6-28-2023 11:00 AM

Psychometric Validation of the Team Resilience Inventory

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A thesis submitted in partial fulfillment of the requirements for the Doctor of Philosophy degree in Psychology

Abstract

Work teams frequently face adversities that may affect group processes and ultimately lead to a loss of performance. Despite a large literature on the characteristics of high-performance work teams, we know little about the processes by which teams resist, persist through, adapt to, recover from, or otherwise be resilient to challenges that they encounter. In part, this is due to the lack of a psychometrically sound and well-validated measure for team resilience; how work teams collectively respond to and 'bounce back' from adversities. The present dissertation project addresses this need in the literature through the development and validation of the Team Resilience Inventory (TRI), a 7-factor measure of team resilience. First, a theoretical overview of resilience in general, and team resilience in particular, is presented along with a review of the existing literature covering the current state of theory behind team resilience. Drawing from this review, I present a model of team resilience consisting of team resilience capacity (i.e., the affective, behavioural, and cognitive resources a team possesses and the ability of a team to persist or adapt if required to be resilient) and emergent team resilience (the demonstration of team resilience through a team's ability to Resist the negative effects of an adversity or Recover from it over time). This review is followed by three empirical studies developing the TRI, establishing its psychometric structure, and examining an initial nomological network of team resilience. In Study 1 (N = 435, k = 103 student engineering design teams) the Affective, Behavioural, and Cognitive resources of team resilience factors were developed and assessed.

The factors were found to have acceptable psychometric properties and initial exploratory analyses suggested that these resource factors were related to various team-level constructs in theoretically consistent ways. Study 2 (N = 1281, k = 222) expanded on this by introducing the team resilience process factors (Adaptation & Persistence), assessing how team resilience relates

to psychological resilience and assessing the TRI's relation to team satisfaction and team potency. The results again supported the factor structure of the TRI and that team resilience, though related to psychological resilience, is a distinct construct. Further, factors of the TRI accounted for significant variance in team satisfaction and team potency, supporting the criterion validity of the construct. Lastly, in Study 3 (N = 145, k = 45), the ability of the TRI to predict emergent resilient team performance was assessed over time in a lab setting. The results supported the ability of the TRI to predict resilient team performance and offer an initial look at how accurately team members are able to evaluate their team's resilience. Future research directions in team resilience are then discussed.

Keywords

Team Resilience, Resilience, Team Dynamics, Psychometrics, Multilevel Modelling, Work groups

Summary for Lay Audience

That the work environment continues to become both more complex and teamwork-based is a well-supported phenomenon. Teams today need to be more resilient to challenges than ever before as work environments become more and more complex. Despite the vast literature on what makes for high-performance teams, our knowledge of how teams are resilient to adversity and what we can do to develop their resilience is limited. In part this is due to difficulty in understanding what exactly team resilience is and how it is best measured. This dissertation project aimed to address this conceptual confusion by outlining a model of team resilience and an associated measure (the TRI; Team Resilience Inventory). Drawing from the existing literature, I outline the current state of theory on both resilience at large and team resilience in particular. A conceptual model is presented showing that team resilience consists of two sub-domains: Team Resilience Capacity (i.e., the team's capacity to be resilient if required) and EmergentTeam Resilience (the team's demonstrated resilience as represented by how well it Resists or Recovers from an adversity). Across three studies, the current project supports the reliability and validity of the Team Resilience Inventory and provides insight into the nomological network of team resilience. In particular, team resilience was found to have the expected pattern of relationships with multiple outcomes such as team satisfaction, team potency, and team performance. Further, I provide support that team resilience is a related but separate concept from an aggregation of team members' individual psychological resilience. Importantly, the Team Resilience Inventory was found to predict variation in a team's ability to both resist the negative effects of an adversity and more quickly recover any performance lost. Overall, this research provides a reliable and valid measure of team resilience, an initial look at how team resilience relates to other team constructs, as well as avenues for future research directions.

Acknowledgements

That resilience is the topic of my dissertation is ironic as this project has been a lesson in persistence and adaptation. Graduate school has been a challenging journey with many ups and downs and writing a dissertation project is no exception. Its completion is a testament to the immensely kind, intelligent, and helpful people who have guided both the development of my thesis as well as who I am as a scientist-practitioner and a person. For every word of feedback, for every opportunity I was connected with, and for every genuine conversation I cannot thank everyone who has been there for me in a way that expresses my gratitude for their support. I hope however, that those who read this know that every moment was formative in my growth, and I hope that I can do justice to the kindness invested in me.

I would like to thank the members of my committee: Drs. Rick Goffin, Natalie Allen, Blair Evans, and John Meyer whose guidance on this thesis and throughout my graduate student experience has been helpful and enlightening. However, I would like to particularly thank my supervisor Dr. Alex Benson. As Dr. Benson's first graduate student I believe this was a learning experience for both of us and it would be understandable if he were still figuring out this role. And yet, that was never my experience, Dr. Benson's support has always been consistent and inspiring. Whether it be sharing his experiences, walking me through different analyses, challenging my critical reasoning skills, or connecting me with developmental opportunities he has always been there for me throughout this project. I can only hope that one day I can pay forward his support and be as effective a mentor for others. Really Alex, these five years working together has been amazing and I would not have wanted to work with anyone else.

My gratitude also goes out to the faculty and students of Western University's I-O program. What a privilege it has been to learn from the very best in the classroom, in

presentations, in elevators, and at the Grad Club. My seven years in this program have been filled with great conversation and even better people. I have been lucky to call many my friends, and I hope I can continue to do so into the future. I have great confidence in the program and hope that future students will continue to find a welcome home here. *If these walls could talk…* In particular, I would like to thank Kabir Daljeet, whose previous office has been host to more than a couple questions, rants, and power naps while waiting for models to run; and Laura Johnson – trivia nights at the Grad Club, co-productive work days both at cafes and over zoom, beach trips, and debriefs playing Overwatch were essential in getting me through grad school. I'm glad we graduate together!

I would also like to thank my partner in adventure, Hailey Rendell. Your willingness to listen, to help me through this process, and your push to maximize every hour has been essential in the last stretch of finishing this dissertation. You challenge me, you believe in me, and I am privileged to love and be loved by someone who is content with nothing less than my best. Lastly, I would like to thank my parents. Their support throughout grad school and my whole life has been unwavering. They knew early a 'normal' life path was not going to be for me, and even though they did not know where I was going their confidence that I would find success my own way never wavered. It looks like I made it guys, who would have guessed it would be here?

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1 General Introduction

Work teams frequently face adversities that may affect group processes and ultimately lead to a loss of performance. Adverse events such as the loss of team members, insufficient resources, project setbacks, or high job demands that present significant challenges for teams are ubiquitous in organizational contexts. These adversities have the potential not only to detrimentally affect individual, team, and organizational performance, they can also contribute to harmful physical and mental strain for individual team members (West et al., 2009) and have detrimental effects on the larger organization they are a part of (Hartmann et al., 2021). While resilience has been the subject of much research in both the psychology (e.g., Sutcliffe & Vogus, 2003) and organizational development (Hartmann et al., 2021) literatures, resilience has been largely unaddressed in small group dynamics (e.g., workplace teams; Chapman et al., 2020). Further, while the cross-level connection between individual and organizational resilience seems intuitive, the emergent processes by which individual, team, and organizational resilience interact is relatively unexplored territory (Hartmann et al., 2021). Understanding team resilience as a meso-level construct offers a valuable multilevel foundation to bridge these two literature bases.

Despite a large literature on the characteristics of high-performance work teams, we know little about the processes by which teams resist, persist through, adapt to, recover from, or otherwise be resilient to challenges they encounter (Hartwig et al., 2020). Preliminary research indicates that a team's resilience to adversities is correlated with important outcomes at the individual-level (e.g., performance and workplace attitudes; West et al., 2009), organizational-level (e.g., withdrawal behaviours such as absenteeism or turnover; Meneghel et al., 2016a; 2016b), and team-level (e.g., team conflict and creativity; West, et al. 2009).

Team resilience capacity has been found to promote both task and contextual performance (Meghal et al., 2016a), and the maintenance of performance over time (Vogus & Sutcliffe, 2012). As developing a team's ability to effectively respond to challenges is an integral component of long-term success, researchers have begun to investigate the factors that enable teams to resist, recover from, and 'bounce back' following experiences of adversity (e.g., Alliger, et al., 2015; Gucciardi et al., 2018; Meneghel, et al., 2016a).

While there is interest in the study of team resilience from both workplace practitioners and academics, current research is largely conceptual in nature or consists of small sample qualitative work (Hartwig et al., 2020). Further, the construct of team resilience is beset with confusion due to conflicting definitions and models, conceptual overlap with other constructs, as well as a lack of a well-validated measure (for recent state of the literature reviews, see Chapman, et al., 2020; Hartwig et al., 2020), with very few theoretical frameworks, measures, or theoretically-related constructs being investigated more than once. In other words, the models, measures, and supposed factors that contribute to team resilience are as numerous as there are papers on the construct, suggesting that resilience has become a clear example of both jingle (where different meanings are attributed to the same construct) and jangle (where a construct label is used for different phenomena) fallacies (Kelley, 1927). In fact, multiple researchers have called for the development of a more integrative theoretical framework and psychometrically sound measure of team resilience (Alliger et al., 2015; Flint-Taylor & Cooper, 2017; Gucciardi et al., 2018; Maynard et al., 2015; Stoverink et al., 2018). The purpose of my dissertation is to address the call for a psychometrically sound measure of team resilience. To accomplish this, the present dissertation project consists of three overarching objectives, including: 1) to conduct an integrative review of the team resilience literature to provide a conceptual framework for team resilience, 2) to identify the content domain, item development, and subsequent

psychometric validation of the Team Resilience Inventory (TRI); and 3) exploring the nomological net of team resilience while testing the criterion validity of the newly developed measure.

Conservation of Resource theory (COR; Hobfoll, 1989; 2001) has been gaining popularity in the team resilience literature as an explanatory theory for how team resilience emerges in response to adversity and how it functions (Hartwig et al., 2020; Stoverink et al., 2020). I continue this trend by drawing from COR theory (Hobfoll, 1989; 2001) to develop and test a resource-based model of team resilience within an Input-Process-Output framework. I argue that COR is a valuable framework to explain how team resilience capacity (i.e., the capability of a team to be resilient to adversity if required) and emergent team resilience (i.e., how resilience is demonstrated in the trajectory of performance on a relevant outcome over time) emerge from individuals investing their own and their team's resources into collective processes through 'resource crossover' (Westman, 2001) to address collectively-faced adversity. The COR framework, in combination with the resource crossover model, offers an established theoretical model in which to situate team resilience and highlights how it emerges through team members investing their resources, through interdependent team processes, and by responding to a collectively-faced adversity (Bowers et al., 2017; Brykman et al., 2021; Hartmann et al., 2021; Stoverink et al., 2020).

1.1 The Nature of Resilience

No entity exists in a state of continuous optimal performance. Whether it be a forest, a community, an organization, an economy, a structural object, or an individual, the experience of adversity that creates disequilibrium is an unavoidable reality (Hodgson et al., 2015). As such, the concept of resilience, from the Latin *resilire,* has a long history of study in the philosophical backstory of psychology (Luthans, 2000) and within the natural sciences (Holling, 1973). From individual mental wellbeing, to material behaviour, to commercial organizations and ecozones,

the concept of resilience spans a wide array of academic disciplines and layers of analyses. In fact, a recent meta-review of resilience found over two million hits for the term on SCOPUS alone (Moser et al., 2019). With this popularity, however, comes confusion. Within this sea of literature, there is a large diversity of definitions, characteristics, and even the epistemological and ontological foundations of the concept (Moser et al., 2019). Further, much of this theory exists in silos, with a particular separation between the social and natural sciences. Where the former often focuses on identifying the traits and resources that make for a resilient individual, organization, community or economy, the latter focuses on describing and measuring changes in the entity in response to stress. Indeed, within the social sciences alone, Meredith et al. (2011) found over 100 definitions of resilience in their review, with significant differences in whether resilience is viewed as a trait or state of an entity, a process (or processes) an entity goes through, or a property of its behaviour in response to adversity. Understandably, this proliferation has led to significant confusion around what exactly resilience is (King et al., 2016; Morgan et al., 2019) and even doubt over its usefulness due to its seemingly endlessly wide boundaries (Sutcliffe & Vogus, 2003).

So where do we begin in nailing down what is meant by resilience? How do we go about operationalizing resilience and how do measure if something is resilient or not? In their systematic review, Moser et al (2019) identified three general categories of research around resilience: 1) a trait/characteristic of a system; 2) a process or set of processes a system goes through; or 3) an outcome an entity arrives at. In the first category, research is primarily focused on identifying the key resilience-related characteristics of an entity. In the second, research is focused on identifying the processes an entity goes through in response to the dis-

equilibrium inducing event, and in the last, research is focused on the changes in and eventual return to an equilibrium point of relevant outcome states and functions. Although these categories are a useful heuristic Moser et al. (2019) note that these categories are not mutually exclusive, that many researchers may include two or more of these categories in how they view resilience, and that all three are necessary to understand resilience. This categorization can help organize the disparate approaches of studying resilience, for example, by fitting what is known about resilience within an input-process-output framework (Moser et al., 2019). However, it does not necessarily clarify the essential properties of resilience.

The myriad definitions and conceptualizations of resilience can be broken down into two perspectives: resistance and recovery (Hodgson et al., 2015). Resilience can refer to an entity's capacity to resist the disruptive effects of adversities (e.g., Holling, 1973) and/or to the processes by which an entity returns to an equilibrium state following disruption from adversity (e.g., Gucciardi et al., 2019; 2021). Resistance describes the immediate impact of a disturbance on an entity's equilibrium state and the degree of change as a result. In contrast, recovery captures the processes, rate, and degree to which the entity recovers its pre-disturbance state. Much of the current literature suggests that these are not mutually exclusive definitions. Rather, resistance and recovery are independent but related properties of behaviour under stress (i.e., performance) and together form 'resilience'; the ability of an entity to resist or recover function in the face of exogenous stress (Hodgson et al., 2015). While some may break rather quickly and aggressively under stress (i.e., low resistance), others may be able to withstand significant stress without change (i.e., high resistance). Where some may shift under stress and not return to their

previous form when the stress is removed (i.e., low recovery), others may ‘bounce-back’ almost immediately (i.e., high recovery). From this perspective, resistance and recovery are properties of an entity’s behaviour when stressed that allows for characterization and comparison (Hodgson et al., 1973). This ‘bounce back’ (sometimes called ‘robustness’ or ‘stability’) perspective of resistance and recovery as the formative properties of resilience has been widely adopted across the natural sciences (Hodgson et al., 2015).

In addition to the bounce back perspective outlined above, some scholars argue that the potential for functional growth following successful resolution of adversity constitutes a particular form of resilience (Lepore & Revenson, 2006). Essentially, this growth perspective suggests that resilience does not always end with the maintenance or recovery of a pre-adversity baseline of functioning. Instead, an entity may experience salutogenic outcomes (e.g., a stronger sense of purpose or greater sense of self-efficacy) that act as protective factors to future adversity. In the context of teams, this may look like developing team member competencies in response to challenges or practicing for future challenges through simulation exercises (Gucciardi et al., 2021). Although resilience and post-traumatic growth are often discussed hand in hand, they are likely two separate processes in response to adversity (Infurna & Jayawickreme, 2019). In the current dissertation, post-adversity growth is outside the scope of the project and is discussed as a potential future direction for research in team resilience.

