainty and, in turn, greater difficulties in obtaining and exploiting relevant and timely information (Burns and Wholey, 1993; Cuijpers, Guenter, and Hussinger, 2011). Similarly, when tasks are interdependent, uncertainty rises because information residing in one unit responsible (and specialized) for a certain task must be integrated with information from other distinct units. Hence, as differentiation and complexity increase, the firm becomes more dependent on the ability to identify, assess, and process distributed information so as to overcome ambiguity and informational asymmetry.

However, this ability is bounded as individuals differ in their perception or '*thought-worlds*' (Griffin and Hauser, 1996). Specifically, individual and managerial access to and interpretation of disparate information is limited by hierarchical positions, experience, and cognitive frames, and is inherently boundedly rational (Foss and Weber, 2016; Puranam et al., 2015). What individuals know may differ significantly across intraorganizational boundaries, along with incentives, language, attitudes, and cultural disposition (Argyres, 1999; Gupta, Raj and Wilemon, 1986; Song, Montoya-Weiss, and Schmidt, 1997). To the extent that separated individuals develop different cognitive frames inspired by specialized tasks and incentives, individual attention will emphasize unit-level priorities (Ocasio, 1997) and information flows will tend

toward hierarchically bounded communication inside functional domains (Bercovitz et al., 2001). Consequently, perceptions and interpretive frames may be incompatible between units (Weber and Mayer, 2014). With cognitive differences, individuals may in turn pursue incongruent objectives and priorities (Swink and Schoenherr, 2015) and possess dissimilar interpretations of similar information and tasks (Schütz and Bloch, 2006). In sum, therefore, organizations seeking to integrate tasks of varying interdependence cannot focus merely on the bridging of informational asymmetries in a narrow sense, but should also recognize and contend with cognitive asymmetries that do not lend themselves to quick resolution. Indeed, specialization is *“not just the simple fact of partition and specialized knowledge [but] fundamental differences in attitude and behaviour”* (Lawrence and Lorsch, 1967: 9).

UNPACKING THE DECISIONAL LOGIC

Essentially, the optimal set of integration mechanisms in any rational organization would be those that manage, at the lowest possible cost, to reduce cognitive and informational disparity among interdependent tasks to such an extent that efficient collaboration is made possible (Hitt, Wu, and Zhou, 2002; Turkulainen and Ketokivi, 2013). To formalize this notion and determine when particular mechanisms are best suited to the integration challenges at hand, scholars have frequently invoked organizational information processing theory (Daft and Lengel, 1986; Galbraith, 1973; Tushman and Nadler, 1978), where each integration mechanism *“is endowed with a specific information-processing capability and must be matched to the information-processing demands of the environment or needs generated by the interdependence of work units”* (Faraj and Xiao, 2006: 1156). Implicitly, the established literature on integration holds that cognitive and informational disparities underlying coordination failure can be addressed by implementing mechanisms with adequate information processing capabilities (Argote, 1982; Scott and Davis, 2007; Van de Ven et al., 1976).

When the complexity of information and degree of interdependence are negligible, organizations are able to rely on standardized processes and interfaces to accomplish coordination (March and Simon, 1958; Pugh et al., 1968). Managers are able to handle exceptions when complexity arises (Garicano and Wu, 2012), but inevitably become constrained and boundedly rational as complexity (Gavetti, Levinthal, and Ocasio, 2007;

Rivkin and Siggelkow, 2003), thus limiting the extent to which hierarchical referral can be relied upon to ensure information processing. To avoid information overload in the hierarchy, organizations are instead advised to rely on lateral and more social integration mechanisms in the face of increasing complexity (Hoegl, Parboteeah, and Munson, 2003; Mullen and Copper, 1994; Van de Ven et al., 1976). While these include informal and transient solutions, e.g. spurring informal relationships and reducing cross-functional equivocality through (managerial) rotation (Daft and Lengel, 1986; Pagell, 2004) or the use of matrix structures (Foss and Weber, 2016; Hax and Majluf, 1981), more enduring (and costly) lateral mechanisms become necessary in non-routine or highly complex settings. This involves the appointment of dedicated liaisons (Brion et al., 2012) or the implementation of cross-functional teams (Lovelace, Shapiro, and Weingart, 2001) to address more permanent information processing needs and mitigate functional differences through greater scope for individual agency (Hirunyawipada et al., 2010; Pagell, 2004).

Moving through these mechanisms towards a progressively greater information processing capability, it is clear that this predicted capability is linked to the increasing emphasis on interpersonal interaction and social cohesion (Lakemond and Berggren, 2006; Nakata and Im, 2010; Van de Ven et al., 1976), as well as the increase in proximity of interdependent units (or, more aptly, of individual representatives of these units), as face-to-face interaction in co-located settings is widely regarded as the richest and most flexible medium (Daft and Lengel, 1986; Kiesler and Cummings, 2002; Von Hippel, 1994).

From this emerges a decisional logic underlying the choice of integration mechanisms in differentiated organizations. As cognitive and informational asymmetries increase, information processing is assumed to benefit from a transition from a predominant focus on impersonal mechanisms, e.g. centralization, formalization, and information systems (Pugh et al., 1968), towards a greater emphasis on personal and group-based mechanisms, e.g. cross-functional teams, integrator roles, and face-to-face interaction (Adler, 1995; Storper and Venables, 2004; Van de Ven et al., 1976). The adoption of more personal, frequent, and costly mechanisms is therefore justified when integration is pursued under increasing interdependence and asymmetry (Lakemond and Berggren, 2006; Nakata and Im, 2010; Swink and Schoenherr, 2015). Indeed, *“studies of coordination [...] have substantiated the core idea that matching increased task uncertainty to*

less formal modes of coordination leads to better performance” (Faraj and Xiao, 2006: 1155). Importantly, this is not to argue that more impersonal mechanisms are crowded out, or that there is a necessary one-to-one relationship between the level of requisite integration and specific integration mechanisms (Gresov and Drazin, 1997; McCann and Galbraith, 1981). Rather, it is an observation that as interdependence and uncertainty increase, organizations will tend towards a greater relative emphasis on individual agency in integration and the structural mechanisms that afford this (Okhuysen and Bechky, 2009).

But if the decisional logic is to be a sufficient guideline for organizational design, then individuals must be assumed to be able to realize the processing potential of the mechanisms in which they are embedded (Okhuysen and Bechky, 2009; Scott and Davis, 2007). Successful integration, and the beneficial allocation and use of human capital, is then reduced to a matter of successfully implementing integrative mechanisms with the requisite information processing capacity (Faraj and Xiao, 2006). Therefore, establishing what causes violations in the ability of individuals to effectively realize this potential provides a behavioral account of why organizations sometimes fail to achieve integration (cf. Radner, 1993; 2000). Conversely, following the logic of Gavetti (2012), the behavioral roots of superior integration and performance can be understood in terms of the behavioral factors that bound individual information processing behavior. In essence, this thesis seeks to isolate such factors by identifying systematic behavioral bounds and impediments to individual information processing and collaboration to better understand and explain deviations from the decisional logic.

This notion that behavioral bounds on the information processing capacity of integration mechanisms should exist is not outlandish or novel (e.g. Puranam et al., 2012; Radner, 1993, 2000). It is individuals who are swayed through these mechanisms to share and process information with bounded rationality and an inclination to systematically bias information (Marschak and Reichelstein, 1998). Yet, the key role played by individuals as the processors of information has consistently remained in the background (Turner and Makhija, 2012).

Behavior is a product of willingness and ability (Blumberg and Pringle, 1982). Similarly, information

processing behavior is determined by the interplay of epistemic motivation and cognitive load. An individuals' *epistemic motivation* denotes the willingness to engage in extensive search and information processing when available information is perceived as insufficient for the task at hand (Chaiken and Trope, 1999). Cognitive load, on the other hand, denotes the strain imposed on individual processing capacity and attention by work related demands for more extensive or varied information processing (Marois and Ivanoff, 2005; Ocasio, 1997; Shah and Oppenheimer, 2008). The foremost premise of this thesis is that while task characteristics and individual cognitive traits may engender higher levels of epistemic motivation and motivate employees to engage in more substantive and thorough information processing (e.g. Cacioppo et al., 1996), this process is effectively constrained, as increases in cognitive load necessitate - and stimulate a preference for - more heuristic and less time-consuming information processing (De Dreu, 2003; Hoffmann, Helversen, and Rieskamp, 2013).

The importance of considering the behavioral and psychological aspects underlying integration is echoed by the observation that interunit collaboration is not simply a motivational issue (Camerer and Knez, 1996, 1997; Heath and Staudenmayer, 2000; Hoopes and Postrel, 1999). Previous work on collaboration between specialized units has often emphasized conflicts of interest or opportunism as the main challenges (e.g. Foss, 2001; Williamson, 1985). In this tradition, self-interested individuals fail to cooperate due to sub-goal pursuit (March and Simon, 1958), misaligned incentives (Hart, 1995; Wageman and Baker, 1997), and greater identification with lower order identities compared to higher order identities (e.g. the prioritization of functional over organizational membership) (Ashforth and Mael, 1989; Ashforth, Harrison, and Corley, 2008). Such misalignment leads to failures of cooperation, which manifest as holdup, shirking, and impaired allocation of resources and information to interunit relationships (Alchian and Demsetz, 1972, Klein, Crawford and Alchian, 1978, Williamson, 1979). While cooperation failures are critical to integration, they may be alleviated through incentives, monitoring, sanctions, or identification (Eisenhardt, 1989; Kogut and Zander, 1996; Williamson, 1985), and may therefore be rather easily incorporated in the structural logic outlined previously.

However, even if opportunism and misaligned interests were resolved, and “*both parties behave in a*

manner that suggests they understand that they must work together to be successful" (Cannon and Perrault, 1999: 443), integration could still fail (Camerer, 2003; Gulati et al., 2005; Srikanth and Puranam, 2008). This is due to failures of coordination, which are "*fundamentally cognitive in origin, and require shared understanding and common knowledge to be solved*" (Kretschmer and Puranam, 2008: 862). Coordination failure refers to the state of impaired or wholly absent alignment or adjustment of actions (Gulati, Wohlgezogen, and Zhelyazkov, 2012), which stems from cognitive and informational disparities between members of differentiated units (Gupta, Raj and Wilemon, 1986; Schütz and Bloch, 2006; Weber and Mayer, 2014). Coordination failures arise due to the cognitive limitations of individuals that deny them comprehensive knowledge of how others will behave in situations of interdependence, and how they are interdependent with others (Weingart et al., 2008); something that is likely to be exacerbated under complexity and uncertainty (Varshney and Oppenheim, 2011). Thus, the identification of behavioral bounds on integration and associated behavioral failures in this thesis adds to this perspective on coordination failure by demonstrating how such failures arise from the interaction of individual behavior and structural mechanisms in the context of integration.

By accentuating the importance of behavioral bounds and their impact on structural integration mechanisms, the thesis is effectively arguing that parts of the extant literature have not adequately accounted for the determinants of integration outcomes. Prior studies have often correlated aggregate measures of organizational performance with integration, operationalized either in structural terms, i.e. as the presence of relevant mechanisms, or in anecdotal terms, i.e. as the level of integration as perceived by one or a few respondents within the organization (see, for instance, Gerwin and Barrowman, 2002; Millson, 2015; Swink and Schoenherr, 2015; Turkulainen and Ketokivi, 2012). While these studies choose to ignore the micro-level determinants of the observed correlation (Frankel and Mollenkopf, 2015), this does not count against their relevance for our understanding of integration (Gerhart, Wright, and McMahon, 2000). Indeed, models of economic and organizational phenomena are often premised on assumptions that are known to be inadequate representations of reality, because they may still offer valuable insights on the variables of interests for particular empirical problems or given certain assumptions (Gilboa et al., 2014; Gul and

Pesendorfer, 2008). The purpose of this thesis is not to find fault with prior research, but to contribute to a more micro-level understanding of the process of integration, and to couple these insights with extant knowledge of structural mechanisms to complement the theory of integration and enable more accurate predictions, as well as an improved scope for management action.

1.3. RESEARCH DESIGN

The thesis consists of three complementary research papers on the cognitive and behavioral implications of organizational design choices on the integration and allocation of human capital. While these constitute self-contained studies with distinct contributions to theory and practice, their combination is thought to provide a coherent perspective on the behavioral antecedents of successful human capital integration, as well as a set of actionable implications for management.

EMPIRICAL FOUNDATION

The papers have a common empirical foundation consisting of three independent data sources from a world-leading hydraulic pump manufacturer. With around 20,000 employees in more than 50 countries and a net turnover of more than \$4 billion in 2015, the company is a dominant figure in the global pump market. Data from the three separate sources in the firm were identified, retrieved, and consolidated specifically for the purposes of this research and therefore represent a unique dataset. While the reliance on a single company sample reduces extraneous variation at firm and industry levels, as well as spurious effects on the hypothesized relationships (Harrigan, 1983; Siggelkow, 2007), we cannot rule out firm-specific effects and therefore cannot make broad claims to generalizability (Hambrick, 1981).

The empirical setting described by the data is the exhaustive set of active new product development (NPD) projects in the firm in the two-year period from January, 2015 to December, 2016. Potential projects emerge from preliminary concept meetings and technology trials in the firm (Adler, 1995; Gerwin and Barrowman, 2002). Provided that projects demonstrate sufficient expected value or technological contributions to be prioritized for further development, their subsequent lifecycle follows a standardized

stage-gate model that spans seven distinct phases from concept development, validation, and approval over production ramp-up to the optimization of final manufacturing and sales release. Collectively, these consecutive and often recursive phases account for the bulk of resource investments made by the firm in innovation, development activities, and human capital integration.

On account of the strategic importance and significant resource commitments, the firm subjects NPD projects to rigorous requirements with regard to the documentation and continuous assessments of current and expected performance. Project management teams are tasked with the formulation of monthly reports with updated estimates on numerous operational indicators describing, e.g., project performance, incurred expenses, activities and challenges, as well as projections for subsequent activities and performance. As the main source of project-level data, the dissertation consolidates data from 501 monthly reports from 45 unique NPD projects in the two-year period.

Given the behavioral and cognitive perspectives informing the research, multiple variables of interest are defined at the individual level. Therefore, the monthly reports were matched with employee data from two other repositories within the firm. Demographic data on all project employees were obtained from the HR database, along with individual data on, e.g., physical location, job position and description, formal project accountability, managerial responsibilities, and departmental affiliation. From the company work time registry, comprehensive information was obtained for each employee detailing the tasks and projects to which the employee contributed in every month, including the number of hours allocated to each of them.

The integration of these sources of employee and project data provides 10,294 project-month-employee observations corresponding to 583 unique individuals contributing with varying frequency across 45 projects in the two-year period. These observations enable the construction of longitudinal measures of individual behavior and project conditions, and allows for the mapping of these phenomena to concurrent variation in important secondary variables at the individual and project levels. Given different statistical specifications, the research papers naturally draw on different subsets of the observations.

CHAPTER SUMMARIES

The common denominator and objective of the chapters in the dissertation is the elucidation and explanation of distinct behavioral phenomena that emerge from the interaction of individual cognition and organizational design choices regarding the allocation and integration of human capital. While the research papers build on a common dataset, there are significant differences in their theoretical emphasis and, therefore, in their primary empirical constructs.

Chapter 2: Valuable to whom: A theory of individual allocation of effort under cognitive load

When organizations implement more personal and frequent mechanisms to enable the integration of interdependent employees and human capital from across the firm, employees are often given considerable autonomy in deciding how to distribute their available time and attention among different tasks and integration demands. Specifically, real authority (Aghion and Tirole, 1997) and greater discretion in terms of the distribution of effort (Leana, 1986) is increasingly delegated to employees on the lower rungs of the organizational hierarchy to economize on scarce managerial capacity (Gavetti et al., 2007; Mendelson, 2000; Schiffrin and Schneider, 1977) and exploit local knowledge and competence (Dobrajska, Billinger and Karim, 2015; Garicano and Wu, 2012; Hayek, 1945). An implicit assumption is that this autonomy is productively used and that employees dedicate sufficient time to the available integration mechanisms so as to enable the intended sharing and processing of information (Puranam et al., 2012; Turner and Makhija, 2012). In response to this assumption, this paper studies the factors influencing effort distribution and argues that the salience of particular factors, and subsequent employee behavior, is impacted by cognitive load.

The study builds on recent experimental insights from psychology and economics on how individuals adjust their collaborative behavior in response to changing workloads (e.g. Cason, Savikhin and Sheremeta, 2012; Schulz et al., 2014; Rand, 2016). Fundamentally, Bednar et al. (2012), using four different games, test behavior under cognitive load and find that overloaded individuals are unable to efficiently choose optimal strategies separately for each task. These findings resonate with the studies by Duffy and Smith (2014) and Schultz et al. (2014) that manipulate cognitive load in multi-player prisoner's dilemma and dictator games, respectively, and find that low load subjects are better able to behave strategically. Specifically, low load

subjects are more likely to strategically defect as repeated games draw to a close, as well as more capable of conditioning their actions on fair displays of collaboration from peers (see also Milinski and Wedekind, 1998). Conversely, studies find that individuals under high cognitive load become more sensitive to risk (e.g. Benjamin, Brown, and Shapiro, 2013). Similar findings indicate a tendency for these risk signals to crowd out other factors (Gilbert, Pelham, and Krull, 1988; Van den Bos et al., 2006). Combining these factors, the paper proposes and tests the argument that individuals respond to *value signals*, i.e. indications of fair efforts and good performance prospects, and *uncertainty signals*, i.e. indications of complexity and risk.

Relying primarily on comprehensive time registration data to trace monthly redistributions of employee working time among competing tasks and projects, the paper finds support for the prevailing effect of value signals under low cognitive load, such that individuals respond by allocating more time to collaborations that are deemed fair and display good value prospects. Conversely, we find that individuals under high cognitive load become mostly insensitive to value signals, but instead respond by defecting comparatively more from projects characterized by high complexity or risk. With these findings, the paper contributes to our understanding of how individuals form – and navigate on – predictive knowledge about the information processing options and interdependencies available in the collaborative context (see Puranam et al., 2012; Turner and Makhija, 2012). We further contribute by providing insights on how individuals constitute the engines that realize or impair structural information processing capacity, as well as how and when the well-intended delegation of autonomy is productively retained and used.

Chapter 3: Carrying the load: Effects of team cognitive load on group performance

When interdependent employees differ with regard to cognitive load, their information processing behavior is likely to differ accordingly and introduce behavioral heterogeneity in the group (O’Leary, Mortensen, and Woolley, 2011; Shah and Oppenheimer, 2008). Given the fact that individuals condition their behavior on the behavior of those with whom they collaborate (Fehr and Fischbacher, 2004), it is natural to expect team members to adapt their information processing behavior on the basis of the heterogeneous behavior of others (Fischbacher and Gächter, 2010; Fitzgerald, Mohammed, and Kremer, 2017). However, our knowledge of

how this process of adaptation occurs and how heterogeneity in cognitive load is aggregated to impact collective outcomes is “*in its infancy*” (Mohammed and Schwall, 2009: 302; Loock and Hinnen, 2015; Vuori and Vuori, 2014). Therefore, this research paper explores how the composition of project teams with regard to cognitive load of team members determines project performance, and how mutual adaptation within the team influences this process.

We gauge variation over time in cognitive load and the associated composition of project teams using comprehensive data from 587 employees within 45 NPD projects. We hypothesize and find empirical evidence of an inverted u-shaped relationship between project performance and the share of team members with high cognitive load. It is theorized that initial increases in the number of team members with high cognitive load helps alleviate extensive analysis and the associated risk of *overfitting* (Gigerenzer, 2008), that is, the failure to appropriately filter out irrelevant past information in decision-making. Moreover, the disruptive effects of differences in information processing behavior are unlikely to manifest at low levels of heterogeneity due to ad-hoc redistributions of workload within the team and the general robustness of collaborative behavior in noisy environments in the short run (McNamara, Barta, and Houston, 2004; Wu and Axelrod, 1995). When team compositions become more skewed towards a higher proportion of team members with high cognitive load, the disruptive effects do manifest as declining project performance. This aligns with the findings of the first paper that collaboration and performance suffer when employees determine their distribution of effort on less valid signals of peer contributions under cognitive load.

On the basis of evidence from economics on conditional cooperation using game theory (Duffy and Smith, 2014; Fischbacher and Gächter, 2010), we demonstrate a moderating effect of the stability of team compositions. When teams maintain their composition over time, i.e. constant ratio of employees with high cognitive load, they experience declining performance as stability increases. This pattern of *cooperation decay* is explained by the compounding effects of team members continually readjusting their effort to the declining aggregate effort of their peers (de Oliveira, Croson, and Eckel, 2015; Gunnthorsdottir, Houser, and McCabe, 2007). Additionally, we demonstrate how the negative effects of team cognitive load are mitigated by increasing metaknowledge, i.e. the extent to which team members accumulate knowledge of the skills and

working conditions of their peers (Hollingshead, 2001; Mell, Van Knippenberg, and van Ginkel, 2014).

The paper contributes to the psychological design of the firm by coupling insights on individual behavior to higher-level organizational design choices and outcomes (Kahneman and Klein, 2009; Milkman, Chugh, and Bazerman, 2009; Powell et al., 2011). We posit conditional cooperation based on cognitive load differentials as the key mechanism governing how individual information processing behavior is aggregated to impact group outcomes. The paper contributes to integration research by demonstrating how the objective of human capital integration, to enable the sharing and collective processing of specialized information, hinges on managerial choices vis-à-vis the allocation of employees and the cognitive composition of teams. Thus, the paper provides clear recommendations for managerial intervention and responds to calls for the use of experimental findings from economics and psychology to pose and answer novel questions concerning organizational design (Agarwal and Hoetker, 2007; de Oliveira et al., 2015; Hartig, Irlenbusch, and Kölle, 2015).

Chapter 4: So close, yet so far: The interdependence of geographical and psychological distance in collaboration

With comprehensive longitudinal NPD data covering 583 employees across 45 NPD projects, this paper investigates the contingent relationship between geographical and psychological distances between interdependent employees. Distance is commonly understood and operationalized as the geographical distance between employees (e.g. Storper and Venables, 2004; Gray, Siemsen, and Vasudeva, 2015), and research from this perspective has demonstrated how physical proximity and face-to-face interaction improves integration and knowledge sharing compared to geographical dispersion (Allen, 1977; Storper and Venables, 2004). But while physical proximity is lauded as an integral element in coordination and collaboration (Daft and Lengel, 1986), studies have found inconsistent evidence on these collaborative effects (Cha, Park, and Lee, 2014; Wilson, Crisp, and Mortensen, 2013) and have ascribed it to the failure of prior research to consider psychological distance (Chong et al., 2012; Wilson et al., 2008).

Exploring the contingencies of these distance dimensions, we confirm negative performance effects of geographical dispersion and psychological distance on team performance. When collaborating employees become psychologically distant, their attention to potential problems and analytical processing is substituted for more abstract cognition (Förster, Friedman, and Liberman, 2004; Liberman, Trope, and Stephan, 2007). However, we find that these distance dimensions have joint effects. Specifically, we argue that the benefits of geographical distance hold true only insofar as team members are psychologically close to the tasks at hand. If this condition is violated and psychologically distant employees come to contribute to the project, the reduced analytical effort and disruptive cognition associated with psychological distance is magnified, thus potentially undermining the collaborative benefits of proximity. Conversely, we find that the negative effects of psychological distance are mitigated when the psychologically distant members are also geographically removed from the immediate team context. We argue that physical impediments impose restrictions on behavior that encourage more selective interventions in team decision processes. This curbs the disruption and could help channel the potential benefits of creative cognition.

The study contributes through an improved understanding of the contingencies of distance dimensions in organizational work (e.g. Trope and Liberman, 2010; Wilson et al., 2013). In particular, the results support the claim that different distance dimensions cannot be adequately understood in isolation (Boschma, 2005; Wilson et al., 2013). We also contribute to emerging research on the value of behavioral insights for organizational design and human capital allocation (e.g. de Vries et al., 2014; Foss and Weber, 2016). By applying insights from CLT to operational challenges to do with the integration and allocation of employees, our research explores the conditions under which the traditional advantages of geographical proximity may be expected and thus outweigh other strategic options (e.g. offshoring). The study therefore holds implications for strategic decision making and organizational design of human capital integration (Higgins, 1996; Rietzschel et al., 2007).

1.4. A NOTE ON TERMINOLOGY AND BEHAVIORAL THEORY

Social science is preoccupied with behavior, but the labelling of theory and phenomena as '*behavioral*' tends to invoke ambiguity and polysemy. In the strategic management literature, the behavioral moniker is routinely associated with the psychological underpinnings of the phenomenon of interest (Powell, Lovallo and Fox, 2011: 1371) and is commonly interpreted as "*being about mental processes*" (Gavetti, 2012: 267). For the purposes of this thesis and the continued development of psychological and cognitive dimensions in strategy research, a more precise definition of behavioral theory is required.

In extant literature, the use of the term has converged on two perspectives that differ mainly in their rationality assumptions (Eisenhardt and Zbaracki, 1992; Lant and Shapira, 2001)¹. One perspective emphasizes the role of bounded rationality and cognitive capacity as constraints on the ability of agents to identify and implement optimal courses of action (Gavetti, 2012; Simon, 1990). The other perspective rejects this notion of optimal choice and instead espouses an ecological view of rationality (Berg and Gigerenzer, 2010; Langlois, 1990) in which strategic action rests on individual interpretations and heuristics that are more or less well-adapted to the situation at hand and therefore more or less rational (Levinthal, 2011; Narayanan, Zane, and Kemmerer, 2010; Weick, 1979). While the first perspective treats limitations in rationality and cognition as deviations from normatively optimal behavior, the second perspective holds that optimal behavior is determined endogenously in the fit between the parameters of the situation and the decisional heuristics of the individual. Thus, the first perspective invokes psychology and cognition to explain *why* observed behavior deviates from normative optima, while the second emphasizes the mechanisms that explain *how* behavior unfolds given cognitive constraints.

If our scholarly ambition is to build comprehensive models of strategic and organizational phenomena, neither perspective should be treated in isolation, as "*these processes coexist in a dynamic interplay*" (Hodgkinson and Healey, 2008). Instead, developments in behavioral theory should seek to encompass cognitive drivers of '*misbehavior*', i.e. the psychologically-based deviations from normative or theoretically predicted agency, as well as the mechanisms and behavioral patterns that rationalize these deviations and

¹ Akin to distinctions between the heuristics-and-biases paradigm (Kahneman, 2003) and the fast-and-frugal paradigm (Gigerenzer and Goldstein, 1996) in the study of decisional heuristics (Loock and Hinnen, 2015)

provide scope for managerial intervention. Thus, as the field matures, we must buttress extant insights on structural mechanisms with microfoundational perspectives on integration to foster the development of multilevel understandings that enable more accurate predictions and well-informed management of integration (Frankel and Mollenkopf, 2015).

CHAPTER 2

VALUABLE TO WHOM?

A THEORY OF INDIVIDUAL ALLOCATION OF EFFORT UNDER COGNITIVE LOAD

Jesper Christensen²

ABSTRACT

This study investigates how individuals distribute their available working time among competing activities under cognitive load. When firms seek to integrate more closely their human capital to amplify the value of knowledge and address complex or dynamic conditions, individuals are often granted more lateral conditions and greater autonomy in the interest of supporting integration and information processing. But individuals do not necessarily distribute their working time to support these goals. Drawing on experimental evidence from psychology and management, the study hypothesizes and finds evidence that individuals allocate their time on the basis of a particular set of signals, *value* signals and *uncertainty* signals, depending on their level of cognitive load. The efficiency of implemented organizational designs for information processing therefore hinges directly on the ability of managers to understand and account for the cognitive load of employees, as employees constitute the engines of information processing inside well-intentioned structures.

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2.1 INTRODUCTION

Coordination problems within the firm have been studied extensively in management and economics (Heath and Staudenmayer, 2000; Kretschmer and Puranam, 2008; March and Simon, 1958). One of the prerequisites for coordination problems to arise is the dispersion of information and knowledge among individual employees (Marschak and Reichelstein, 1998; Tushman and Nadler, 1978). When tasks require the integration of dispersed information and human capital, firm performance becomes contingent on the adoption of appropriate structures that ensure the effective management of knowledge (Daft and Lengel, 1986; Turkulainen and Ketokivi, 2012, 2013; Tushman and Nadler, 1978).

Prior literature has largely adopted a structural contingency view of integration (Tushman and Nadler, 1978; Lawrence and Lorsch, 1967), which has ignored the role of individuals and the interaction between individuals and organizational design choices by assuming that “*structural features automatically give rise to consistent information processing*” (Turner and Makhija, 2012: 662; see also Faraj and Xiao, 2006). As operational uncertainty and environmental instability introduce complexity in tasks and problems, firms often implement more lateral and personal coordination mechanisms to accommodate the growing need to combine and amplify distributed knowledge from across the organization to resolve complex challenges and explore new ventures (Van de Ven et al., 1976).

An integral part of the adoption of these mechanisms is the delegation of more real authority and autonomy to employees (Aghion and Tirole, 1997), as the lower rungs of the hierarchy are expected to outperform management in terms of the productive combination of knowledge resources and human capital (Dobrajska et al., 2015; Garicano and Wu, 2012). But individuals face cognitive limitations that constrain their ability to adequately perceive and act upon interdependencies (Gulati et al., 2012); these are often not recognized or underestimated to the detriment of coordination (Heath and Staudenmayer, 2000). As individuals possess distinct belief structures (Walsh, 1988), studies have shown that even relatively similar individuals within an organization or group may exhibit representational gaps (Cronin and Weingart, 2007), that is, inconsistencies in individual conceptualizations of information, interfaces, or common tasks.

The implicit assumption that delegated authority is in fact retained and productively used in integration by individuals in the face of informational asymmetry and uncertainty deserves exploration. With privileged access to longitudinal data from a global manufacturing firm, this paper studies how employees in a knowledge-intensive development setting choose to distribute their available working hours in response to increasing cognitive load. Drawing on experimental evidence from the economics and psychology literatures on how individuals condition their behavior on signals from their peers and environment (Cason, Savikhin and Sheremeta, 2012; Duffy and Smith, 2014; Rand, 2016), we demonstrate how cognitive load emanating from the allocation of employees to lateral coordination structures influences the types of signals to which the employee responds and, hence, the ways in which working time is distributed. Specifically, we show how individuals with higher cognitive load become less sensitive to signals of fairness in collaboration and value potentials, but rather begins navigating according to signals of complexity and risk in a risk-averse manner.

Our findings have implications for the use of lateral mechanisms as a means of fostering increasing levels of integration and collaboration. Specifically, we provide further evidence that the realized information processing capacity of adopted mechanisms (e.g. cross-functional teams) is fundamentally contingent on individuals as the engines of information processing (cf. Turner and Makhija, 2012) and the ways in which individuals are made to perceive their environment (cf. Puranam et al., 2012). Secondly, our findings cast more light on the puzzling observation in recent studies (Hartig et al., 2015; Van den Berg et al., 2015) that individuals may respond in completely opposite ways to heterogeneous behavior amongst their peers; heterogeneity begets heterogeneity. By arguing that individual variation in cognitive load underlies the allocation of attention to particular signals and therefore entails different behaviors in situations with apparently identical stimuli, we sketch the contours of a mechanism that might help explain heterogeneous responses to homogenous situations.

2.2 THEORETICAL FOUNDATION: AUTONOMY AND THE SUFFICIENCY PRINCIPLE

ANTECEDENTS OF AUTONOMY IN EFFORT DISTRIBUTION

When interdependencies between differentiated tasks become more pronounced, the integration mechanisms and hierarchical forms best suited to manage the associated complexity and informational asymmetry vary accordingly (Allen and Gabarro, 1972; Foss and Weber, 2016). In an information processing framework, the aptness of any class of integration mechanism is determined by the level of requisite integration, i.e. the amount of disparate information that must be integrated, and the amount and complexity of information that the mechanism in question is assumed to be able to facilitate. Organizations are regularly able to standardize non-complex interactions through established rules and procedures (March and Simon, 1958; Pugh et al., 1968). But this is only feasible to the extent that interaction is predictable and amenable to routinization (Galbraith, 1973). Given complexity, standardized tasks generate exceptions as employees encounter non-routine challenges that are communicated to management under the assumption that *“knowledge of the solutions to the most common and easiest problems is located at the production floor, whereas the knowledge about the more exceptional and harder problems is located at the higher layers of the hierarchy”* (Garicano and Wu, 2012: 1387).

As interdependencies become ever more complex and idiosyncratic, it is unlikely that standardization and hierarchy will suffice to ensure integration (Gattiker, 2007). Centralization of decision making (Child, 1973) is bounded in its ability to facilitate integration by the cognitive capacity of the individual to whom decision rights are allocated (Mintzberg, 1979; Rivkin and Siggelkow, 2003; Simon, 1990). Indeed, individual processing capacity is limited by scarcity of attention (Ocasio, 1997; Shiffrin and Schneider, 1977) and short-term working memory (Barrett, Tugade, and Engle, 2004; Colom et al., 2004; Evans, 2011). Centralization and dependence on hierarchical referral in the context of high uncertainty and interdependence is therefore likely to produce information overload on the part of managers and fall short of the intended integration (Gavetti et al., 2007; Mendelson, 2000).

Given these information processing limits of vertical coordination mechanisms, scholars have instead emphasized the viability of lateral and more social mechanisms in dealing with increasing interdependence and complexity (Hoegl et al., 2003; Mullen and Copper, 1994; Van de Ven et al., 1976). These mechanisms span a wide range of structural and informal arrangements characterized by the delegation of autonomy and

decision making rights to the level at which the relevant information resides (Jensen and Meckling, 1992). Thus, lateral mechanisms avoid information overload in the hierarchy by instead relying on individual autonomy and interpersonal relations (McCann and Galbraith, 1981). Perhaps the least resource intensive of these personal mechanisms involves the spurring of informal relations through managerial rotation and engagement across multiple task environments and functions so as to reduce cross-functional equivocality and improve communication (Daft and Lengel, 1986; Pagell, 2004). For instance, when interdependencies exist between functions, hierarchical forms akin to a project matrix have been proposed to enjoy an integration advantage over unitary or multidivisional forms due to more frequent redeployment of employees (Foss and Weber, 2016; Hax and Majluf, 1981). Redeployment is expected to limit informational asymmetries relative to functional organizations, as employees are exposed to more diverse information and a greater range of interpretations (Dougherty, 1992; Hobday, 2000) and become skilled at negotiating common interpretations with their collaborators and predicting the behavior of others (Bunderson and Sutcliffe, 2002; Cronin and Weingart, 2007).

With more frequent and permanent information processing needs, more enduring (and costly) lateral mechanisms may be instituted, such as the appointment of an individual to a liaison or integrator role (Lawrence and Lorsch, 1967; Galbraith, 1973). For instance, the notion of boundary spanners is well-established (Marrone, 2010; Tushman and Katz, 1980). Relatedly, the notion of temporary task forces or dedicated cross-functional teams continues to enjoy prominence within OT and OM literatures as a means of mitigating silo-thinking and sub-optimization, as well as providing a platform for dynamic interaction and knowledge sharing across functional boundaries (Lovelace et al., 2001; McDonough, 2000; Wheelwright and Clark, 1992). Establishing interdepartmental teams as a means of supporting information processing between differentiated units is premised on the assumption that teams afford a greater scope for individual agency and thereby facilitate cooperation through interpersonal relationships and individual autonomy (Hirunyawipada et al., 2010; Pagell, 2004).

THE SUFFICIENCY PRINCIPLE IN EFFORT DISTRIBUTION

Optimal behavior in traditional information processing theory is when individuals dedicate the time and effort necessary to realize the information processing capacity of implemented mechanisms. But the information processing behavior of individuals is contingent on the perceived sufficiency of information (Chaiken and Trope, 1999). When available information and knowledge is deemed insufficient to the task at hand, individuals will display a higher level of epistemic motivation to engage in effortful and substantive information processing (Kruglanski and Webster, 1996). Conversely, when existing information or prior experience is seen as sufficient, epistemic motivation is reduced as individuals consider the relevant information requirements to be met and are able to rely more extensively on extant knowledge, expertise, and even heuristic reasoning (De Dreu, Nijstad, and van Knippenberg, 2008; Scholten et al., 2007).

This sufficiency principle is consistent with dual process models of human cognition (Evans, 2008). When epistemic motivation is high, individuals will seek to engage in substantive information processing and allocate more time and effort to thorough elaboration of task-relevant information (Kahneman, 2003). At the group level, this involves “*the exchange of information and perspectives, individual-level processing of the information and perspectives, the process of feeding back the results of this individual-level processing into the group, and discussion and integration of its implications*” (Van Knippenberg, De Dreu, and Homan, 2004: 1011).

Substantive processing is often implicitly assumed when lateral integration structures are touted as superior mechanisms, since diverse information is expected to be effectively shared and processed among team members to foster more well-informed decisions (Hinsz et al., 1997; Jehn, Northcraft, and Neale, 1999). Evidence would indicate, however, that this is not always the case (Kerr and Tindale, 2004; Lau and Murnighan, 2005). It is only individuals with high epistemic motivation who are expected to dedicate sufficient effort to afford this improved information processing capacity by fostering a joint skepticism of the adequacy of initially shared information and an openness to others’ unique information (Galinsky and Kray, 2004; Scholten et al., 2007). Therefore, when organizations implement integration mechanisms that enable more personal and frequent interaction, high levels of epistemic motivation are expected to help realize the

benefits of diversity and pooled information processing by avoiding decisions made only on the basis of initially shared information and preferences while ignoring unshared information (Stasser and Titus, 1985).

The withholding or redistribution of effort, on the other hand, implies the use of comparatively simple heuristic reasoning as a means of preserving cognitive resources for alternative or competing activities (e.g. Gavetti and Levinthal, 2000; Gigerenzer and Goldstein, 1996; Hogarth and Karelaia, 2005). With low levels of epistemic motivation, individuals may substitute the substantive sharing and processing of diverse information for more associative and intuitive information processing that exploits experience and environmental regularities (Kahneman and Klein, 2009). Heuristic reasoning relies on the use of adaptive strategies in uncertain situations with complex informational characteristics (Rusou, Zakay, and Usher, 2013) that systematically ignore available information (Gigerenzer and Gaissmaier, 2011) and reduce the tendency to exchange information (Kelly and Loving, 2004). As such, heuristic reasoning is linked to reduced time and cost of information processing and decision making. In groups, heuristic reasoning has also been shown to support coordination and knowledge sharing by reducing the complexity and therefore the absorptive capacity requirements of the information being communicated. Thus, heuristic strategies are described as “*efficient cognitive processes that ignore information*” (Gigerenzer and Brighton, 2009: 107) and have been identified as “*potentially valuable firm resources*” (Maitland and Sammartino, 2015: 1574).

2.3 HYPOTHESIS DEVELOPMENT

COGNITIVE CONSTRAINTS ON THE SUFFICIENCY PRINCIPLE

Whether individuals regard available information as sufficient depends on interactions between task characteristics and psychological traits (De Dreu et al., 2008; Nijstad and De Dreu, 2012). Individuals with more pronounced needs for cognitive closure (Webster and Kruglanski, 1994) tend to prefer rapid acquisition and processing of information to arrive at feasible decisions (Kruglanski and Webster, 1996), as compared to individuals disposed to avoid closure. Preference for closure means epistemic motivation is comparatively low and the sufficiency condition is satisfied with less effort. Heuristic reasoning is therefore more prevalent. In contrast, when individuals possess high needs for cognition and are more tolerant of ambiguity (Cacioppo

et al., 1996), with an overall openness to experience (Homan et al., 2008), higher epistemic motivation ensues. This leads individuals to engage in more substantive information processing and to be more cognizant of divergent input (Kearney et al., 2009).

When tasks are beset by urgency and time pressure, the effect of need for cognitive closure on epistemic motivation is augmented so as to motivate more heuristic reasoning (De Dreu, 2003). Under similar conditions, the impact of a higher need for cognition and tolerance for ambiguity on epistemic motivation is mitigated, which restrains the push for more analytical reasoning (Verplanken, 1993). As detailed below, such findings on urgency and time pressure are symptomatic of a wider range of research into elements of organizational structure, job design, and task characteristics that dictate the level of cognitive load experienced by each employee and, hence, their preferred information processing strategy (Marois and Ivanoff, 2005; Ocasio, 1997; Shah and Oppenheimer, 2008). However, measures of time pressure, urgency, and general task complexity (Campbell, 1988; Hærem, Pentland, and Miller, 2015) are often wedded to the particular characteristics and conditions of the task at hand, which may be difficult for managers to anticipate and consistently account for. It is therefore relevant to consider the cognitive effects of more transparent and malleable elements of the organization design; in particular the allocation of employees and their attendant workload (see also Turner and Makhija, 2012).

Individuals are boundedly rational with cognitive constraints (Simon, 1990). Their processing capacity is limited by finite cognitive resources (Marois and Ivanoff, 2005), scarcity of attention (Ocasio, 1997; Shiffrin and Schneider, 1977), and short-term working memory (Barrett, Tugade, and Engle, 2004). As cognitive and attentional resources are strained by work requirements, individuals compensate by satisficing in information acquisition and processing (Simon, 1955) through problemistic search and heuristic reasoning as a means of adapting to rationality constraints (Kahneman, 2003). Individual behavior is therefore sensitive to changes in task environments and working arrangements that increase cognitive load by diluting attention and introducing more extensive information processing requirements (Shah and Oppenheimer, 2008).

Managerial decisions on the allocation of employees to tasks and domains within the firm, as well as the

reification of those decisions through organizational structure and working arrangements, determine the variation in task environments experienced by employees. This includes the variety of tasks to which each employee must pay attention and contribute (Harrison and Klein, 2007; Ocasio, 1997), as well as the number and types of interdependencies with other individuals and units (Puranam et al., 2012). When organizational tasks are associated with greater knowledge intensity and (causal) ambiguity, it is often necessary to bring a broader range of knowledge and skills to bear on each differentiated task (Tushman and Nadler, 1978). Collaboration between heterogeneous individuals within and across organizational units therefore becomes increasingly common (Mathieu et al., 2014), along with the need to mitigate the coordinative and collaborative difficulties that arise when individuals hold different perceptions and asymmetric knowledge (Dougherty, 1992; Kretschmer and Puranam, 2008). As such, recent research has emphasized multiple team memberships as an increasingly common characteristic of life in the firm (O'Leary et al., 2011); particularly among knowledge workers and in dynamic contexts (Cummings and Haas, 2012).

Organizational design choices to promote multiple memberships are justified by productivity concerns. Specifically, it enables an improved utilization of individual resources and time, since the distribution of individual workload tends to be uneven and, therefore, inefficient when confined to only one task or team (O'Leary et al., 2011: 466; Milgrom and Roberts, 1992: 409). Yet, these gains come at a cost. Scholars have proposed a curvilinear relationship between productivity gains and the number and variety of tasks or teams to which one is allocated (O'Leary et al., 2011). This expectation is based mainly on the observation that a higher level of utilization and an increasing number and variety of contexts to which the individual must respond will render individuals less flexible and, hence, more likely to have to coordinate asynchronously with team members, which increases processing time (Postrel, 2009). Furthermore, alternating between different task contexts engenders switching costs in the form of higher cognitive load and information processing time (LePine, Podsakoff, and LePine, 2005; Rubinstein, Meyer, and Evans, 2001) due to increases in perceived complexity (Meyer and Kieras, 1997: 10). Specifically, interpersonal complexity is expected to increase as multiple memberships create more interfaces between individuals with different knowledge, perceptions, prioritizations, and professional languages (De Vries, Walter, Van der Vegt, and

Essens, 2014; Dougherty, 1992). Similarly, architectural complexity is expected to increase as individuals are made to participate in more contexts, because they require greater architectural knowledge of “*how the components of a system are related to each other*” (Puranam et al., 2012: 420), yet face constraints to individual attention that restrict their ability to recognize, understand, and respond to a large number of interfaces (Ocasio, 1997; Park and Ungson, 2001). This is especially true as interdependencies change dynamically (Stan and Puranam, 2016). It follows that although analytical reasoning is well suited for more complex tasks, organizational design choices that increase utilization and perceived complexities push boundedly rational individuals towards heuristic reasoning as a means of managing and compensating for cognitive load (Gavetti, Levinthal, and Rivkin, 2005; Shiffrin and Schneider, 1977). Hence, we fundamentally expect cognitive load to be negatively associated with allocated effort.

Hypothesis 1: When cognitive load increases, individuals will allocate less effort to a project.

ALLOCATING ON THE BASIS OF VALUE SIGNALS

There is mounting evidence that individuals condition their collaborative effort on signals from their peers (Fehr and Fischbacher, 2004; Fischbacher and Gächter, 2010). A large cadre of experimental studies in the economics and psychology literatures have explored how subjects factor in the expected or revealed contributions of others in their decisions on how much to contribute in collaboration (Brandts and Schram, 2001; Frey and Meier, 2004). Explanations of this phenomenon have centered on issues of fairness and equitable distribution (Chaudhuri, 2011). Specifically, humans are inherently reciprocal creatures and often share an aversion towards perceived inequity either in gains or in effort (Fehr and Schmidt, 1999; Rabin, 1993). Notably, this has been shown to hold both under conditions of advantageous and disadvantageous distributions, thus promoting discussion on inequity aversion as an integral part of utility (Binmore and Shaked, 2010; Bolton and Ockenfels, 2000).

Fundamentally, perceived fairness is expected to elicit reciprocal cooperation (Axelrod and Hamilton, 1981; Fehr and Fischbacher, 2003), while perceived unfairness engenders reciprocal defection

from collaboration (Fehr and Fischbacher, 2004). Relatedly, evidence from recent experiments in the psychology literature provides another important link between cognitive load and conditional cooperation by demonstrating the existence of *behavioral spillovers* (e.g. Cason et al., 2012). In essence, behavioral spillover effects occur when individuals replicate strategies used in predictable settings into more complex and uncertain settings as a means of conserving cognitive resources. Using four different games, Bednar et al. (2012) explore behavioral spillover effects under cognitive load and find evidence that overloaded individuals are fundamentally impaired when it comes to efficiently selecting more valuable strategies separately for each task. Instead, they replicate strategies from low entropy settings into high entropy settings, indicating that the behavioral impact of cognitive load is pervasive and can lead individuals to maintain or adopt sub-optimal strategies.

These findings are reinforced in a recent study by Duffy and Smith (2014), who manipulate cognitive load in a prisoner's dilemma game with multiple players and conclude that low load subjects are better able to behave strategically. Specifically, low load subjects will strategically defect the game more readily as repeated games draw to a close, and are therefore more capable of conditioning their behavior on prior displays of collaboration from peers (see also Milinski and Wedekind, 1998). Similarly, Schulz et al. (2014) find that low load individuals are more likely to seek advantageously unfair outcomes and are more sensitive to perceived inequality, which adds to the fundamental insight that high cognitive load precludes strategic adaptation of behavior. This aligns with findings from research on the *social heuristics hypothesis* (Rand, 2016), which demonstrate that low load subjects engage in more selfish behaviors and are more likely to adapt their behavior to maximize personal pay-offs, as compared to high load subjects. In game theory terms, increasing cognitive load functions as a corner solution that locks subjects into stable and rather indiscriminate strategies without responding to indications of reciprocity or fairness. While this may promote cooperation and preclude opportunistic adaption, it may at the same time lead to the maintenance and augmentation of objectively inferior strategies (Cason et al., 2012; Van Huyck, Battalio, and Beil, 1991).

The above findings lead us to predict individuals without high cognitive load to be better able to respond to signals of fairness as a means of improving equitable distribution of effort, and to be more responsive to value signals indicating strategic opportunities to redistribute (or reaffirm) effort to maximize perceived

value generated (Rand, 2016). On the contrary, individuals under high load will be comparatively insensitive to value signals, as they are less able to respond strategically and rather rely on more indiscriminate and replicating strategies (Duffy and Smith, 2014). Hence, we propose the following hypothesis set:

Hypothesis 2a: In the absence of high cognitive load, individuals will allocate more effort to a project as value signals become stronger.

Hypothesis 2b: When cognitive load is high, individuals will not change their effort allocation in response to value signals.

ALLOCATING ON THE BASIS OF UNCERTAINTY SIGNALS

The level of heterogeneity or noise in peer contributions has recently come under scrutiny (Hartig et al., 2015; Van den Berg et al., 2015) with the explicit expectation that individuals condition their own cooperation on this variation. In line with expectations, studies generally find that individuals contribute less and are less likely to reciprocate and cooperate in the face of greater heterogeneity in peer contributions (see also Cheung, 2014). A likely explanation for this is that heterogeneity decreases the perceived predictability of peers and, therefore, makes expectations regarding reciprocity and cooperative behavior less reliable (Wolf, Van Doorn and Weissing, 2011).

When the collaborative environment is comparatively noisy with less reliable sociocognitive perceptions, adaptation is limited and individual information processing behavior becomes sticky (Rand, 2016). Specifically, individuals with low cognitive load may choose to maintain their level of contribution in spite of initial violations of reciprocity. When information about peer behavior is uncertain and perceptions are less reliable, there is an incentive to avoid punishing one-time defectors that perhaps defect by accident or are justified in doing so for unobservable reasons, as these peers may again become cooperative (Van den Berg et al., 2015). This concern with avoiding the “*continuing echo of a single error*” under uncertainty (Wu and Axelrod, 1995: 188) is replicated by Fudenberg et al. (2012: 721) who find that “*while there are*

evolutionary arguments for cooperation in repeated games with perfectly observed actions, the evolutionary arguments for cooperative equilibria are even stronger with imperfect observations, as the possibility that punishment may be triggered by ‘mistake’ decreases the viability of unrelenting or grim strategies that respond to a single bad observation by never cooperating again”. Relating these findings more directly to the notion of variability and heterogeneity, McNamara et al. (2004: 745) argue that “if variability is maintained, and hence there is a chance that an opponent will cooperate, then there is the potential for a substantial gain, and it may be worth cooperating initially in the hope that the opponent is cooperative”.

In a similar vein, low load individuals have been shown to respond more reasonable and patiently to more complex tasks and prospects, despite their intuitive aversion to higher processing demands and the inherent uncertainty (Shamosh and Gray, 2008). For instance, cognitive load manipulations have been found to increase impulsive behavior in high load subjects (Hinson, Jameson, and Whitney, 2003; Shiv and Fedorikhin, 1999) and, by the same token, lead to more risk-averse behavior (Benjamin et al., 2013; Whitney, Rinehart, and Hinson, 2008). In terms of the dual process theory with which we began this chapter, that is, the distinction between analytical and heuristic modes of thinking, low load subjects may simply be superior in activating analytical resources to avoid bias and curb risk-aversion for long enough to properly assess and distinguish between signals of complexity, which may indicate potentials for value-maximizing problem-solving (Loewenstein and O’Donoghue, 2005; Fudenberg and Levine, 2006), or more indeterminate risk. Building on these insights, we hypothesize that individuals without high load are better able to accommodate and distinguish between uncertainty signals and may therefore respond by allocating more time to complexity signals and remaining rather insensitive to risk. On the contrary, high load employees are expected to reduce effort in the presence of either form of uncertainty signal.

Hypothesis 3a: In the absence of high cognitive load, individuals will maintain effort or allocate more effort to a project as uncertainty signals become stronger.

Hypothesis 3b: When cognitive load is high, individuals will allocate less effort to a project as uncertainty signals become stronger.

On a final note, it may be worth considering the role of management teams in the ability of employees to respond to signals. Specifically, it is a well-established fact in management literature that the delegation of autonomy from management teams to project employees is directly contingent on managerial workload. Hence, Yukl argues that “*decisions may be delegated because the manager responsible for them is overloaded and unable to give the decision adequate attention*” (1981: 227). Similarly, Leana (1986) found support for the hypothesis that “*subordinates whose supervisors are facing greater workloads will be delegated more authority*”. Therefore, we hypothesize, quite simply, that increasing cognitive load of the management team may constitute a necessary condition for employees to act on risk-averse behavior.

Hypothesis 4: As the cognitive load of the management team increases, employees will allocate less effort to a project as risk levels increase.

2.4 DATA AND METHODS

The empirical setting for this study is new product development (Adler, 1995). Specifically, we benefit from privileged access to comprehensive data relating to the full set of active NPD projects in a global hydraulic pump manufacturer over a two-year period. Our primary source of information for this study is the employee time registration system, which contains monthly data on the distribution of working hours among projects, tasks, and other activities for all employees below top management level. Employees are requested to log between 90-95% of their working time, including absence, illness, meetings, and other more fixed activities. Implicitly, employees have significant autonomy in the prioritization and allocation of significant parts of their time, due largely to the managerial expectation that employees need this level of freedom to effectively generate value for the company.

To describe and control for contextual and individual factors that will likely influence the distribution choices of the individual employee, we consolidate data from 501 monthly reports from 34 unique NPD projects in the two-year period and obtain matching HR data for all individual employees in the project sample across all months. These human resource data include information on individual demographics, job

descriptions, physical location, and departmental affiliation, among other things, and allows us to track changes in these factors over time. Thus, by matching time registration data with demographic and work-related information, we are able to longitudinally trace important variation in the performance of projects, the composition and effort of teams, and cognitive load differentials between team members, to better describe and control for the determinants of individual choices.

The combination of three distinct data sources with separate contributors (project management teams, individual employees, and the HR department, respectively) helps mitigate concerns of common method bias (Podsakoff et al., 2003), which is a significant risk with this type of self-reported data that is prone to measurement error (Boyd, Dess, and Rasheed, 1993). Integrating these data sources, we end up with 5,102 useable project-month-employee observations corresponding to 451 unique employees across 30 projects over 24 months. It is important to recognize that employees are effectively nested within projects. While our dependent variable matches this data structure by being unique to the employee on each project in a given month, we nevertheless exploit project-level independent and control variables. We are therefore faced with separate error terms at the individual and project levels. To account for this fact, we employ robust standard errors (adjusting for 1,195 clusters in the panel) to account for repeated observations at the project level. We also employ fixed effects estimation (on the basis of a Durbin-Wu-Hausman test) to limit between-unit variation and further mitigate residual non-random effects.

Variable construction

Dependent variable

Individual effort allocation ($\bar{x} = 0.35$; $\sigma = 0.33$) represents the distribution of employee working hours among the projects to which an employee contributes in a given month. The measure is constructed as a ratio of the number of working hours allocated by the employee to each project compared to the total number of working hours clocked by the employee. As this distribution changes between months and as a consequence of ongoing variation in the particular subset of projects to which the employee actively contributes, each

observational pair (project-month-employee) in the dataset represents a uniquely meaningful observation. The measure is adjusted to account for the fact that not all hours registered in a month are free to vary. We specifically exclude hours dedicated to absence (holiday and illness) and preplanned educational activities (formal education or seminars) to improve our approximation of the conditions underlying effort allocation decisions in the firm.

Independent and moderating variables

Value rank ($\bar{x} = 7.56$; $\sigma = 0.81$) represents the performance ranking in a given month of all projects to which the employee contributes. The measure is constructed as a simple ranking with higher values signifying that the observed project is performing well relative to other projects of which the individual is part. The underlying performance metric used to construct the ranking is project timeliness, which is estimated using monthly project reports as the difference between the objective deadline, fixed by project management at the outset or midway point of the project, and currently expected completion date, which is updated continuously by project management if there is need to adjust expectations. Using this continuously adjusted measure effectively incorporates delays that have been anticipated by the management, but may not have had time to manifest.

To account for differences in project size and their obvious impact on expected duration and magnitude of delays, we weigh the calculated difference by the planned project lifespan. The timeliness metric is further adjusted for delays incurred at the outset of the active phase in order to avoid inducing downwards bias in timeliness estimates. Given our access to the full ensemble of monthly reports, it is possible to estimate, at any given point in a project, the amount of additional delay that will be incurred beyond the current completion date estimate. This excess delay is most likely attributable to errors committed between phase inception and the point at which the delay is recognized and incorporated as an updated completion date. Hence, excess delay is allocated equally to each month in this period to control for hidden errors. These adjustments improve the statistical properties of our model, but all findings remain robust to their exclusion.

Fairness ($\bar{x} = 0.69$; $\sigma = 0.07$) is measured as a Blau Index (Blau, 1977) of the amount of hours contributed by each group member to a given project in a given month. To abide by the requirements of the Blau Index that the underlying distribution is organized categorically, the continuous measure of allocated hours was subdivided into six categories. The subdivision was determined on the basis of the nominal hours expected from employees, that is, a monthly average of 165 hours according to common Danish work time regulations. As employees are requested to register between 90-95 % of their work time in the work time registration system, we chose to center our subdivision equidistant between the full nominal hours and the 90% cut-off point so as to avoid biasing our measure either way. Two additional cut-off points in either direction from this centre value, corresponding to 15 % intervals, were then used to generate six categories that each constitute between 11.8% and 24.5 % of the sample.

Task complexity ($\bar{x} = 6.2$; $\sigma = 5$) is defined and measured at the project level. Specifically, complexity is proxied by the number of identified and active problems currently undergoing analysis and problem solving. These numbers are updated monthly. As the number of identified problems increase, additional resources are dedicated to their resolution, including analysis, meetings, and finding relevant countermeasures. Requirements for analytical information processing are expected to increase accordingly. Project managers are limited to reporting a maximum of five active problems at any given time. However, they are required to describe the severity of each on a four-point scale spanning (1) problem identified; (2) owner/investigation; (3) containment in place; and (4) countermeasure confirmed. Our complexity measure is constructed by tallying the reversed values of the ratings of each active problem in order to assign more weight to unresolved problems.