1.1.1 The nature of adversity

Resilience is loosely conceptualized as a process “(i) of something, (ii) to something, (iii) to an endpoint” (Allmark et al., 2014, p.62). As such, it begins with an entity’s exposure to ‘something’ with the potential to disrupt its homeostatic equilibrium. A point of agreement in the resilience literature is that it is elicited in response to strain induced by an exogenous disturbance

that stresses the entity (Hodgson et al., 2015 Moser et al., 2019; Hartwig et al., 2020). The incursion of an adversity (also referred to as a stressor, challenge, trauma, disturbance, or shock) is a catalyst to start the resilience process to maintain or recover functioning on a given outcome, which can only be observed in reaction to the adversity. As systems have a tendency towards routines and to protect resources to maintain equilibrium (Gersick, 1991), disruption of these routines or states by adversities will negatively impact functioning (Gucciardi et al., 2018), triggering homeostatic mechanisms intended to maintain or recover the pre-adversity state. In the context of teams, I draw from Dietz et al.'s (2017) definition: "team-based stressors (i.e., adversities) are stimuli, or conditions, that influence the team's capability to interact interdependently or capacity to achieve their goals" (p. 296).

It is important to separate the adversity (i.e., the exogenous stimuli) from its effects (i.e., the strain that causes disequilibrium). Whereas the adversity refers to any stimuli that has the potential to impact the entity, the effect of exposure to that adversity is the strain which elicits disequilibrium (Dove-Steinkamp, 2017). Adversities can vary in a number of dimensions, including the type of the adversity and the frequency of their occurrence and their duration. In addition, adversities are often layered on top of each other, occurring at different points in time and with differing effects on the system. For example, a team may face continuous, chronic sources of adversity (e.g., high workload, being short-staffed) with relatively minor impact, as well as acute, episodic adversities (e.g., the loss of a team member, changing objectives, new deadlines) layering onto each other and creating unique interaction effects. In addition to frequency and duration of an adversity, the degree of strain created by the adversity can also vary in its magnitude (i.e., the subjective experience of how impactful the effect is on a given function).

In physical sciences, this can be relatively easy to measure (e.g., the tensile stress induced by pressure on a material can be measured in force per unit area, such as pounds per square inch). However, measuring the strain induced by shocks to human systems is much less clear (Ratcliffe et al., 2019). While losing a team member is likely to create more strain on a team's functioning than, for example, a minor miscommunication about a team task, there is no readily available way to operationalize the strain created by each adversity and the difference between them. Building on this difficulty, the magnitude of strain an adversity can create is only half the equation. How a human system subjectively experiences an adversity also matters (Gucciardi et al., 2018). The stress literature in psychology (e.g., Ego depletion theory, Baumeister, 2002; transactional theory of stress and coping, Lazarus & Falkman, 1984; diathesis-stress models; Monroe & Simmons, 1991) consistently highlights that the strain induced by a stressor stimulus is only partially predicated on the magnitude of the stressor. The resources available to the system to be resilient to the stressor and the context in which it occurs will also shape how the stressor and its associated strain is subjectively experienced. In other words, the severity of an adversity (i.e., the subjective experience of strain induced by an adversity) is in the eye of the beholder (Bonanno et al., 2015). For example, the loss of a team member may be considered a significant stressor likely to severely impact a team's ability to function. However, the actual experienced strain may be influenced by many things. Does the team have redundant human capital such that they are not losing irreplaceable skills or capacities? Was the removed team member a significant source of discoordination or conflict and thus their removal actually improves functioning? Two teams subjected to the same adverse stimuli may actually experience the strain it creates very differently due to the unique context in which they experience it and the resources available to them to respond. As such, rather than attempting to operationalize the

energy an adverse stimulus could introduce, a better approach when dealing with human systems may be to focus on the subjective experience of strain (i.e., severity), which can be more easily conceptualized and measured through self or observer reports (Paulhus & Vazire, 2007).

In essence then, adversities and their adverse impact can be operationalized and described in terms of their type, frequency, duration, and severity (Bonanno et al., 2015; Sarafino & Smith, 2014). These dimensions align with the tenets of event system theory (Morgeson et al., 2015), which argues that the salience and impact of an event on a system is defined by its novelty, disruptiveness, and criticality. Further, these dimensions may help delineate under which adverse conditions routine coping mechanisms fail and resiliency processes are activated (Richardson, 2002). Whereas coping mechanisms are often conceptualized in the context of long-term, but low magnitude stressors (Vogus & Sutcliffe, 2007), resilience may be better suited to episodic and high-impact stressors that necessitate significant effort to address (King & Rothstein, 2010; Vogus & Sutcliffe, 2003). Presumably, more frequent, longer duration, and more severe adversities will have a greater magnitude and hence greater disruption to functioning (Bonanno et al., 2010). Indeed, resilience is often studied in the context of unexpected, abrupt, and severe adversities, such as trauma-inducing events (Patterson, 2002). Some authors argue that ‘significant impact on functioning’ is a necessary boundary condition to separate resilience from other stress-management concepts (Gittell et al., 2006; Williams & Shepherd, 2016), while others suggest that chronic exposure to lower impact adversities that accumulates over time may compound and overwhelm and disrupt functioning (Vogus & Sutcliffe, 2007), eliciting resiliency processes in response.

1.1.2 Resilience in Organizational Management

Resilience has been studied for decades as an important construct in organizational management concerning how people "bounce back" and positively adapt after experiencing adverse events (King et al., 2016; Sutcliffe & Vogus, 2003). Such adversities come in myriad forms in the workplace, ranging from individual setbacks (e.g., overwhelming workload), team setbacks (e.g., a major project falling through due to employee turnover), all the way to large-scale organization-wide or even industry-wide setbacks (e.g., the ongoing supply chain shocks experienced across the globe in the wake of the 2020 COVID-19-related lockdowns; Sultan, 2022).

Beginning with the individual, resilience is generally defined as "positive adaptation within the context of significant adversity" (Luthar et al., 2000; p. 543) and is used to characterize how an individual copes with adversity and recovers a pre-adversity level of wellbeing (Vogus & Sutcliffe, 2003). The history of psychological resilience begins with attempts to understand differences in how individuals recover from significant childhood trauma (Bonanno et al., 2010; Wright et al., 2013). Early researchers believed that some characteristic was responsible for the variance in recovery, and thus early research into resilience focused on identifying protective traits, resources, or processes an individual uses to protect themselves from the negative effects of an adversity. Psychological resilience later began to emerge in the context of organizational behaviour in the late 1980s and 1990s with the rise of new research paradigms such as positive psychology (Seligman & Csikszentmihalyi, 2000) and positive organizational behaviour (Luthans, 2002), and remains the most studied level of analysis in the field (Shen et al., 2012). Luthans' (2007) model of psychological capital, in which resilience, alongside optimism, hope, and self-efficacy make up the key psychological resources an

individual can draw from in the face of adversity has emerged as the most popular conceptualization of psychological resilience.

This line of research on characteristics of a resilient individual has highlighted the importance of employee resilience as a key human capital resource for maintaining or recovering job performance and well-being under adverse conditions (Fletcher & Sarkar, 2013) and the various ways organizational settings affect employee resilience (Bardoel et al., 2014). Given the various detrimental outcomes, such as burnout, turnover, and team conflict associated with the experience of significant strain from overwhelming job demands, psychological resilience has a strong tradition of research in the work stress literature. For instance, psychological resilience has been shown to be a protective factor against the experience of workplace stress (Chen et al., 2017) as well as a positive antecedent of well-being (Pangallo et al., 2016), task performance (Ceschi et al., 2017), and work engagement (King et al., 2015).

The other traditional line of resilience research in the organizational management literature is at the organizational level (Kahn et al., 2018; Sutcliffle, 2011; Weick & Sutcliffe, 2001). Beginning in the 1980s (e.g., London, 1983; Meyer, 1982), the notion of high-reliability organizations gained popularity as a descriptor for organizations designed to survive or even thrive in response to market shocks, such as international conflict and recession (Riolli & Savicki, 2003; Weick, 1993). Since then, the concept has gained popularity as organizations face an ever more global, fast-paced, and complex market environment that increasingly raises the magnitude of adversities, such that even distant adversities will have wide-reaching and often unpredictable effects (Taleb, 2007). For example, the number of organizational resilience publications in peer reviewed journals more than doubled following the 2007 financial meltdown (Raetze et al., 2022). Again, research into organization-level resilience began with static trait

descriptions, eventually evolving to include dynamic process models (Kahn et al., 2018; Ortiz-de-Mandojana & Bansal, 2016; Vogus & Sutcliffe, 2007).

1.2 Team Resilience

As contemporary work becomes increasingly dynamic and team-based models continue to gain prominence in organizations, so too does the importance of understanding team processes to promote effective performance (Hollenbeck et al., 2012). However, in contrast to the rich literature base on resilience elsewhere, the concept of 'team' resilience has received little attention in group dynamics (Hartmann et al., 2021; Stoverink et al., 2018). A scoping review by Chapman et al. (2020) identified only 27 journal articles on team resilience as of 2017, with none published before 2009. Hartwig et al.'s (2020) review of workplace team resilience found 35 articles published as of 2018, with over half of them since 2016.

Hand in hand with the rise of team resilience research (Chapman et al., 2021; Hartwig et al., 2021; Reidt et al., 2022), there has been a proliferation of conceptual confusion, overlap with other constructs, and a fragmented body of research. As noted by others (Chapman et al., 2021; Hartwig et al., 2021; Maner et al., 2019), research on team resilience can be categorized by the ontological assumption that resilience is best characterized as a capacity, process, or outcome. In other words, as an emergent state regarding a team's capacity to 'bounce back' from adversity if required, a dynamic team process that outlines the actions a team takes to respond to adversity and re-establish equilibrium, or as a property of a core team function that implies a positive response following the adversity.

Because of the multi-disciplinary interest in team resilience, many definitions and conceptualizations of team resilience have been proposed in the literature with few receiving repeated use. Two definitions put forward by West et al. (2009) and Morgan et al. (2013),

however, have received the most attention. West et al. (2009) define team resilience as a team's "capacity to bounce back from failure, setbacks, conflicts, or any other threat to wellbeing that they may experience" (p. 253). This definition of team resilience positions resilience as a global capacity. It is primarily concerned with potential of a team to be resilient and is largely associated with input factors. In contrast, Morgan et al. (2013) define team resilience as "a dynamic, psychosocial process which protects a group of individuals from the potential negative effect of stressors they collectively encounter. It comprises of processes whereby team members use their individual and collective resources to positively adapt when experiencing adversity" (p. 552). In this definition, the focus is primarily on the process; how team members respond to collectively experienced adversity through social and task interaction.

Recent definitions (e.g., Bowers et al., 2017; Gucciardi et al., 2018; Hartwig et al. 2020) take a more expansive view that argues team resilience is an emergent state or outcome that forms out of various capacities, processes, and outcomes. For example, Hartwig et al. (2020) define team resilience as "a team's capacity to withstand or recover from the adversity that may lead to a breakdown of group functioning. This capacity is an emergent state that arises out of a variety of preparative, adaptive, and reflective processes and is demonstrated in trajectories of team performance following exposure to adversity" (p. 190). Although many definitions of team resilience have been proposed, there are a few key universal themes: a) team resilience is elicited in response to adversity; b) the adversity must be collectively experienced; c) there must be some form of eventual positive response, whether that be in the form of resisting, recovering, or growing from the negative effects of the adversity; and d) there are protective resources and processes that benefit a team's resilience (Chapman et al., 2020).

Despite differences in specific factors, current conceptualizations of team resilience generally follow an Input-Process-Output (IPO; Ilgen et al., 2005) model. Inputs refer to the pre-existing individual (e.g., personality), team (e.g., team structure), and contextual (e.g., organizational support) resource factors. Mediators refer to the processes by which inputs are translated into outcomes through social interactions among team members. Lastly, outcomes refer to salient results of this process of interaction (Ilgen et al., 2005). However, our understanding of team resilience is limited by a lack of consensus on where exactly team resilience fits in an IPO model (Chapman et al., 2020; Hartmann et al., 2021). Team resilience has been operationalized as a set of relatively stable capacities a team can hold that only become apparent when under duress (e.g., Meneghel et al., 2016; West et al., 2009), a series of psychosocial processes that emerge over time to effectively manage adversities (e.g., Morgan et al., 2013), or the output-indicators that a team has 'recovered' (i.e., maintained or returned to a pre-adversity equilibrium state, adapted to maintain function, bounced back) on relevant outcomes like performance (Flint- Taylor & Cooper, 2017). Others suggest that team resilience is a second-order function that underlies the inputs, processes, and trajectory of function on relevant outcomes (Bowers et al., 2017; Gucciardi et al., 2018; Stoverink et al., 2018). From this perspective, team resilience may be seen as being a full IPO model in itself. In the following sections, I will review the existing literature from each of these capacity, process, and outcome perspectives.

1.2.1 Capacities of a Resilient Team: What Resources Does a Resilient Team Have?

In terms of capacities, team resilience is treated as either a 'trait-' or 'state'-like characteristic of the team, which can include factors endemic to the team (e.g., the state of trust) or originating outside the team (e.g., organizational supports and resources). These capacities operate as protective factors, meaning they modify an effect in a positive direction (Luthans et

al., 2000) for a team to be resilient against adversity, reducing the severity of an adversity if and when it hits. These protective factors have also been referred to as adaptive capacities (Dalziell & McManus, 2004). This approach of identifying and describing team resilience resources (e.g., see table 1 for some example resources) is the most researched area in the team resilience literature, which is not surprising given its predominance in other areas of organizational management literature (Reidte et al., 2022).

As a set of capacities possessed by a team, importance is placed on the availability and mobilization of resources that make up the latent capacity of a team to deal with adversity (Gucciardi et al., 2018; Stoverink et al., 2018). For instance, a team could be designed to recover from or adapt efficiently to breakdowns in unit processes by training for redundancy in member knowledge, skills, and functions. This perspective suggests that while adversity must occur for a team to demonstrate resilience, it is not necessarily a prerequisite for a team to develop the capacities required to be highly resilient. Hartmann et al. (2021) suggest that "Team resilience capacity describes the potential of a team to show positive adaptation if and when the team faces adverse circumstances" (p. 45), a capacity which can exist whether or not the team is ever required to use them (Stoverink et al., 2020). Following COR theory (Hobfoll, 2000) teams are motivated to build their resource stocks (e.g., engage in team capacity building exercises, acquire new skills or knowledge, make connection with potential beneficiaries) in anticipation of future adversities and invest in measures to avoid resource loss (e.g., developing succession plans, developing contingency plans for challenges) when adversity strikes.

Table 1

Example Characteristics of Resilient Teams

Source	Contributing Resources
Brykman & King, 2021	Voice climate, leadership
Burke et al., 2006	Leadership
Carmeli et al., 2013	Emotional connectivity
Gucciardi et al., 2018	Knowledge, skills, abilities and other attributes
Meneghal et al., 2016a	Shared enthusiasm, optimism, comfort within the team
Meneghal et al., 2016b	Emotional carrying capacity
Morgan et al., 2013	Group structure, mastery approach, social capital, collective efficacy
Morgan et al., 2017	Protective factors, Vulnerability factors
Stephens, et al., 2013	Coping skills, trust
Stoverink et al. 2018	Team potency, mental models of teamwork, capacity to improvise, psychological safety
Van Der Kleij et al., 2011	Transformational leadership
Vera et al., 2017	Teamwork experience

Conceptualizing team resilience as a capacity emphasizes a team's potential to be resilient given a sufficiently challenging adverse event (Chapman et al., 2020). However, defining team resilience as a capacity of a team does not address how teams express team resiliency when challenged. For example, measuring the resilience-related capacity of a team in an applied setting would not inform practitioners of the behaviours a team engages in to address adversity they encounter, only the resources available to them. A second issue is that there appears to be little consensus on what exactly characterizes a resilient team (Bowers et al., 2017; Chapman et al., 2020). Table 1 provides an overview of some characteristics of highly resilient teams, identified in the team resilience literature, thought to be generalizable to most adversities a team may face. However, an important caveat here is that given the massive variance in the type, frequency, and magnitude of an adversity, what makes for resilience capacity is likely largely contingent on the adversity itself (Hartmann et al., 2021). A similar issue is found in the individual and organizational resilience literature as well, where the proliferation of relevant characteristics is referred to as the 'laundry list' problem. By viewing team resilience as a set of team capacities that can be invested as resources into addressing adversity (Bowers et al., 2017; Gucciardi et al., 2018), the list of constructs that may be considered a resilience resource may be as large as the list of 'generally good things a team can be or do' (Chapman et al., 2020). Given these limitations, team resilience research has shifted towards process models, highlighting the longitudinal and multilevel nature of team resilience responses to adversity.