Risk level ($\bar{x} = 2.02$; $\sigma = 0.78$) is reported monthly in the project manager report as a complement to the measure of number of active problems (complexity), mainly because the number of problems may signify either dire straits for the project or simply an astute and diligent management team. The risk level is measured as either (1) No risk, (2) Some items behind schedule but no risk to project, or (3) Genuine risk to project, and accounts for unobserved variation in the status of the project as a meaningfully distinct signal of uncertainty.

Cognitive load is measured in this paper as individual *structural load* ($\bar{x} = 3.6$; $\sigma = 2.7$); a composite measure of the number of projects and other tasks to which the employee contributes ($\alpha = 0.75$). Multiple projects and tasks engender switching costs and an increasing strain on cognitive capacity (LePine et al., 2005; O’Leary et al., 2011). Relatedly, this involvement in multiple arenas may lead to social complexity, to the extent that the employee must engage with an increasing number of people with separate professions, perspectives, and languages (De Vries et al., 2014; Dougherty, 1992). Hence, we control for individual *interpersonal load* ($\bar{x} = 39.7$; $\sigma = 22.2$), measured as the number of individuals that are interfaced with in a given month. This measure is used as a robustness check of cognitive load.

To account for variation in the delegation of authority and frequency of direct involvement as alternative influences on information processing and performance (Leana, 1986), we control for the *cognitive load of the management team* ($\bar{x} = 9.3$; $\sigma = 2.3$). As we lack time registration data for all managers (they are not subject to the same requirements as other employees), we rely instead on a composite average of the total number of management teams each manager actively participates in and the number of unique individuals that co-participate in these teams in the same month ($\alpha = 0.7$).

Control variables

As time registrations are structured with monthly intervals, *month* dummies are included to control for aggregate time-series trends. By the same token, *phase* dummies are added in light of the standardized stage-gate structure of NPD projects to capture phase-specific effects, e.g. different mean levels of work intensity, uncertainty, or integration frequency. The inclusion of categorical variables to account for the fundamental structure of our data helps mitigate omitted variable bias. Their exclusion would risk spurious regression results (Malmendier and Nagel, 2011).

We control for *management team size* ($\bar{x} = 9$; $\sigma = 1.2$) to account for the well-known effects of group size on team functioning and the tendency to delegate (Hackman, 1983; Thomas and Fink, 1963). We measure employee *managerial responsibilities* using a dummy to capture unregistered workload.

Additionally, we control for individual *temporal load* ($\bar{x} = 139$; $\sigma = 52.7$) as the number of hours registered, subtracting all hours registered as absence or illness.

We control for project member *seniority* ($\bar{x} = 14.8$; $\sigma = 10.5$) and *age* ($\bar{x} = 44.5$; $\sigma = 9.5$) to account for the myriad effects related to both aging and experience. Building relevant expertise and accumulating domain-specific knowledge takes time and deliberate practice (Armstrong and Mahmud, 2008; Ericsson and Charness, 1994). Expertise and domain-specific knowledge correlate highly with problem solving efficiency (Gick, 1986; Larkin et al., 1980), improved decision making (Kahneman and Klein, 2009; Salas, Rosen, and Diaz Granados, 2010) and job performance (Dreyfus and Dreyfus, 2005; Ericsson and Lehmann, 1996; McCloy, Campbell, and Cudeck, 1994). But experience has a darker side as domain-entrenchment (see Dane, 2010; Holyoak, 1991) may lead to loss of flexibility and adaptability in experienced individuals. This may directly influence collaborative abilities (Camerer, Loewenstein, and Weber, 1989). Moreover, it may leave the acquired competences vulnerable to change and diminish the ability of the individual to adapt and integrate (Cañas et al., 2003). Similarly, age is associated with multiple effects on ability and performance. Chiefly, aging is seen to directly impact cognitive capacity and decision making (Glisky, 2007; Mell et al., 2009; Mutter, Strain, and Plumlee, 2007), but aging decision makers have demonstrated an ability to compensate to some degree by adapting their decision heuristics to environmental characteristics (Hertwig and Todd, 2003; Mata et al., 2012; Mata, von Helversen, and Rieskamp, 2010). Therefore, both variables are sources of important variation in decision-making and allocation of time.

Correlation matrix and descriptive statistics (standard deviations and mean, minimum, and maximum values) are reported in Table 2.1.

2.5 RESULTS

The results from our hierarchical regression are presented in Table 2.2. All control variables and the four main independent regressors are included in Model 1. This constitutes our baseline model. The baseline is expanded in Model 2, as all four main independent regressors are interacted with our measure of cognitive

load to test the hypothesized moderating effects of cognitive load on the salience of each signal for effort distribution. Model 3 introduces an interaction between the cognitive load of the management team and the reported risk level to test the expected enabling effect of management cognitive load on risk-aversion in effort distribution. Models 4 and 5 include robustness checks. As all but the first model include two-way interactions, all non-binary regressors were mean centered. Independent and average variance inflation factors (VIF) did not indicate multicollinearity (1.01-1.78, $\bar{x} = 1.32$).

Consistent with our first hypothesis, our structural measure of cognitive load is negatively associated with the amount of hours allocated to the project ($p < 0.001$) across all models. This aligns with our fundamental expectation that cognitive load induces compensatory behavior on the part of the individual, as well as the use of more heuristic reasoning to conserve cognitive resources. Interestingly, it can be observed from Model 1 how the four signals impact allocation in the main. In line with our theoretical argument, value signals (fairness and value rank) motivate the allocation of more hours to a project. Similarly, risk level is associated with lower allocation. However, and in line with Hypothesis 3a, task complexity is seen to motivate more effort. This may simply reflect the fact that in the absence of cognitive load, individuals are able to better assess and act upon complexity as a potential for value-maximizing action ((Loewenstein and O'Donoghue, 2005; Fudenberg and Levine, 2006).

Consistent with our second set of hypotheses, Hypothesis 2a and 2b, we find in Model 2 and 3 that individuals with low (mean) levels of cognitive load are comparatively more likely to allocate more of their available time to projects with clear value signals. Thus, we find highly significant interactions of structural load with both value rank ($p < 0.001$) and fairness ($p < 0.001$). To support these interpretations, we plot the effects of each interaction in Figures 2.1 and 2.2, respectively. Figure 2.1 shows the expected increase for mean load subjects, but a decline for high load subjects, as value generation prospects increase. Figure 2.2 shows a similar increase for mean load subjects to teams with fair distributions of effort, and no identifiable change for high load subjects, which is in line with the hypothesized insensitivity.

Hypothesis 3a and 3b find partial support in our regression. The results demonstrate a significant interaction between structural load and *task complexity* ($p < 0.05$), but no significant interaction with *risk level*. The significant interaction with task complexity is plotted in Figure 2.3 and indicates the expected decline in effort for high cognitive load individuals. Interestingly, we see an increase in effort from mean load subjects, which is in line with our hypothesis that in the absence of cognitive load, employees may be better able to accommodate complexity and distinguish it from more general signals of risk as a potential for value-adding behavior and problem-solving (Loewenstein and O'Donoghue, 2005; Fudenberg and Levine, 2006).

Finally, our fourth hypothesis on cognitive load of the management team as an enabling condition for risk-averse behavior is supported by the significant interaction term between *risk level* and *cognitive load of management team* in Model 3 ($p < 0.001$). Graphing this interaction in Figure 2.4, we find that increasing load is correlated with a general decline in the amount of hours allocated to a project under risk, while we observe a minor increase with mean levels of cognitive load of the management. This minor increase is likely due to the fact that in the absence of high cognitive load, management will be both more inclined and better able to push for more involvement from employees to address risk.

In sum, we confirm a substantial part of our hypotheses. We do not find direct support for Hypothesis 3b, but we do find support for Hypothesis 4, which posits an alternative and more indirect relationship that may explain the insignificant findings on the relationship between *risk level* and *structural load*.

We conduct two separate robustness checks. First, a major concern with our statistical specification is the simultaneity of our dependent variable on observed time distribution and our independent variables on cognitive load and the distinct signals. While the measures underlying these constructs are all reported in hindsight (managers assess the status of the project; employees register their working time), and therefore correspond in time, there is a plausible argument to be made that adjustments in time distribution patterns occur, at least partially, as a lagged phenomenon, as employees have to recognize, process, and consciously adapt to perceived signals, and to opt out of particular arrangements that may be sticky in terms of short term

participation. To check the robustness of our findings against these concerns, we lag our cognitive load measure by one month and re-run the regression. As seen in Model 4, all findings lend themselves to similar interpretation and do in fact improve both in terms of statistical significance and graphical features.

Second, a valid concern arises from our inability to observe *objective* cognitive load, i.e. the neurological correlates of our variables of interest. While the accumulation of such data outside laboratory conditions would be highly expensive and limiting in terms of sample size and general feasibility, it is nevertheless potentially problematic to use the number of projects and tasks as a direct measure of cognitive load when the dependent variable of interest is time distribution. Hence, a competing interpretation of our findings could be that having more projects to attend to would limit the ability to distribute much time to either of them and therefore reduce the average time allocated to each project. There are, however, relevant arguments against such an interpretation. First, even if the competing interpretation were correct, this would only impact our observed main effect of structural load (Hypothesis 1), essentially as a spurious effect. However, there is no immediate reason to expect the observed pattern of associations between cognitive load and our four signal indicators, if increasing cognitive load were unequivocally tied to reductions in average time allocation. Second, employees generally do not allocate all of their time to projects and project-related tasks, but instead allocate parts of their time to meetings, helping behavior, department time and departmental activities, etc. It is plausible that time would be siphoned from these sources as readily, or perhaps more readily, than from competing projects, at least in the short term. Despite these arguments, we re-specify our model to use temporal load as a substitute for structural load. The measure is only weakly correlated with structural load (0.08), probably due to the significant variation in the proportion of working time dedicated to project work. As shown in Model 5, we partially confirm our findings. The interaction with risk level remains insignificant, similar to Model 3. In addition, the interaction term between temporal load and fairness becomes wholly insignificant, and the interaction with complexity, while significant, becomes harder to interpret meaningfully in terms of effect size and sign of effect. The contingent effects of value rank are confirmed. Such inconclusive and partially conflicting findings only emphasize the need for more fine-grained measures of cognitive load and related variables, as discussed further in the following section.

2.6 CONCLUDING DISCUSSION

There is an assumption in the literature that delegation of decision authority to lower hierarchical levels is desirable both for upper and lower tiers of organizations. Delegation reduces the cognitive burden in the upper echelons (Harris and Raviv, 2002; Mintzberg, 1979), collocates decision authority with decision specific knowledge (Jensen and Meckling, 1992) and grants autonomy to front line employees, which in turn motivates them (Bénabou and Tirole, 2003) to exert greater effort and initiative in problem solving. At the same time, however, the existence of clear bounds on human cognition has been taken to imply a negative association between increasing workload and firm performance (e.g. LePine et al., 2005; O’Leary et al., 2011; Rubinstein et al., 2001). If greater delegation through more lateral integration mechanisms induces cognitive load by increasing both the variety of tasks to which an employee must pay attention (Harrison and Klein, 2007; Ocasio, 1997), the number of interdependencies with other employees and tasks (Puranam et al., 2012), and the cognitive costs incurred by having to switch more frequently between different tasks (O’Leary et al., 2011; LePine et al., 2005), then it is relevant to explore the boundary conditions of more lateral mechanisms and delegation in terms of their ability to promote information processing and integration.

In this paper, we explore and attempt to nuance this expectation that lateral mechanisms foster greater information processing capacity through more personal relationships and more individual autonomy by showing how cognitive load may interfere with the implicit assumption that individuals allocate sufficient time and effort to these mechanisms. We argue that the individual allocation of effort among competing tasks and projects depends fundamentally on the level of cognitive load, as differences in cognitive load will lead individuals to base their decisions and prioritizations on different signals. Specifically, we argue that individuals without high cognitive load will navigate mostly on value signals, which include differences in performance between projects and the fairness of contribution exhibited by team members. Conversely, we expect individuals with high cognitive load to become insensitive to value signals and to instead base their

behavior on uncertainty signals, which include task complexity and generalized risk, and to do so in a risk-averse manner (Benjamin et al., 2013; Whitney et al., 2008).

Drawing on extensive data from the time registration records of a global manufacturing firm, we find support for our general hypothesis that the realized information processing capacity of lateral mechanisms (i.e. the use of cross-functional teams and project organizing with autonomous behavior) is contingent on the cognitive load and allocative behavior of individuals. Specifically, we find that while individuals tend to generally reduce their commitment under cognitive load (Hypothesis 1), mean load subjects increase their commitment in order to reciprocate fairness within the team and to maximize value by contributing mostly to those projects that display best performance (Hypothesis 2a). High load subjects are insensitive to such value signals (Hypothesis 2b). Similarly, while mean load subjects tend to increase their commitment in response to complexity, largely, we theorize, due to their ability to construe complexity as an opportunity to generate valuable contributions, individuals with high cognitive load become risk-averse and reduce their effort in such settings (Hypothesis 3a). While we find no evidence of a direct effect of employee cognitive load in conjunction with risk (Hypothesis 3b), we do find that the cognitive load of the management functions as an enabling conditions for individuals to act on risk-aversion, due to the expected increase in delegation and autonomy (Hypothesis 4).

Our findings tie together a conflux of theoretical perspectives and findings on both the use of lateral mechanisms and multiple team memberships to support integration (O'Leary et al., 2011; Van de Ven et al., 1976), the effects of delegation on employee behavior (Aghion and Tirole, 1976; Bénabou and Tirole, 2003), the tendency for individuals to condition their behavior on signals from both their environment and their peers (Cason et al., 2012; Duffy and Smith, 2014; Rand, 2016), and the role of cognitive limitations and cognitive load in determining the allocation of effort (Hinson et al., 2003; Loewenstein and O'Donoghue, 2005; Shiv and Fedorikhin, 1999). On the basis of these combinations, we are able to provide novel explanations of how and when the use of lateral mechanisms is an efficient means of fostering integration and aligning employee behavior with the interests of the organization. Specifically, we shed light on the question of when intended information processing capacity is in fact realized (Turner and Makhija, 2012) by

demonstrating the role of individual choice behavior under cognitive load. These findings have implications for the theoretical cohesiveness and practical applicability of organizational information processing theory (Tushman and Nadler, 1978) as a framework for the adoption of particular structures and organizational designs to support the integration of dispersed knowledge and human capital from separate parts of the organization.

In general, the paper contributes to the emerging view that there is not necessarily a strict relationship between cognitive load, rationality constraints, and decreased information processing performance (e.g. Berg and Hoffrage, 2008). While we are not directly concerned with performance in this paper, our findings on the allocation of effort inform the distinction in much management theory between more heuristic and more analytical processes (Maitland and Sammartino, 2015; O’Leary et al., 2011; Vuori and Vuori, 2014). One of the key distinguishing features of these two classes of information processing strategies is their differences in effort and time requirement (Marois and Ivanoff, 2005; Ocasio, 1997; Shah and Oppenheimer, 2008).

Whether alignment within a group of employees occurs around high or low effort, and around analytical or heuristic information processing strategies, the available evidence indicates self-reinforcing effects (Hartig et al., 2015; Van den Berg et al., 2015). Homogeneity begets homogeneity. As described, individuals condition their behavior on the contributions of their peers to mitigate perceived inequality (Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000) or sustain a fair equilibrium level of contribution through reciprocal altruism or punishment (Axelrod and Hamilton, 1981; Fehr and Fischbacher, 2004b). With comparable levels of effort, group members will tend to prefer similar information processing strategies and, hence, exhibit similar contribution patterns within the group. Cheung (2014) corroborates this self-reinforcement by demonstrating that individuals contribute the most when peers contribute equally, which confirms prior findings (Gunnthorsdottir et al., 2007). With equality of behavior and contribution, there is no apparent incentive to punish and no one is compelled to adapt their privately preferred strategy. Instead, homogeneity enables reliable predictions of peer behavior, which promotes conditional cooperation and mutual reinforcement of commonly preferred strategies (Van den Berg et al., 2015; Wolf et al., 2011).

Thus, whether an observed decrease in effort negatively impacts outcomes and performance is not a simple question. Rather, the efficacy of decreased effort and more heuristic information processing under cognitive load depends on the structure of the environment, and how well heuristics exploit regularities in an environment (a logic related to *ecological rationality*, see Gigerenzer and Brighton, 2009: 116). In this paper, we have demonstrated how structural choices condition the level of cognitive load, and how this in turn leads individuals to perceive respond to different signals with implications for behavior. However, whether the inclination of cognitively loaded individuals to reduce their effort levels in response to complexity and risk is in fact an instance of detrimental risk-aversion, or rather an adaptive choice to rely on heuristic reasoning to conserve resources for other tasks while arriving at similar or superior solutions, is contingent on the abilities of the individual and the characteristics of the task. Prahalad and Bettis (1986: 489) echo this as they argue that individual representations or schema “*permit managers to categorize an event, assess its consequences, and consider appropriate actions (including doing nothing)*”. However, they acknowledge also that such schema “*are not infallible guides to the organization, [and that] in fact, some are relatively inaccurate representations of the world*”. By emphasizing both the structural and sociocognitive antecedents of effort distribution and information processing behavior, this paper may help pinpoint the conditions under which heuristic reasoning or analytical processing emerge to be efficient by expanding the standard notion of ecological rationality to include considerations of cognitive load and environmental signals.

In accordance with this, the paper contributes also to the view of strategy as diligence (Powell, 2017), and the notion of individual agency as the engine that determines information processing capacity (Puranam et al., 2012; Turner and Makhija, 2012). By affording attention to seemingly mundane elements of human capital allocation, and how these induce patterns of behavioral adaptation and deviation from expected behavior, it is possible to better identify and address the less grandiose challenges facing firms on a day-to-day basis as a complement the more mainstream views of strategy as driven by competitive advantage.

Limitations and future research

The study is limited by our inability to directly observe cognitive load. We proxy on the number of tasks and projects to which the employee contributes actively, and use more generalized time measurements as robustness, but we are nevertheless fundamentally barred from bridging the gap between inferred and perceived levels of cognitive load. As such, we cannot account for differences in the way individuals construe the same objective conditions. This concern mirrors the notion of individually perceived complexity (Davis, 1989; Igarria, Parasuraman, and Baroudi, 1996), which holds, essentially, that individuals may experience different levels of complexity depending on their abilities and organizational context. Allowing for such perceptible differences implies that complexity and other constructs are not determined solely by structure or characteristics of the task, but depend also on perception and individual heterogeneity (e.g. De Vries et al., 2014; Hørem et al., 2015). Organizational design choices impact both structural and perceptible complexities and, therefore, have the effect of increasing individual variability. Future research would need to adopt complementary measures to address these concerns. One apparent method would be to survey perceived cognitive load, complexity, and uncertainty at the individual level to capture relevant variation in the way these perceptions both deviate from secondary proxies and moderate the relationship between integration effort and integration outcomes.

Additionally, while single-firm sampling accounts for firm and industry effects and mitigates extraneous variation (Harrigan, 1983; Siggelkow, 2007), it simultaneously exposes our conclusions to firm-specific effects. Relatedly, we are unable to properly mitigate survivor bias arising from the fact that we only observe active and completed projects. Future research would need to ensure that failures are not underweighted in the sample (Cooper and Kleinschmidt, 1990), as well as expand the sampling strategy to multiple firms to improve our confidence in the generalizability of the results.

Our findings hint at an explanation for the puzzling observation in recent studies (Hartig et al., 2015; Van den Berg et al., 2015) that individuals respond heterogeneously to heterogeneous behavior amongst their peers; heterogeneity begets heterogeneity. For instance, Van den Berg et al. (2015) find that more heterogeneity in collaborative effort leads to “*more variable (and more extreme) contributions in response*”. Similarly, Hartig et al. (2015: 52) find a “*strong and significant positive relationship between contribution*

heterogeneity and variation in contribution responses [suggesting that] the more spread out others' contribution behavior, the higher the variation in contribution responses". Thus, the available evidence points to a *variation breeds variation* effect that is not readily explained by previous findings on conditional cooperation. Our findings would indicate that variation is explained through cognitive load, as differences in cognitive load leads individuals to observe, and therefore act on, different signals in objectively similar environments. While this provides a starting point for future research on this phenomenon, scholars may also want to consider previous findings on environmental noise. For individuals with more pronounced levels of cognitive load, the environment becomes noisier, which decreases the predictability of peer behavior and makes sociocognitive perceptions of reciprocity more uncertain (cf. Wolf et al., 2011). Building on the work of Axelrod on tournament games, Bendor, Kramer, and Stout (1991) find that collaboration is more robust in noisy environments, as generosity outperforms immediate reciprocation. The observation that behavioral variation and noise partially mitigates defection is robust in subsequent research using game theory (McNamara et al., 2004; Wu and Axelrod, 1995).

Our arguments are premised on conditional cooperation between interdependent agents. A number of important extensions of our study relate to this theory in particular. If a relationship is due to end, for instance, the threat of punishment and promise of collaboration would not be expected to remain credible deterrents of non-cooperative behavior. Dufwenberg and Kirchsteiger (2004) and Falk and Fischbacher (2006) test this expectation by extending their model to encompass repeated games and sequential reciprocity. As expected, there is evidence that cooperation tapers off as the end of the relationship approaches. As we do not observe collaboration directly, and since our sample is mostly consisting of active projects, we are not able to properly account for this effect. Future research would do well, therefore, to include measures of planned relationship duration.

Along the same lines, some have proposed a need to distinguish situations where direct observation of the behavior of others is either possible or precluded. Specifically, they have raised concerns with the Fischbacher et al. (2001) study and other studies for their use of the "*strategy method*", which has participants responding to a range of hypothetical contributions rather than the observed behavior of others.

The main concern is that the hypothetical nature of this method, along with one-shot games that do not allow subjects to in fact observe the behavior of others, will not elicit the same behavior as more realistic methods that allow for direct observation. While we have contributed to this by testing some of these findings in a real-world setting, more research is needed to establish confidence in the results and their applicability.

Finally, our findings have practical implications. To the extent that managers determine the allocation and rate of utilization of their human resources, and impact this through organizational design decisions (De Vries et al., 2014; O'Leary et al., 2011), they are effectively also impacting on the cognitive load and, hence, the behavior of their subordinates. By adopting a more informed view of the behavioral implications of cognitive load, managers may be better able to predict and even control the outcomes of allocation decisions and the adoption of particular organizational design elements. This relates to the larger concern in the management literature with the discriminating effects of particular governance choices on behavior (Foss and Weber, 2016; Turner and Makhija, 2012; Weber and Mayer, 2014).

TABLE 2.1 – CORRELATION MATRIX, ALL VARIABLES

	Effort	Structural Load	Value Rank	Fairness	Task Complexity	Risk Level	Interpersonal Load	Cognitive Load of Management Team	Seniority	Age	Managerial Responsibilities	Temporal Load	Management Team Size	Phases	Current\month
Effort	1.00														
Structural Load	-0.56	1.00													
Value Rank	0.23	-0.27	1.00												
Fairness	0.19	-0.08	0.01	1.00											
Task Complexity	0.03	0.06	-0.02	0.15	1.00										
Risk Level	0.00	0.02	0.10	0.20	0.41	1.00									
Interpersonal Load	0.14	0.06	-0.19	0.48	0.13	0.13	1.00								
Cognitive Load of Management Team	0.08	-0.04	-0.07	0.00	-0.04	-0.17	0.09	1.00							
Seniority	-0.06	0.11	-0.06	-0.01	0.10	0.02	0.06	-0.02	1.00						
Age	-0.05	0.10	-0.06	-0.01	0.10	0.05	0.02	-0.02	0.65	1.00					
Managerial Responsibilities	-0.07	-0.00	-0.00	-0.00	0.01	0.01	0.01	0.03	-0.05	-0.00	1.00				
Temporal Load	-0.10	0.14	-0.06	0.02	0.00	-0.02	0.05	0.01	0.02	0.01	0.02	1.00			
Management Team Size	-0.00	0.05	-0.15	-0.04	0.40	-0.04	-0.11	-0.01	0.06	0.09	0.02	0.01	1.00		
Phases	-0.17	0.08	0.04	-0.19	-0.22	-0.09	-0.16	-0.11	-0.07	-0.07	-0.00	-0.02	-0.09	1.00	
Current\month	-0.05	0.13	0.14	0.04	0.03	0.09	-0.04	-0.19	0.08	0.09	-0.00	0.06	0.00	0.15	1.00
Mean	0.35	3.59	7.56	0.7	6.2	2.02	39.67	9.29	14.75	44.5	0.038	135.13	9.03	5.09	670.63
SD	0.33	2.69	0.8	0.07	4.99	0.78	22.19	2.29	10.5	9.5	0.19	39.53	1.16	1.48	6.99
Min	0	0.5	1	0	0	1	0	1.67	1	19	0	1	4	2	660
Max	1.28	22.5	8	0.75	15	3	122	15.25	49	77	1	300	15	8	683

TABLE 2.2 – REGRESSION MODELS

	(1) Effort b/se	(2) Effort b/se	(3) Effort b/se
Structural Load	-0.063*** (0.01)	-0.061*** (0.01)	-0.061*** (0.01)
Value Rank	0.048*** (0.01)	0.055*** (0.01)	0.054*** (0.01)
Fairness	0.117+ (0.06)	0.021 (0.06)	-0.006 (0.06)
Task Complexity	0.004** (0.00)	0.004** (0.00)	0.004** (0.00)
Risk Level	-0.024** (0.01)	-0.026** (0.01)	-0.026** (0.01)
Value Rank # Structural Load		-0.021*** (0.00)	-0.021*** (0.00)
Fairness # Structural Load		-0.206*** (0.04)	-0.205*** (0.04)
Task Complexity # Structural Load		-0.001* (0.00)	-0.001* (0.00)
Risk Level # Structural Load		-0.001 (0.00)	
Cognitive Load of Management Team	-0.005 (0.00)	-0.005 (0.00)	-0.002 (0.00)
Risk Level # Cognitive Load of Management Team			-0.009*** (0.00)
Interpersonal Load	0.001** (0.00)	0.001** (0.00)	0.001** (0.00)
Seniority	0.010 (0.01)	0.013 (0.01)	0.012 (0.01)
Age	-0.015 (0.01)	-0.013 (0.01)	-0.013 (0.01)
Managerial Responsibilities	-0.224*** (0.05)	-0.164*** (0.04)	-0.171*** (0.02)
Temporal Load	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)
Management Team Size	0.002 (0.01)	0.011 (0.01)	0.010 (0.01)
Phase 2	0.000 (.)	0.000 (.)	0.000 (.)
Phase 3	0.042 (0.05)	0.039 (0.05)	0.043 (0.05)
Phase 4	0.003 (0.05)	-0.003 (0.05)	0.000 (0.05)
Phase 5	-0.036 (0.06)	-0.038 (0.06)	-0.036 (0.06)
Phase 6	-0.134* (0.07)	-0.169* (0.07)	-0.137+ (0.07)
Phase 7	-0.153* (0.06)	-0.145* (0.06)	-0.140* (0.06)
Intercept	0.371*** (0.05)	0.374*** (0.05)	0.362*** (0.05)
N	5102	5102	5102
R2	0.202	0.229	0.232
DF	1194	1194	1194