1.3 Processes of a Resilient Team: What Does a Resilient Team Do?

In contrast to capacity conceptualizations of team resilience, there has been a shift across many disciplines, including psychology and organizational management, to view resilience as something a system does (Bonanno et al., 2015; Mayner et al., 2019). From this perspective, resilience encompasses a pattern of responses to adversity that unfolds over time. As a process,

team resilience is how a team prepares for and responds to adversity to preserve or return to a state of equilibrium on some outcome of interest (e.g., team performance) and includes "interactive, coordinative and synergistic team interaction processes, which describe the actual behaviors teams use to cope with adversity" (Hartmann et al., 2021, p. 42). Resilient team processes are theorized to emerge from team members' combined knowledge, skills, and abilities (Gucciardi et al., 2018; Hartwig et al., 2020). To date, there is no consensus on what inputs exactly lead to the emergence of team resilience processes, or indeed what processes are relevant to team resilience (see Table 2). For example, Stoverink et al. (2018) argue that team resilience is a higher-order process consisting of persistence and adaptation, whereby teams respond to adversity by choosing to either 'stay the course' and persist through adversity, or by adapting the nature of their team to respond to the adversity. In their theoretical framework, when teams collectively encounter challenges in their goal pursuit, they go through a process of identifying the challenge, deciding whether to adapt or persist in their work processes, and investing resources to address the challenge based on their preferred process. Alliger et al.'s (2015) mitigation (proactively planning how to address hypothetical adversities), management (addressing current adversities) and mending (restoring team functions following the negative effects of adversity) is a popular stage model to organize group processes involved in team resilience.

Table 2

Example Psychosocial Processes of Resilience in Teams

Source	Contributing Psychosocial Processes
Alliger et al., 2015	Minimizing, managing, monitoring processes

Edson, 2012	Adaptation
Gucciardi et al., 2018	Affective, behavioural, cognitive coordination
Morgan et al., 2013	Adaptation
Stoverink et al., 2018	Persistence, adaptation, minimizing, managing, monitoring processes

A process perspective highlights how team members work interdependently to recover from an adverse event (Chapman et al., 2020). If resilience is conceptualized as a process, the nature of the trajectory, mechanisms, and paths of these processes are unclear. For example, team adaptation ("a change in team performance, in response to a salient cue or cue stream, that leads to a functional outcome for the entire team"; Burke et al., 2006, p. 1189) tends to be the most commonly researched pathway of resilience, to the point that many researchers use adaptability and resilience interchangeably (e.g., Meneghal et al., 2016b; van der Kleij et al., 2011).

1.4 Outcomes of a Resilient Team: How do Resilient Teams Perform?

A third approach is to view team resilience as an emergent state or outcome. Following the resource crossover model (Hobfoll, 2015), it emerges from the interdependent investment of resources into adversity response processes (Bowers et al., 2017; Gucciardi et al., 2018; Hartwig et al., 2020). Gucciardi et al. (2018) suggest that an important distinction to note here is the separation of a team's resilience trajectory as a property of a relevant outcome's functioning over time, and the team members' shared perception or belief that their team is resilient that team members converge on through repeated observation of their collective ability to handle adversity. While both may be termed as team resilience, the first is a configural construct that characterizes a team's performance as it unfolds over time in response to adversity, while the other is a

compositional construct that emerges from the aggregation of team member perceptions (Kozlowski & Klein, 2000).

From the emergent outcome perspective, team resilience can be viewed as a team's 'trajectory' of functioning on an outcome variable following disequilibrium (Gucciardi et al., 2018). For example, in the case of team performance, if a team experiences a disruption that adversely impacts their performance (e.g., loss of a member, experiencing conflict, going virtual due to a pandemic), resilience is the trajectory of how a team recovers their pre-adversity level of functioning over time. Gucciardi et al. (2018) propose three separate trajectories of resilient performance: resistance (relatively unaffected by the adversity), bouncing back (characterized by a quick return to a pre-adversity equilibrium), and recovery (a large deviation, followed by a gradual return). These three trajectories differ by the degree of deviation from a pre-adversity baseline and the length of time required for an eventual return to the pre-adversity equilibrium. While Gucciardi et al. (2018) remain the only source outlining trajectories of resilience within the team resilience literature, defining resilience as a property of an outcome in response to adversity that unfolds over time is the norm in physical sciences (Hodgson et al., 2015) and has gained increasing traction in psychological resilience (Bonanno et al., 2010; Norris et al., 2009).

1.5 Defining Team Resilience: Evaluating Definitions

Due to the conceptual confusion surrounding the construct of team resilience, the development of the TRI began with a close review of various definitions found in the literature. A scoping review was performed in 2019 which identified eight definitions of team resilience available. To assess the quality of the definitions, I followed Podsakoff et al.'s (2016) six criteria for high quality definitions for psychological constructs, which includes: 1) property and entity (does the definition specify the entity and nature of the phenomenon?); 2)

necessary and sufficient attributes (does the definition include both necessary and sufficient criteria?); 3) dimensionality (does the definition specify the dimensionality of the construct?); 4) stability (does the definition specify the temporal characteristics of the construct); 5) nomological network (does the definition specify relations to other constructs?); and 6) delineated (does the definition specify how the construct is different from related constructs?). Multiple definitions were identified (e.g., Alliger et al., 2015; Gucciardi et al., 2018; Morgan et al., 2013; Stoverink et al., 2017) and are summarized in Table 3. Nine studies were included based on the inclusion of an original definition and meeting at least 1 of the criteria listed above (Podsakoff et al., 2016).

From review of these definitions, there are some commonalities and some unique features to how previous scholars have defined team resilience. All the reviewed definitions suggest that the presence of some form of collective stressor/challenge/adversity is necessary for team resilience to be demonstrated, and that these perturbations may originate within or from outside the team (e.g., Gucciardi et al., 2018; Morgan et al., 2013). Few definitions made explicit reference to the temporal components of team resilience (e.g., Gucciardi et al., 2018; Van der Kleij et al., 2011), however a temporal component appears implied in almost all definitions through terms such as ‘bounce back’, ‘recovery’, ‘growth’ that imply some timeframe is necessary for team resilience to occur in. As discussed in the literature review, there is debate in the wider team resilience literature as to whether team resilience is best considered a team capacity, process, or outcome (Gucciardi et al., 2018; Hartwig et al., 2020; Stoverink et al., 2020), and this is reflected in the available definitions as well. The majority of the available definitions explicitly state that team resilience is a capacity, however it appears that the role of processes and outcomes in team resilience is implied through reference to temporal conditions, and variations in level of functioning on some relevant outcome such as team performance, suggesting that despite the conceptual confusion in explicitly stated definitions and

their associated operationalizations across studies, there is an underlying assumption of team resilience as a higher-order state that includes multiple inputs, processes, and outcomes.

Table 3

Example Definitions of Team Resilience

Source	Definitions	Psychometric properties of definition					
		PE	EA	DM	S	N	D
Alliger et al., 2015, p. 177.	“The capacity of a team to withstand and overcome stressors in a manner that enables sustained performance; it helps teams handle and bounce back from challenges that can endanger their cohesiveness and performance.”	✓	✓	✗	✗	✓	✗
Bowers et al., 2017	"A critical team level capacity that facilitates the rebound of teams after an adverse event."	✓	✓	✗	✗	✗	✗
Gucciardi et al., 2018, p. 740.	"an emergent outcome characterized by the trajectory of a team’s functioning, following adversity exposure, as one that is largely unaffected or returns to normal levels after some degree of deterioration in functioning."	✓	✓	✓	✓	✓	✓
Hartwig et al., 2020	"A team’s capacity to withstand or recover from adverse events (i.e., events that may lead to losses or breakdown of independent team processes), which we conceptualize as an emergent team state that results from preparative, adaptive, and reflective team	✓	✓	✓	✓	✓	✓

	processes and which is demonstrated by a persistence, recovery, or growth trajectory of team functioning following exposure to adversity."						
Kennedy et al., 2016, p. 468	“Shared belief held by the team that it can respond to disruptive and challenging events, recover from setbacks, and thrive as a team under these conditions.”	✓	✓	✗	✗	✗	✓
Morgan et al., 2013, p. 552	“A dynamic, psychosocial process which protects a group of individuals from the potential negative effect of stressors they collectively encounter. It comprises of processes whereby team members use their individual and collective resources to positively adapt when experiencing adversity.”	✓	✓	✓	✓	✓	✗
Rodríguez-Sanchez et al., 2015, p. 30	"A capacity that teams have in order to overcome crisis and difficulties.”	✓	✗	✗	✗	✗	✗
Stoverink et al., 2017	"A team’s capacity to bounce back from adversity-induced process loss."	✓	✓	✗	✗	✗	✗
van der Kleij et al., 2011, p. 4	"Ability of teams to respond to sudden, unanticipated demands for performance quickly and with minimum decrement of performance."	✓	✓	✗	✗	✓	✗
West et al., 2009, p. 253.	“Provides teams with the capacity to bounce back from failure, setbacks, conflicts, or any	✓	✓	✗	✓	✓	✗

	other threat to wellbeing that they may experience.”

Note. PE = property and entity; NS = necessary and sufficient attributes; DM = dimensionality; S = stability over time/context; N = nomological network; D = delineation (Podsakoff et al., 2016).

Two definitions were identified as being sufficiently high quality for measure development based on Podsakoff et al.’s (2016) criteria:

1) *"An emergent outcome characterized by the trajectory of a team’s functioning, following adversity exposure, as one that is largely unaffected or returns to normal levels after some degree of deterioration in functioning."* (Gucciardi et al., 2018, p. 740).
2) *“A dynamic, psychosocial process which protects a group of individuals from the potential negative effect of stressors they collectively encounter. It comprises of processes whereby team members use their individual and collective resources to positively adapt when experiencing adversity.”* (Morgan et al., 2013, p. 552).

Both definitions meet the majority of Podsakoff’s (2016) criteria for a high quality definition, however there are some significant differences in the ontology of the constructs they describe. The Morgan et al. (2013) definition specifically views team resilience as a psychosocial process, whereas the Gucciardi et al. (2018) definition views team resilience as an emergent outcome (i.e., a property of team functioning over time). In general, the Morgan et al. (2013) definition highlights the process of investing team resources into responding to collectively faced adversity and is an advancement over previous definitions in terms of Podsakoff’s (2016) definitional criteria, meeting all of the criteria except for the dimensionality of team resilience. There were two issues that complicated the dimensionality of team resilience

in this definition. First, Morgan et al. (2013), and later publications in the same line of research (e.g., DeCroos et al., 2017; Morgan et al., 2015; 2019) refer to a wide variety of psychological and team constructs that represent essential attributes of team resilience (e.g., mastery experiences, collective efficacy, group structure, social capital, leadership, social identity, team learning, positive emotions); however, it is unclear why exactly these constructs, and not others, are necessary to characterize team resilience. In further development of Morgan et al.'s (2013) conceptualization of team resilience, DeCroos et al. (2017) categorized these various constructs into protective factors (i.e., those that promote the capacity of a team to be resilient to adversity) and vulnerability factors (i.e., those that make them vulnerable to adverse events). This criticism reflects the wider criticism of psychological resilience research in general as attempting to define resilience by its potentially unlimited 'laundry list' of contributing factors rather than as a separate construct itself (Garmezy, 1993; Riley & Masten, 2005; Smith et al., 1995). From this approach, a myriad of variables may be seen as necessary components of team resilience, without ever clearly specifying when the construct domain is sufficiently identified (Gucciardi et al., 2018). Further, while some variables may facilitate resilience across a variety of situations, it is often the case that at least some resources required to address an adversity are unique to it. Related to this issue, Morgan et al.'s (2013) definition also does not clearly differentiate team resilience from the closely related construct of team adaptation or specify how these two constructs relate to each other. From the definition, it may be implied that there is little to no difference between a team that is resilient to an adversity, and one that successfully adapts to an adversity. It may be, as suggested by Stoverink et al. (2020), that team adaptation is a sub-process of team resilience, or that they are completely interchangeable.

Regarding the Gucciardi et al. (2018) definition, the emphasis is placed on viewing team resilience as an emergent property of a relevant team outcome, for example a trajectory of performance recovery following the experience of adversity. The strength of this definition is that it clearly defines the property (variability of team functioning following adversity), entity (the team), necessary attributes (unaffected or recovered functioning), and stability over time (explicit reference to temporal nature). Though not directly referred to in the definition, Gucciardi et al. (2018) establish the dimensionality of team resilience elsewhere in their theory development as encompassing affective, behavioural, and cognitive characteristics (i.e., resources and inputs to be invested in responding to adversity), and processes (the act of responding to the adversity). This extends from their separation of the *readiness* for team resilience from its *emergent demonstration* through trajectories of functioning over time. As discussed in the literature review, these differences reflect the wider issue of whether team resilience is a capacity (what resources does a team have?), a process (what a team does in response to adversity), or an outcome (a property of team functioning). However, this definition is also limited in that although the affective, behavioural, and cognitive characteristics and processes may be necessary and sufficient for conceptualizing the capacity for a team to be resilient, they are also quite abstract and may not provide clear guidance for what resources, traits, processes, motivational states, group structures, etc. affect team resilience and why.

To draw from the strength of both these definitions, I developed the Team Resilience Inventory (TRI) with both of the previous definitions in mind. Team resilience was defined as "*an emergent state and outcome that reflects a team's capacity to resist or recover from the collectively experienced adverse events. It emerges through the interactions between team members as they invest resilience-related resources in persisting through and/or adapting to*

adversity in pursuit of resisting adversity or recovering a point of equilibrium on a relevant team-level outcome (e.g., team performance).” This definition captures both *resilience capacity* (i.e., the team resilience characteristics and processes that contribute to a successfully resilient response to adversity) and its *emergent demonstration* (i.e., the team’s demonstrated ability to resist and recover from the negative effects of adversity).

1.6 The Need for a Measure of Team Resilience

Across disciplines, the vague meaning of resilience and how it should be operationalized has been an obstacle to rigorous measurement (Moser et al., 2019). This conceptual fuzziness, as outlined above, makes it difficult to identify necessary and sufficient conditions to delineate team resilience, specify the resources of a resilient team or the processes they engage in, or develop stable metrics for how to measure it that can be applied across contexts (Hartwig et al., 2020). Review of primary studies measures shows that team resilience researchers conceptualize and measure team resilience in different ways.

Regarding current measurement instruments for evaluating team resilience, there appear to be three trends. The first is to referent-shift (Chen, 1998) the content of psychological resilience questionnaires to apply to the team (e.g., Brykman & King, 2021; Hendrikx et al., 2022; Pavez et al., 2021; West et al., 2009). Early research in team resilience adopted this approach by altering the instructions or object referents of scales originally designed to measure psychological resilience, such as the PsyCap questionnaire (Luthans, 2007). This comes with the assumptions that team level and psychological resilience are sufficiently similar and that team resilience is best understood as an aggregate of psychological resilience (i.e., referent shifting from ‘I’ to “my team” captures team-level resilience). Assuming this isomorphism does not account for the interactive team processes that occur within a resilient team (e.g., coordination of

resources). Further, referent shifting a scale is not always a straightforward process, and such practices may alter the psychometric properties of the scale (Morgeson & Hoffman, 1999). Referent shifting the items and how the responses are to be aggregated may change the meaning of the construct. For example, the aggregation of how individual team members view their own resilience (self-referent) is a very different construct than aggregating team members' perceptions of their team's resilience overall (team-referent; Kozlowski & Klein, 2003).