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

FIGURE 2.1 – VALUE RANK # STRUCTURAL LOAD

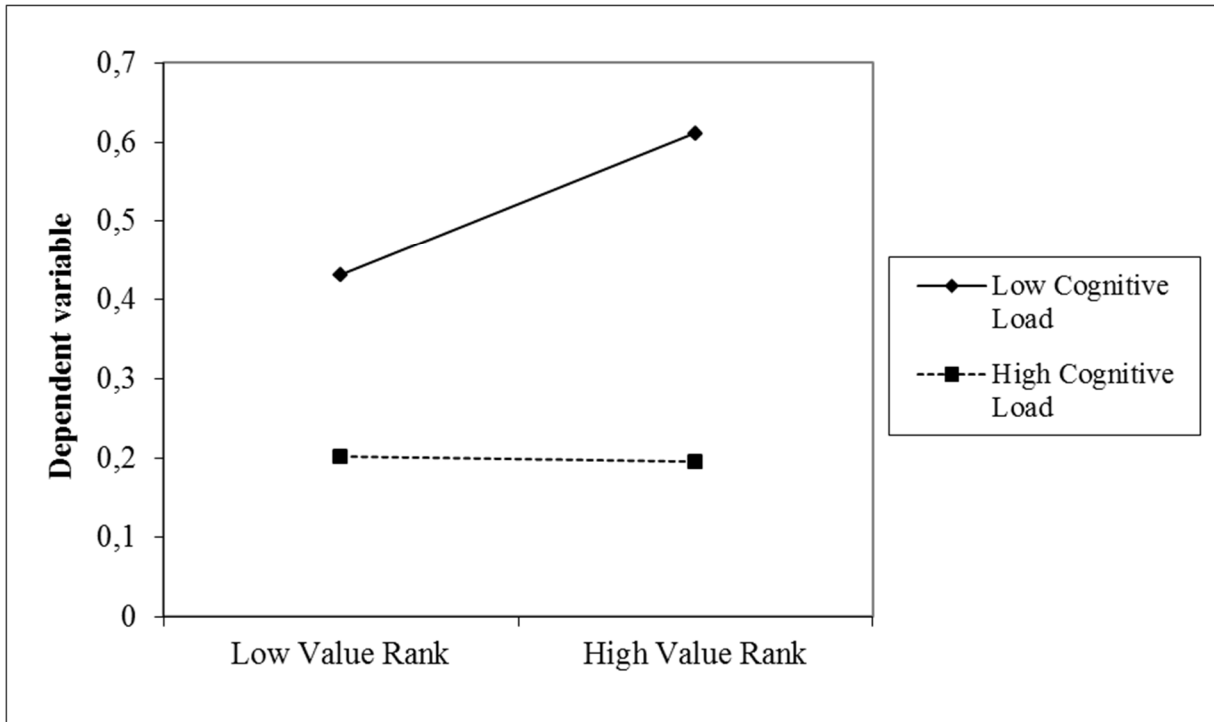


FIGURE 2.2 – FAIRNESS # STRUCTURAL LOAD

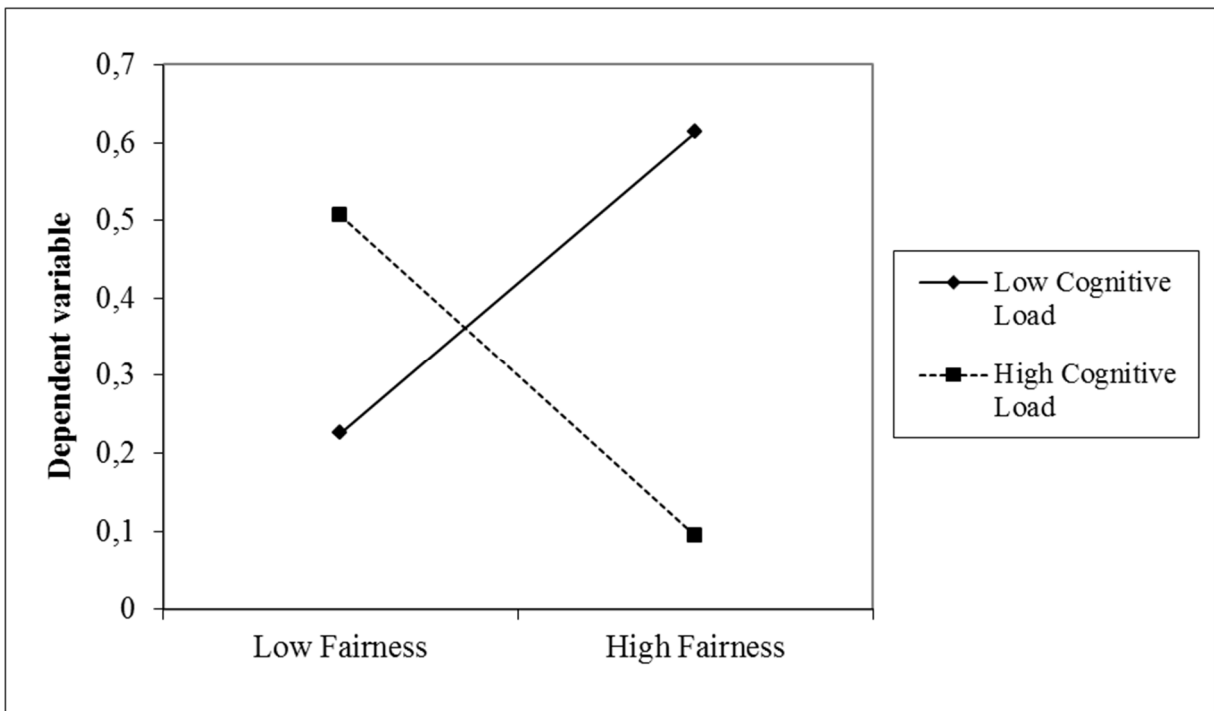


FIGURE 2.3 – TASK_COMPLEXITY # STRUCTURAL LOAD

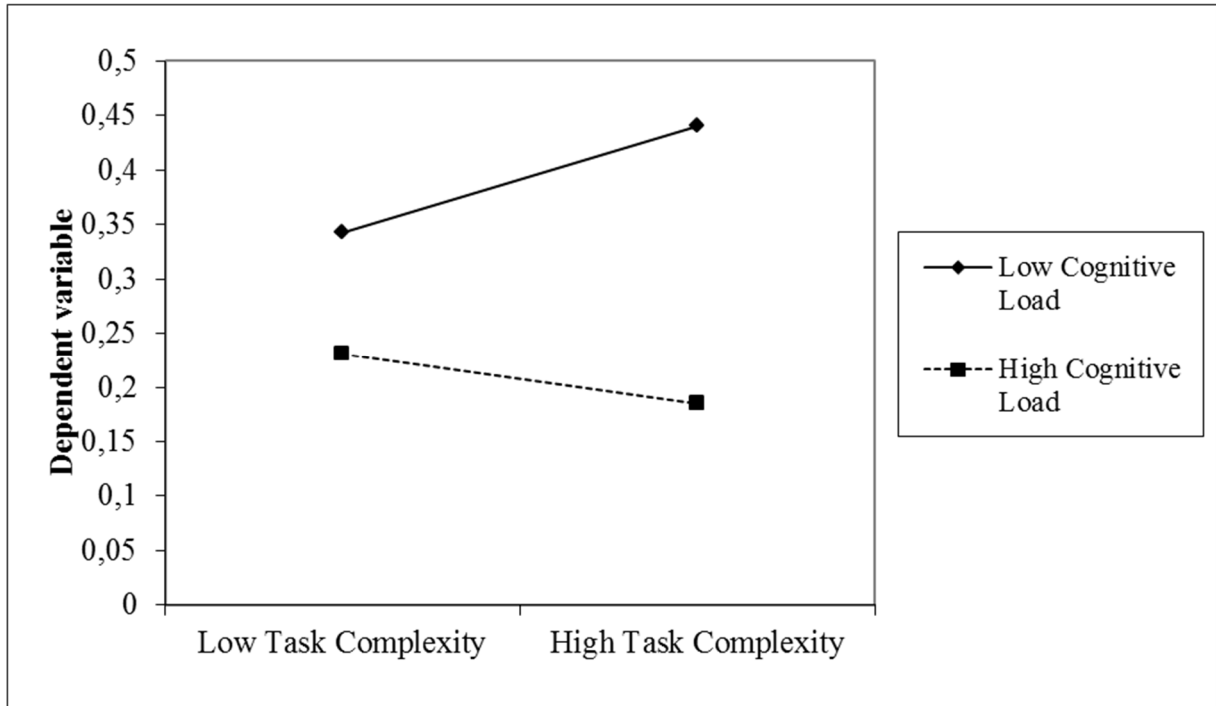
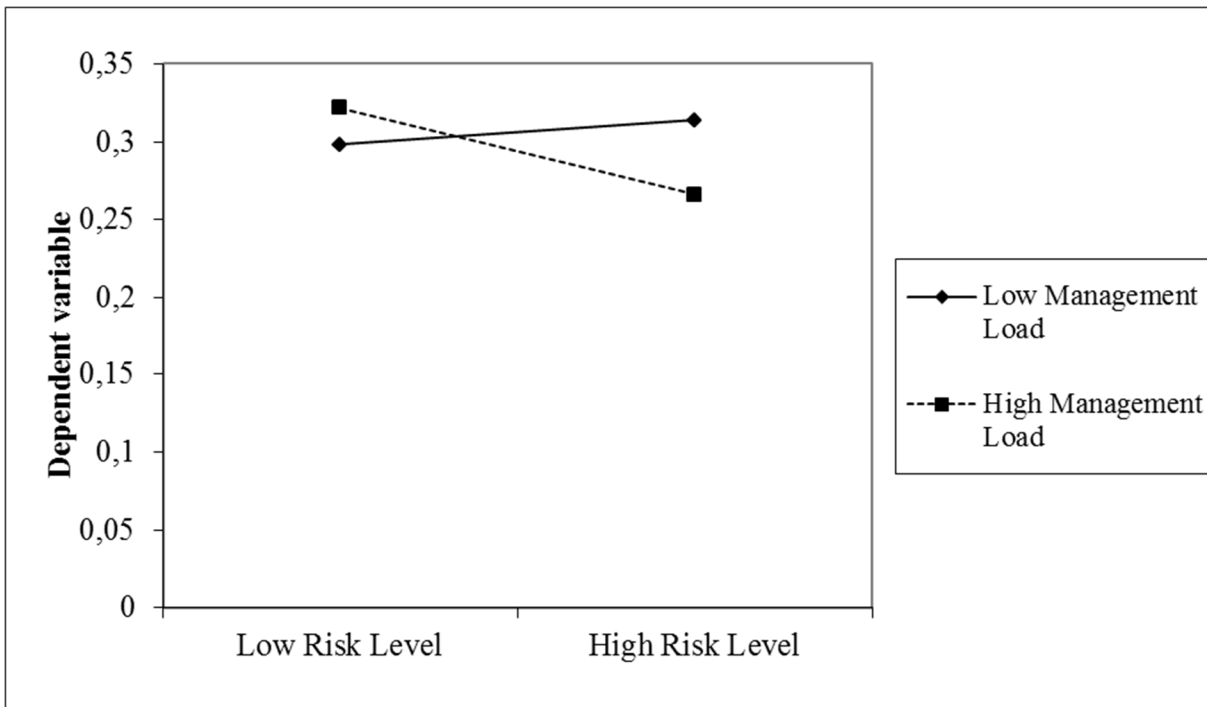


FIGURE 2.4 – RISK_LEVEL # MANAGEMENT LOAD



CHAPTER 3

CARRYING THE LOAD

EFFECTS OF TEAM COGNITIVE LOAD ON GROUP PERFORMANCE

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Torben Pedersen²

ABSTRACT

The human capacity for information processing is naturally limited. While research in economics, management, and psychology has repeatedly demonstrated the fundamental truth that individuals adapt their information processing behavior from analytical and elaborate processing to more heuristic reasoning as processing demands and cognitive load increase, comparatively little is known about how the information processing behavior of individuals combine under collaboration to influence the behavior and efficacy of the group in the aggregate. Even less is known about how individuals adapt or augment their behavior in response to different patterns of behavior among others in the group. Drawing on comprehensive data from a global manufacturing firm, we find that the association between cognitive load of team members and team performance approximates an inverted u-shaped relationship. While teams experience initial benefits from members with high cognitive load mainly through the tempering the tendency toward extensive analysis, an increasing proportion induces a decline in performance by impairing the collective sharing and processing of information in the team. We find evidence a several moderating effects on this negative association. Our findings contribute to our knowledge of how to effectively organize knowledge sharing and collaboration in organizations by demonstrating the interdependencies between the allocation of employees and information processing effectiveness.

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3.1 INTRODUCTION

Across disciplines, scientists are attempting to learn how human behavior is interdependent and contagious within and across social networks (Aral and Nicolaides, 2017; Aral and Walker, 2012; Burt, 1987; Van den Bulte and Lilien, 2001). In management, scholars have long since recognized how strategy implementation and firm outcomes are rooted in myriads of decisions made collectively by interdependent employees throughout the organization. How separate strands of information held by individuals are pooled and processed to enable informed decisions is therefore an important issue (Collins and Smith, 2006). The common assumption is that unique information held by team members must be shared and discussed to ensure sufficient decision quality (Hinsz, Vollrath, and Tindale, 1997; Jehn et al., 1999). The associated costs and time are often seen as necessary and even profitable investments (Homan et al., 2007; Van Ginkel and Van Knippenberg, 2008).

In truth, individuals often fall short of these requirements to extensively share and efficiently process information (Lau and Murnighan, 2005; Stasser, 1999; Wittenbaum and Stasser, 1996), as they are boundedly rational with limited processing capacity and finite attentional resources (Marois and Ivanoff, 2005; Ocasio, 1997; Shiffrin and Schneider, 1977). When work requirements place a strain on cognitive capacity, individuals *satisfice* in information acquisition and processing (Simon, 1955) through heuristic reasoning to compensate for rationality constraints (Kahneman, 2003). Individual behavior is therefore sensitive to changes in task environments and working arrangements that increase cognitive load and dilute attention through more extensive information processing requirements (Shah and Oppenheimer, 2008).

Numerous studies have explored the relative merits of more heuristic or more analytical modes of sharing and processing information (Ayal et al., 2015; De Dreu et al., 2008). Recent studies provide substantial evidence to indicate that reliance on fewer informational cues and more heuristic and experiential decision-making may, at times, outperform analytical strategies (Berg and Hoffrage, 2008; Marewski, Gaissmaier, and Gigerenzer, 2010; Rusou et al., 2013). Yet, despite our knowledge of their relative benefits, and of the conditions that determine whether individuals engage more heuristically or analytically with their work, our understanding of how the information processing behavior of individual employees interacts and is

aggregated within the team to impact collective outcomes is “*in its infancy*” (Mohammed and Schwall, 2009: 302; Loock and Hinnen, 2015: 2033; Vuori and Vuori, 2014: 1691) with few exceptions (Fitzgerald et al., 2017; Maitland and Sammartino, 2015).

While important advances have been made through simulation studies to better understand how team information processing depends on the behavior of individual members (e.g. Luan, Katsikopoulos, and Reimer, 2012; Reimer and Hoffrage, 2006; Reimer, Reimer, and Czienskowski, 2010), these tend to presuppose homogenous agents or unitary aggregation rules. Both of these conditions are often violated. When interdependent employees differ in terms of cognitive load, their information processing behavior is likely to differ accordingly so as to introduce behavioral heterogeneity in the team (O’Leary et al., 2011; Shah and Oppenheimer, 2008). Additionally, individuals condition their behavior on the behavior of others (Fehr and Fischbacher, 2004; Fischbacher and Gächter, 2010). It is therefore reasonable to expect potentially disruptive effects, as team members adapt their behavior and possibly reduce effort on the basis of the heterogeneous behavior of their peers (Fischbacher and Gächter, 2010; Fitzgerald et al., 2017). Our purpose in this paper is to empirically explore how such heterogeneity in cognitive load and information processing behavior impacts the functioning of the team, and how mutual adaptation within the team influences this process.

With comprehensive longitudinal data from a global manufacturing firm, we trace the working arrangements of 587 employees across 45 new product development projects over a two-year period to gauge variation in *team cognitive load* (TCO) over time³. Using this information, we find evidence of an inverted u-shaped relationship between project performance and the team composition of TCO with initial positive returns to cognitive load and subsequent decline. We theorize that when a team possesses a low TCO ratio, it experiences beneficial effects as team members are dissuaded from extensive analysis, and the associated risk of informational *overfitting* (Gigerenzer, 2008), when less extensive processes are sufficient. In addition, the disruptive effects of misaligned information processing behavior are likely absorbed by the team at low

³ TCO is defined and operationalized as the ratio of team members with high cognitive load.

TCO ratios (Bendor et al., 1991; McNamara et al., 2004). As teams evolve towards a higher TCO ratio, disruptive performance effects manifest as team members reduce their effort out of necessity or in reciprocity to perceived reductions in peer effort, thereby constraining the information processing capacity of the team (Hartig et al., 2015; Van den Berg et al., 2015). We find that this decline in performance is particularly pronounced given increasing task complexity, but is mitigated to some extent as team members come to develop greater metaknowledge of each other. In addition, we find that even when teams are stable in TCO (i.e. absent changes in team composition or the average working conditions of team members), the mere passage of time induces *cooperation decay* in teams with moderate or high TCO ratios, as team members continuously re-adapt to the perceived decline in the contributions from their peers.

This paper is an attempt to strengthen the psychological design of the firm and its constituent decision processes by coupling insights from psychology on individual behavior to higher-level organizational structures and outcomes (Kahneman and Klein, 2009; Milkman et al., 2009; Powell et al., 2011). By combining experimental evidence on conditional cooperation with a view of cognitive load as an antecedent of information processing behavior, we explore how individual information processing behavior combines to determine collective outcomes. An important implication is that managerial decisions on human capital allocation directly determine TCO and, therefore, influence the aggregation of individual behavior to collective outcomes in a predictable manner that is open to managerial control. Thus, the paper represents a response to calls for the extension of experimental findings on conditional cooperation from economics and psychology to questions of organizational design and the use of human capital (de Oliveira et al., 2015: 131; Hartig et al., 2015: 55).

3.2 COGNITION, AGGREGATION, AND CONDITIONAL COOPERATION

Cognitive load is defined as the strain imposed on individual attention and processing capacity by work related demands for more extensive or rapid information processing (Marois and Ivanoff, 2005; Ocasio, 1997; Shah and Oppenheimer, 2008). The strain on cognitive capacity increases, for instance, when

employees hold multiple project memberships and need to alternate between different tasks and projects, which engenders switching costs as the individual must continuously reorient attention (LePine et al., 2005; O’Leary et al., 2011). Similarly, multiple memberships are expected to increase social complexity by forcing the individual to interface with an increasing number of people with different specializations, perceptions, and professional languages (De Vries et al., 2014; Dougherty, 1992). High network centrality can produce similar effects (Brass et al., 2004; Labianca and Brass, 2006; Podolny and Baron, 1997).

The prevailing finding in prior research is that increasing cognitive load will lead individuals to abandon more elaborate and analytical modes of thinking to search for heuristic means of accomplishing more in less time (O’Leary et al., 2011; Waller, Zellmer-Bruhn, and Giambatista, 2002). These studies have commonly explored the workings and effects of heuristic reasoning at the individual or organizational levels (e.g. Bingham and Eisenhardt, 2011; Scholten, Van Knippenberg, Nijstad, and De Dreu, 2007), leaving open the question of how individuals adapt their information processing behavior in teams (Fitzgerald et al., 2017), and how these adaptations may in turn impact the functioning of the team. Studies attempting to span the individual and collective levels remain a minority (e.g. Levinthal, 2011; Maitland and Sammartino, 2015). Part of the reason for this is the lack of consistent models for aggregating behavioral variation at the individual level to the team and organizational levels (cf. Kozlowski and Chao, 2012).

Research has often employed a *social combination approach* (Hastie and Kameda, 2005; Reimer and Hoffrage, 2006) to attempt to explain how team members with different pre-formed opinions use various social combination rules as mechanisms for prioritizing and selecting among competing solutions to the issue at hand. Prominent combination rules include majority rule, voting, and averaging (Csaszar and Eggers, 2013). While these and other decision rules are important for our understanding of team decision dynamics, their emphasis on team members’ preformed opinions has the unfortunate effect of pushing individual adaptation to the backseat and ignoring the potential changes in individual information processing that ensue from team member differences in cognitive load and processing behavior. Additionally, when team outcomes are determined by a tally or by fiat at the hands of a powerful individual or dominant coalition (Ten Velden, Beersma, and De Dreu, 2007), team efficacy becomes simply a matter of matching the preferences of the

dominant coalition with task requirements. Paying attention to the adaptive patterns that emerge when teams are composed of heterogeneous members promises a more nuanced view of decision making dynamics and collective implications.

We propose conditional cooperation as a useful lens for understanding aggregation in teams. A significant number of experimental studies in psychology and economics have tested and confirmed the hypothesis that humans factor in the revealed or expected level of contribution of others when deciding how and how much to contribute to a common outcome (Brandts and Schram, 2001; Frey and Meier, 2004). In their seminal study, Fischbacher et al. (2001) test conditional cooperation, that is, the human inclination to contribute more to a common outcome when others are perceived to contribute more. They adapt the standard linear public goods game by having participants decide how much of a fixed endowment to contribute at various average levels of contribution from other team members. Although the marginal pay-off of a contribution is negative in the experiment, only around 30 percent of subjects behave in accordance with the standard assumption of free-riding, whereas more than half of subjects display conditionally cooperative behavior, as is repeatedly confirmed in subsequent studies (Chaudhuri, 2011).

Numerous explanations have been offered for this behavioral phenomenon. Following Chaudhuri (2011), these fall in two main categories concerned either with issues of equitable distribution or with participants' sociocognitive perceptions and beliefs about the actions of others. Fehr and Schmidt (1999) propose inequity aversion as a reason for the observed conditionality, assuming that people inherently dislike unequal distributions, regardless of whether distributions are advantageous or disadvantageous for the individual (Binmore and Shaked, 2010; Bolton and Ockenfels, 2000). Studies in the second category build on Rabin's (1993) original notion of fairness equilibria in coordination, where subjects exhibit reciprocal behavior to maintain coordinative equilibria perceived to be fair. Fairness is judged on the basis of subjects' perceptions and beliefs about the contributions of others. Perceived fairness elicits reciprocal altruism and cooperation (Axelrod and Hamilton, 1981; Fehr and Fischbacher, 2003), whereas perceived unfairness motivates reciprocal punishment and defection from collaboration (Fehr and Fischbacher, 2004). In the following, we

expand upon this notion of conditional cooperation as driven fundamentally by perceptions of fairness to understand the mechanism linking individual cognitive load with collective information processing.

3.3 HYPOTHESIS DEVELOPMENT

We derive a set of hypotheses associating TCO with project performance. These hypotheses rest on the premise that team members under cognitive load will tend to reduce their collaborative effort to conserve time and resources (Kahneman, 2003; Shah and Oppenheimer, 2008).

TCO and performance

Much research holds that analytical processing is generally superior to less elaborate and more heuristic decision modes, due to the greater emphasis on detail and thorough processing of informational cues (Kahneman and Frederick, 2002). When team members are aligned around low or moderate levels of cognitive load, analytical information processing is possible with few constraints on the retrieval and use of salient information cues (De Dreu, 2003; Shah and Oppenheimer, 2008). This is expected to enable potentially high-quality team decisions as individuals display higher commitment (Tsui, Egan, and O'Reilly, 1992); as task representations become better aligned as shared cognition (Cronin and Weingart, 2007; Healey, Vuori, and Hodgkinson, 2015); and as the diversity of information and perspectives held by members are discussed and integrated in a more cohesive and less conflict-prone manner (Homan et al., 2007; Jehn et al., 1999; Van Ginkel and Van Knippenberg, 2008; Van Knippenberg et al., 2004).

In this view, the failure of more heuristic thinking modes to incorporate information and understand the idiosyncrasies of the task is correlated with greater susceptibility to bias and inefficient use of available information (Banks and Oldfield, 2007; MacGregor and Armstrong, 1994; Stanovich and West, 2008). This is supported by studies demonstrating comparatively higher accuracy and consistency of analytical deliberation on numerical tasks (Beilock and DeCaro, 2007; McMackin and Slovic, 2000), and by evidence

demonstrating high correlations between analytical thinking modes and the Adult Decision Making Competence scale, a widely-used and robust measure of decision making quality (Bavol'ár and Orosová, 2015; Bruine de Bruin et al., 2007, 2012).

Increases in individual cognitive load stimulate a preference for - and eventually necessitate - more heuristic and less time-consuming information processing (De Dreu, 2003; Hoffmann, Helversen, and Rieskamp, 2013) as a means of conserving time and cognitive resources. In these conditions, employees rely on experiential judgment and intuition, and engage less in analytical processes and knowledge sharing within the team (Epstein, 1994; Kahneman, 2003). And while the fact that individuals engage in both analytical and heuristic modes is well-established (Evans, 2008), there is increasing disagreement on their relative utility and the conditions under which either mode is advantageous (Rusou et al., 2013).

To understand how team performance is contingent on TCO, it is important to recognize that conditional cooperation is fundamentally fragile (Van den Berg et al., 2015; de Oliveira et al., 2015). Specifically, the maintenance of cooperation within the team depends on perceived reciprocity, but individuals cannot be expected to weigh signals of cooperative behavior in equal measure to signs of defection and failures to reciprocate (see De Dreu et al., 2008: 42 for a similar logic). Unfair or unequal contributions from peers crowd out positive cooperative behavior (cf. Kahneman and Tversky, 1979) and lead the contributing individual to either reciprocally defect to lower levels of contribution or engage in other forms of punishment (cf. Gächter, Renner, and Sefton, 2008). Simply put, sociocognitive perceptions of behavior do not weigh positive and negative signals equally. This implies that when perceived effort is unbalanced, which becomes increasingly likely with increasing TCO ratios, it may only require a handful of instances where cooperation is not reciprocated to outweigh the effects of multiple cooperating peers. When negative signals outweigh the stabilizing effects of multiple conditional cooperators, the perceived defection of a few team members will spur further defection and induce a shift in the team equilibrium toward a less analytical information processing strategy. Recent experimental evidence lends support to this proposition. For example, Hartig et al. (2015: 53) find that “*conditional cooperators are more inclined to follow the bad example of a low contributor rather than the good example of a high contributor*”. Similarly, de Oliveira et al. (2015),

Gunthorsdottir et al. (2007), and Fehr and Fischbacher (2003:785) demonstrate that a relatively small number of selfish individuals can “*induce a large number of altruists to defect*”. We therefore expect a negative impact on team information processing capacity and team performance as TCO ratios increase.

However, limited differences in the level of cognitive load among team members need not result in deteriorating team functioning. In favour of this, research has documented how teams engage in ad-hoc sharing of workload, and how collaboration tends to remain robust in noisy environments in the short run, when the motives of others are difficult to ascertain and leniency and helping behavior therefore trump immediate reciprocation (Bendor et al., 1991; McNamara et al., 2004; Wu and Axelrod, 1995). In fact, there is reason to expect beneficial effects when a minority of team members experience high cognitive load, as this would serve to counteract the documented tendency to carry on analyses for as long as time is available, even beyond what is necessary to reach well-informed conclusions (e.g. Gutierrez and Kouvelis, 1991; Latham and Locke, 1975). Specifically, when a team minority does not reciprocate the analytical behavior of the majority, team members are likely to respond by limiting the extensiveness and depth of analysis (Gunthorsdottir et al. 2007; Hartig et al., 2015). While this does not amount to a significant decline in the information processing activity of the team, it is expected to help limit exposure to problems of overfitting (Gigerenzer, 2008). Overfitting describes the phenomenon where the use of more information biases non-routine decisions, as the uncertainty of non-routine decisions makes it difficult to assess the applicability of information from similar decisions in the past. Past information may contain ample amounts of irrelevant information that does not apply but is not filtered out or ignored (Hertwig and Todd, 2003).

In sum, while we predict an overall negative association between project performance and increases in TCO ratios, we predict beneficial effects on team functioning as long as this ratio remains a minority.

Hypothesis 1: There is an inverted u-shaped relationship between TCO and project performance.

The moderating effect of task complexity

Contrary to this common understanding of information sharing and analytical processing as generally superior (e.g. Dawes, Faust, and Meehl, 1989), an increasing number of studies challenge the proposed association between intuitive thinking modes and biased decision making (Ayal, Hochman, and Zakay, 2011; Ayal, Zakay, and Hochman, 2012). In fact, there is accumulating evidence of specific instances of more heuristic thinking modes leading to more accurate decision making (Acker, 2008; Glöckner and Herbold, 2011; Usher et al., 2011), and analytical thinking modes producing significantly biased decision behavior (Ayal and Hochman, 2009; Dijksterhuis and Nordgren, 2006; Nieuwenstein et al., 2015).

As proposed by Ayal et al. (2015), these contradictory findings are plausibly explained by the common methodological disposition in prior research toward experimental studies that isolate decision processes from contextual factors. Indeed, earlier contributions to decision research demonstrate how “*decision-making ... is highly contingent on the demands of the task*” (Payne, 1982:382). In favor of this, Hammond et al. (1987) manipulate participant thinking modes by changing the format of the provided information and demonstrate synergies between task characteristics and thinking modes. Similar contingencies between the nature of the task and individual cognition have been repeatedly demonstrated (Ayal et al., 2015; Shanteau, 1992; Thomas and Millar, 2011). In general, complex tasks are more compatible with more elaborate and analytical processing of information (Homan et al., 2007; Jehn et al., 1999; Usher et al., 2011). The same goes for more intellectual tasks with “*definitive objective criterion of success*” (Laughlin, 1980: 128; Dane and Pratt, 2007), predictable or known associations between actions and outcomes (Hammond et al., 1987), and logical sub-tasks that enable task decomposition (Dane, Rockmann, and Pratt, 2012; MacGregor, Lichtenstein, and Slovic, 1988). Conversely, for more judgmental tasks with “*no objective criterion or demonstrable solution*” (Laughlin, 1980: 128) and a more uncertain organizing principle between actions and outcomes (Epstein, 1994), more experiential and heuristic information processing is found to be the more compatible strategy (Ayal et al., 2015; Rusou et al., 2013).