A second trend in the literature is to develop brief measures (e.g., Carmeli et al., 2013; Meneghal et al., 2016a; 2016b; Salanova et al., 2012) with little to no reliability and validity testing and not intended to be used outside the context of a particular study (i.e., *ad hoc* measures; an overview of examples can be found in Table 3). Many primary studies of team resilience rely on *ad hoc* measures developed specifically for a given study, which often neglect to assess or report the psychometric quality of these measures, impacting the ability to accurately evaluate and interpret results. Reliability and validity are fundamental facets of psychometric quality and researchers should provide some evidence regarding the psychometrics of their measure. In the case of team resilience, these statistics tend to either be not reported or limited to measures of internal reliability (i.e., Cronbach's *a*). It appears that researchers largely rely on the face validity of these measures. This limits the ability to assess the degree of accuracy of any

Table 4

Example Ad Hoc Measures in Team Resilience Research

Reference	Definition	Factors	Ontological State	Operationalization	Items	Sample	Reliability/Validity
Blatt, 2009	"The capacity to rebound from adversity strengthened and more resourceful.''	N/A	Inputs	referent-shifted items from the 'Safety Organizing Survey'' (Vogus & Sutcliffe, 2007) and the "Brief Resilient Coping Scale" (Sinclair & Wallston, 2004), aggregation not specified.	6	k = 122 entrepreneurial teams	no available reliability or validity statistics
Salanova et al., 2012	"The ability to manage disturbances of the normal workflow and to recover a dynamically stable state that allows the organization's goals of production and safety to be achieved."	N/A	Inputs	group-level items developed for the study, aggregation not specified.	7	N = 710, k = 303 workplace teams	a = .83, r_{wg}(14) = .78
West et al., 2009	"The capacity to bounce back from failure, setbacks, conflicts, or any other threat to well-being that a team may experience."	N/A	Inputs	items adapted from PsyCap (Luthans et al., 2007) using a reference shift approach, aggregation not specified.	6	N = 308 university students, k = 90 randomly assigned teams	a = .76, r_{wg} = .6
Van Der Kleij et al., 2011	"The ability of teams to respond to sudden, unanticipated demands for performance quickly and with minimum decrement of performance"	N/A	Process	unspecified	5	N = 105 university students, k = 35 randomly assigned teams	a = .85

results reported, the ability to compare results across studies, and generalize results outside the context of the study. Last, there is a push to develop team resilience measures with published psychometric validation results (DeCroos et al., 2017; McEwen & Boyd, 2018; Sharma & Sharma, 2016). Similar to the *ad hoc* measures discussed above, these three measures of team resilience each take a different approach to the content domain, dimensionality, emergence, and measurement of team resilience. A brief overview of these measures can be found in Table 5. These measures have been criticized for potentially capturing only the antecedents of resilience rather than the construct itself, having suboptimal psychometric indicators, and an inability to account for temporal properties of team resilience (Hartmann et al., 2021; Stoverink et al., 2018). As Stoverink et al. (2018) argue: "(I)t appears as though these scales might actually measure various antecedents of team resilience (e.g., resourcefulness, robustness, self-care) that reflect factors contributing to the capacity to bounce back, rather than directly capturing the capacity itself. In light of this limitation, and to facilitate a consistent and uniform stream of empirical research, we call on scholars to develop and validate a scale that captures…team resilience." (p. 44). In other words, measures of team resilience to date have focused almost exclusively on what resources make for a strong team resilience capacity, with little consideration of how team resilience is enacted by the team or its demonstration in key outcomes.

Table 5

Overview of Current Team Resilience Measures

Reference	Factors	Operationalization	Items	Sample	Reliability	ICC(1)	X^2	RMSEA	CFI/TLI	SRMR
Team Resilience Scale (Sharma & Sharma, 2016)	Group Structure, Mastery Approaches, Social Capital, Collective efficacy	Supervisor perception ratings of team characteristics	67	IT team 43 supervisor s (N = 152)	a = .72 (team efficacy) to .88 (shared language)	N/A	(1130) 1519.002*	.048	.93/.92	.059
Resilience at Work scale (R@W, McEwen & Boyd, 2018)	Resourceful, Robust, Perseverance, Self-care, Capability, Connected, Alignment	Mean-aggregated score of team member perceptions	42	N = 344, k = 31 work teams	overall a = .98, .81 (connected ness) to .89 (capability)	split half indicators = .18, .15	(1631) 3345.87*	.006	.87/.86	.05
Characteristics of Resilience in Sports Teams Inventory	Resilient Characteristics, Vulnerabilities under pressure	Mean-aggregated score of team member perceptions	20	N = 473, k = 53 sport teams	ω(between) = .90 (.99)	.37	(166) 303.95*	.045	.94/.93	.045

(CREST; DeCroos, Line,

Morgan et al., 2017)

This review of team resiliency measures suggests there is a need for a well-validated, theoretically-informed measurement instrument for team resiliency. This sentiment has been echoed by other authors as well (e.g., Alliger et al., 2015; Hartmann et al., 2021; Stoverink et al., 2018). Although recent years have seen an uptake in theoretical model building, as of yet no measure exists that considers the process aspects of team resilience (Stoverink et al., 2018). In light of the limitations discussed and to facilitate empirical research, the purpose of this dissertation is to develop and validate a comprehensive measure for team resiliency that can be used in future research and applied settings.

1.7 Conceptual Model of Team Resilience for the TRI

COR theory (Hobfoll, 1989; Hobfoll et al., 2000) has emerged as a popular and potentially well-fitting theoretical framework to understand team resilience (e.g., Brykman & King, 2021; Hartwig et al., 2021; Hobfoll et al., 2015; Stoverink et al., 2020). The core idea of COR theory is that we strive to obtain and retain valued resources to assist with goal achievement and lead to further resource accrual (Hobfoll, 2001). Such resources could include objects, personal attributes, skillsets, finances, and social supports that are considered relevant and useful in dealing with potential environmental threats. These resources can be either relatively global (e.g., team communication skills, trust among members) or relatively specific to an adversity (e.g., redundancy of team member knowledge and skills if a team member is removed). In applying COR theory to psychological resilience, Hobfoll et al. (2015) argue that resource rich environments that promote resource growth and mitigate resource loss are the foundation for developing resilience capacity. They further argue that resources often come in "caravans" (Hobfoll et al., 2018); that is, resources often come bundled together, for example

how teams with a strong sense of team trust are also likely to be highly coordinated, as each member trusts each other to perform their function. These resource caravans are mutually supportive in that increases or losses in any team resource is likely to augment other resources that make for a team's capacity to be resilient. COR has also been applied to resilience at the level of organizations. For example, a standard practice in commercial organizations for buffering against forecasted market shocks is to stockpile resources (e.g., stockpiling financial capital through cost-cutting procedures or liquidating product) and invest resources into actions to mitigate future resource loss (e.g., investing onto change management consultants and training for the leadership team, Hartmann et al., 2019).

Two further arguments of COR theory are that resource loss is disproportionately salient compared to resource gain, and that in order to mitigate potential resource loss in the future, current resources must be invested to protect against loss and to increase the potential for gain (Hobfoll, 1998), which suggests that resilient capacity can be developed by acquiring and investing resources into building resilient-promotive capacities. As such, individuals, teams, or organizations that already have significant resources to invest are more likely to continue gaining resources over time as a result of the investment, a phenomena Hobfoll refers to as 'resource-gain spirals' (1989, p #?). For individuals, this may include things like developing knowledge and skill base through education, physical exercise, or developing a career that leads to better physical health and financial outcomes in the long term despite initial costs. For teams this may look like investment in employee development, acquiring and training new members, adequate compensation to avoid employee turnover, or working on long-term projects. On the other hand, those with few resources are often more vulnerable to threats (i.e., adversities) because they lack the resources to mitigate the adverse effect and thus lose even more resources than others,

leaving them more vulnerable to future threats. This phenomenon is referred to as a ‘resource loss spiral’ (Hobfoll, 2001). Clearly then, the resource gain and loss prevention perspective of COR theory fits well with the capacity approach to identifying team resilience resources, where teams are motivated to acquire resources in anticipation of adversity and prevent resource loss if and when adversity strikes.

In application to team resilience, COR theory lines up well with the IPO model of team resilience and has been applied in the ‘capacities’ theme of team resilience research. This framework interprets team resilience capacities as resources (e.g., group structure, financial resources, knowledge and skills of team members, leadership ability, team trust) that can be acquired, invested, developed, or lost to either prepare for or respond to adversity (i.e., the ‘inputs’ of team resilience; Stoverink et al., 2020).

In responding to adversity, COR theory and its extension the ‘Crossover model’ (Hobfoll et al., 2018; Westman, 2001) may explain how individual team members go through a mediating process of collectively experiencing an adversity, forming a shared perception, and ultimately responding through investing their resources. Crossover refers to the interpersonal process that occurs when the strain experienced by one individual transmits to others within their social groups (e.g., workplace teams). Westman (2001) argues this can occur in three ways: 1) direct crossover of strain from one individual to others through empathy; 2) indirect crossover, where mediating and moderating factors of either partner (e.g., resilience capacity, coping mechanisms) affect the transmission of the experience; and 3) spurious crossover, where shared stressors may lead to common effects (e.g., high job demands causing burnout in multiple team members). Further, Westman (2001) suggests that the crossover model is applicable to the transmission of resources (e.g., positive mental states, knowledge and skill sharing) among social partners, not

just strain. Just as one team member's experience of burnout may crossover to others, so too may their resilience capacities (Hobfoll et al., 2018).

The crossover model may also explain how team resilience may in part emerge from psychological resilience. First, the crossover model suggests adversity may become collectively experienced when individual strain transmits between team members (e.g., burnout), or when an adversity that affects the team as a whole has a similar effect on all team members (e.g., the loss of a team member). Second, the crossover model suggests that team resilience capacity can be built as team members invest their resources into each other and developing collective capacities, such as knowledge sharing among team members. Third, the psychological resilience capacities of members moderate and mediate how adversity may crossover between team members, how each member may experience the same adversity, and ultimately how shared the experience is. The sharedness of the adversity and the interdependence of the team members is likely to influence the degree to which team members respond to the adversity individually versus as a team. When the adversity is shared and team interdependence is high, team members are more likely to perceive addressing the adversity as a collective, rather than individual goal and thus the degree to which they are motivated to cooperate and respond as a unit (Westman, 2001) If an adversity is judged as requiring a collective response, ideally team members would address this collective adversity through the exchange and coordination of their resources within their group. That is, in an ideal world, team members will share resources and invest in each other to support the achievement of collective goals, with the assumption that achieving them will provide return on investment of their individual resources (e.g., by investing time and financial resources into developing a team member's skillset to adapt to a gap created by an essential team member leaving the team). As such, COR and crossover theory offer a theoretical framework that integrates the capacities and processes approaches to team resilience research within an

IPO model.

Based on COR theory then, a highly resilient team is one that has acquired ample resilience-related resources that can be invested into a team's response process when adversity strikes. A non-resilient team would be one that has few resources to respond with or is unable to effectively invest them into a response. Teams with a high capacity for resilience are better able to respond to the adversity and thus experience less resource loss, potentially even experiencing resource gain spirals in terms of knowledge, skill, and team efficacy developments (Stoverink et al., 2020), whereas teams with low resilience capacity will likely be more negatively affected by adversity, take longer to recover, and potentially never fully recover or be left even more vulnerable to future adversities (i.e., a resource-loss spiral). Thus, a team's resilient capacity can evolve over time (Gucciardi et al., 2018; Pavez et al., 2021).

1.7.1 Emergence and Multilevel Considerations

Team resilience emerges from observing, sharing, and building resilience resources among team members as they work to accrue team resources in preparation for adversity and ultimately invest in responding to collectively faced adversity if and when the need arises. As such, it is inherently a multilevel construct, as team members draw from the resilience capacities of their individual members, the supports and resources found in their social environment (e.g., organization, community, social network), and from emergent resources of the team (e.g., team trust, coordination). At the same time, a team's resilience also effects individual team members and that of their larger social groups. For example, a highly resilient team is a potential protective factor for its members' psychological resilience as it may buffer the potential negative effects of team-level adversities, such as high workload, that may otherwise affect the individual

members directly. Similarly, highly resilient teams may act as a resource an organization can draw on. A highly resilient operations team may be resilient to the chaotic effects of supply chain disruptions, quickly adapting to the adversity and restoring normal functions and by extension mitigating the effect on the larger organization. To understand team resilience then, and indeed, resilience at other levels of analysis within the organizational management literature, we need to consider the cross-level interactions of resilience (Hoegl & Hartmann, 2021). In other words, a full understanding of team resilience requires a nested view of resilience within social systems that acknowledges cross-level interactions among different levels of analysis (i.e., cross-level effects).

1.7.1.1 Team Resilience is Conceptually Different than the Resilience of Individual Team Members.

Team resilience is more than just an aggregate of each team member's psychological resilience. Although the function of individual and team resilience is similar (i.e., 'bouncing back' from adversity), the form (i.e., the inputs, processes, and outcomes) of individual and team resilience is not. As such, psychological and team resilience are not isomorphic across levels (Gucciardi et al., 2018; Hartmann et al., 2021). For example, reference-shifted individual resiliency measures are unable to capture the social interaction component of team resilience. Team level constructs such as team trust, team coordination, and transactive memory systems are examples of this. Neither team interdependence nor coordination exists at the individual level of analysis; however, they represent important components of many group-level functions. That is not to say, however, that there are no relationships between psychological and team resilience (Brykman et al., 2021; West et al., 2009). For example, resilient individuals are likely to have more resources to offer their team in times of need (e.g., a sense of optimism, commitment to the

collective goal, bandwidth to provide emotional support for others), while resilient teams may act as sources of social support for individual members. Moreover, Hendrikx et al. (2022) found that psychological resilience predicted 12.4% of variance in team resilience ratings in a hierarchical regression controlling for team familiarity and coordination. In the same study, the authors also found that team familiarity (e.g., degree of experience working with each other) had a direct, positive effect on team resilience that was not mediated through psychological resilience, further supporting that these constructs are not isomorphic, and that the two have distinct antecedents. Further, in their principal components analysis, items from Luthans' (2007) team resilience measure loaded separately from psychological resilience as measured by the PsyCap questionnaire, suggesting that aggregated psychological resilience scores can be statistically distinguished. In essence then, psychological and team resilience appear to be related but separate constructs that only partially explain each other's variance (Hendrikx et al., 2021). An aim of the current dissertation was to develop a team resilience inventory to capture emergent properties of team resilience that do not have individual-level analogs.

1.7.1.2 Team Resilience Includes a Temporal Process and Requires Appropriately Timed Assessment

Team resilience research has almost exclusively relied on static designs (Hartwig et al., 2020). Single time point designs offer some insight into the associations between team processes and covariates; however, these approaches have limited ability to address temporal dynamics at play in the emergence and function of team resilience (Gucciardi et al., 2018). Static designs imply that the construct is largely stable across time and contexts, which is not the case in team processes such as team resilience (Bowers et al., 2017; Morgan et al., 2013). Team resilience is a dynamic construct that spans across the IPO model (Bowers et al., 2017; Gucciardi et al., 2019; Stoverink et al., 2018). An empirical challenge of research on team resilience is that the

phenomena encompasses: 1) the initiating adversity; 2) reactions to the adversity; 3) the resources a team can draw on; 4) the processes by which a team endeavours to return to equilibrium; and 5) the trajectory of functioning on relevant performance outcomes. Following Gucciardi et al.'s (2018) suggestions, the TRI was developed with a dynamic conceptualization of resilience.