In accordance with these findings from decision research, we propose that the negative performance effects of increasing TCO are contingent on task complexity. When task characteristics are difficult to assess and decompose, and when the relevance of existing information is fundamentally uncertain, information

processing in the team is less likely to benefit from extensive information sharing and collective discussion (Gigerenzer, 2008; Hertwig and Todd, 2003). Additionally, a reliance on more heuristic and experiential approaches will entail the commitment of fewer resources to problem solving and may therefore be better able to accommodate operational constraints.

Hypothesis 2: The negative effect of TCO on project performance is moderated by task complexity. In the presence of task complexity, team performance is more susceptible to increases in TCO.

The moderating effect of stability

Conditional cooperation implicitly assumes that team members are able to observe the behavior of others and respond directly. We cannot ignore, however, that the process of adapting to others is an inherently temporal thing in the sense that perceptions and reactions occur sequentially (cf. Ancona et al., 2001; Mitchell and James, 2001). When time is considered, adaptation within the team becomes an evolutionary effect, in the sense that team members continually adjust to incremental changes in the behavior of their peers. Even with moderate levels of TCO, and even in the absence of exogenous changes in team composition, we expect a process of mutual adaptation and consecutive shifts toward lower aggregate effort, as team members continuously adjust their behavior to reciprocate the observed adaptation by their peers. As this decay progresses, heuristic reasoning and lower average levels of effort emerge as the equilibrium strategy to which the team will eventually conform.

This chain of adaptation resonates with studies in the economics and psychology literatures that observe cooperation decay in repeated games (de Oliveira et al., 2015; Fehr and Fischbacher, 2003; Fischbacher and Gächter, 2010). This phenomenon is partly explained by conditional cooperators becoming discouraged by perceived selfishness and lower contribution among peers (Gunnthorsdottir et al., 2007). A complementary explanation is that individuals become increasingly strategic toward the end of relationship, when the costs to defection decrease (Duffy and Smith, 2014; Keser and Van Winden, 2000). Moreover, cooperation decay

over time is observed even in relatively homogenous teams (de Oliveira et al., 2015), which demonstrates how conditional cooperation is not inherently stable even in homogenous teams due to our inability to accurately perceive and assess peer behavior (Fehr and Schmidt, 1999; Fischbacher and Gächter, 2010).

To the extent that stable patterns of TCO initiate processes of mutual adjustment and cooperation decay, teams are expected to gravitate towards lower levels of information processing effort, thereby decreasing team performance as stability persists for consecutive periods.

Hypothesis 3: The negative effect of TCO on performance is moderated by team stability. The negative effect of TCO on performance increases, as teams remain stable around a particular level of TCO for consecutive time periods.

The moderating effect of meta-knowledge

Work on transactive memory systems (Brandon and Hollingshead, 2004), shared cognition (Healey et al., 2015), and collective interpretation (Gavetti and Warglien, 2015) have offered explanations of how teams and networks of interdependent individuals may over time come to develop and exploit shared representations of where and through which interfaces relevant information resides. These lines of research complement the fundamental insights from media richness (Daft and Lengel, 1986) and channel expansion theory (Carlson and Zmud, 1999) that the information processing capacity of organizational mechanisms and structures (e.g. teams) is not predetermined, but is rather expanded (or diminished) over time as individuals become familiar with both the structure of the teams and the behavior of interdependent others (Fraidin, 2004).

As team members become familiar with the abilities, work constraints, and behavioral patterns of their peers, a cognitive division of labour may arise so as to improve team functioning and streamline the identification, retrieval, and application of available knowledge (Hollingshead, 2001). Team members are said to develop meta-knowledge (i.e. knowing who knows what). An immediate implication of this is a

reduction in the social and structural complexity perceived by team members, as the effort associated with locating and communicating with others that hold specialized stocks of relevant knowledge is decreased. Similarly, the development of mutual knowledge is expected to improve the ability of team members to perceive and understand the causes of heterogeneity in peer contributions (e.g. other commitments), which would in turn mitigate the tendency to reciprocate by reducing effort (Hartig et al., 2015; Van den Berg et al., 2015).

Hypothesis 4: The negative effect of TCO on project performance is moderated by team member meta-knowledge. As team members build more extensive metaknowledge, the negative association between TCO and project performance is reduced.

3.4 DATA AND METHODS

Common to our hypotheses is the assumption that changes in TCO impact project outcomes by *causing* adaptation in psychosocial aspects of collaboration; specifically by impacting individual information-processing behavior and adaptation within the team. Our research design should therefore plausibly disentangle the hypothesized relationships from aggregate trends and other spurious effects of cognitive load. This would be difficult to accomplish with cross-sectional measures, as the effects of compositional changes in project teams manifest primarily over time and in environments with repeated observations. Absent useful instruments, hypothesis testing in our study must rely on longitudinal data with repeated within-unit observations to identify relevant patterns and interactions with stable sample characteristics.

To this end, we trace the new product development (NPD) efforts of a world-leading manufacturing firm over a two-year period. NPD projects are dedicated to the development and maturation of product concepts and process technologies (Adler, 1995). Projects span from initial design decisions over the development, validation, and approval of concepts to the optimization of final manufacturing. These sequential and interdependent activities account for the majority of development and project organizing within the firm.

These projects represent immense resource investments and strategically important undertakings for the firm and are therefore subject to considerable documentation requirements and ongoing assessments of performance. Given their standardized structure, projects move through predefined stage gates with common criteria for progression that form the basis for monthly reports on key operational indicators delivered by the project management team. Main indicators include salary and development costs, project activities, staffing, timeliness and delays, product quality, and manufacturing efficiency. Moreover, managers are expected to enumerate and describe ongoing concerns and specific problems currently being addressed and analyzed by team members, and to provide generalized risk assessments in relation to project objectives and deadlines.

Aside from providing current estimates on all operational indicators, project managers are also requested every month to provide adjusted estimates of expected future performance on most operational indicators for the remaining phases. Additionally, project management is expected at the inception and midway point of a

project to provide best estimates on central operational metrics for the remainder of the project. The main emphasis here is on establishing deadlines for all remaining stage gates and realistic targets for the quality and cost of product development. These fixed estimates are logged in all monthly reports to serve as unbiased anchors against which ongoing performance is assessed. The continuously updated estimates are logged as well so as to make visible the number and magnitude of prior changes in expected project duration and performance as a way of motivating deadline adherence and debiasing future estimates. The combination of fixed estimates of expected performance and continuously updated measures and re-estimations enables us to meticulously trace and pinpoint developments in performance and deviations from both original expectations and recent best estimates.

We consolidate data from 501 monthly reports from 34 unique projects in the two-year period from January, 2015 to December, 2016. We were unable to obtain monthly reports for every project in every month, as some projects are initiated (11) or completed (4) within this period, meaning the panel is naturally unbalanced.. We obtain comprehensive data from the company work time registration system on the distribution of working hours for project employees and managers. Specifically, the system registers all tasks and projects to which an employee has contributed in the specific month, including the amount of hours allocated to each. We obtain matching employee data from the company HR database on individual demographics, departmental affiliations, job descriptions, managerial responsibilities, and physical location in terms of country, city, building, and floor of main work station. Our combination of these distinct data repositories enables the construction of longitudinal measures of individual cognitive load and TCO, and allows us to trace changes in team composition and other important secondary variables. Additionally, it helps mitigate concerns of common method variance (Podsakoff et al., 2003), which is a significant risk with management reports and similar self-reported data that is prone to measurement error when illusory correlations and implicit theories inform subjective estimates (Boyd, Dess, and Rasheed, 1993).

The combination of individual and project data provides 7,429 useful project-month-employee observations corresponding to 486 unique individuals allocated across 34 projects over 24 months. Due to the nature of our inquiry and the structure of our data, individuals are effectively nested within projects.

While important independent regressors are measured at the individual level, the dependent variable resides at the project level, and we therefore have to contend with separate error terms at the individual and project levels. To this end, we employ robust standard errors (adjusting standard errors for 1,635 clusters in the panel) to control for repeated observations at the project level and account for the dual error terms. Additionally, the Durbin-Wu-Hausman specification test indicates that the regressors in our model are correlated with unique errors, so we employ fixed effects estimation to further limit between-unit variation and alleviate residual non-random effects in the sample. We also conduct bootstrap reestimations as a means of resampling with replacement from our sample to alleviate concerns that the obtained standard deviations are unduly biased on account of our data structure. Bootstrapping with varying sample sizes, even well below the number of clusters in the full model ($N = 200$), confirms our findings.

Variable construction

Dependent variable

Project performance is multidimensional with an emphasis on accelerating time to market without compromising product quality or development cost (Ragatz, Handfield, and Scannell, 1997). Temporal metrics are generally more sensitive to deviations in performance as compared to assessments of costs and quality, due to the relative ease of discovered and quantifying delays against preset deadlines. We therefore operationalize performance as project timeliness ($\bar{x} = -0.3$; $\sigma = 0.31$), captured as differences between the latest estimated completion date of the current phase and the associated objective deadline (fixed by management at project inception and updated at the midway point).

By using the difference between objective deadline and expected completion date as our performance metric, rather than the more intuitive difference between objective deadline and current month, we take advantage of the fact that the latest estimated completion time incorporates errors and delays that have already been committed and recognized by the management team. To account for the obvious impact of

differences in project size and expected duration at project outset on the magnitude of delays, we weigh the estimated difference by the planned lifespan of the project.

We further improve our timeliness metric by adjusting for delays that were already incurred at the inception of the present phase, so as to not bias timeliness downwards. Moreover, we are in a position to use future monthly reports to estimate, at any given point in a project, how much additional delay is going to be incurred in excess of the currently estimated completion date. It is likely that this excess delay is attributable to errors committed between the start of the phase and the time at which the excess delay is incorporated into the estimated completion date. We therefore allocate excess delay equally to all months in this period as a means of accounting for hidden errors. Notably, while the described adjustments improve the statistical properties of our regression, our results and conclusions are robust to their exclusion.

Independent and moderating variables

TCO ($\bar{x} = 0.28$; $\sigma = 0.12$) is defined as the ratio of team members clocking more than their nominal hours. Nominal hours is defined according to common Danish work time regulations as a monthly average of 165 hours. By virtue of the comprehensive records on work time distributions in the firm, we are able to adjust our measure to account for absence due to illness or holiday. Additionally, in view of the fact that employees may grow accustomed to slight variation in actual working time across months, we intentionally reduce the sensitivity of our measure by defining the cut-off point for individual cognitive overload to be a half working week (18.75 hours) above nominal hours. While this slightly improves the statistical properties of our model, all findings are robust to the use of unadjusted nominal hours. To enable more specific tests of moderating effects on the negative effect of *TCO*, we compute the inflection point of the variable in the regression model. We find that negative performance effects set in at *TCO* ratios above 30 % and construct a dummy variable to reflect when *TCO* is above this inflection point.

This measure is based on the level of cognitive load of each individual team member and provides us with the ability to track longitudinal changes in the composition of the team without relying on averaging, which would reduce the sensitivity of the measure. By virtue of our access to data on how the number and

distribution of hours continuously changes for each employee, the overload ratio enables us to capture team-level effects of cognitive load on collaboration. Team overload ratio takes on values between 0 and 1, with 0 representing teams with no members experiencing significant cognitive load, and 1 signifying the obverse scenario in which all members are overloaded.

Task complexity ($\bar{x} = 6.2$; $\sigma = 5$) is measured at the project level. While no direct measures of complexity are available, the number of identified and unresolved concerns in need of analysis and problem solving are reported on a monthly basis. When the number of concerns increases, additional resources and manpower are dedicated to analysis, meetings, and the development of relevant countermeasures. We therefore regard the number of active concerns to be an appropriate proxy for task complexity and the associated requirements for analytical information processing and knowledge sharing. Project managers may report a maximum of five concerns in any given month, and are expected to report the severity of each on a four-point scale covering (1) problem identified; (2) owner/investigation; (3) containment in place; and (4) countermeasure confirmed. We construct a measure of analytical requirements by totaling the reversed values of each active problem (so as to assign greater value to unresolved challenges).

Stability ($\bar{x} = 0.5$; $\sigma = 0.85$) is simply a count of the number of consecutive months in which the TCO composition remains stable. Stability is defined with a percentage bound of change to allow for the fact that teams are able to absorb (or, indeed, fail to recognize) minor variations in TCO over time (Bendor et al., 1991; McNamara et al., 2004; Wu and Axelrod, 1995). Specifically, teams are considered stable to the extent that monthly changes in TCO do not deviate more than 5% from the prior month. The use of percentage bounds of change is superior to the use of simple TCO intervals, as intervals may positively bias stability estimates (when TCO is equidistant from cut-off points and hence can change significantly without compromising stability) or negatively bias estimates (when TCO coincides with a particular cut-off value and minor changes therefore register as instability).

Metaknowledge ($\bar{x} = 0.34$; $\sigma = 0.4$) is measured for each individual employee, and may differ across all projects to which this individual contributes. Specifically, metaknowledge is expressed as the ratio of

familiar team members to team size, where familiarity is captured by counting the number of team members on the focal project which the individual is simultaneously collaborating with on other tasks or projects. Hence, the measure intentionally ignores prior collaborations on the grounds that working conditions and associated behaviors of employees may change rather rapidly. An extended measure accounting for prior collaborations is included later as a robustness check.

Control variables

As observations in our data set are structured with monthly intervals, we include *month* dummies to account for aggregate time-series trends. In similar fashion, we add *project phase* dummies to capture phase-specific effects in the standardized NPD design, as for instance different mean levels of technical uncertainty or cross-functional integration. Failure to do so amounts to potential omitted variable bias and risks producing spurious regression results (Malmendier and Nagel, 2011).

Our measure of task complexity cannot be expected to comprehensively depict the state of the project. While more concerns are likely to be associated with more information processing, an increase in the number of reported concerns might signify either extensive problems or simply an astute management team. In order to adequately account for unobserved variation in project health, we control for the level of *project risk* ($\bar{x} = 2$; $\sigma = 0.78$), assessed monthly by project management as either (1) No risk, (2) Some items behind schedule but no risk to project, or (3) Genuine risk to project.

We measure *team size* ($\bar{x} = 38$; $\sigma = 20$) and *management team size* ($\bar{x} = 9$; $\sigma = 1.2$) to address the diverse effects of size on team processes, collaboration quality, and communication efficiency established in the literature (Hackman, 1983; Thomas and Fink, 1963). Additionally, team size has been shown to directly influence the magnitude of variation (Ancona and Caldwell, 1992).

To account for variation in the delegation of authority and frequency of direct involvement as alternative influences on information processing and performance (Leana, 1986), we control for the *cognitive load of the management team* ($\bar{x} = 9.3$; $\sigma = 2.3$). As we do not have access to time registration data for all managers, we

instead rely on a composite average of the total number of management teams each manager contributes to and the number of unique individuals with which the manager collaborates ($\alpha = 0.7$).

In the interest of controlling for alternative sources of cognitive load for individual employees, we include a measure of individual *structural load* ($\bar{x} = 3.6$; $\sigma = 2.7$); a composite average of the number of projects and other tasks to which the employee contributes in the given month ($\alpha = 0.75$). Alternating between multiple tasks and projects generates switching costs and an exponential strain on cognitive capacity (LePine et al., 2005; O’Leary et al., 2011). Multiple memberships also amplify social complexity, when individuals need to engage with an increasing number of people with different specializations, perspectives, and professional languages (De Vries et al., 2014; Dougherty, 1992). We therefore control for individual *interpersonal load* ($\bar{x} = 39.7$; $\sigma = 22.2$), measured as the number of other employees with which the individual interfaces in a given month. Additionally, we add a dummy control for employee *managerial responsibilities* to capture unregistered workload and interactions. Finally, we control for individual *temporal load* ($\bar{x} = 139$; $\sigma = 52.7$) by a simple measure of the number of hours clocked by the employee, which corresponds closely to the measure of cognitive load used to compute TCO. It is included to help control for possible multilevel issues.

We control for project member *seniority* ($\bar{x} = 14.8$; $\sigma = 10.5$). Acquiring relevant expertise and domain-specific knowledge has been consistently demonstrated to require time and deliberate practice (Armstrong and Mahmud, 2008; Ericsson and Charness, 1994). In turn, expertise and domain-specific knowledge have been demonstrated to correlate highly with more efficient problem solving (Gick, 1986; Larkin et al., 1980), improved decision making (Kahneman and Klein, 2009; Salas et al., 2010) and similar benefits so as to bolster overall job performance (Dreyfus and Dreyfus, 2005; Ericsson and Lehmann, 1996; McCloy, Campbell, and Cudeck, 1994). Conversely, however, experience has been associated with a number of limitations related to domain-entrenchment (see Dane, 2010; Holyoak, 1991). Entrenchment involves a loss of flexibility and adaptability in experienced individuals, such that the ability to assume the perspectives of others and appreciate contrary thoughtworlds is constrained (Camerer, Loewenstein, and Weber, 1989). Moreover, the individual tends to become more vulnerable to changes in extant routines and less able to

integrate new conditions into their mode of operating (Cañas et al., 2003). Thus, while the performance implications of project member seniority are uncertain, it is an important source of performance variation.

We also control for project member *age* ($\bar{x} = 44.5$; $\sigma = 9.5$), which has a similar dual role with regard to project outcomes. Consider, for instance, the deteriorative impact of aging on cognitive capacity and decision making (Glisky, 2007; Mell et al., 2009; Mutter et al., 2007). Yet, despite progressive deficiencies in learning, contingency judgment, and memory, aging decision makers have been observed to compensate for superior cognitive capacity by adapting their selection strategies and decision heuristics to environmental characteristics (Hertwig and Todd, 2003; Mata et al., 2012; Mata, von Helversen, and Rieskamp, 2010). Hence, the aging decision maker is able to disregard available information to reduce processing load without significant losses in decision quality (Mata and Nunes, 2010); a phenomenon that is also observed among experts (Garcia-Retamero and Dhami, 2009) and ascribed to the level of experience with a particular decision type or context (Merritt, Karlsson, and Cokely, 2010). Specifically, we control for non-linear effects of age, as the impact of cognitive decline is expected to eventually supplant the efficiency of compensatory strategies and experience (Mata et al., 2012).

Correlation matrix and descriptive statistics (standard deviations and mean, minimum, and maximum values) are reported in Table 3.1.

3.5 RESULTS

Our results from the hierarchical regression are presented in Table 3.2. Model 1 consists of all controls and the four main independent regressors. This baseline model is expanded with a quadratic term of TCO in Model 2 to test the hypothesized inverted u-shaped association between TCO and project performance. Model 3 relies on the computed TCO dummy to test the hypothesized moderating effect of task complexity, stability, and metaknowledge on the negative association between TCO and project performance. The dummy is defined as 1 for all observations with TCO values above the calculated inflection point for the inverted u-shaped relationship (calculated at 0.3). Due to the inclusion of two-way interaction terms, all non-

binary regressors were centered on their respective means. Except for obvious correlations between age and the corresponding squared term, neither independent nor average variance inflation factor scores indicate multicollinearity (1.04-2.89, $\bar{x} = 1.6$).

Consistent with our first hypothesis, the regression results in Model 1 and 2 demonstrate a statistically significant inverted u-shaped relationship between TCO and project performance ($p < 0.001$). When team members are homogenous around low levels of cognitive load or experience only moderate levels of cognitive overload within the team, individuals will reciprocate by maintaining collaboration and their extant levels of contribution. As the degree of cognitive overload within the team increases towards higher TCO ratios, there emerge more apparent incentives to defect from collaboration and reciprocate by adjusting contributions to the perceived effort of others (de Oliveira et al., 2015; Van den Berg et al., 2015). This hypothesized adjustment toward lower levels of information sharing and analytical information processing detrimentally impacts performance.

Substituting our dependent variable for the computed TCO dummy in Model 3, we find support for our second hypothesis that task complexity moderates the negative effects of TCO on project performance ($p < 0.01$). When task complexity increases in the form of more pressing needs for analysis and problem solving behavior, the disruptive performance effects of increasing TCO ratios and subsequently decreasing effort and analytical behavior become salient in the team. Conversely, and in accordance with theoretical predictions, these disruptive effects are less salient in teams facing fewer acute problems and more options to rely on experiential and heuristic reasoning.

Consistent with our third hypothesis, being stable around TCO ratios greater than 30% is seen in Model 3 to negatively moderate the association between TCO and project performance ($p < 0.001$). These results confirm our expectation that while a stable distribution of cognitive load might have positive implications in terms of team members becoming familiar with and better able to compensate for this inequality (main effects of stability are consistently significant and positive in all models, $p < 0.001$), there is nevertheless significant risk of cooperation decay as time progresses, even in the absence of exogenous changes in team

composition of TCO (Fehr and Fischbacher, 2003; Fischbacher and Gächter, 2010; Gunnthorsdottir et al., 2007). Cooperation decay implies an aggregate shift in team behavior toward less elaborate and more heuristic information processing with generally detrimental consequences for project performance.

Finally, our fourth hypothesis is rejected in Model 3, as we see a statistically significant and negative moderation effect of metaknowledge on the association between TCO and project performance ($p < 0.001$). This runs contrary to our expectation that more extensive familiarity with team members provides opportunities to improve information search within the team, thus reducing the reliance on effortful information acquisition (Brandon and Hollingshead, 2004; Healey et al., 2015; Hollingshead, 2001). Rather, an interpretation of this may be that more frequent interactions in different settings may in fact have detrimental consequences, if one observes behavior that motivates reciprocity (e.g. non-cooperation or reduced effort). These reciprocity effects would explain our findings, as the behavioral spillover effect (Bednar et al., 2012; Cason et al., 2012) would induce team members to be more sensitive to perceived reductions in effort or, alternatively, to simply reciprocate prematurely on account of behavior observed outside the team.

We observe several significant controls. Particularly interesting is the consistently significant quadratic effect of age on project performance ($p < 0.05$). In accordance with theoretical predictions, we observe decreasingly positive returns to age, which provides support for the bounded ability of aging team members to compensate for cognitive decline (Mata et al., 2012). The consistently insignificant effects of all three cognitive load parameters at the individual level lend credence to our expectation that the primary performance effects of cognitive load manifest as a collective phenomenon. Indeed, we find that both team size and management team size strongly predict negative performance ($p < 0.001$), which could also be taken as an indication that mutual adaptation and overall team effects of cognitive load manifest more clearly in teams above a certain threshold minimum size. The notion of cognitive load as a collective phenomenon is supported as well by the consistently significant and positive effect of management team cognitive load ($p < 0.001$). As management face more numerous and varied tasks, they are likely to substitute detrimental micromanagement for greater delegation of real authority (Leana, 1986; see also Aghion and Tirole, 1997).

Robustness analyses

To assess the robustness of our independent variables, we undertake meaningful adjustments of their operationalization as a way of ensuring that the observed results are not an artefact of our variable construction. In the regression models, TCO was based on measures of individual cognitive load, measured as the number of hours put in by the individual (adjusted for absence). Specifically, individuals were defined to be cognitively overloaded when their working hours exceeded nominal hours by more than half a working week (18.75 hours). As a robustness check, we recalculate TCO using less sensitive cut-off values of individual cognitive load amounting to an entire working week in excess of nominal hours (37.5 hours). Though significance levels are reduced slightly, the interpretation of our findings remains similar.

All moderating variables are adjusted in similar fashion. Thus, our task complexity measure is adjusted to only include concerns that have not yet been rated as 4) countermeasure confirmed, as these problems are less likely to require significant analytical activity. We adjust the percentage bound of change underlying our stability measure from 5% to 10% to test if the time-dependent adaptive processes within the team are maintained in the presence of more variation in TCO ratios over time. Neither adjustment produces meaningful changes in our main regression results.

Finally, with regard to meta-knowledge, there is an implicit assumption in research on familiarity and collective systems of knowledge that all team members develop the same level of meta-knowledge. Recent research has challenged this assumption and proposed that meta-knowledge may instead be concentrated with one member (Mell et al., 2014). In teams with concentrated meta-knowledge, the central member is proposed to act as a catalyst for the identification and integration of distributed knowledge. The individual effectively adopts a brokering role to mitigate unnecessary cognitive effort and search costs on the part of each other member. With extensive knowledge of each team member, the central individual may broker relevant meetings between team members to share and process complementary information without them having to engage needlessly with others. Thus, while decentralized meta-knowledge has an advantageous

effect on the cognitive load of team members, centralized meta-knowledge may be sufficient to reduce peer sensitivity to differences in contributions among members, as relevant interactions are ensured. As members are less motivated to react to perceived differences in contributions, the negative implications of TCO are mitigated. However, operationalizing centralized meta-knowledge as the highest level of individual meta-knowledge in the team, we find similar results compared to decentralized meta-knowledge.

3.6 CONCLUDING DISCUSSION

This article contributes to our knowledge of collective information processing behavior in organizations. Organizations routinely seek to integrate dispersed and specialized human capital from across the firm to improve decision-making and problem solving, but these efforts fall short when individuals fail to share and process available information (Lau and Murnighan, 2005; Stasser, 1999; Wittenbaum and Stasser, 1996). While information processing behavior has been studied extensively in psychology and management (Ayal et al., 2015; Gavetti and Levinthal, 2000; Hogarth and Karelaia, 2005), our understanding of how variation in the information processing behavior of team members impacts collective outcomes is “*in its infancy*” (Mohammed and Schwall, 2009: 302; Loock and Hinnen, 2015: 2033; Vuori and Vuori, 2014: 1691), despite the prevalent use of team structures to facilitate coordination (Mathieu et al., 2014). Considering information processing behavior across different levels implies a departure from extant research, which has routinely emphasized individual-level strategies with an impact on individual decision making (Hogarth and Karelaia, 2007; Vuori and Vuori, 2014), or organizational-level strategies with an impact primarily on unit or organizational outcomes (Bingham, Eisenhardt, and Furr, 2007).

We explore cognitive load as an antecedent of individual information processing behavior (Shah and Oppenheimer, 2008) and, in turn, as an antecedent of collective performance. Specifically, we argue that conditional cooperation functions as the primary mechanism underlying both the adaptation of individual information processing within the team, and the aggregation of individual behavior to collective outcomes.

Drawing on comprehensive NPD data from a global manufacturing firm, we find evidence of an inverted u-shaped association between TCO, i.e. the ratio of team members with high cognitive load, and project performance (Hypothesis 1). We argue that low levels of TCO have beneficial implications for team information processing and performance, mainly because teams are less likely to engage in extensive analyses that are prone to overfitting through the inclusion of irrelevant information (Gigerenzer, 2008; Gutierrez and Kouvelis, 1991; Hertwig and Todd, 2003). While disruptive performance effects do manifest as TCO ratios increase further, we find that this decline in performance is moderated by three distinct factors. First, teams become more susceptible to the disruptive effects as task complexity increases (Hypothesis 2), due to their impaired ability to adequately address complex problems through the sharing and collective processing of available information. Second, when teams remain stable around moderate or high TCO ratios, performance continues to decline with consecutive periods of stability (Hypothesis 3). We attribute this to cooperation decay within the team, as team members keep re-adjusting their effort to the perceived effort of others, thereby inducing consecutive downward shifts in aggregate effort. Third, we find that as teams develop more extensive metaknowledge, the negative effects of misaligned behavior at higher TCO ratios is potentially amplified, contrary to our prediction (Hypothesis 4). Greater metaknowledge, it seems, enables *bad* behavior to influence multiple team contexts through behavioral spillover effects (Bednar et al., 2012; Canon et al., 2012).

The proposed relationships between cognitive load, collective behavior, and project performance are heavily premised on research into conditional cooperation (e.g. de Oliveira et al., 2015; Fischbacher and Gächter, 2010) and the effect of cognitive load on cooperative behavior (Duffy and Smith, 2014; Schulz et al., 2014). The majority of research in these areas employs game theoretical research designs to study the cooperative behavior of subjects under diverse conditions with the most prominent research design being public good games (Van den Berg et al., 2015; Fischbacher et al., 2001) and variations on the standard prisoners dilemma (McNamara et al., 2004). While game theoretical research has enabled significant advances in our understanding of human cooperation, they also suffer from particular limitations going forward. Nijstad and De Dreu (2012: 19) note that the empirical foundations often derive “*from tightly*

controlled laboratory experiments with ad hoc groups of students performing relatively short-lived tasks with hypothetical rather than real consequences to the individuals and their groups (or the wider organization)". While there are numerous efforts to actively address these concerns in repeated games, it is important to test derived hypotheses in the field where *"the cooperative and competitive motives could be induced by features of the relevant context"* to substantiate the inferences drawn from the lab (Toma and Butera, 2015: 464). As such, a key contribution of this paper is to adapt findings from the lab and test their validity in real-world settings. Additionally, there is significant room for qualitative studies to explore how separate information processing behaviors compete or complement each other in specific contexts (e.g. Maitland and Sammartino, 2015), and for studies in general to consider the *"full ensemble of games than an individual faces"* to account for behavioral spillover effects (Bednar et al., 2012: 13), possibly by use of proxies such as cognitive load.