1.7.2 Operationalizing Team Resilience as a Shared Perception

Emergence refers to the dynamic process in which a higher-order construct emerges over time from the complex interactions of lower-level units over time (Kozlowski & Bell, 2013). In the team resilience literature, interactions among individual members within the context of the adversity leads to the integration of resources available to the team in ways that create a pattern (Kozlowski & Klein, 2000). I argued above that this occurs through the crossover of strain experiences and resources between team members. When teams face a collective adversity, they invest their individual resources into Persistence and Adaptation to achieve the goal of maintaining or recovering a pre-adversity state. Similar arguments are made elsewhere. For example, Gucciardi et al. (2018) suggest human capital resources across team members are invested into recovery from adversity through sequential interdependence to create team performance trajectories.

Both of these approaches reflect compilational emergence (Kozlowski & Klein, 2000). Compilational constructs, however, are notoriously difficult for measurement development as they are not amenable to questionnaire formats (Kozlowski & Klein, 2000). Gucciardi et al. (2018) make the argument that while team resilience itself is a compilational emergent state or outcome, individual members do have a perception of their team's resilience. Over time, these perceptions will converge based on repeated observations leading to a degree of sharedness. Compositional constructs emerge over time from the convergence of lower-level inputs such as beliefs, perceptions, or attitudes (Kozlowski & Klein, 2000). As a compositional construct, a shared

perception of team resilience emerges among team members through repeated social interaction and observations of team functioning across performance events (Gucciardi et al., 2019). From this perspective, team resilience can be measured as a shared perception of how a team performs in response to adversity that arises out of mastery experiences (Gucciardi et al., 2018; Meneghal et al., 2016a; 2016b). As such, the TRI was designed to measure team members' perceptions of their team's resilience-related resources, processes, and performance over time.

Further, team resilience perceptions are best characterized by a referent-shift composition model in which individual perceptions are aggregated to form a higher-level construct (Chan, 1998). Following best practice suggestions (e.g., Kozlowski, 2012), the TRI uses group referents (e.g., "Our team feels good about being on this team" rather than "I feel good being on this team") to align item operationalization with the entity of team resilience, as this approach tends to yield higher within-group agreement and places focus on perceptions of the team's average score. In this approach, team member perceptions all refer to the same higher-order object (e.g., the team's resilience) and is likely best represented by aggregate mean scores or a latent unobserved mean score. When assessing individuals' perceptions of team resilience, these perceptions are expected to be shared to some degree within teams (i.e., a compositional construct). As such, the TRI takes a reference-shift approach to measuring team resilience perceptions. A reference-shift model calculates the team members' average perception as a "point measurement" of group-level characteristics; and their within-team agreement as the emergent state of those characteristics (Kozlowski, 2015).

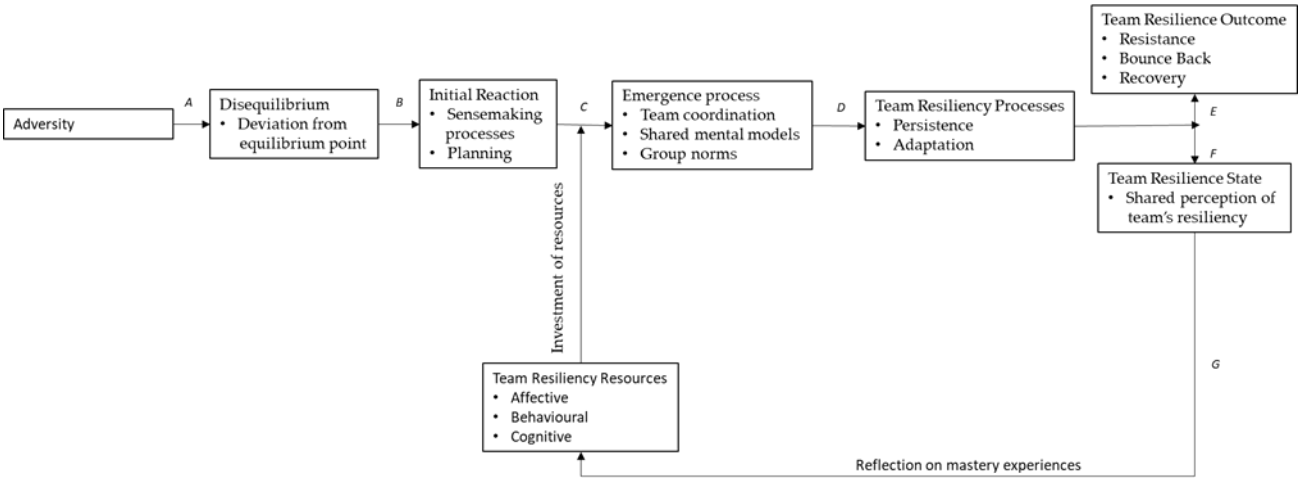
1.8 Summarizing the Conceptual Model

Drawing from COR theory and the crossover model, the conceptual model for the TRI is predicated as a goal-oriented approach to either maintaining or returning to a point of equilibrium on valued team outcomes following a disruption due to adversity. In essence, the model posits that team resilience is elicited in response to disequilibrium following exposure to a sufficiently salient adverse event (Figure 3, path A). Team members then go through a process of making sense of this effect and developing a response to address the disequilibrium (Figure 3, path B). Once a response has been developed, team members then invest their resources towards addressing the adversity through interdependent social and task interactions (Figure 3, path C). The sharing of resources toward the collective goal of addressing the adversity through interdependent exchange is the mechanism of emergence for team resilience as a property of a team function (Figure 3, Path D). These resources can originate at the individual (e.g., human capital resources), team (e.g., team trust; team potency beliefs), or organizational (e.g., organizational support) level. The myriad processes involved in maintaining or recovering team functioning eventually culminate in the decision to continue to invest resources and effort into addressing the adversity (Persistence) and the decision to either maintain or modify (Adaptation) the team's structure and functions to bear through or adapt to the adversity (Figure 3, Path E). As such, the TRI focuses on Persistence and Adaptation as the two key processes in overcoming adversity. Ultimately, how a team responds to the adversity dictates how they either maintain (resist the negative effects of the adversity) or recover (bounce back from the negative effects of the adversity) a state of equilibrium on a resiliency related outcome (Figure 3, Path F). How a team experiences success or failure throughout the adverse event and interprets the contribution of various resources, processes, and strategies (i.e., mastery experiences) informs team members'

perceptions of their team's resilience capacity to successfully manage similar adversities in future scenarios (Path G; Gucciardi et al., 2018). These perceptions then provide the basis for attitudinal resources that can be invested in future scenarios, such as team potency and efficacy beliefs and motivation for acquiring further resources (Path H; Gucciardi et al., 2018).

Figure 1

General Conceptual Model of Team Resilience for the Team Resilience Inventory



Based on this conceptual model, the key aim of my dissertation is to develop a measure of team resilience that considers the capacity, process, and outcomes perspectives of team resilience within an internally consistent framework. In the following section, I outline the domain development and item generation for the seven factors included in the TRI based on the literature review. This includes defining the domains and the rationale for inclusion, item generation for each, and the expert panel review for content validity.

2. Development of the Team Resilience Inventory and Overview of Studies

The TRI is a 7-factor, 41 item measure of three team resilience resource dimensions (affective, behavioural, and cognitive) two team resilience processes (persistence and adaptation), and two properties of resilient team functioning (resistance and recovery). For an outline of the current format of the TRI, see appendix A. Responses are rated on a 1 ("*strongly disagree*") to 7 ("*strongly agree*") Likert scale. Scores on the TRI are aggregated to the team level by calculating a group mean. In addition to the factors, the TRI includes a cognitive prompt regarding a recent adverse event a team experienced that the team can use as a reference event when responding to the questionnaire.

For clarity's sake, the development of the TRI was an iterative process that spanned over 5 years from 2016 to 2021. The content domains and corresponding items changed significantly in response to new directions in the team resilience literature, feedback from data analysis, and the integration of resilience theory from outside the realm of psychology. As such, each study reflects changes in the literature and the inclusion of new factors as a result.

Study 1 was conducted during the 2018-2019 academic year and the sample consisted of engineering project design students operating in teams of 4 to 6 people. The purpose of study 1 was to evaluate the measurement model and reliability of the TRI, with exploratory analyses of how the TRI may relate to other team constructs such as team conflict and coordination. In response to the results of study 1 and developments in the literature, minor changes were made to the resource factors (i.e., reduction of items) and two new factors were included: Persistence (the continued exertion of effort and investment of resources in responding to an adversity) and Adaptation (the modification of team structure and/or work processes to respond to adversity). Study 2 was also conducted with student engineering teams with two cohorts from the 2019-

2020 and 2020-2021 academic years that were merged into one sample. The purpose was to confirm the measurement model of the TRI, establish its discriminant validity from psychological resilience, and to begin exploring the nomological network of team resilience. Last, study 3 was designed to investigate how team functioning over time can be operationalized and measured as resilient. This study introduces Resistance (how well a team maintains function following exposure to an adversity) and Recovery (how well a team eventually recovers functioning in comparison to a pre-adversity baseline following exposure to adversity) as two components of resilient team performance and investigates the ability of the TRI to predict these outcomes.

2.1 Team Resiliency Inventory Domain Development

This section provides an overview of the team resiliency resource factors of the TRI, including theoretical development and content identification. With each study, new factors were added in response to developments in the literature. Study 1 included the affective, behavioural, and cognitive resource factors, study 2 added the adaptation and persistence factors, and study 3 added the resistance and recovery factors. Table 6 provides an overview of the TRI domains, including example items. Throughout the rest of this section, I outline the domain development for each factor followed by the item generation process.

Table 6

Domain definitions and overview for the TRI

Domain Definitions	Behavioural Attributes	Example Items	# Items

Affective: Team resources that facilitate members' sense of emotional well-being and self-esteem	Maintain a sense of optimism, feeling safe to voice opinions around other team members, positive regard for other team members, and being able to identify, reason with, and understand team members' emotions	"Our team members trust one another to support them"	7
Behavioural: Team resources that contribute to the team's capacity to coordinate team behaviour to either adapt to adversity, stay the course, or otherwise persist despite changing environmental constraints and opportunities.	Remaining united while pursuing goals, monitoring members' task focus, cooperation, and being competent and capable of dealing with challenges	"Our team can perform well in the absence of any team member"	6
Cognitive: Team resources that provide a sense of coherence and coordination to the team	Learning orientation and seeking out new experiences and encounters, the ability to deal with uncertainty, strategy development, problem- solving, discretionary communication, as well as being open-minded and attentive to different sources of information	"Our team has a variety of expertise we can draw upon"	9
Team Adaptation: Team adaptation refers to a strategy in which teams respond to a collectively shared adversity by modifying their team structure, processes, and/or strategy.	Modification of team structures, modification of teamwork processes, collective ideation of alternative responses to the adverse situation	"Our team adapts to respond to challenges"	6
Team Persistence: Team persistence refers to a strategy in which teams respond to adversity by continuing to exert effort and invest resources into team functioning.	continued exertion of effort towards collective goals, escalation of resource and effort investment, maintenance of status quo approach to team functioning.	"Our team persists through challenges"	5
Resistance: The degree to which a team is able maintain functioning following exposure to an adverse exogenous event.	Operationalized as the decrement in performance between a baseline level and the initial timepoint after exposure to the adversity event.	"Our team was able to resist the negative effects of the challenge."	3
Recovery: The degree of return to a pre-adversity baseline of functioning following adversity-induced disequilibrium	Operationalized as the degree, if any, of the final timepoint and the baseline level of functioning.	"Our team was able to bounce back from the challenge."	3

Team Resilience Resource Factors

Drawing from COR theory (Hobfell, 2002), I view team resilience resources (affective, behavioural, and cognitive) as including individual and team-level resources teams can draw on to manage collective adversity. The 'capacity' or potential for a team to be resilient if required is formed from the sharing and investing of these affective, behavioural, and cognitive resources through crossover (Westman, 2001). Teams with a large pool of resources to draw on will have a larger repertoire of responses to adversity available to them in times of difficulty. Further, COR theory postulates that individuals and groups strive to accumulate resources over time and those resources tend not to exist in isolation, but rather they aggregate such that team members share resources in a multiplicative way rather than additive (Hobfoll, 2002). The cross-level effect of team members interacting and sharing resources is outlined by most contemporary models of team resilience (Gucciardi et al., 2018; Hartwig et al., 2020; Stoverink et al., 2018).

The majority of the team resiliency literature conceptualizes team resiliency as characteristics, traits, or capacities of a team that contribute to the team's ability to either resist the negative effects of external challenges or bounce back from any loss of function introduced by adversity (e.g., Meneghal et al., 2019; West et al., 2009). Chapman et al. (2020) found that 38% of the studies in their review had adopted this definition of team resilience. Characteristics of team resilience in the literature range greatly, with few receiving support from more than one study. As such, my approach to identifying the resources that make for a resilient team was expansive. Resources were grouped into affective, behavioural, and cognitive resources to include a wide variety of constructs. Domain definitions, example behaviours, and example items can all be found in Table 6. My goal in developing the team resilience resources was not necessarily to be exhaustive in the list of predictors but to be generally representative of the potential resources identified in the literature.

Affective resources primarily represent the attitudes, beliefs, mood, and emotional support behaviours of the team that can be invested in being resilient. For example, positive emotionality is a resource of resilient teams (Alliger et al., 2015; Stoverink et al., 2018). Through affective transfer processes such as emotional contagion, positive emotions that benefit a team's resilience crossover between individual members of a team, leading to the emergence of collective positive emotional states (Meneghal et al., 2016b). Behavioural resources encompass the resources team members draw on to coordinate action in response to adversity. Example resources are team structure and communication (Gucciardi et al., 2018). In essence, this component is a catch-all for aspects of the team that enable them to quickly and effectively coordinate action responses to adversity. Lastly, Cognitive resources refer to team resources that promote a sense of coherence for the team and enable them to notice, interpret, and analyze adversities to formulate effective responses. Example resources in this area include the strength of transactive memory systems (Gucciardi et al., 2018), planning, sensemaking, and information seeking (Alliger et al., 2015).

2.2 Team Resilience Processes: Adaptation & Persistence

Switching from analyzing what resources make for a resilient team to how teams invest those resources into responding to adversity requires a process-based conceptualization of team resilience. This section outlines a dual process pathway (i.e., Persistence and Adaptation) of how teams respond to adversity through exerting effort towards recovery goals and effective adaptation. For the TRI, I specifically focus on the managing processes stage of addressing collective adversity as outlined in Alliger et al.'s (2015) model. During this stage, teams must assess the adversity, commit effort towards their goal of addressing the adversity (Persistence), and make modifications as necessary (Adaptation) to address the adversity. In a systematic review of work team resilience, Hartwig et al. (2020) found that "resilient teams were mostly characterized as being able to cope well with adversity, to recover from the disruptive events by

employing adaptive processes, and to show perseverance throughout" (p. 9). Researchers have consistently highlighted the role of adaptation (often to the point of interchangeability), and persistence of effort as psychosocial processes critical to team resilience (e.g., Gucciardi et al., 2018; Maynard & Kennedy, 2016; Stoverink et al., 2017). In line with Stoverink et al. (2018) and Gucciardi et al. (2018), I position persistence and adaptation as the overarching functions of the various processes a team goes through to address adversity with the primary motivation of maintaining or recovering a pre-adversity level of team performance.