More generally, the paper seeks to strengthen the psychological design of the firm and its constituent decision processes by coupling insights from psychology to higher-level organizational structures and outcomes (Kahneman and Klein, 2009; Powell et al., 2011). Specifically, we have identified the adaptive implications and performance correlates of different team compositions, which enables us to make novel predictions on the management and allocation of employees with different levels of cognitive load, and to better ensure the integration of human capital despite differences in workload. This insight that employee behavior is interdependent and contingent on the sociocognitive composition of the team *"will enable us to transition from independent intervention strategies to more effective interdependent interventions that incorporate individuals' social contexts into their treatments"* (Aral and Nicolaides, 2017: 2). Additionally, by tying individual cognition and behavior directly to elements of organizational design that are amenable to managerial control, the propositions provide avenues for the profitable execution of strategy (Powell et al., 2011). Here, firm performance arises not only from the novelty or inimitable advantages of firm strategies, but rather from the application of insights from behavioral research to identify and address systematic errors in decision-making, invisible patterns of behavioral adaptation, and general deviations from predicted rationality in more mundane and fundamental activities.

The proposed theory has important practical implications. As managers decide on the task allocation and rate of utilization of their employees, and often reify those decisions through organizational design (De Vries et al., 2014; O’Leary et al., 2011), they simultaneously govern employees’ cognitive load, which in turn impacts their proclivity for either heuristic reasoning or more analytical information processing (Homan et al., 2007). By linking analytical and heuristic reasoning with managerial choices vis-à-vis the task allocation and utilization of employees, the paper proposes a relationship between human capital, organizational design, and performance that is malleable and amenable to managerial control. In this sense, the paper can be said to address the issue of how and when our insights on individual behavior and cognition, as derived from studies of isolated individuals under the auspices of psychology, become valid and valuable in turbulent, temporal, and multi-agent organizations (see Bingham and Eisenhardt, 2011; Vuori and Vuori, 2014). Thus, the paper aligns with recent microfoundations literature, which calls for exploration of the processes through which characteristics of heterogeneous individuals interact and are aggregated within and across organizational structures (Felin et al., 2012; Gavetti et al., 2007).

In doing so, the paper contributes also to an emerging line of research on the discriminating effects of structural arrangements and governance choices on cognition and behavior (Foss and Weber, 2016; Turner and Makhija, 2012; Weber and Mayer, 2014). Becoming aware of the impact of different organizational design choices on the exacerbation or mitigation of interpretative conflict, cognitive adaptation, and similar issues promises new avenues for management to improve the functioning and predictability of their organization.

Limitations and future research

While our single company sample improves our ability to control for extraneous variation at the level of the firm and the industry (see Siggelkow, 2007), and simultaneously reduces the likelihood of spurious influences on the hypothesized mechanisms and relationships (Harrigan, 1983), we cannot exclude the existence of firm-specific effects. Future research would need to confirm and build on our findings using

data from multiple firms to improve generalizability (Hambrick, 1981). To this end, it is advisable to balance fine-grained research strategies, such as ours, with more accessible cross-sectional samples to approach a “*medium-grained methodology wherein the generalizability of cross-grained methodologies is combined with the detail of fine-grained methodologies in large sample studies*” (Harrigan, 1983: 399).

The study is limited by our inability to directly observe collaboration. We infer collaboration from the co-allocation of individuals in the same period, but this need not be true. Future studies need to devise ways to better discriminate collaboration and co-allocation. By the same token, we do not observe technical contingencies (e.g. breakdowns) or resource constraints (e.g. delayed equipment delivery or staffing limitations) that may significantly impact performance but do not pertain to team dynamics. Moreover, we are faced with potential survivor bias, as our sample consists only of active and completed projects. While the firm screens project proposals extensively to minimize the risk of project termination, we cannot exclude the potential bias of failures being underweighted in the sample (Cooper and Kleinschmidt, 1990).

Another potential limitation of the theory is the intentionally broad conceptualization of heuristic reasoning as a reduction in the amount and depth of salient information considered (Shah and Oppenheimer, 2008), despite the vast literature on different forms of heuristics that reduce information according to various rules with different implications for information processing (e.g. Gigerenzer and Goldstein, 1996). As demonstrated by Maitland and Sammartino (2015), different individuals in a decision-making team will draw on different heuristics to search for, discover, and analyze information. As such, convergence on heuristic reasoning does not equal convergence in terms of the particular heuristic rules followed by individual agents. However, to the extent that such heuristics have similar implications in terms of reducing salient information and relying on fewer informational cues (Gigerenzer and Brighton, 2009), the expectation that information elaboration processes will be constrained in such contexts should remain valid. Nevertheless, while this approach aligns with calls to “*push past just generating heuristic lists*” to look for general truths about heuristic reasoning (Maitland and Sammartino, 2015: 1556), it does constitute a conscious limitation and potential blind spot in the argument. Future research would need to test whether interactions between cognitive load and team performance are impacted by the particular heuristic rules used by collaborating

individuals. Additionally, future research should consider substitutability or complementarity of team members in terms of their applied strategies and knowledge (e.g. Camerer and Fehr, 2006; Nijstad and De Dreu, 2012; Postrel, 2002). When certain members are indispensable to team outcomes, their behavioral preferences are likely to impact the team equilibrium more than dispensable members, who are more easily ejected or denied influence. This relates more broadly to the argument that more powerful members are able to sway the team to their preference (Ten Velden et al., 2007; 2010).

TABLE 3.1 – CORRELATION MATRIX, ALL VARIABLES

	Timeliness	TCO	Task Complexity	Stability	Metaknowledge	Team Size	Structural Load	Interpersonal Load	Temporal Load	Seniority	Age	Phases	Current\Month
Timeliness	1.00												
TCO	-0.20	1.00											
Task Complexity	0.20	0.10	1.00										
Stability	0.10	-0.12	0.19	1.00									
Metaknowledge	-0.23	-0.03	-0.39	-0.09	1.00								
Team Size	0.15	-0.13	0.36	0.28	-0.31	1.00							
Structural Load	-0.08	0.17	0.01	-0.01	0.11	0.00	1.00						
Interpersonal Load	0.03	-0.12	0.14	0.18	0.11	0.68	0.21	1.00					
Temporal Load	0.02	0.16	-0.00	-0.01	0.01	0.02	0.09	0.03	1.00				
Seniority	0.03	0.03	0.08	0.03	-0.04	0.08	0.04	0.03	0.00	1.00			
Age	0.02	0.05	0.08	0.01	-0.06	0.03	-0.02	-0.02	0.00	0.66	1.00		
Phases	-0.44	0.22	-0.24	-0.14	0.25	-0.27	0.10	-0.13	-0.02	-0.06	-0.05	1.00	
Current\Month	-0.22	0.32	0.03	-0.10	-0.28	0.09	0.14	-0.04	0.07	0.04	0.06	0.17	1.00
Mean	-0.3	0.29	6.2	0.5	0.34	37.93	3.59	39.67	135.13	14.75	44.5	5.09	670.63
SD	0.32	0.12	4.99	0.85	0.41	20.07	2.69	22.19	39.53	10.5	9.5	1.48	6.99
Min	-1.95	0	0	0	0	1	0.5	0	1	1	19	2	660
Max	0.1	1	15	4	1	79	22.5	122	300	49	77	8	683

TABLE 3.2 – REGRESSION MODELS

	(1) Timeliness b/se	(2) Timeliness b/se	(3) Timeliness b/se
OverLoadRatio_weighted	-0.053* (0.02)	0.238*** (0.05)	
OLOL		-0.375*** (0.07)	
TCO_Dummy			-0.014*** (0.00)
Task Complexity	-0.006*** (0.00)	-0.007*** (0.00)	-0.006*** (0.00)
Stability	0.013*** (0.00)	0.012*** (0.00)	0.019*** (0.00)
Metaknowledge	0.040* (0.02)	0.037* (0.02)	0.078*** (0.02)
TCO_Dummy # Task Complexity			-0.003** (0.00)
TCO_Dummy # Stability			-0.021*** (0.00)
TCO_Dummy # Metaknowledge			-0.103*** (0.01)
Team Size	-0.002* (0.00)	-0.002** (0.00)	-0.002* (0.00)
Structural Load	0.000 (0.00)	0.001 (0.00)	-0.000 (0.00)
Interpersonal Load	0.000 (0.00)	-0.000 (0.00)	0.000 (0.00)
Temporal Load	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)
Seniority	-0.008 (0.01)	-0.008 (0.01)	-0.007 (0.00)
Age	0.050+ (0.03)	0.044+ (0.03)	0.048+ (0.03)
Age, Squared	-0.001+ (0.00)	-0.000 (0.00)	-0.000+ (0.00)
Phase 2	0.000 (.)	0.000 (.)	0.000 (.)
Phase 3	0.051** (0.02)	0.070*** (0.02)	0.064*** (0.02)
Phase 4	0.245*** (0.02)	0.264*** (0.02)	0.254*** (0.02)
Phase 5	0.233*** (0.03)	0.250*** (0.03)	0.248*** (0.03)
Phase 6	0.081*** (0.02)	0.093*** (0.02)	0.094*** (0.02)
Phase 7	0.198*** (0.02)	0.204*** (0.02)	0.219*** (0.02)
Intercept	-1.120+ (0.61)	-1.047+ (0.60)	-1.083+ (0.61)
N	7342	7342	7342
R2	0.559	0.565	0.568
DF	1559	1559	1559

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

FIGURE 3.1 – TCO # TCO

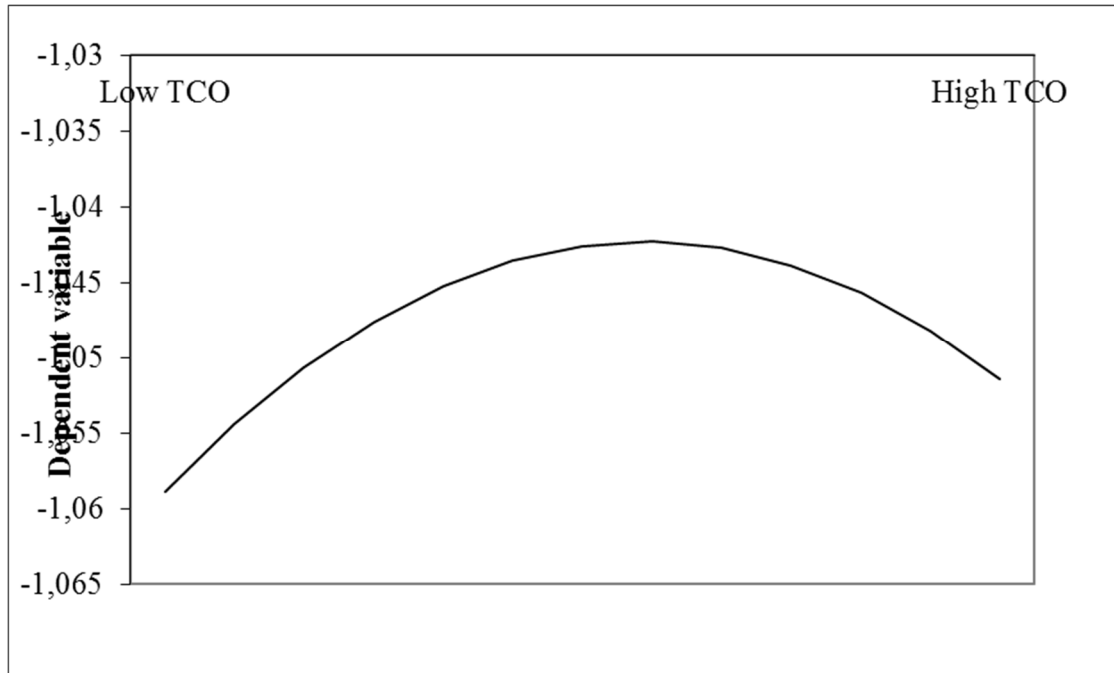


FIGURE 3.2 – TCO_DUMMY # TASK COMPLEXITY

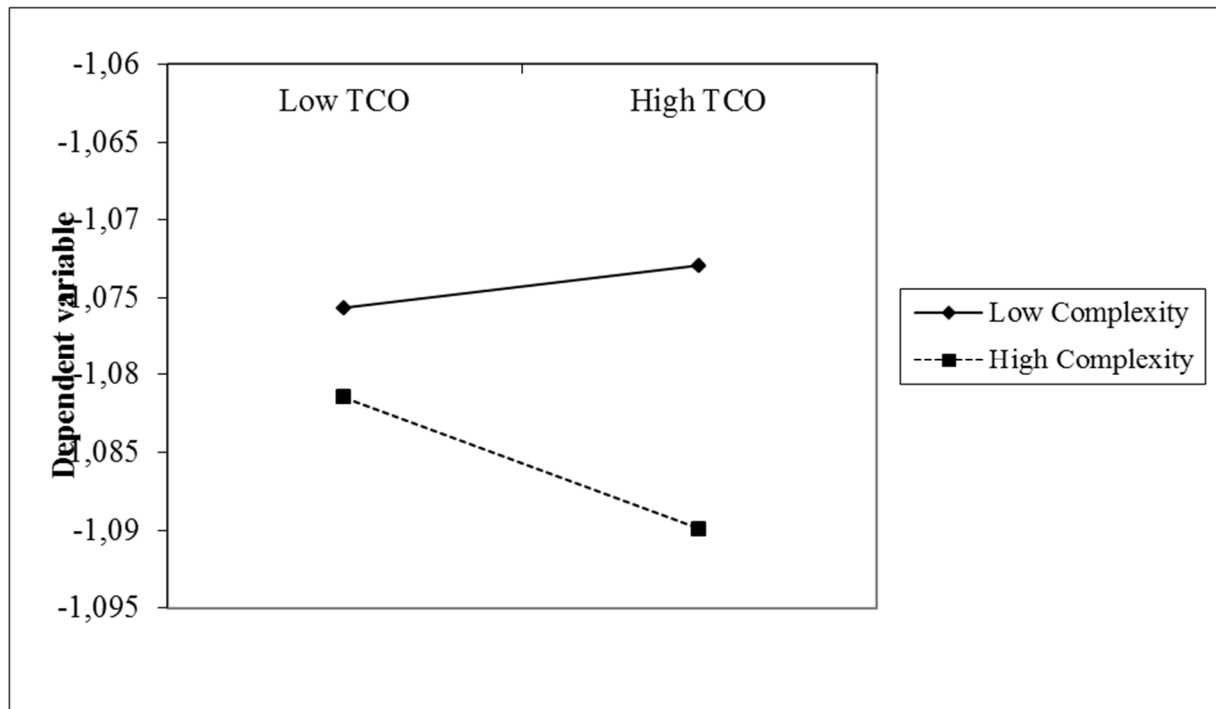


FIGURE 3.3 – TCO_DUMMY # STABILITY

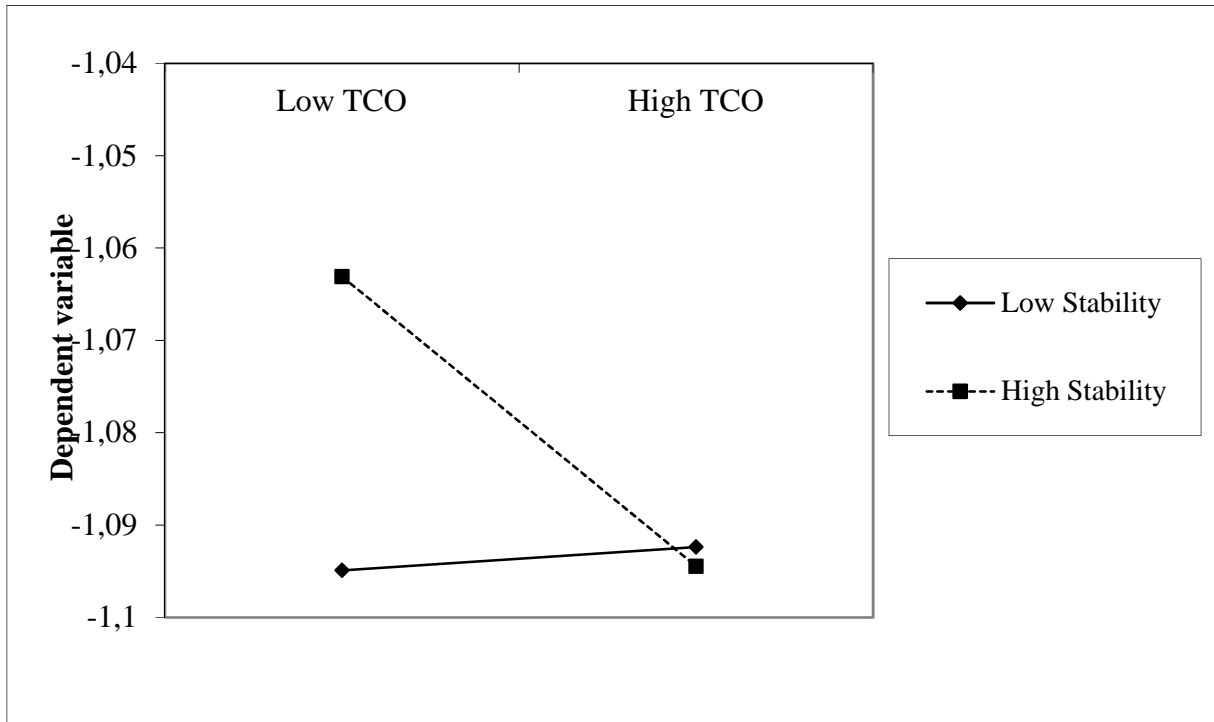
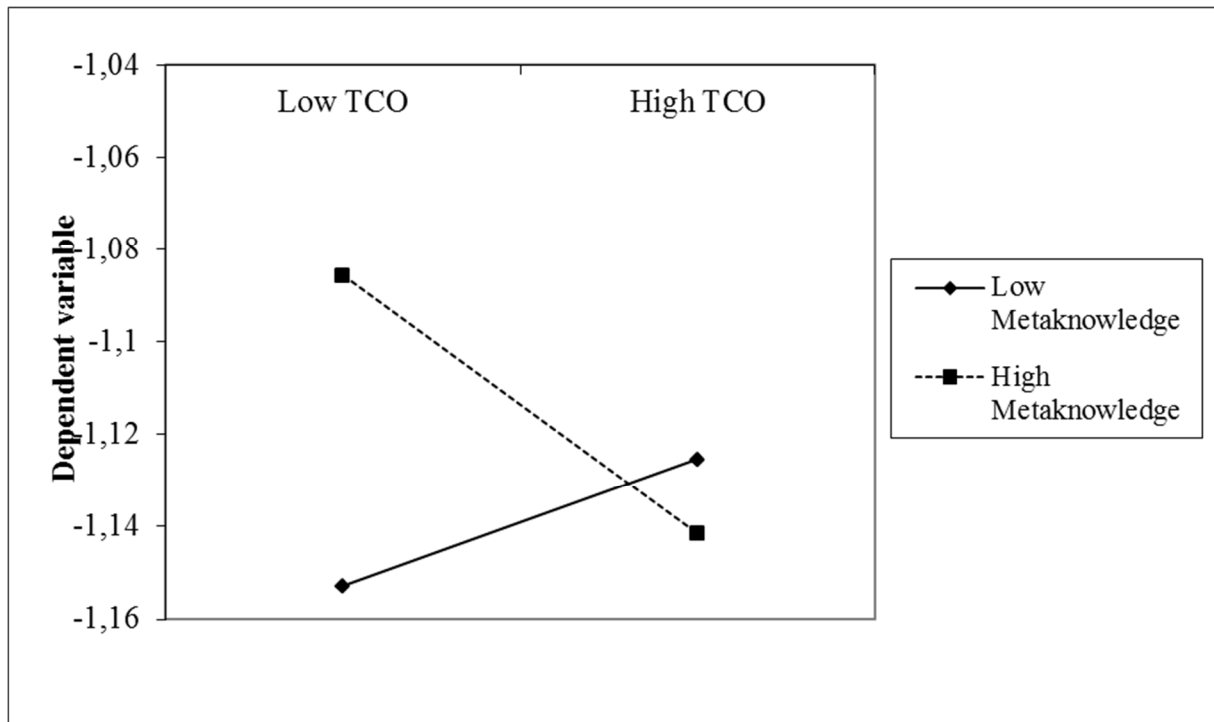


FIGURE 3.4 – TCO_DUMMY # METAKNOWLEDGE



CHAPTER 4

SO CLOSE, YET SO FAR

THE INTERDEPENDENCE OF GEOGRAPHICAL AND PSYCHOLOGICAL DISTANCE IN COLLABORATION

Jesper Christensen¹

Marcus M. Larsen²

ABSTRACT

When companies engage in non-routine work, the ability to combine human capital from across the organization to mitigate complexity and enable novel solutions is highly valuable. Conversely, the physical separation of functions and units is often beneficial when complexity is less pronounced and independent units are allowed to hone their specializations and reduce unwarranted coordination costs. However, firms often struggle to strike an appropriate balance between integration and separation and make timely decisions on the allocation of employees. In this paper, we propose that the quality of collaboration and the ability of employees to contribute to project performance cannot be managed on the basis of geographical distance alone, but rather depends on the interaction of multiple dimensions of distance. We hypothesize and find support for the argument that collaboration quality and subsequent performance hinges strongly on the degree of psychological distance perceived by each employee. We show how performance varies with the degree of psychological distance from the task at hand, and how this association is moderated by the level of geographical dispersion of employees. Thus, the paper proposes contingent interaction effects between multiple dimensions of distance that better predict collaboration quality and improves the basis for strategic decision making on organizational design, location choice, and the allocation of human capital within the firm.

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4.1 INTRODUCTION

When companies undertake non-routine projects, there is often a need for employees from across the organization to collaborate (Adler, 1995; Brown and Eisenhardt, 1995; Majchrzak, More, and Faraj, 2012). Yet, existing evidence indicates that efforts to integrate specialized and diverse human capital across functional and departmental boundaries produce mixed results, often at disproportionate costs (Lovelace et al., 2001; Sivasubramaniam, Liebowitz, and Lackman, 2012).

The inconsistent outcomes of integration efforts are often attributed to challenges of coordination (Kretschmer and Puranam, 2008). Coordination problems arise due to the lack of shared and accurate knowledge about how and when one is interdependent with others and about the decision rules that others are likely to use (De Vries et al., 2014). Specifically, coordination is impeded when individuals employ different cognitive frames (Dougherty, 1992; Weber and Mayer, 2014), hold inconsistent representations of tasks and the organization (Cronin and Weingart, 2007; Cronin, Weingart, and Todorova, 2011), or are misaligned with regard to project scope, technical ambitions, and expectations regarding the capabilities and limitations of others (Gulati et al., 2005). A common source of such misalignment is distance; when employees are separated, common ground and mutual understanding becomes more difficult to develop and maintain (Allen, 1977; Hinds and Bailey, 2003).

In this article, we explore how two distinct dimensions of distance between interdependent employees influence collaborative behavior and project performance. Distance is commonly understood and construed as the geographical distance between employees (e.g. Storper and Venables, 2004; Gray et al., 2015). Seeing organizations as “*interrelated behaviors of people who are performing a task that has been differentiated into several distinct subsystems, each subsystem performing a portion of the task*” (Lawrence and Lorsch, 1967: 3), research has demonstrated how physical co-location of employees and organizational units, with face-to-face interaction in particular (Allen, 1977; Storper and Venables, 2004), enables more frequent interactions and knowledge flows compared to geographical dispersion. But while geographical proximity has long been lauded as a particularly effective mechanism to foster coordination and collaboration (Daft and Lengel, 1986), studies have found inconsistent evidence for this expectation (Cha et al., 2014; Wilson et al.,

2013), which has been ascribed in part to the failure of prior studies to account for variation in psychological distance (Chong et al., 2012; Wilson et al., 2008). Specifically, our perception of objects (e.g. tasks, teams, or colleagues) depends on their distance from us either in time, in terms of social or professional differences, or in their relevance to our immediate context (Trope and Liberman, 2003; Pronin, Olivola, and Kennedy, 2008), which impacts information processing, decision-making, and collaboration. Psychologically distant objects become less salient and are construed in more abstract terms, causing individuals to deemphasize relevant details and idiosyncrasies in favour of more creative cognition (Förster et al., 2004; Liberman et al., 2007).

Consolidating comprehensive longitudinal data from a world-leading hydraulics manufacturer, we explore the contingencies between geographical and psychological distances among interdependent employees. We confirm a negative effect of geographical dispersion on team performance. Similarly, we observe negative effects of psychological distance when collaborating employees are psychologically distant with reduced attention to detail and analytical thinking in favour of more creative and potentially disruptive cognition. However, when exploring the interaction between these dimensions, we find that geographical dispersion positively moderates the effects of psychological distance. To explain this, we argue that while teams do benefit from geographical proximity, this holds true only when team members are psychologically close to the tasks at hand. When this condition is violated, e.g. when teams engage with outside professionals in search of knowledge or attempt to anticipate conflict by involving employees and departments that will assume responsibility for the project in the future, the disruptive cognition and reduced analytical effort associated with psychological distance is magnified in local teams that lack appropriate mechanisms to limit or guide this behavior, thereby undermining the collaborative benefits of proximity. Conversely, we find that the negative effects of psychological distance are mitigated as teams become more dispersed. We theorize that geographical dispersion imposes restrictions on the behavior of team members so as to encourage more selective contributions and interventions in team decision processes. This curbs the potentially disruptive effects of psychological distance and helps channel the potential benefits of creative cognition.

The study responds to calls for an improved understanding of the contingencies between distance dimensions in organizational work (e.g. Trope and Liberman, 2010; Wilson et al., 2013). Our findings lend

credence to the claim that the effects of different distance dimensions cannot be adequately assessed in isolation (Boschma, 2005; Wilson et al., 2013). Moreover, our findings contribute to the expanding research stream on the relevance of behavioral insights for organizational design and the allocation of human capital (e.g. de Vries et al., 2014; Foss and Weber, 2016). By bringing insights from CLT on the antecedents of collaborative behavior to bear on operational challenges to do with the allocation and integration of employees, our study helps clarify the conditions under which the advantages of close collaboration manifest and are likely to outweigh other strategic options (e.g. outsourcing and geographical dispersion of organizational units). Thus, the study carries implications for strategic decision making and the organizational design of collaboration and knowledge sharing (Higgins, 1996; Rietzschel et al., 2007).

4.2 THEORETICAL FOUNDATION: CONSTRUAL LEVEL THEORY

Psychological distance resonates with research into Construal Level Theory (CLT) that shows how individuals construe and evaluate information about tasks and individuals differently depending on their social, temporal, or hypothetical distance from them, which prompts individuals to adapt their information-processing and decision-making behavior accordingly (Liberman and Trope, 1998; Trope and Liberman, 2003; Pronin et al., 2008). Greater psychological distance has been linked to more abstract and creative cognition (Förster et al., 2004), and to more global cognition that emphasizes potentials and common ground over problems and dissimilarities (Förster, 2009; Giacomantonio, De Dreu, and Mannetti, 2010). A reverse pattern has been observed for psychologically proximate individuals, who emphasize detail, identify immediate challenges and dissimilarities, and engage in more constrictive and analytical thinking (Eyal et al., 2004).

In prior studies, psychological distance is determined by variations in temporal and spatial distance (e.g. working with immediate or distant deadlines), social distance (e.g. social projections and ingroup/outgroup membership, see Clement and Krueger, 2002), and the extent to which tasks and decisions are hypothetical or have tangible implications (Fujita et al., 2006; Liberman, Sagristano, and Trope, 2002; Smith and Trope,

2006). In theory, psychological distance is rooted in the interaction of these dimensions (Giacomantonio et al., 2010).

When an individual perceives a task or other individuals to be distant along one or more of these dimensions (e.g. when tasks are due in the immediate or the more distant future, or when collaboration involves colleagues from different departments or hierarchical strata), detailed and pertinent information about the idiosyncrasies of the work or the activities and intentions of colleagues become more difficult to access and experience. Psychological distance therefore induces individuals to employ more general schema and representations to categorize and understand tasks and other people (Trope and Liberman, 2010); a phenomenon known as high-level construal. These mental representations are more abstract and decontextualized, as they organize available knowledge around few general elements; “*one focuses on the forest rather than on the trees*” (Giacomantonio et al., 2010: 762; Smith and Trope, 2006).