2.2.1 Adaptation

Team adaptation refers to the ways in which a team may modify its structure, work processes, or strategy to adapt to collectively experienced adversities (Maynard & Kennedy, 2016). Of the team resiliency processes identified, team adaptation has the strongest conceptual and empirical foundations in relation to team resilience (Gucciardi et al., 2018, Hartmann et al., 2021; Stoverink et al., 2020). Definitions of team resilience often have conceptual overlap with team adaptation (e.g., Morgan et al., 2013; 2015). For example, Maynard and Kennedy (2016) conceptualized team resilience as an emergent state that is affected by the team's ability to adapt and is a central outcome of adaptation. Both team resilience and team adaptation can be layered on an IPO model (Maynard & Kennedy, 2016), and just like with team resilience, change is central to the notion of team adaptation as teams modify their structure and functions in response to internal and external adverse stimuli (Maynard et al., 2015).

Despite this overlap, there are some clear conceptual boundaries. Team adaptation is a response to adversity where teams modify an aspect of itself to deal with a challenge. The core function of team resilience, however, is a return to a pre-adversity level of functioning. Adapting to adversity is one potential method of doing this, but they are not necessarily interchangeable. Specifically, team adaptation encompasses modifications to the team in response to a challenge (Maynard et al., 2015) that can lead to a variety of outcomes, not all of which involve returning

to competent levels of functioning following adversity or withstanding the maladaptive effects of adversity. Secondly, my conception of team resilience is based on relative indicators of functioning before and following exposure to adversity. Team adaptation, however, does not necessarily include this relative comparison, instead focusing on modifications made following adversity. In line with contemporary team resilience models, I view team adaptation as a contributing factor to team resiliency by offering teams a potential strategy for dealing with adversities (Gucciardi et al., 2019; Stoverink et al., 2018).

While a more adaptable team is one more likely to be resilient, this may not always be the case. If resilience is viewed as a property of functioning on a given outcome, the most resilient team is the one that sees the least decrement in function within a given timeframe. Adaptation to an adversity (i.e., a shift in the standard work procedures, group structure, objectives, etc.) is sometimes necessary, but change often comes with process loss, as team members will be required to change over to the new model and 'get up to speed'. During this process they are likely to experience performance decrements and may appear less resilient than a team that faces the same adversity but remains steadfast and bears through its effects. In essence, rather than assume the beneficial effects of adaptation, team members should carefully consider the pros and cons of maintaining their current structure versus change, including the difficulty, resource cost, and timeframe of implementing change.

2.2.2 Persistence

While team adaptation has received much theorizing and empirical support as a key component of team resilience, resilient teams need to be not only adaptive but also have the grit to persist through adversities (Hartwig et al., 2020; Stoverink et al., 2018). However, previous research on team resilience has shown that behavioural, cognitive, affective, and relational resources support persistence in the face of adversity, which in turn predicts maintaining team performance during adverse situations (Lengnick-Hall & Beck, 2005). For example, Dimas et al.

(2019) found that effective transformational leadership promoted a team's motivation to commit resources and persist through challenging conditions, leading to maintained team performance. In qualitative interviews, DeCroos et al. (2017) found that persistence of effort was a key theme in team resilience and was included as a core component of team resilience in the development of their measure. In their study, a team's belief in their ability to persist under adverse conditions formed part of an overall team resilience factor, which was positively associated with collective persistence in two studies (r = .87; .77, p = < .001).

Stoverink et al. (2018) argue that persistence (i.e., committing effort to stay the course and 'bear through' an adversity) is an alternative and sometimes complementary course of action a team can take to adaptation. I take a somewhat different approach by conceptualizing persistence as the continued commitment of resources to a course of action to either maintain or recover performance during adversities. The key difference is that Stoverink et al.'s (2018) conceptualization conflates the continued commitment of resources to address an adversity, with a strategic decision to also maintain the status quo approach to team structure and functions.

Originally, I had parsed these two aspects into Persistence (i.e., of effort and resource allocation) and Steadfastness (a commitment to the status quo as an address to adversity) as separate process domains within the TRI. Subject matter expert feedback to this approach was mixed, with some support for Persistence and Steadfastness being separate factors, some for being subdimensions of a larger factor, and some for being essentially the same. This was reflected in high Aiken's V values and cross-loadings of items for Persistence and Steadfastness. In review of the team resilience literature, I decided to remove the steadfastness factor, as in terms of measurement, Steadfastness would like be an inverted mirror of Adaptation. As such, my definition of Persistence focuses on the persistence of effort and resource allocation, rather than including the persistence of a team's status quo as an approach to addressing adversity. By including Persistence as a key process of team resilience, I answer team researchers' calls to

examine alternatives to adaptation as a means of being resilient (e.g., Maynard et al., 2015).

2.3 Resilient Team Outcomes: Resistance and Recovery

As noted in the literature review, Resistance and Recovery are often regarded as two overarching constructs that together define resilience in the wider literature (Adger, 2000; Hodgson et al., 2015; Linnenluecke & Griffiths, 2012). Indeed, there are calls for Resistance and Recovery to be adopted as standardized measures of resilience across all fields of study (Hodgson et al., 2015). Resistance is characterized as continued function despite exposure to adversity (Bruneau et al., 2003; Hodgson et al., 2015). It is operationalized through minimal departure from a baseline level of functioning over time on a relevant team outcome (e.g., team performance). Recovery is characterized by a return to pre-adversity baseline of performance following a loss of function after exposure to an adversity. This construct is operationalized as the degree of performance recovered within the relevant timeline relative to the pre-adversity baseline of performance (Bruneau et al., 2003).

Viewing team resilience through the lens of Resistance and Recovery focuses on how a team's core functions are impacted over time following exposure to adversity (Gucciardi et al., 2018). A highly Resistant team is one that demonstrates resilience through being relatively unaffected by adversities, maintaining the status quo despite strain. Conversely, a team with low Resistance is one that shows significant loss of function after being exposed to adversity. As such, Resistance can be conceptualized as ranging from weak (i.e., highly vulnerable to strain) to strong (i.e., robust, relatively unaffected by adversity). A team with high recovery will quickly 'bounce back' following exposure to adversity. That is, any loss of function is quickly recovered and a pre-adversity status quo is returned to, and so can be conceptualized as ranging from slow to fast. Importantly, how Resistance and Recovery are operationalized in specific situations relies heavily on the nature of the relevant adversity, the team's task, their dynamics, and the context they're situated in (Gucciardi et al., 2018; Hartwig et al., 2020; Hodgson et al., 2015).

Although Resistance and Recovery are constituent parts of resilience and in the context of people and social groups may share some antecedent resources (e.g., team efficacy, leadership effectiveness), they are orthogonal, and may sometimes even be at odds (Hodgson et al., 2015; Maynard & Kennedy, 2016). We might find one team to be highly resilient because it is resistant to adversity and does not lose functional performance in the first place, while another is more resilient because it has a quick recovery time, rapidly bouncing back despite initial vulnerability to adversity. As an example from ecology, elephants have a persistent low population and reproductive cycle, but a low mortality rate as well. Their long lifespan and survivability make them highly resistant to population disturbance, but if disturbed, they have a very slow population recovery. Conversely, pigeons have a wealth of predators, are often one of the first affected species in ecological shocks, and very short lifespans. However, their high reproduction rate means that as a species, they recover very quickly from population shocks. While these two species have opposing resilience strategies, both may be considered resilient to ecological shocks (Capdevila et al., 2020). A similar principle may be applied to team resilience. A team dynamic built around a strong hierarchy and dominant leadership may be highly resistant to adversity but unable to respond if adaptation is required. In contrast, a team with a relatively flat hierarchy and democratic leadership may have difficulty resisting adversity yet will be quick to adapt and recover (Bunderson et al., 2016). As such, there may be direct trade-offs between Resistance and Recovery for teams. What may be beneficial for one (e.g., strict hierarchy) may be detrimental to the other, and thus teams need to be strategic in how they invest their resources into preparing for and responding to adversity.

Figure 2

Illustration of Trajectories of Resilient Team Performance Over Time

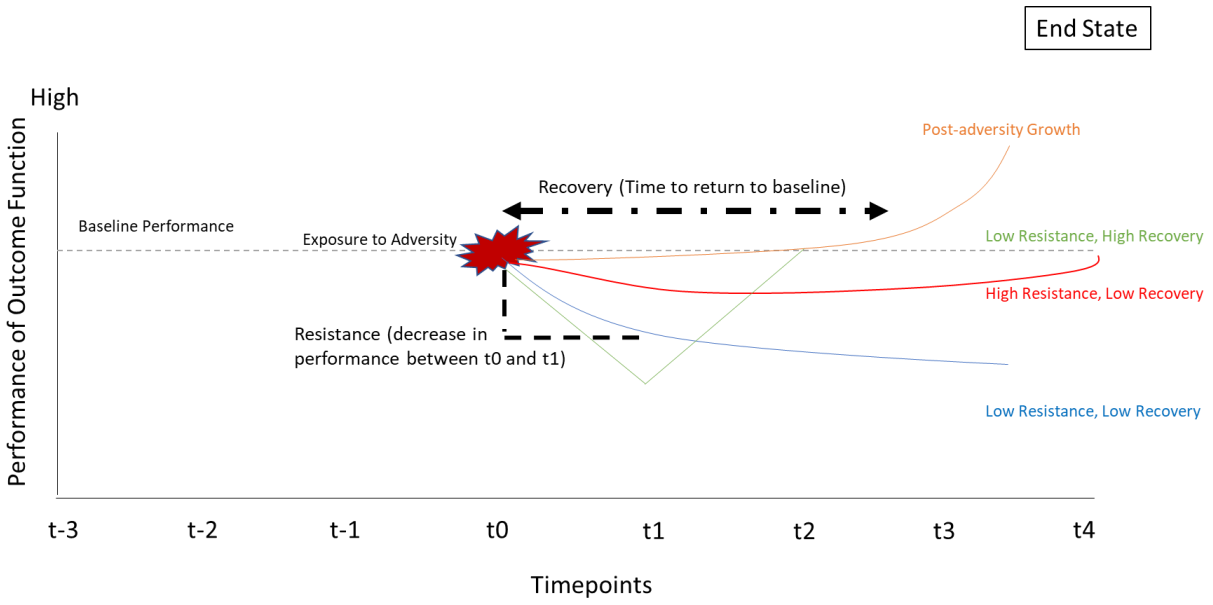
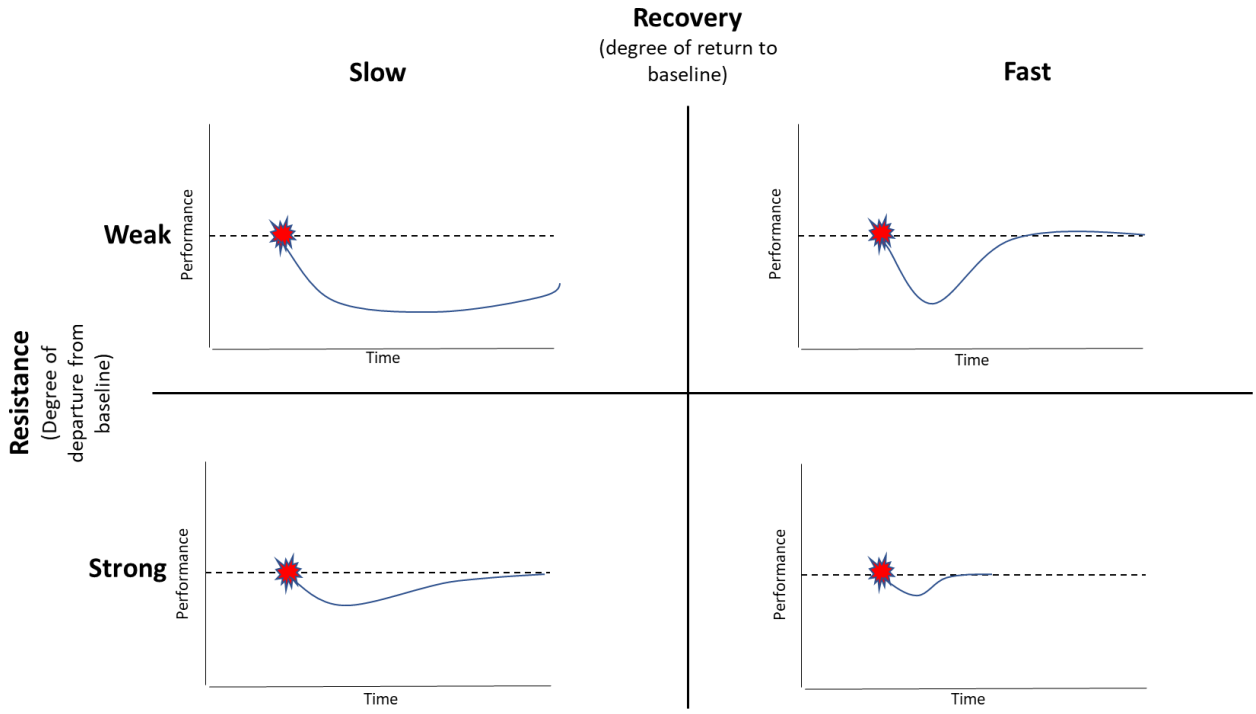


Figure 3

Illustration of Strong/Weak Resistance and Fast/Slow Recovery in Resilient Team Performance.



2.4 Domain Identification and Item Generation of the TRI

In this section, I outline the process of identifying and delineating the TRI domains. This process began with the resource facets in 2018, while Adaptation and Persistence were developed in 2019 as part of study 2, and Resistance and Recovery in 2021 as part of study 3. The resource and process facets went through separate stages of item generation and expert panel review, which are outlined below. Resistance and Recovery did not go through an expert panel review process.

Hinkin (1995) argues that content validity is a core criterion for quality measure development. Beginning with the resource facets, a deductive, theory-driven approach was taken to domain identification and item generation. Review of sources available on team resilience at the time of development showed that the content domain of team resilience was large and encompassed a wide diversity of affective, behavioural, cognitive, and resources. Items for the resource facets were generated based on this existing team resiliency research (e.g., Alliger et al., 2015; Carmelli et al., 2013; Meneghal et al., 2016a; 2016b; Morgan et al., 2013; 2015) with the Workplace Resiliency Inventory (McLarnon & King, 2013) as a guideline for structure and organization. The items were developed to minimize bias by avoiding jargon, double-barreled questions, being specific with simple language and to separate team processes from their potential outcomes. Items were formed as statements, and participants are asked to rate the extent to which they agree or disagree on a Likert-type scale, ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). In total, 27 items were constructed for the initial item pool.

Following item generation, the domain descriptions and items were reviewed by a panel of nine subject matter experts (three individuals with a Ph.D., four Ph.D. candidates, three Master's students; M_{age} = 26; Female = 5) for theoretical clarity and consistency. The raters were

provided with the definitions of the relevant domains. The experts then made judgements of how well each item mapped onto each relevant dimension (e.g., affective, behavioural, or cognitive resources), on a scale ranging from 1 (*poor match*) to 5 (*excellent match*). The experts were blind to the target domain for each item throughout the process. The purpose was to identify the extent to which each item reflected its target dimension and was divergent from the others.

Aiken's *V* (Aiken, 1985) and Cohen's *d* scores were used to assess the quality of the items. Aiken's *V* scores can indicate the validity of an item; however, it cannot ascertain the degree of an item's domain overlap with other facets in a measure. As such, planned contrasts were conducted to compare the items' average loading scores between the target domain and relevant other domains. A high score on the target dimension and low scores on all other dimensions is an indication of content relevance. Cohen's *d* effect sizes were then calculated for each item to assess whether the item was a clear indicator of the target domain. Items with a validity index below $V = .81$ and effect sizes below $d = .80$ were eliminated (Dunn et al., 1999). The experts were also given the opportunity to provide qualitative feedback on content domain, item wording, domain representativeness, etcetera, throughout the review procedure. In total, three resource items were eliminated, and two had their wording slightly modified.