When tasks or colleagues are perceived to be psychologically close, specific and discrete information is more readily available, which enables low-level construal with more detailed, contextualized, and nuanced representations (Förster et al., 2004; Liberman et al., 2007). This implies less schematic perceptions that accommodate contextual specificity and associate available knowledge with a larger set of distinct categories and elements (Förster et al., 2004); “*one focuses on the trees rather than on the forest*” (Giacomantonio et al., 2010: 762).

4.3 HYPOTHESIS DEVELOPMENT

We develop a set of hypotheses associating project performance with the geographical dispersion of the project team and the psychological distance between employees and tasks. While each distance dimension is expected to exert a negative effect on performance, we posit that geographical dispersion moderates the effects of psychological distance on collaborative behavior and project performance.

Geographical distance

Geographical proximity and distance are important organizational design parameters (Kraut et al., 2002; Monge et al., 1985). Specifically, the distance between organizational members has been suggested to impact the quality of interpersonal collaboration and the pursuit of joint behavior across units, partly because “*where activities take place partly determines what actors can do, what they know, and what they can learn*” (Tyre and Von Hippel, 1997: 3).

Prior studies indicate that collaboration and knowledge sharing decrease when individuals and units are physically dispersed (Allen, 1977; Hansen and Løvås, 2004; Staats, 2012; Van den Bulte and Moenaert, 1998). Studies have also associated distance with moral hazard and coordination problems, especially when collaboration builds on tacit knowledge (Storper and Venables, 2004; Sonn and Storper, 2008). As organizational members cannot easily build interpersonal relationships and trust and are prevented from direct observations of each other (Zaheer and Venkataraman, 1995; Zollo, Reuer, and Singh, 2002), distance has often been associated with consequences such as inertia, organizational complexity, and coordination costs (Cummings and Kiesler, 2007; Larsen, Manning and Pedersen, 2013; Rawley, 2010).

Given the challenges emanating from distance, spatial proximity has often been lauded as a particularly beneficial mechanism to foster improved integration and collaboration (Faraj and Xiao, 2006; Gray et al., 2015; Kahn and McDonough, 1997). When activities are interdependent and must be “*integrated to achieve effective performance of the system [and] unity of effort among the various subsystems*” (Lawrence and Lorsch, 1967: 3-4), proximity allows organizational members to build collegial social environments and common ground (Clark and Brennan 1991, Kraut et al. 1990), especially through more frequent face-to-face interaction (Storper and Venables, 2004) Accordingly, much research has linked proximity with a vast array of performance benefits, such as improved cross-functional collaboration and coordination (Jassawalla and Sashittal, 1999; Song et al., 1997), innovation performance (Hoegl and Proserpio, 2004), and knowledge sharing (Frank, Ribeiro, and Echeveste, 2015; Staats, 2012). Based on these considerations, we expect a negative association between the geographical distance between project team members and the performance of the project.

Hypothesis 1: Geographical distance between project members negatively impacts project performance.

Psychological distance and formal responsibility

Changes in psychological distance and mental construal have important and rather immediate cognitive and behavioral implications (Braga, Ferreira, and Sherman, 2015; Liberman et al., 2002; Wilson et al., 2013). Studies have established an association between psychological distance and more creative and expansive cognition that implies a greater tolerance for variation. Being psychologically distant promotes an abstract and more holistic approach to collaboration with an emphasis on identifying areas of agreement and entertaining novel perspectives (e.g. Giacomantonio et al., 2010; Henderson, Trope, and Carnevale, 2006). Conversely, psychologically close activities are approached through more detail-oriented and constrictive frames that emphasize the identification and resolution of immediate concerns (Förster et al., 2004). In support of this, Förster (2009) demonstrates how people engaging in high-level construal tend to emphasize similarities and possibilities over dissimilarities and potential problems, whereas individuals with low-level construal tend toward the reverse. Similarly, psychological distance has been shown to impact negotiation tactics so as to optimize mutual gain and perceived fairness, as opposed to maximizing individual outcomes (Henderson et al., 2006; Henderson and Trope, 2009).

The mechanism underlying psychological distance and the attendant changes in mental construal and behavior is one of cognitive salience (Braga et al., 2015; Wilson et al., 2013). When psychological distance is assessed in terms of the social relationship between individuals or the temporal separation of individuals and tasks, it is to capture the “*subjective experience that something is close or far away from the self, here, and now*” (Trope and Liberman, 2010: 440). When individuals perceive tasks or colleagues as being distant, it is beneficial to preserve and emphasize only the essential and stable properties of the thing, whereas when objects are perceived as more proximate, it is useful to identify the minute details to enable action and decision-making. The mechanism therefore aligns cognitive functions with perceived requirements to help process objects effectively.

Research into the behavioral effects of accountability mirrors this mechanism by showing how formal accountability stimulates greater subjective salience of tasks and information (Lerner and Tetlock, 1999). Accountable individuals are subject to outside assessment of their work and will likely have to justify

decisions (Frink and Klimoski, 1998; Weigold and Schlenker, 1991). This reduces psychological distance to the task and encourages preemptive self-criticism (Tetlock, 1983; Tetlock, Skitka, and Boettger, 1989) – that is, individuals engage in more thorough and complex thinking as they attempt to challenge and re-think their conclusions and anticipate possible objections. Thus, when individuals are formally accountable for the outcomes of group processes or specific tasks, the perceived level of responsibility induces greater cognitive effort and more extensive information processing of pertinent details and potential impediments to task completion (Blaskovich, 2008; Karau and Williams, 1993). Similarly, felt responsibility leads employees to avoid and more likely punish cognitive and social loafing within the group (Weldon and Gargano, 1988).

In sum, individuals with low perceived accountability (e.g. when presently responsible or expected to assume formal responsibility in the near future) will experience low levels of psychological distance and therefore engage with greater attention to detail, more extensive cognitive effort, and a more pronounced emphasis on potential impediments to progress. Conversely, contributing individuals with more distant prospects of formal accountability are expected to engage with more holistic perceptions, an emphasis on novel perspectives over more immediate details and concerns, and less cognitive engagement with pressing analytical requirements (Lieberman et al., 2002). As a rule, the downsides of reduced analytical effort and attention to detail are expected to impede project performance.

Hypothesis 2: Psychological distance between project members negatively impacts project performance.

Bounded interventions

While we have posited main effects of geographical and psychological distance, it is important to recognize that employees are always situated both geographically and psychologically in relation to their work. It is reasonable to expect potential contingencies between these dimensions of distance, as the relevance of proximity tends to vary with context and task (March and Simon, 1958; Thompson, 1967). For instance, research points to performance and innovation benefits accruing from access to diverse knowledge and comparative advantages in distant locations (Dunning, 1993; Lewin and Peeters, 2006). In addition, when activities require different methods and knowledge, their separation enables organizations to

economize on bounded rationality and benefit from specialization (Connor and Prahalad, 1996). Consequently, the organizational design necessary to manage particular interdependencies may vary considerably (Foss and Weber, 2016; Lawrence and Lorsch, 1967; Van de Ven et al., 1976), with more integrated and proximate arrangements often reserved for complex tasks with more extensive analytical requirements (Cuijpers et al., 2011; Mishra and Shah, 2009). When work requires less explicit elaboration and processing of pertinent information, the benefits accruing from geographical proximity are expected to be less pronounced (Braga et al., 2015; Wilson et al., 2013).

Similarly, the negative effects of psychological distance are expected to depend on the degree of geographical dispersion. As dispersion increases, the frequency of interaction decreases and teams become less able to maintain extensive mutual knowledge (Hoegl and Proserpio, 2004). Contextual information about the local conditions and constraints of individual members is not communicated effectively, as dispersed members become increasingly selective in their contributions and in their ability to recognize the information that would impact collaboration (Cramton, 2001; Hinds and Bailey, 2003). However, when distant team members are forced to be more selective in their interventions and communication to the group, this could help curb and filter the potentially detrimental emphasis on creativity and novel perspectives associated with psychological distance and high-level construal. As the required effort to communicate and understand the specificities of the team and the task increases with distance, individuals are incentivized to interact less frequently with the team and become more cognizant of the quality and relevance of their suggestions (Carlile, 2004; Zaccaro and Lowe, 1988). As such, distant team members have been observed to be less able to initiate the restructuring of work processes or objectives within the team without local support (Hoegl and Proserpio, 2004).

In sum, when combining the effects of geographical dispersion with its expected ability to constrain the disruptiveness of creative cognition from psychologically distant members, we hypothesize a positive moderation effect of geographical distance on psychological distance and, hence, on project performance.

Hypothesis 3: Geographical distance positively moderates the negative association between psychological distance and project performance.

4.4 DATA AND METHODS

To examine the effects of psychological distance and geographical distance on project performance, we exploit an opportunity to trace the new product development (NPD) efforts of a world-leading hydraulics pump manufacturer over a two-year period. Drawing on both internal and external sources of new knowledge and innovation, NPD projects emerge from initial technology trials within the firm and are tasked with developing and maturing new product concepts and process technologies (Adler, 1995). Their lifecycle spans from preliminary design decisions and strategic prioritizations over concept development, validation, and approval to ramp-up and optimization of final manufacturing. Collectively, these activities account for the bulk of resources invested in development activities and project organizing within the firm.

Given their strategic importance and significant resource commitments, NPD projects are subject to extensive standardization, rigorous documentation requirements, and continuous assessments of both current and prospective performance. All projects are comprised of seven distinct phases and follow a standardized stage gate model with predefined tasks and responsibilities in each phase and preset criteria for progression from one phase to the next. Within this structure, each project management team is tasked with delivering monthly reports that detail project performance on key operational indicators and potential deviations. Main operational indicators include project timeliness and delays, salary expenses, expected unit production costs, direct development costs from materials and project activities (e.g. workshops, meetings, and travel), and investment costs accruing from new equipment acquisitions and internal costs of factory time. The management team is also expected to account for and describe all problems currently being analyzed and resolved by the project team, and to provide an overall assessment of the current level of risk to the objectives of the project. Additionally, as projects mature, the management team is expected to provide quarterly estimates on product quality, warranty rates, sales volume, and turnover.

Every monthly report provides updated estimates on all operational indicators. This includes estimates pertaining to the current phase, e.g. expected date when the stage gate will be passed, expected total costs at phase completion, and current risk level and number of active problems. However, reports also include

updated estimates for all future project phases, as it is often necessary to adjust future deadlines and operational expectations in accordance with present delays and overruns. As each project proceeds to pass successive stage gates, the realized completion date and operational metrics for each completed phase is logged in the monthly reports to serve as fixed points against which prior estimates and re-estimates for that particular phase, as well as estimates for future phases, can be measured to determine the patterns and variations in estimation error and performance over time.

Naturally, performance is also assessed against pre-set criteria and objectives. Project management is requested at the outset of the project and at the midway point to establish fixed objectives for each remaining phase in terms of time and operational metrics. These reflect reasonable expectations based on project characteristics and available information to enable ongoing measurements of how much the project deviates from original intentions and the business case. These remain fixed and visible in all future monthly reports to serve as a means of debiasing ongoing estimates as well as to motivate deadline adherence. Assessing project performance against these fixed metrics provides a measure of performance that enables cross-project comparisons (e.g. for resource allocation purposes), whereas assessments based on the continuously updated estimates allows for the pinpointing of when delays and overruns occur and, therefore, better enables fair estimates of current monthly performance.

We consolidate data from 501 monthly reports from 45 unique projects in the two-year period from January, 2015 to December, 2016. As our primary independent variables on distance are defined at the individual level, we couple the panel data set with matched data from two other repositories within the firm. From the company HR records, we obtain data on individual demographics (e.g. age, seniority, and gender), department, job position and description, managerial responsibilities, and geographical location in terms of city, building, and floor of main work station. From the company work time registry, we obtain detailed records for each employee concerning all tasks and projects to which the individual has contributed in a given month, as well as the number of hours allocated to each of these tasks. Combining these repositories allows us to construct longitudinal measures of geographical distance and psychological distance at the employee level, while tracing changes in important secondary variables, including individual work load in terms of hours and number of projects, as well as changes in team compositions and distance dimensions.

Combining these sources of employee data with project data, we obtain 7,536 useable project-month-employee observations corresponding to 583 unique individuals appearing with varying frequency in the 45 projects over 24 months. Given the continuous distribution of the dependent variable and the hypothesized linear relationships, we conduct a hierarchical regression analysis with Ordinary Least Squares (OLS) estimation. The hierarchical structure of the model is appropriate for illustrating and sequentially testing the hypotheses with the proposed interaction between psychological distance and geographical distance.

While our main independent regressors are measured at the individual level, outcomes are measured at the project level. Individuals are nested within projects, and we therefore have separate error terms at the individual and project levels. We employ robust standard errors (adjusting for 1,635 clusters in the panel) to control for repeated project-level observations and account for the dual error terms. Additionally, we use fixed effects estimation to limit between-unit variation in the sample³ and mitigate remaining non-random effects at the project level.

Our use of different sources of data on project performance, team compositions, individual distances, and other variables helps mitigate potential common method variance from illusory correlations and implicit theories within the reporting management teams (Podsakoff et al., 2003), which is expected to be prevalent in contexts such as ours given the presence of measurement error and subjective estimates (Boyd et al., 1993).

Variable construction

Project performance ($\bar{x}=-0.3$; $\sigma=0.32$) is commonly considered multidimensional with an emphasis on accelerating time to market without compromising product quality or development cost (Ragatz et al., 1997). Compared to assessments of costs and quality, temporal metrics are highly sensitive to changes in project performance given the relative ease with which delays may be discovered and quantified against preset deadlines. Thus, our key dependent variable exclusively captures time performance, calculated as the difference between the most recently estimated completion date and the preset deadline for the active phase

³ A Durbin-Wu-Hausman specification test rejects the null hypothesis that unique errors are uncorrelated with the regressors in our model.

(established by project management at the inception of the project and updated only at the midway point).

The difference is weighted by the planned lifespan of the project to account for the effects of duration on the magnitude of delays.

We further improve our time performance metric by adjusting for the amount of delay already incurred at the inception of the current phase, so as to not bias phase performance downwards. Additionally, we exploit the fact that for most observed months, we know from subsequent reports when the current phase was in fact completed and, hence, how much delay will be incurred in excess of the currently estimated completion date. As this excess delay is attributable to errors committed at some time between phase inception and the time at which the excess delay is incorporated into the estimated completion date, we allocate excess delay equally between all months in this period.

Psychological distance ($\bar{x}=1.04$; $\sigma=1.3$) is defined for each employee as the number of stage gates between the current phase to which the employee contributes and the nearest phase for which the employee holds formal responsibility. The individual degree of formal responsibility for each phase is derived from the relationship between the activities and requirements associated with each project phase and the departmental affiliation and job description of each employee as reported in the company HR database.

In early project phases, the new technology or product concept is often fluid and loosely defined. Employees experiment with the physical and technological limits of the concept, as well as its possible applications and value creation potential. Activities revolve around R&D with expansive experimentation, technological design, and explorative testing. In later phases, the concept matures and is increasingly adapted for production and specific applications. Employees seek to reduce variability and to define in detail the characteristics and specifications of the product or technology in an effort to align with the capacity and capabilities of the manufacturing system in preparation of ramp-up and initial production.

This gradual progression from explorative R&D to full-scale manufacturing and sales release enables the mapping of the individual degree of formal responsibility at any given stage of a project. As a baseline, all departments in the firm are classified as belonging to either R&D, which holds formal responsibility up to and including the third phase, or Operations, which assumes responsibility from the fourth phase onwards.

With this, the departmental affiliation of each employee is sufficient to establish which phases the individual is formally associated with.

A valid concern with this approach would be that employees within departments vary significantly with regard to their specific job function and project roles. To remedy this, we use records of job positions and job descriptions from the company HR directory to further specify the particular phases that each employee is primarily responsible for. Different job roles hold formal responsibility for distinct subsets of project phases, and may therefore span across R&D and Operations or be nested entirely within one of them. To illustrate, quality engineers, machine operators, and technical marketing personnel become formally responsible in the sixth and seventh phases, whereas design engineers and mechanical engineers are primarily responsible in the second and third phases. If a design engineer were to become involved in the fifth phase of a project, perhaps to ascertain previously agreed specifications or engage in technical adjustments or rework, the engineer would be two stage gates removed from formal responsibility and thus experience moderate levels of psychological distance. Notably, certain job roles (e.g. managers and lead analysts) tend to have wider scopes of responsibility that span most if not all project phases.

Geographical distance ($\bar{x}=0.41$; $\sigma=0.5$) is defined for each individual project member as the average distance in meters to all other project members in a given month. Physical distance is measured as the shortest walking distance for all project members in close vicinity (i.e. same city), and as the shortest travelling distance (by car or by plane) for project members in different cities within Denmark. For project members outside Denmark, physical distance is simply the beeline Euclidian distance between them. This measurement differentiation is used to best approximate the experienced physical distance between individuals. Combining these measures, individual physical distance is calculated as the Euclidian distance from the focal individual to all other team members (O'Reilly, Caldwell, and Barnett, 1989; Wagner, Pfeffer, and O'Reilly, 1984).

To account for the disproportionate difference in distance between co-located team members and team members in different countries, we calculate the square root of the mean squared distance between team members. Given the wide dispersion of project members across Europe, China, India, and the US, we logarithmically transform our individual distance measures to further reduce the skew introduced by project

members situated in China, India and the US in particular. Additionally, we weigh our distance measures by the hours contributed by each employee to avoid distorting the average dispersion measure for local project teams on account of a few hours clocked by a foreign employee⁴. This weighting simultaneously addresses the plausible endogeneity issue that individuals are positioned according to their predicted work patterns with co-located individuals expected to collaborate more extensively on overlapping tasks and projects.

We include a number of control variables at the individual and project levels. To capture unobserved effects of distance we include *Global Breadth* ($\bar{x}=2.27$; $\sigma=1.28$) as a measure of the number of foreign production sites that are actively part of the project. The measure varies from 0 for local projects to 5 for highly internationalized projects.

At the project level, it is important to recognize that observations in our data set are structured with monthly intervals due to the reporting practices of the firm. We therefore include *month* dummies in our regression to capture the impact of aggregate time-series trends in the two-year period. Failure to control for such aggregate trends amounts to omitted variable bias and risks producing spurious regression results (Malmendier and Nagel, 2011). Similarly, we account for the effects of the standardized NPD project structure by adding dummies for each project phase. This helps control for the performance variation that occurs due to phase-specific characteristics, e.g. different mean levels of cross-functional collaboration or technical uncertainty.

We include measures of *team size* ($\bar{x} = 38$; $\sigma = 20$) and *management team size* ($\bar{x} = 9$; $\sigma = 1.2$) to control for the plethora of established effects of size on group process, collaboration efficiency, and communication quality (Hackman, 1983; Thomas and Fink, 1963). Additionally, group size may directly influence the magnitude of the coefficient of variation (Ancona and Caldwell, 1992).

At the level of the individual employee, we control for cognitive load as an alternative source of variation in individual information processing behavior and decision making. Cognitive load is defined as the strain imposed on individual attention and processing capacity by work-related demands for greater collaboration and more extensive or rapid information processing (Marois and Ivanoff, 2005; Ocasio, 1997;

⁴ Measurements were obtained using Google Maps.

Shah and Oppenheimer, 2008). When employees hold multiple project memberships, the need to alternate between tasks and projects engenders switching costs and an exponentially increasing strain on cognitive capacity (LePine et al., 2005; O'Leary et al., 2011). We therefore control for individual *structural load* ($\bar{x}=3.59$; $\sigma=2.69$); a composite measure of the number of projects and the number of other tasks to which the individual employee contributes in the focal month ($\alpha = 0.75$). Moreover, multiple memberships are expected to increase social complexity by forcing individuals to interface with an increasing number of people with different specializations, perceptions, and professional languages (De Vries et al., 2014; Dougherty, 1992). We therefore control for individual *interpersonal load* ($\bar{x}=39.7$; $\sigma=22.2$), measured as the number of other employees with which the individual interfaces in a given month. Additionally, we add a dummy control of whether employees have *managerial responsibilities* ($\bar{x}=0.038$; $\sigma=0.19$) to capture unregistered workload and interactions, and we control for individual *temporal load* ($\bar{x}=139$; $\sigma=52.7$) by a simple measure of the number of hours clocked by the employee. Lastly, we control for the *cognitive load of the management team* ($\bar{x}=9.3$; $\sigma=2.3$) by a composite average of the number of management teams each manager is allocated to and the number of other individuals with which the manager collaborates ($\alpha = 0.7$).

Our development of the psychological distance construct relies on an important premise. We propose accountability as an independent dimension of psychological distance that is not adequately captured by extant measures of temporal, social, and hypothetical distance (Liberman et al., 2002; Pronin et al., 2008), meaning our construct ought to be robust to the inclusion of other measures of psychological distance. To this end, we control for *deadline proximity* ($\bar{x}=133.2$; $\sigma=120.9$), the number of days until the next deadline on the focal project, and *project priority* ($\bar{x}=2.27$; $\sigma=1.28$), the number of other deadlines on other projects to which the individual contributes that are temporally closer, so as to capture different aspects of temporal and hypothetical distance in the work situation of the employee (Trope and Liberman, 2010).

We control for project member *age* ($\bar{x}=44.5$; $\sigma=9.5$) and *seniority* ($\bar{x}=14.8$; $\sigma=10.5$) with the firm, measured as years of employment, to account for beneficial effects of domain-specific knowledge and expertise (Armstrong and Mahmud, 2008; Ericsson and Charness, 1994) and the associated improvements in problem solving and decision-making quality (Dreyfus and Dreyfus, 2005; Kahneman and Klein, 2009; Salas

et al., 2010). By the same token, we account for negative effects of domain-entrenchment (Camerer, Loewenstein, and Weber, 1989; Dane, 2010) and the deteriorative impact of aging on cognition and decision making (Glisky, 2007; Mell et al., 2009; Mutter et al., 2007).

Correlation matrix and descriptive statistics (standard deviations and mean, minimum, and maximum values) are reported in Table 4.1.

4.5 RESULTS

The hierarchical regression results are presented in Table 4.2. Model 1 is comprised of all control variables and the main independent variables representing geographical distance and psychological distance. This baseline model is expanded in Model 2, which adds the interaction of geographical distance and psychological distance to explore the hypothesized moderating relationship. Model 3 includes quadratic terms of geographical and psychological distance as a robustness check on model specification. As the second and third models include two-way interactions, non-binary regressors were mean centered. Independent and average variance inflation factors (VIF) did not indicate multicollinearity (1.01-2.61, $\bar{x} = 1.55$)⁵.

Consistent with our first and second hypotheses, the main effects of psychological distance and geographical distance on project timeliness are statistically significant and negative across all models ($p < 0.05$)⁶. Consistent with our third hypothesis, Model 2 demonstrates a statistically significant and positive interaction between geographical distance and psychological distance ($p < 0.001$), while the main effects remain significantly negative ($p < 0.05$). This provides initial support for our expectation that geographical distance positively moderates the association between psychological distance and project performance.

However, to comprehensively understand the hypothesized effects, we plot the two-way interaction in Figure 4.1 to interpret the individual configurations graphically (Aiken, West, and Reno, 1991; Jaccard and Turrisi, 2003). The illustration supports the statistical interpretation that performance declines with

⁵ VIF exceeds 2 for *Group Size* and *Global Breadth*. Our findings are robust to their exclusion.

⁶ As expected and explained in the following section, psychological distance is significant and positive in Model 3.

psychological distance when geographical dispersion is low. This aligns with our prediction that performance benefits the most when individuals are proximate and responsible for the tasks at hand, and that the abstract cognition and emphasis on novel perspectives associated with increasing psychological distance may eventually become disruptive when frequent collaboration is unconstrained. Moreover, these negative effects of psychological distance are mitigated when geographical dispersion is high, which corresponds to our hypothesis that dispersion constrains the frequency of collaboration and encourages more selective contributions on the part of distant team members.

While these results lend further credence to the existence of a moderating relationship between physical and psychological distance in organizational work, it is notable that the presence of psychologically distant team members appears to cultivate an advantage in dispersed teams. This hints at a more nuanced role for psychological distance in explaining project performance that needs to be explored to improve confidence in our findings.

We observe a number of significant controls. It is particularly interesting that one of the alternative measures of psychological distance, *deadline proximity*, is highly significant across all specifications ($p < 0.001$), indicating that we have successfully accounted for alternative sources of psychological distance. Additionally, *Global Breadth* is consistently significant and positive ($p < 0.001$). One interpretation of this effect is that projects with more global involvement and more production sites involved across the globe will likely be more high profile within the firm and, as a consequence, have access to the necessary resources and quality of manpower. Lastly, the size of the project team exerts consistently negative effects on project timeliness. While this likely reflects the expected increase in group heterogeneity with regard to specializations, perceptions, and professional languages (De Vries et al., 2014; Dougherty, 1992), it is also the case that larger groups will experience greater geographical dispersion and, hence, more difficult working conditions.

Robustness and alternative specifications

Project performance is multidimensional and often encompasses aspects of time, cost, and quality (Ragatz et al., 1997). While cost measures inherently co-vary with temporal measures, and hence would not

alleviate simultaneity or omitted variable bias, project quality is impacted by a wider range of factors and does not vary predictably with time or cost (i.e. timely projects may signify greater underlying quality, or, alternatively, more time spent could produce improved quality). To ascertain the robustness of our results against this observation, we construct an alternative dependent variable composed of a set of project quality metrics on warranty rates, turnover, and sales volume. We calculate each as a ratio of the achieved level of quality to the preset target so as to account for their naturally different measurement scales. The composite dependent variable is calculated as an average of the three continuous metrics.

As shown in Model 3, our findings are robust to the alternative dependent variable, though the statistical properties and interpretations of this model are comparatively weaker due to the considerable drop in observations and, therefore, reduced levels of statistical power (see Aiken and West, 1991; Dawson and Richter, 2006; Cohen et al., 2013). We rerun the regression with a dummy-based composite measure (with a value of 1 indicating stable or increasing performance compared to the month prior) to account for unwarranted skew between the continuous metrics, and find similar results.

By their nature, monthly reports are reflective of past events. Thus, a valid objection to our regression specification is the simultaneity of our dependent variable and certain independent regressors. Specifically, the data obtained from the company work time registry and HR records are potentially misaligned with the monthly reports by one month, due to the lagged nature of the reports and management perception. To account for this, we lag the variables derived from the work time registry and HR records by one month and rerun the regression, obtaining qualitatively similar and statistically robust results with a significantly reduced sample size ($N = 3,947$; observations are dropped in case of gaps in the panel and from the last observed month in each project).

An issue remains with our conceptualization of psychological distance using formal job roles, since formal roles may be expanded or adjusted informally over time through the adoption of new work arrangements and through informal knowledge seeking and networks (Gulati and Puranam, 2009). By contrast, our previous conceptualizations are based solely on formal elements that may not sufficiently capture variation at the individual level over time. To address this, we combine our formal measures of responsibility with time registration data to discern patterns of how individuals have actually contributed to

particular phases in the two-year period. We reduce psychological distance accordingly for phases that an individual has been working consistently and extensively on for the majority of the period. While this risks biasing our psychological distance measure toward zero and reducing its sensitivity, our findings remain unchanged with and without this adjustment.

To ensure the robustness of our measure of geographical distance, we computed travel times between all project member locations using the same measurement differentiation as with geographical distance. Travel times between countries were computed using the shortest travel time by plane and the shortest travel times by car or public transportation to and from the airport. The analysis yields qualitatively similar results when travel times are substituted for geographical distance. In the same vein, we eliminated project members from China, India, and the US to minimize the impact of geographical outliers, but the results remained robust.

An important alternative specification of our study is found in the construal level literature. Trope and Liberman (2010) propose that psychological distance behaves as a concave, logarithmic function in accordance with the Weber-Fechner law, as opposed to a simple linear function. In other words, the impact of psychological distance on construal and cognition may be non-linear and exponentially decreasing with greater social, temporal, or spatial distances. Other studies have provided evidence that both temporal and spatial distances display this pattern (Holyoak and Mah, 1982; Zauberan et al., 2009), prompting Trope and Liberman (2010: 444) to call for investigations of the functions that relate different measures of distance to psychological distance as an important addition to extant research. Accordingly, we specify an expanded regression model (Model 4) with quadratic terms for geographical distance and psychological distance to account for potential non-linear effects of distance. While the quadratic effects are significant ($p < 0.001$) and indicate, as expected, decreasingly negative effects as distance increases, neither graphical interpretation nor average marginal effects reveal any meaningful deviations from a simple linear relationship.

4.6 DISCUSSION AND CONCLUSION

Our study is motivated by the familiar story that as projects and other non-routine work progresses, formally defined teams and responsible individuals often come to realize that much relevant knowledge and

skill resides outside both the team and the department (Allen, James, and Gamlen, 2007). When knowledge holders from different functions within the organization become involved, and are brought together in close quarters to improve communication, knowledge sharing, and frame alignment (Allen, 1977; Daft and Lengel, 1986), the degree of knowledge activation varies significantly, meaning that the expected collaborative advantages sometimes fail to manifest (e.g. Jehn and Mannix, 2001; Jehn et al., 1999; Lakemond and Berggren, 2006).

Accordingly, while the potential upsides to geographical proximity with regard to coordination and collaboration are widely acknowledged in the literature, we argue and empirically demonstrate that the observed inconsistencies are, at least in part, explained by interactions with psychological distance (see also Chong et al., 2012; Wilson et al., 2008). Drawing on prior research that demonstrates cognitive and behavioral implications of psychological distance (e.g. Giacomanonio et al., 2010; Sagristano et al., 2002), along with findings from research into individual accountability that demonstrate a positive correlation with cognitive effort and negative correlations with cognitive and social loafing (Blaskovich, 2008; Karau and Williams, 1993; Weldon and Gargano, 1988), we argue that psychological distance in collaboration is a particularly important and dynamic source of psychological distance.

The paper empirically explores the interactions between psychological distance and geographical distance, along with their combined and contingent effects on project performance. Our findings demonstrate the expected negative main effects of psychological distance and geographical distance on project performance, but also provide support for the existence of a positive moderation effect of geographical distance on the negative association between psychological distance and performance. Specifically, while increasing psychological distance among team members implies declining performance when team members are highly proximate, the reverse is true in geographically dispersed teams.

Accordingly, the paper proposes two main contributions. First, we employ extensive longitudinal microdata to approximate causal explanations of the contingencies among distance dimensions in their impact on collaboration and, therefore, on performance across different task environments. Second, we develop and test an accountability-based proxy for psychological distance. In this sense, accountability functions as an important consideration in organizational design and work design that may considerably

shape the expected effects of geographical proximity and, hence, provide a more nuanced premise for strategic management decision to engage in co-location, re-shoring, and similar organizational design considerations. Additionally, accountability is arguably more amenable to managerial action and more malleable in the short term than other dimensions of psychological distance, e.g. social or temporal distance, and therefore more resource efficient with regard to organizational change.

Our findings have implications for established knowledge regarding co-location and the organizational allocation of human capital in general (Agrawal, Kapur, and McHale, 2008; Boschma, 2005; Ganesan, Malter, and Rindfleisch, 2005; Kiesler and Cummings, 2002). Specifically, geographical proximity is often implicitly assumed to mitigate or completely remove the effects of other dimensions of distance among employees, e.g. temporal and social distance. Rather, we propose psychological distance as a central lynchpin between geographical distance and the quality and performance implications of team decision making. In doing so, the paper aligns with other remarks that “*the effectiveness of structural changes such as team arrangements and collocation depends more on the behavioral aspects of how they are employed rather than the extent to which they are employed*” (Swink, Talluri, and Pandejpong, 2006: 557). Thus, the paper provides an alternative and managerially actionable explanation for the absent or contingent effects of proximity found in other studies (Carmel, 1999; Cha et al., 2014).

A tangential discussion has to do with the benefits of knowledge diversity. Spatial proximity and cross-functional integration are regarded as means to bring diverse knowledge and human capital to bear on complex or non-routine tasks (Van Knippenberg, De Dreu, and Homan, 2004). However, while some studies find that knowledge diversity positively predicts performance and the quality of decision making (Dahlin, Weingart, and Hinds, 2005; Van der Vegt et al., 2005), others report negative relationships (Jehn and Mannix, 2001; Jehn et al., 1999) or an absence of evidence for significant direct effects (Kochan et al., 2003; Pelled, Eisenhardt, and Xin, 1999). This lack of a clear consensus regarding the performance effects of investments in diversity and cross-functional collaboration further motivates our study as an examination of the antecedents of successful integration of human capital (Joshi and Roh, 2009; Mohammed and Nadkarni, 2011).

As for strategic management and decision making, the study holds certain implications concerning the decision about where to locate more or less interdependent firm activities, as physical separation or proximity might not be the sole determinant of collaboration quality in a multinational setting. Indeed, as firms become more knowledge-intensive, the need for integration is expected to increase between functions that were previously separable, because interfunctional interdependencies and the requisite interaction frequency increase to accommodate more complex knowledge and more extensive information processing (Galbraith, 1973; Ketokivi and Ali-Yrkkö, 2009).

Accordingly, the traditional assumption that R&D and manufacturing are distinct units with different operational logics that require separation or even offshoring (Jansen et al., 2009; Pisano and Shih, 2009) is nuanced by the recognition of knowledge interdependencies among R&D and manufacturing in knowledge-intensive firms (Gray et al., 2015; Fuchs and Kirchain, 2010). This is particularly true with regard to new product development processes (Adler, 1995; Nihtilä, 1999; Olson et al., 2001). In other words, because manufacturing and R&D are increasingly reciprocally interdependent, the complexity and coordination costs that would result from offshoring with ICT as the primary coordination mechanism might become untenably high. As requisite integration grows, other forms of organizing with other coordination mechanisms, e.g. co-location, are adopted to better suit the information processing needs of the firm.

While our findings enable more appropriate organizational design of co-located and integrated production through an understanding of the contingent effects of work requirements and psychological distance, it is important to note how our results also point to hidden costs of co-location and integration that mirror studies on the hidden costs of offshoring (Larsen et al., 2013). Specifically, our analysis demonstrates how geographical proximity might constrain and limit the effects of psychological distance to engage in expansive and innovative cognition in situation with low task complexity. To the extent that spatial proximity promotes attention to detail and more constrictive cognition, parts of the firm value chain could in fact benefit from increased geographical distance to bolster the positive effects of psychological distance on creative cognition and greater tolerances for variety.

Limitations and future research

Our research design allows us to trace the longitudinal effects of psychological and geographical distance on project performance, but we are hesitant to claim causality due to certain limitations.

An important limitation of our study is single company sampling. While this improves our ability to implicitly control for extraneous variation at the firm and industry levels (see Siggelkow, 2007), and reduces the likelihood of capturing external contingencies that may spuriously influence the hypothesized mechanisms and relationships (Harrigan, 1983), we are fundamentally barred from excluding the possibility of firm-specific effects. This provides an obvious opportunity for future research to confirm and improve upon our findings by adopting a research design with multiple firms to improve generalizability (Hambrick, 1981). However, purely cross-sectional research designs would potentially be unable to account for the mechanisms proposed in this paper. Therefore, future studies should consider balancing out fine-grained research strategies, such as ours, with the commonly encountered and empirically more accessible cross-sectional designs to approach a “*medium-grained methodology wherein the generalizability of cross-grained methodologies is combined with the detail of fine-grained methodologies in large sample studies*” (Harrigan, 1983: 399).

Another limitation of our research design is our inability to observe collaboration directly. In effect, we infer collaborative activity from the fact that individuals are allocated to the same team within the same period, while this need not be true. Being able to discriminate better between individuals that do in fact collaborate and individuals that are merely co-allocated would bolster confidence in our findings. By the same token, we cannot sufficiently adjust variation in project performance for technical contingencies (e.g. breakdowns) or resource constraints (delays in equipment delivery or bottlenecks in factory time) that negatively influence performance but do not pertain to collaboration or other issues arising from distance.

We were also unable to satisfactorily control for the managerial experience of employees and managers, despite the likely correlation with seniority. With experience, project managers and management teams are expected to be better able to anticipate and incorporate slack in both the preset objectives and ongoing estimates to improve (perceived) adherence (Huckman, Staats, and Upton, 2009: 95). Moreover, our dataset consists solely of active and completed projects, meaning survivor bias is a concern in our sample. While the firm employs extensive screening measures to ensure only viable projects enter the NPD process, we cannot

fully mitigate the potential positive bias that arises when failures are underweighted in the sample (Cooper and Kleinschmidt, 1990).

These shortcomings provide straightforward avenues for future research to explore. Additionally, to the extent that these shortcomings - and the adoption of hybrid strategies in general - prove difficult to circumvent due to empirical constraints, scholars are encouraged to employ the logic of interdependent distance dimensions to other levels of analysis where data may be more readily available. For instance, research on the organizational design of global value chains and strategic decision making vis-à-vis location choice and cross-country collaboration between independent units might benefit from conceptualizing responsibility and psychological distance at the company unit or subsidiary level. To the extent that the aggregate behavior of employees in a business unit or subsidiary are influenced by the absence of formal unit responsibility or the prospect of the unit becoming responsible in the short run, it is plausible to expect psychological distance to complement the usual geographical considerations in determining the conditions under which offshoring, outsourcing, or co-location may be beneficial or riddled with hidden costs.

TABLE 4.1 – CORRELATION MATRIX, ALL VARIABLES

(1)

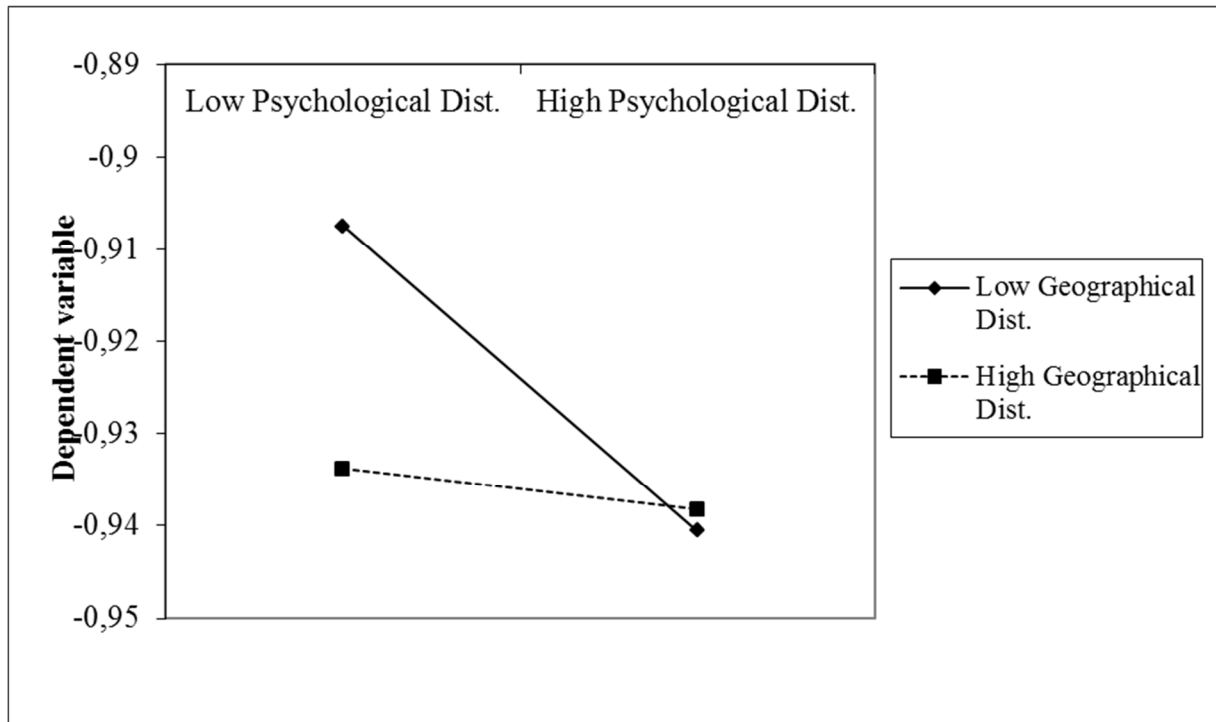
	Timeliness	Psychological Distance	Geographical Distance	Deadline Proximity	Project Priority	Interpersonal Load	Structural Load	Temporal Load	Age	Seniority	Managerial Responsibilities	Team Size	Risk Level	Global Breadth	Phases	CurrentMonth
Timeliness	1.00															
Psychological Distance	0.02	1.00														
Geographical Distance	-0.21	0.07	1.00													
Deadline Proximity	-0.05	0.02	0.06	1.00												
Project Priority	-0.04	0.17	0.09	0.23	1.00											
Interpersonal Load	0.03	-0.05	-0.34	-0.08	0.26	1.00										
Structural Load	-0.08	-0.03	0.09	0.04	0.35	0.21	1.00									
Temporal Load	0.02	-0.04	-0.02	-0.01	0.03	0.03	0.09	1.00								
Age	0.02	-0.06	-0.09	-0.01	-0.03	-0.02	-0.02	0.00	1.00							
Seniority	0.03	-0.08	-0.10	0.01	0.01	0.03	0.04	0.00	0.66	1.00						
Managerial Responsibilities	0.01	0.11	0.00	-0.03	-0.00	-0.01	-0.05	0.02	-0.00	-0.06	1.00					
Team Size	0.15	-0.22	-0.47	0.00	-0.08	0.68	0.00	0.02	0.03	0.08	-0.02	1.00				
RiskLevel	-0.20	-0.14	-0.11	-0.18	-0.07	0.12	0.02	-0.01	0.04	0.03	0.00	0.23	1.00			
GlobalBreadth	0.10	-0.28	-0.29	0.18	-0.07	0.33	0.02	0.04	0.07	0.13	-0.02	0.71	0.21	1.00		
Phases	-0.44	0.22	0.28	0.50	0.20	-0.13	0.10	-0.02	-0.06	-0.06	-0.00	-0.27	-0.08	-0.25	1.00	
CurrentMonth	-0.23	-0.43	-0.01	0.14	-0.13	-0.04	0.14	0.07	0.07	0.04	-0.00	0.09	0.11	0.16	0.17	1.00
Mean	-0.3	1.03	0.41	133.15	1.77	39.67	3.59	133.13	44.5	14.75	0.038	37.93	2.02	2.28	5.09	670.63
SD	0.31	1.3	0.5	120.9	1.23	22.19	2.69	39.53	9.5	10.5	0.19	20.07	0.78	1.28	1.48	6.99
Min	-1.95	0	0	0	1	0	0.5	1	19	1	0	1	1	0	2	660
Max	0.11	5	15.5	610	11	122	22.5	300	77	49	1	79	3	5	8	683

TABLE 4.2 – REGRESSION MODELS

	(1)	(2)	(3)	(4)
	Timeliness	Timeliness	Quality	Timeliness
	b/se	b/se	b/se	b/se
Psychological Distance	-0.007*	-0.007*	-0.034	-0.013**
	(0.00)	(0.00)	(0.02)	(0.00)
Geographical Distance	-0.015**	-0.012*	-0.158+	-0.030***
	(0.00)	(0.01)	(0.08)	(0.01)
Psychological Distance # Geographical Distance		0.011***	0.152**	0.009**
		(0.00)	(0.05)	(0.00)
Psychological Distance, Squared				0.007**
				(0.00)
Geographical Distance, Squared				0.002**
				(0.00)
Deadline Proximity				
Project Priority	-0.001	-0.001	-0.046***	-0.001
	(0.00)	(0.00)	(0.01)	(0.00)
Deadline Proximity	-0.001***	-0.001***	-0.000	-0.001***
	(0.00)	(0.00)	(0.00)	(0.00)
Interpersonal Load	0.000	0.000	0.002***	0.000
	(0.00)	(0.00)	(0.00)	(0.00)
Structural Load	-0.000	0.000	-0.003	0.000
	(0.00)	(0.00)	(0.01)	(0.00)
Temporal Load	0.000	0.000	0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)
Age	0.008	0.008	0.027	0.009+
	(0.01)	(0.01)	(0.03)	(0.01)
Seniority	-0.004	-0.004	-0.028	-0.004
	(0.00)	(0.00)	(0.03)	(0.00)
Managerial Responsibilities	-0.023	-0.096***	0.000	-0.083**
	(0.03)	(0.03)	(.)	(0.03)
Team Size	-0.003***	-0.003***	-0.002	-0.003***
	(0.00)	(0.00)	(0.00)	(0.00)
Risk Level	-0.008	-0.009	-0.159***	-0.009
	(0.01)	(0.01)	(0.03)	(0.01)
Global Breadth	0.137***	0.137***	0.639***	0.137***
	(0.01)	(0.01)	(0.04)	(0.01)
Phase 2	0.000	0.000		0.000
	(.)	(.)		(.)
Phase 3	0.119***	0.119***		0.117***
	(0.01)	(0.01)		(0.01)
Phase 4	0.374***	0.375***	0.000	0.381***
	(0.02)	(0.02)	(.)	(0.02)
Phase 5	0.399***	0.399***	-0.184+	0.396***
	(0.03)	(0.03)	(0.10)	(0.03)
Phase 6	0.403***	0.405***	0.000	0.413***
	(0.03)	(0.03)	(.)	(0.03)
Phase 7	0.605***	0.604***		0.590***
	(0.03)	(0.03)		(0.03)
Intercept	-0.925***	-0.932***	-1.617	-0.958***
	(0.25)	(0.25)	(1.55)	(0.25)
N	7325	7325	2379	7325
R2	0.631	0.633	0.660	0.635
DF	1552	1552	558	1552

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

FIGURE 4.1 – PSYCHOLOGICAL DISTANCE # GEOGRAPHICAL DISTANCE



CHAPTER 5

CONCLUSION

With the aim of improving our understanding of the behavioral underpinnings of human capital integration, the thesis investigates the interdependent roles of cognitive load and organizational design in determining information processing and performance in organizations. The thesis proposes and demonstrates the importance of accounting for cognitive load in decisions on employee allocation, and argues for the need to apply these insights to the selection and implementation of integration mechanisms intended to support collaboration and integration. Failure to do so might induce unexpected deviations in employee behavior and collaboration that erode performance and impair the ability of the firm to capitalize on knowledge resources.

The thesis consists of three research papers that rely on comprehensive longitudinal data from a global manufacturing firm to explore related aspects of human capital integration. The first paper (Chapter 2) studies how individuals decide on the distribution of available working hours among competing projects and requirements. The paper hypothesizes and finds evidence that employees navigate on the basis of particular organizational signals when allocating their time and attention. In the absence of cognitive load, employees are able to navigate on *value signals* to reciprocate the collaborative efforts of others and allocate effort to those endeavors promising greater contributions to performance, both in terms of engaging with complexity and contributing more to well-functioning projects. In the presence of cognitive loads, employees lose their sensitivity to value signals and instead begin distributing their time on the basis of *uncertainty signals* so as to avoid complexity and display risk-averse behavior. The cognitive load of the management team is shown to enable risk-averse behavior, arguably because more autonomy is delegated.

The second paper (Chapter 3) builds on the findings of the first paper by studying how individuals adapt their information processing behavior in teams in response to cognitive load and the observed behavior of other team members. The paper proposes conditional cooperation as a sociocognitive mechanism governing both the mutual adaptation between team members and the process through which differences in cognitive load and information processing behavior are aggregated to impact team performance. The paper finds evidence of an inverted u-shaped relationship between the ratio of team members with high cognitive load and team performance. When team compositions exceed a particular threshold, estimated at around 30 %, performance decreases as the ability of teams to effectively share and process requisite information begins to decline. We demonstrate how this negative association is exacerbated by task complexity and over time, but is mitigated by the development of metaknowledge among team members.

The third paper (Chapter 4) argues that geographical and psychological distance between interdependent employees represents an important set of organizational design parameters that exert isolated as well as joint effects on collective information processing. While the physical separation of interdependent employees has detrimental performance effects due to declining coordination frequency and impaired mutual understanding, the negative effects of psychological separation, e.g. through differences in the degree of accountability, are rooted in the tendency for psychologically distant employees to engage in more abstract or creative cognition to the detriment of thorough information processing and problem identification. Outside of these negative effects, we find evidence that the effects of psychological distance are mitigated by geographical distance, which indicates a phenomenon where spatial separation induces psychologically distant employees to more selectively assess their creative or divergent contributions so as to not disrupt information processing, but rather improve performance through more timely suggestions.

Collectively, the three papers regard human capital integration as neither fundamentally structural nor wholly behavioral. Important contingencies emerge when aspects of organizational design and employee allocation impact cognitive load and induce behavioral adaptation at the individual (Chapter 2) and team levels (Chapter 3) in such a way as to determine the realized information processing capacity of implemented structures. Moreover, organizational design choices that do not directly impact cognitive load may influence

information processing behavior in related ways (Chapter 4), thus producing team heterogeneity and the foundation for further adaptation within the group. The primary finding of the thesis, therefore, is the dynamic relationship between organizational design choices, cognitive responses, and behavioral adaptation at individual and group levels that fundamentally determine information processing capacity. With these interactions in mind, it is possible to provide more detailed or even novel answers on well-known operational questions concerning, for instance, the low rate of knowledge sharing in teams despite being co-located.

THEORETICAL IMPLICATIONS AND FUTURE RESEARCH

The findings of this dissertation have important theoretical implications and provide a number of relevant avenues for future research. These fall into three related categories. First, the thesis provides an expansion of traditional information processing theory to better account for behavioral elements and their interaction with common integration mechanisms and key organizational design choices. Second, the thesis provides insights and recommendations to better align decisions on organizational design, employee allocation, and the location of firm activities with the common objectives of improving information processing capacity and the integration of human capital. Third, the thesis highlights and explores relevant overlaps between the field of management, economics, and psychology to both pose new questions and provide new answers.

First, the thesis addresses the sufficiency of the decisional logic underlying traditional information processing theory in terms of the choice of appropriate integration mechanisms (Tushman and Nadler, 1978; Van de Ven et al., 1976). This logic differentiates mechanisms on their expected information processing capacity and assumes this capacity to increase with the level of human agency embedded in the structure. The fundamental argument of the thesis is that while this logic serves as an excellent foundation, it is susceptible to behavioral variation at the individual and team levels as employees adapt to the structural conditions and the cognitive strain imposed by them. This perspective is not outlandish (Puranam et al., 2012; Radner 1993, 2000; Turner and Makhija, 2012) and indeed several scholars have called for the exploration of more micro-level data on integration (Griffin and Hauser, 1996; Malhotra and Sharma, 2002;

Oliva and Watson, 2011) in order to elucidate and better understand the microfoundational and behavioral elements that influence the realized information processing capacity of implemented mechanisms (Turner and Makhija, 2012) and, hence, the practical applicability of the theory (Van de Ven et al., 2013).

The dominant explanation for the limited success in prior studies to validate the traditional information processing perspective is the difficulty of capturing intervening variables that govern the relationship between structural choices and outcomes (Abell et al., 2008; Puranam et al., 2015; Siggelkow and Rivkin, 2009). This thesis contributes specifically to this point by defining and measuring several intervening elements that constitute first steps towards a better understanding of how information processing capacity is both bounded and enabled along behavioral dimensions. In particular, the thesis defines and measures the role of cognitive load (Shah and Oppenheimer, 2008) as an intervening variable in two respects. First, cognitive load functions as the key individual condition that is impacted by organizational design choices so as to determine how the individual perceives various environmental signals and, hence, how the individual chooses to allocate effort between competing activities. Second, cognitive load is proposed and tested as a fundamental source of team heterogeneity that influences processes of within-team adaptation and, in turn, indirectly influences how individual variation is aggregated to impact the efficacy of the team as a whole.

Moreover, aside from merely identifying and investigating cognitive load as an individual-level determinant of behavior, the thesis moves on to define two separate phenomena that either amplify or mitigate the effect of individual differences on information processing effectiveness and collective outcomes. First, the thesis explores conditional cooperation as the central mechanism underlying the aggregation of individual variation to team and firm levels. Second, the role of psychological distance is explored as an alternative mechanism, rooted in organizational design, which may filter or exacerbate the individual tendency to either reduce effort and rely on abstract and heuristic cognition or maintain effort and engage more fully in elaborate, analytical processes.

Taken together, the thesis identifies two intervening variables and two complementary mechanisms that interact to explain the relationship between higher-order structural choices and observed outcomes at the

individual and team levels (Siggelkow and Rivkin, 2009). In doing so, the paper adds to a growing line of research on the discriminating effects of organizational design choices and hierarchical forms on cognition and behavior (Foss and Weber, 2016; Turner and Makhija, 2012; Weber and Mayer, 2014). Highlighting the potential for different organizational design choices to both exacerbate and mitigate interpretative conflict, cognitive adaptation, and similar issues promises new avenues for management to improve the functioning and predictability of their organization. Future research would need to further explore the interaction between the identified variables and mechanisms in other contexts, as well as to define and explore new intervening elements that help nuance the impact and efficacy of organizational design.

As a second main contribution, the thesis has sought to strengthen the psychological design of the firm and its embedded decision processes by demonstrating how the identified relationships between individual cognitive load, information processing behavior, and collective outcomes are clearly amenable to managerial influence and intervention. Specifically, the key variables on cognitive load and psychological distance lend themselves to longitudinal measurement within a firm by the use of often pre-existing data on the allocation of individuals between tasks, projects, and locations. By tying individual behavior and cognition to elements of organizational design that are amenable to managerial control, the thesis and the findings of the individual chapters provide distinct avenues for the profitable execution of strategy (Powell et al., 2011). Profitability here, arises not from the definition of new and superior strategic endeavors, so much as it stems from the application of simple insights on how individuals are likely to respond to seemingly mundane changes in task composition, workload, allocation and separation, and how these reactions may be mapped in terms of their probable influence on decision quality, knowledge sharing, and information processing. By becoming better able to identify systematic errors in decision-making, hidden patterns of behavioral adaptation, and repeated deviations from predicted rationality, it may be possible for managers to generate more value from extant initiatives and structures without change and, hence, provide a better foundation for learning economics within existing structures. In general, this ambition to identify predictable relationships between human capital, organizational design, and performance is reflective of the larger objective to learn how and when our insights on individual behavior from psychology and related disciplines in fact become valid and

valuable in turbulent, time-dependent, and multi-agent organizations (see Bingham and Eisenhardt, 2011; Vuori and Vuori, 2014). In attempting to do so, the thesis aligns with recent calls in the microfoundations literature for studies into the processes through which characteristics of heterogeneous employees interact and are aggregated within and across firm structures (Felin et al., 2012; Gavetti et al., 2007).

Third, the thesis demonstrates the substantial benefits that accrue from pursuing multidisciplinary research (Agarwal and Hoetker, 2007). By drawing specifically on research into conditional cooperation (de Oliveira et al., 2015; Van den Berg et al., 2015; Hartig et al., 2015), cognitive load (Cason et al., 2012; Schulz et al., 2014; Rand, 2016), and psychological distance (Giacomantonio et al., 2010; Sagristano et al., 2002) from the economics and psychology literatures, we are able to adopt novel perspectives on relevant constructs (e.g. cognitive load and psychological distance) and explanatory mechanisms (e.g. conditional cooperation) that help us pose new questions and interpret our findings from a more varied range of perspectives (Barney and Zajac, 1994; Mahoney, 2005). Others have contributed immensely to our understanding of management in this manner, e.g. Simon (1955), Cyert and March (1963), or even Kahneman and Tversky (Tversky and Kahneman, 1986), which corresponds to the claim by Simon (1997: 70) that *“the most important data that could lead us to an understanding of economic processes and to empirically sound theories of them resides inside human minds...[so] we must seek to discover what went on in the heads of those who made the relevant decisions”*. In a limited way, this thesis contributes to this tradition specifically by tying together research on conditional cooperation, cognitive load, and organizational design to demonstrate key linkages that help explain important organizational phenomena, e.g. why some firms excel at sharing knowledge and extracting value from human capital, while others struggle to do so in spite of excellent employees and resources. Additionally, however, we consider it a contribution that this form of multidisciplinary research acts as a proving ground for mono-disciplinary theories to establish, for instance, whether observations on human behavior are consistent and reliable outside laboratory settings, or in situations with actual stakes as opposed to hypothetical scenarios (Cheung, 2014; Fischbacher et al., 2001). In this sense, multidisciplinary research provides its own rationale above and beyond the integration of pre-existing insights. In posing this argument, we concur with Weber and Mayer

(2014: 361) that “*multidisciplinary research allows different questions to be explored than those typically examined within one of the base disciplines alone*” (see also Agarwal and Hoetker, 2007).

CONCLUDING REMARKS

Powell (2017) speaks of a Chess syndrome in our application, as scholars and practitioners, of organizational theories and strategy. He emphasizes the ubiquitous dangers of assuming that planned implementations of structure and strategy necessarily realize their intended impact. In this thesis, we have drawn on a multidisciplinary set of theories to inform and expand traditional information processing theory in a bid to strengthen the psychological design of our organizations and their ability to generate value from their human capital. By delving into the black box of individual cognition and adaptation within integration research, we demonstrate how the information processing implications of different integration mechanisms and attendant management practices (e.g. the allocation of employees) are fundamentally determined along certain behavioral dimensions. By shedding light on some of these, we hope to temper the view that integration is necessarily beneficial, as well as to provide a better foundation for managers to both assess the potential value of integration and specifically intervene to increase this value potential. As such, we claim to have laid the groundwork for a model of integration that incorporates a cognitive perspective and sketches the contours of a behavioral theory of integration (Gavetti and Warglien, 2015; Kretschmer and Puranam, 2008; Postrel, 2002; Turkulainen and Ketokivi, 2013).

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