Similar to the item development process for the resource facets, the development of the domain definitions and items for the Adaptation and Persistence facets took a deductive approach. Domain definitions for Adaptation and Persistence were developed from a review of definitions in the literature (e.g., Bowers et al., 2017; Maynard et al., 2016; Stoverink et al., 2020). Items were then generated using behavioural examples of team-level Adaptation and Persistence specified in the literature (e.g., Alliger et al., 2015; Stoverink et al., 2020).

The items and domain definitions for Adaptation and Persistence were then subjected a panel of nine subject matter experts, all of whom had a Ph.D. with expertise in social or organizational psychology. The review panel protocol followed that outlined above for the resource facets. In total, six items were removed, two were slightly reworded for clarity, and one item was added, reducing the item pool for the resilience process components from 17 to 12. The item review process also showed that the reviewers perceived the domain definitions and items as clearly defined and understandable.

3. Study 1: Development of the TRI and Initial Pilot Results

Currently available measures of team resilience are largely limited to measuring only potential inputs into the capacity for a team to be resilient, with little consideration for the processes teams go through to respond to adversity in a resilient manner, or to the criterion we can use to demonstrate and quantify resilient team functioning (Stoverink et al., 2020). Given the challenge of quantifying both resilience capacity and its demonstration in function, the lack of convergence on theory and measurement of team resilience is unsurprising (Hartwig et al., 2021). Therefore, the three studies included in my dissertation project were conducted to develop and refine the TRI and assess its psychometric properties. In addition, these studies were also designed to provide an initial assessment of the nomological network of team resilience, including establishing its criterion validity through convergent and divergent relations with theoretically-related covariates.

The primary objective of study 1 was an initial assessment of the team resilience resource factors psychometric properties, including the factor structure and model fit. To this end, Study 1 included a series of confirmatory factor analyses (CFAs) and multilevel-confirmatory factor analyses (MCFAs) that assess the factor structure using the within and between-level covariance

matrices (i.e., within- and between-teams). In addition, the data for the TRI were gathered as part of a larger, perennial research project generally related to group processes using the engineering design project teams. This dataset included a variety of variables that could be related to team resilience (e.g., team conflict, team satisfaction, or team potency). This offers a unique opportunity to explore the relationship between team resilience and various individual and group level constructs that were not pre-specified as part of my dissertation project. Particularly for a nascent construct like team resilience, the number and complexity of possible relationships it may have with other constructs is beyond the scope of any one project. However, exploratory research is invaluable for outlining the scope of team resilience's nomological network and generating future research. As such, I conducted a series of exploratory analyses based on the availability and feasibility of potential relations between team resilience and various constructs that were included in the same dataset as part of a larger research project. The analyses included in this section are data-dependent post dictions that were not generated independently from the data. Multilevel partial correlations and regression analyses were performed to investigate these potential relationships and the results of these exploratory analysis were later used inform hypothesis development and the decision of what variables to include in studies 2 and 3.

3.1 Methods

3.1.1 Participants

Participants in this study consisted of student engineering design teams (N = 448, k = 105) from a large Canadian university. The average age of the sample was 18.13 (σ = 1.43), 70% were male, and the ethnic composition of the sample was 45% White, 25% Asian, and 30% other. Participant teams consisted of four to six members (the average number of respondents per team after accounting for missing data was 4.1). The participants were enrolled in an

introductory engineering design course that was developed to closely simulate the real-life work context of engineering design teams. The teams were required to complete multiple engineering design projects throughout the 27-week school year, with a large project at the end of the course. The course was heavily team-based, as 80% of the course grade was reserved for the team assignments, as well as 12% reserved for peer ratings of teamwork, including input, attitudes, and general teamwork skills.

Data were collected at four time points throughout the course (t_0 = September 2019, t_1 = mid-January, t_2 = late February, t_3 = early April). All participants were informed that filling out the questionnaires at each time point was voluntary and that all results were completely anonymous and for research purposes only. Although completion did not impact the participants' grades directly, they were given a bonus 2% on their end-of-term grade if they filled out the questionnaires at all three time points.

3.2 Measures

In addition to the TRI resource facets, several other measures were included as part of the exploratory analyses. The possible covariates consist of team-level processes and outcomes that were part of the same larger dataset gathered from the engineering project design teams in 2018. This section briefly covers these measures and the relevant psychometric properties.

Team conflict states: Task, relationship, and process conflict (Jehn, 1995) were measured using Behfar et al.'s (2011) measure of conflict in small groups. This measure included 10 items, anchored from 1 (*a very small amount*) to 5 (*a lot*) in 4 factors: task, relationship, logistical, and contributional conflict, the latter two of which were combined as the measure for process conflict.

Team Satisfaction: Team satisfaction was measured using a single item *("Overall, how satisfied were you with your team?"*) anchored from -3 (*very dissatisfied*) to 3(*very satisfied*).

Team Conflict Management (Competitive and Cooperative): Competitive (e.g., Individual team members demand that I agree to their position) and cooperative (e.g., *"Individual team members encourage a 'we are together' attitude"*) team conflict management processes were measured using subscales from Barker et al.'s (1998) team conflict scale. There were 7 items for each subscale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*).

Status Conflict: Status conflict was measured using the status conflict questionnaire (Bendersky & Hays, 2012). The measure consisted of 4 items anchored by 1 (*a very small amount*) to 5 (*a lot*).

Cognitive Prompt: In the instructions for the TRI, the participants were asked to think of the hardest challenge their team has faced in the past, and to keep this adverse event in mind when responding to the team resilience processes items. In addition, the participants were asked to briefly describe the nature of this adversity. It is important to note that in reviewing the adversities described by the participants, team members had different adversities in mind, which may affect the sharedness of their perceptions of team resilience. This limitation was addressed in studies 2 and 3.

3.3 Analytic Procedures

The analytic procedure for this study largely followed the guidelines for conducting Multilevel confirmatory factor analysis (MCFA) outlined by Dyer et al. (2005). All analyses were performed in MPlus version 8.2. All analyses were set to 5000 iterations. Some authors have recommended that due to the complexity of MCFA models, simpler models should be

conducted as a preliminary step to performing an MCFA (Dyer et al., 2005; Hox, 2002). The total-variance CFA does not consider the two-level structure of the data and uses the total covariance matrix of the observed items (meaning it is not decomposed into the individual and pooled within team covariance matrices). As such, CFA analyses were first performed on the total covariance matrix specifying the three hypothesized factors. The maximum likelihood estimator that produces standard errors that are robust to non-normality (MLR) was used.

Following this, I used MCFA to investigate the measurement model in a multilevel context (i.e., the within-team level and between-team level variance parsed), as well as the measurement model when either the within-team or between-team level were saturated. MCFAs extends the ability of CFAs to accommodate data that are nested within higher-order clusters (e.g., teams). This allows us to explore the factor structures, loadings, and errors at between- and within-group hierarchical levels. All analyses were performed using the weighted least-squares mean variance (WLSMV) estimator, and the estimation maximization algorithm. Further, the residual variances for the between-groups level intercepts were fixed to zero. Hox (2002) states that fixing residual variances to zero at the between level is often necessary in MCFA when sample sizes at the between-groups level are small and the true between-group variance is close to zero, which was the case in the current study. As such, the residual variances for the latent factors were set to zero at the within- and between-levels of analysis. Previous research using MCFAs has tended to find a smaller number of between-team factors relative to the within-group level (Hox, 2002). As such, this procedure was repeated specifying either three distinct latent factors or a unidimensional factor at the between-teams level.

Across all models, several statistical indicators were used to assess of goodness of fit statistic. As the chi-square may be statistically significant even when the model is substantially

correct if the sample size is large, the normed comparative fit index (CFI; Bentler, 1990), Tucker-Lewis index (TLI; Kline, 2005) root mean square error of approximation (RMSEA; Steiger, 1990), and the standardized root mean square residual (SRMR; Hox, 2002) indicators were also included as guides in assessing goodness of fit. Cut-off points for good model fit indices (chi-square non-significant; CFI >.90; TLI >.90; RMSEA <.08; SRMR <.08) were informed by Hooper et al., (2008). For multi-level analyses, the weighted root mean square residual (WRMR) index was also included. The WRMR is used when data includes categorical variables (i.e., clusters such as teams) and goodness of fit values are generally in line with other indicators. DeStefano et al. (2018) suggest a cutoff score of < 1.0 as having acceptably low type 1 error rates. Investigations of how model fit indices interact in MCFAs are ongoing; however, what information is available suggests that the RMSEA and CFI may only reflect within-level fit. The within-SRMR should be used in combination with RMSEA and CFI to evaluate the within covariance matrix. On the other hand, SRMR for between-model may be less likely to detect between-model misspecifications when ICCs are low. Lastly, the WRMR may be more susceptible to misfit in the within matrix and is less likely to detect the misspecified between-models when ICCs are low. Therefore, WRMR is best used to evaluate the between-model fit when the within-models are correctly specified and the ICC is not too small (DiStefano et al., 2018).

3.4 Reliability and Inter-Rater Agreement

Before conducting the full MCFA, the variability within and between the teams was assessed by computing the intraclass correlation coefficient (ICC (1)) values for each of the 27 items. ICC refers to a group of analyses for assessing the reliability of ratings for clusters of data (e.g., teams). The ICC (1) can be interpreted as the proportion of total variance in a lower level

unit (i.e., an individual) that can be attributed to being nested within a higher-order unit (e.g., a team; Bliese, 2000). A sufficiently large value (i.e., >.10, Hox, 2010) can be considered justification for the inclusion of higher-order factors. The ICC(2) on the other hand can be used as an indicator of the reliability of group means and is used to justify aggregation of lower-order units to the higher (i.e., aggregated perceptions of team resilience). An ICC(2) closer to 1 indicates higher agreement among raters, while an ICC closer to 0 indicates lower agreement. There are no strict guidelines for deciding how large the ICC(1) must be to warrant multilevel analyses, however, most published MCFAs have reported ICCs > .10 (e.g., Dyer et al., 2005; Hox, 2002) and others suggest there is no downside to conducting multilevel analysis-even when the ICC(1) values are low (Bliese, 2018).

3.5 Results and Discussion

3.5.1 Descriptive Statistics

Table 7

Descriptive and Reliability Statistics for the Resource Factors

	N	*M(SD)*	Skew	Kurtosis	ICC (1)	ICC (2)	α / *w*
Affective	**443**	**5.40(1.40)**	**-1.40**	**1.89**	**.16**	**.73**	**.95/.95**
TRA_1 "Our team sees things positively"	443	5.49(1.57)	-1.44	1.54	.11		
TRA_2 "Our team members support one another emotionally"	443	5.04(1.63)	-.88	.20	.12		
TRA_4 "Our team ensures all members are comfortable speaking up in team discussions"	439	5.54(1.59)	-1.37	1.36	.09		
TRA_5 "Our team members are able to control their emotions"	442	5.60(1.53)	-1.46	1.73	.09		
TRA_6 "Our team members are friendly with one another"	441	5.33(1.68)	-1.18	.70	.19		
TRA_7 "Our team members trust one another"	443	5.36(1.60)	-1.28	1.11	.18		
TRA_8 "Our team is confident in its ability to perform well"	443	5.43(1.59)	-1.28	1.09	.12		
Behavioural	**440**	**5.38(1.31)**	**-1.49**	**2.47**	**.21**	**.64**	**.91/.92**
TRB_1 "Our team can work well in the absence of any team member"	442	5.38(1.59)	-1.22	.88	.10		
TRB_2 "Our team shares the workload in a fair way"	442	4.97(1.78)	-.90	-.17	.17		
TRB_4 "Our team is quick to respond to changes"	439	5.37(1.51)	-1.25	1.22	.17		

TRB_6 “Our team cooperates to accomplish our goals”	441	5.62(1.46)	-1.57	2.79	.17		
TRB_7 “Our team ensures each member is up to date on what we are doing”	441	5.18(1.57)	-1.05	.47	.15		
TRB_8 “Our team expects one another to do their best”	442	5.74(1.45)	-1.68	2.71	.17		
Cognitive	**438**	**5.27(1.23)**	**-1.18**	**1.88**	**.16**	**.64**	**.94/.94**
TRC_1 “Our team can handle vague goals and tasks”	440	5.11(1.53)	-.96	.47	.08		
TRC_2 “Our team seeks input from every member before making decisions”	440	5.09(1.60)	-.98	.22	.15		
TRC_3 “Our team sees challenges as opportunities for learning”	440	5.14(1.49)	-.93	.56	.12		
TRC_4 “Our team is on the same page regarding what we are supposed to do”	439	5.35(1.51)	-1.18	1.09	.14		
TRC_5 “Our team plans how to respond to challenges we may face in the future”	440	5.12(1.47)	-.94	.60	.11		
TRC_6 “Our team is quick to think of a new approach if something does not work”	440	5.59(1.37)	-1.42	2.07	.09		
TRC_7 “Our team has a variety of skills and knowledge we can draw upon”	440	5.46(1.51)	-1.9	1.04	.11		
TRC_8 “Our team is always thinking of ways to improve”	439	5.28(1.5)	-1.03	.74	.14		
TRC_9 “In our team, mistakes are openly discussed to learn from them”	439	5.22(1.54)	-.96	.40	.16		

I began with reviewing the descriptive analyses for each item and facet to ensure the data did not violate any assumptions for factor analyses or multilevel analyses. The results of these analyses can be found in Table 7. Review of the obtained skew and kurtosis results did not show any outstanding values (i.e., no skew values less than -2 or greater than 2 and no kurtosis values less than -10 or greater than 10; George & Mallery, 2010). As there was some positive skew observed (i.e., mean scores for each item and domain were higher than the median response option), I performed the analyses using the MLR estimator in MPlus v8.2. This estimator performs maximum likelihood estimation with robust standard errors that is resilient to non-normal data distributions and missing cases and is often used when the data has some skew.

The ICCs(1) for each of the observed items ranged from .008 (TRC_1 "Our team can handle vague goals and tasks") to .18 (TRA_7 "Our team members trust one another"), with an average of .11, meaning on average ~11% of the observed variance in the items can be attributed to group membership. At the facet level (i.e., domains), ICC(1) scores ranged from .16 to .21 suggesting substantial enough variance attributed to group-membership for the team resilience resource facets to justify multilevel modeling. ICC(2) scores were also computed for the TRI facets. ICC(2) scores index the reliability of group level means as representative of group members' individual scores (Bleise, 1998). In the current study, the ICC(2) scores ranged from .64 to .73, all of which are within the acceptable threshold of >.40 suggested by Fleiss (1986). These values indicated there was enough between-group variance and inter-rater reliability to continue to the multilevel analysis.

The mean inter-item correlation of the TRI facets was assessed using Cronbach's α and McDonald's *w*. Cronbach's α is a measure of internal consistency, or how closely related a set of

items are as a group. A high alpha value indicates that the relevant items have high inter-item correlation. An α value of 0.7 has been widely used as the minimum acceptable level of reliability for psychological measures (Taber, 2016). Cronbach's α coefficients in the current study ranged from .91 to .95. McDonald's *w* coefficient was also assessed for all three facets. This coefficient addresses the shortfalls of Cronbach's a by not assuming the equivalence of each items' covariances with the total score. In the current study, the observed *w* scores were nearly identical to the alpha scores, suggesting the items were similarly representative of the total facet scores.

3.5.2 Total-Variance CFA Results

I tested two alternative model structures (i.e., a single factor model labeled team resources, and a 3-factor model with the separate team resources factors using robust maximum likelihood. I also tested the factor structure of each facet individually. The results are summarized in Table 8.

Table 8

CFA Results for Total Variance Models

	χ^2	*df*	RMSEA (90% CI)	CFI/TLI	SRMR
Team Resources (1 factor)	1114.43**	209	.099 (.093, .105)	.824/.805	.063
Team Resources (3 factor)	442.735**	206	.049 (.042, .055)	.958/.953	.032
Affective	72.337*	14	.097 (.076, .120)	.953/.930	.026
Behavioural	22.369	9	.058 (.028, .089)	.986/.977	.019
Cognitive	67.172*	27	.058 (.041, .076)	.976/.968	.025

N = 441, * *p* <.01 ** *p* <.001

A single factor solution that included all three resilience resources facets indicated a significant lack of fit, χ^2 (209) = 1114.43, RMSEA = .099, CFI = .824, TLI = .805, SRMR = .063. Alternatively, the 3-factor solution showed improvement, χ^2 (206) = 442.735, RMSEA = .049, CLI = .958, TLI = .953, SRMR = .032. Although the χ^2 value was still significant, alternative model fit indices that are less affected by sample size suggested acceptable model fit. The RMSEA value of .049 and SRMR value of .032 were both below Hooper et al.'s (2008) suggested cut-offs of <.08, and the CFI and TLI indices of .958/.953 were within the realm of acceptable fit (Bentler & Bonett, 1980). Regarding the individual factor models, the behavioural and cognitive team resilience resources facets showed exceptional model fit. The affective resources facet, however, had a large RMSEA value, suggesting that the model underfit the data. Exploring the modification fit indices suggested that the relationship between TRA_5 and TRA_6, and TRA_5 and TRA_7 were both > 10. Despite this, the items had a high loading on the affective resources factor and were thus retained in the model. All factor loading coefficients were significantly different than 0 ($p \leq .001$). The standardized loadings for the total-variance matrix ranged from .655 to .897 and are provided in Table 10.

3.5.3 Multilevel-CFA Results

For the multilevel confirmatory factor analysis (MCFA), I began by specifying a 3*3 factor structure model in which the affective, behavioural, and cognitive components of the TRI are separate factors. Model fit indices for this model (χ^2(412) = 521.742, RMSEA = .025, CFI/TLI = .943/.936, SRMR/Between = .031/.076) showed good model fit. The χ^2 of 521.742, while significant, was less than twice the degrees of freedom, which may be a better indicator of model fit with large samples (Hox, 2002). The between-groups SRMR, however, was just within

suggested cut-offs (i.e., between .03 and .08; Asparouhov, 2018), suggesting that there may be some misspecification in the between-groups covariance matrix. The between level SRMR is particularly sensitive to factor structure misspecification and is likely high in response to the large correlations between the different TRI facets at the between level.

Because of the high inter-factor correlations between the team resilience resources at both the within and between levels (i.e., .80 and up), two alternative factor structures were explored for better model fit. The first specified a 1*1 team characteristics model in which all items were loaded onto a single factor, and second a 3*1 factor structure in which the items loaded onto the affective, behavioural and cognitive factors separately at the within-teams level, and onto a single factor at the between-teams level. Both models however were found to have worse model fit and did not improve the between-level SRMR index, and thus were rejected as factor solutions.

Within-team and between-team item loadings for the 3*3 model are presented in Table 10. In general, the item loadings for the within-team factor structure were acceptable, and all items were significant. At the between-level of analysis however, the item loadings were problematic due to non-positive definiteness occurring in the model.

Table 9

Multilevel Confirmatory Factor Analysis Model Fit Indices Results

	X^2	*df*	*RMSEA*	*CFI/TLI*	*SRMR/Between*
Team Resources (1*1 factor)	1236.372	418	.067	.577/.532	.069/.086

Team Resources (3*3 factors)	521.742	412	.025	.943/.936	.031/.076
Team Resources (3*1factors	522.797	415	.024	.944/.938	.031/.086
Affective	96.278	28	.074	.963/.945	.041/.221
Behavioural	53.577	18	.067	.975/.958	.024/.070
Cognitive	158.657	54	.067	.961/.948	.031/.095

Note: $N = 440$, $k = 103$, * $p < .001$

Table 10

Item Factor Loadings for the Team Resilience Inventory

	Total	Within	Between
TCA_1	.828	.821	.852
TCA_2	.846	.806	1.052
TCA_4	.844	.831	.925
TCA_5	.824	.808	.769
TCA_6	.878	.875	.926
TCA_7	.897	.897	.948
TCA_8	.860	.878	1.006
TCB_1	.655	.623	.853
TCB_2	.779	.760	.937
TCB_4	.849	.810	.995
TCB_6	.895	.864	1

TCB_7	.821	.813	.938
TCB_8	.832	.812	.892
TCC_1	.672	.685	.853
TCC_2	.742	.721	.986
TCC_3	.841	.830	.937
TCC_4	.859	.842	.998
TCC_5	.812	.768	.868
TCC_6	.782	.767	.981
TCC_7	.785	.771	1
TCC_8	.890	.847	.966
TCC_9	.811	.758	1

Note: All item loadings significant at $p < .001$

3.5.4 Exploratory Analyses

In addition to investigating the psychometric properties of the team resilience resource dimensions, I explored how the resource facets related to several team processes and emergent team states that may covary with team resilience (i.e., team potency, competitive and cooperative conflict management processes, team conflict, team satisfaction, and status conflict) using multilevel regression analyses. It is important to note that these regression models are not *a priori* hypotheses—I did not have any predictions for how these variables may relate to the TRI facets. Instead, the variables were chosen by convenience as they were included in the larger dataset. The results of these exploratory analyses may be informative for future hypothesis development but should be interpreted cautiously.

To begin, partialled correlations were conducted and are summarized in Table 11. The correlation results showed that all three of the TRI facets were significantly related to each of the

exploratory variables. In general, the team resilience resources positively correlated with 'beneficial' team processes and outcomes (e.g., cooperative conflict management and team potency), and negatively related to 'detrimental' processes and outcomes (e.g., competitive conflict management, process, status, and relationship conflict).

Next, a series of multilevel linear regressions were performed to assess the ability of the TRI facets to predict the potential covariate variables. As the internal factor structure of the TRI facets are already presented above and the factor structure of the other variables are not the primary concern, observed scores (i.e., the aggregated mean scores for each variable for each team) were used rather than latent means in order to reduce the number of parameters being estimated. All multilevel regressions were performed in MPlus v. 8.2 using the MLR estimator. The results of the multilevel regression models are summarized in Table 12. For brevity, only the total regressions will be discussed. The TRI facets each had a similar pattern in how they predicted the potential covariates (i.e., positively predicted beneficial covariates, negatively predicted detrimental covariates) with some variation in the strength of the *b* values.

Table 11

Correlations for Exploratory Variables

Team Resources	Affective	Behavioural	Cognitive	Comp	Coop	TC	PC	SC
Affective								
Behavioural	.77**							
Cognitive	.72**	.82**						
Team Potency	.15**	.21**	.27**					
Competitive	-.32**	-.28**	-.25**					

Cooperative	.35**	.39**	.42**	-.15**				
Task Conflict	.18**	.25**	.20**	-.23**	.28**			
Process Conflict	-.33**	-.31**	-.30**	.40**	-.36**	0.05		
Status Conflict	-.36**	-.29**	-.31**	.47**	-.35**	-0.07	.47**	
Relationship Conflict	-.45**	-.43**	-.39**	.48**	-.46**	-.21**	.55*	.72**
Team Satisfaction	.41**	.50**	.51**	-.23	.55**	.28**	-.33**	-.33**

Note: N = 435, * p <.05, ** p <.001. Comp = Competitive conflict management style, Coop = Cooperative conflict management style, TC = Task Conflict, PC = Process Conflict, SC = Status Conflict.

Table 12

Multilevel Regressions for Exploratory Variables

	TC	PC	RC	SC	Comp	Coop	T. Sat
Affective							
Total	**.10****	**-.32****	**-.44****	**-.21****	**-.35****	**.25****	**.14***
Within	.06	-.27**	-.36**	-.27**	-.19*	.25**	.11
Between	.37*	-.99**	-.84**	-.83**	-.99**	.99**	.41
Behavioural							
Total	**.25****	**-.30****	**-.42****	**-.28****	**-.28****	**.38****	**.20****
Within	.17*	-.24**	-.35**	-.22**	-.14	.28**	.20*
Between	.67**	-.98**	-.66**	-.55*	-.94**	.99**	.20
Cognitive							
Total	**.19****	**-.19****	**-.39****	**-.30****	**-.26****	**.41****	**.26****
Within	.13*	-.25**	-.35**	-.26**	-0.16*	.32**	.26**
Between	.56*	-.77*	-.57**	-.54**	-.74**	.99**	.22**

Note: N = 438, k = 103, average cluster size = 4.28, all reported beta coefficients are standardized. * p <.05, ** p <.001** TC = Task Conflict, PC = Process Conflict, SC = Status Conflict, Comp = Competitive conflict management, Coop = cooperative conflict management, T. Sat = Team satisfaction.

3.5.5 Summary & Conclusions

The TRI was developed in response to the need for a theoretically informed, well-validated measure of team resilience to facilitate empirical study. For study 1, I examined the psychometric properties of three facet scales that represent affective, behavioural, and cognitive resources that are presumed available to a highly resilient team as well as explored their association with a variety of potentially relevant covariates. The results supported the specified 3-factor model at both the within and between-team levels of analysis. The individual facet scales, as well as the overall 3-factor scale showed good model fit, and the item loadings for each of the three factors and inter-factor correlations were approximately equivalent between levels 1 and 2.

Overall, the psychometric results for the TRI resilient characteristics facets were mixed. When viewing the total covariance matrix results, the TRI facets showed acceptable model fit and predicted theoretically relevant criterion constructs in an unsurprising way. However, as team resilience is theorized to be an emergent, group-level variable, it is essential to examine the multilevel properties of the construct. Although the specified 3-factor model showed strong model fit at the within-team level of analysis, there were a few issues that warrant attention at the between-team level of analysis. First, the between-level covariance matrix was not positive-definite, meaning that the model identified negative Eigen values. After reviewing the data for violation of these assumptions, it is not completely clear what the cause of this non-positive

definite matrix. However, the most likely sources are either too little of the variance is accounted for by group membership (the average variance explained by group membership for the TRI items was 11%), or high inter-facet correlations (i.e., >.80). As such, the results reported for the between-teams level of analysis should be interpreted with caution. Despite these issues with the multilevel model, given the strong model fit and item loadings in the single level CFAs, no changes were made to the item wording or factor structure of the resilient resources facets.

4 Study 2: Psychometric Validation of the TRI

Study 2 took place over the 2019-2021 academic years and consisted of two data cohorts, with three general objectives. First, to theorize, develop, and test the psychometric properties of two new domains for the TRI (i.e., Adaptation and Persistence) that were added between studies 1 and 2 in response to developments in the literature. Second, to provide confirmatory psychometric reliability and validity results for the TRI. This included assessing the measurement model and reliability of the TRI, its discriminant validity from psychological resilience, and its criterion validity through testing its ability to predict theoretically relevant team outcomes (i.e., team satisfaction and potency) with formal hypothesis testing. The following section provides an overview of rationales for the hypotheses developed for study 2.

4.1 Discriminant Validity of Team and Psychological Resilience

Research on the relation between psychological and team resilience raises important questions concerning the discriminant, convergent, and incremental validity of these two concepts (e.g., Hartwig et al., 2020; West et al., 2009). Psychological and team resilience have overlap in functional properties, such as sensemaking and response formulation (Hartwig et al., 2020; McEwen & Boyd, 2018), and both have a core functioning of resisting and/or recovering from an adversity such that pre-adversity functioning is maintained or returned to (Gucciardi et

al., 2018). Further, psychological and team resilience may have a recursive relationship in that each may act as a resource to be drawn on in promoting the other (Raedte et al., 2022). Given the social interactionist component of team resilience, however, multiple researchers have made the argument that team resilience should be operationalized and measured differently from psychological resilience (e.g., DeCroos et al., 2017; Gucciardi et al., 2018; Morgan et al., 2015). Hartwig et al. (2020) argue that there may be cross-level effects between individual and team resilience such that individual resilience may be a key antecedent of team resilience formation, and, in turn, team resilience may promote individual resilience through access to social capital resources (Gucciardi et al., 2018). For example, highly resilient individuals may teach other team members to be more resilient through social learning mechanisms (Flinter-Taylor & Cooper, 2017), and aligned with COR theory, highly resilient individuals may be able to offer more resources to invest in adversity management (Gucciardi et al., 2018). Previous studies on team resilience have largely lacked this multilevel perspective, which runs the risk of obfuscating cross-level effects and the unique contributions of team resilience beyond psychological resilience for the effective management of collectively-faced adversity.

The differences between resilience at the individual and group levels (i.e., nature of adversities, mechanisms of recovery, salient outcomes) suggest that although likely related, individual and team resilience should not have substantial overlap and that psychological resilience is not a necessary or sufficient condition for team resilience to emerge (Gucciardi et al., 2018; Morgan et al., 2015). Although this is commonly accepted in the literature (e.g., Gucciardi et al., 2018; Stoverink et al., 2017), this proposition has yet to be empirically tested and some studies have used aggregated psychological resilience scores as a way of operationalizing team resilience (e.g., West et al., 2009). As such, the first objective of study 2 is

to investigate the discriminant and convergent validity of psychological and team level resilience by identifying the degree of common variance. To address this, study 2 included a 10-item brief adaptation of the Connor-Davidson Resilience Scale (CD-RISC; Connor & Davidson, 2003) created by Campbell-Stills and Stein (2007). The CD-RISC scale is likely the most popular and robust measure of psychological resilience (Windle et al., 2011). The version used in this study is a brief adaptation of the original scale, which was argued to contain redundant items (Campbell-Stills & Stein, 2007) and has emerged as a popular alternative to the original psychological resilience factor scale from the CD-RISC.

Assessing the discriminant and convergent validity of team and psychological resilience included multiple indices. First, conforming to the guidelines proposed by Raykov (2011), discriminant validity for constructs at different levels of analysis can be inferred if the factor scores of the relevant measure correlate no more than .30 with the discriminant measure (i.e., if the TRI resource factors scores correlate with the CD-RISC score at $r = <.30$).

> *H_1: The team resources facets of the TRI and the psychological resilience factor of the CD-RISC will not significantly correlate above r = .3*

4.3 Internal Relationships

Following the results of Study 1, it is expected that the facets of the TRI will have significant, moderate correlations with each other. Conceptually, team members should invest individual and collective resources (e.g., team resources) into adversity management strategies (e.g., team processes) in order to resist or recover from adversity-induced strain (Gucciardi et al., 2018; Hartwig et al., 2020). Teams that have an abundance of access to resilience promoting resources have more options available to them and are better able to respond to collective adversities by investing those resources into successfully persisting through and adapting to

adversity. As such, it is expected that the team resources components at t3 will significantly predict the team processes components at t3 and t4.

H_2: The team resources dimensions of the TRI will significantly and positively predict Persistence and Adaptation.

4.4 Team Satisfaction & Team Potency

In line with the theoretical assumption that in adversity situations, persistence and adaptation act as mediating processes that translate resilience-related team resources into successful resistance and recovery of function, I also hypothesized that persistence and adaptation will mediate the effect of the team resource facets on team outcomes (i.e., team potency and team satisfaction).

Team satisfaction refers to the overall extent to which team members are satisfied with their team's outcomes (Van Der Vegt et al., 2001), and is one of the fundamental outcomes in team research (Hackman, 1987). As an attitudinal construct, team satisfaction involves both positive affect for the group, as well as positive appraisal of its performance (Garcia-Buades et al., 2020). Research suggests that when team satisfaction emerges as a shared phenomenon, it activates greater collaboration and occupational citizenship behaviours among team members. Although team satisfaction is in part derived from satisfaction with the quality of relationships between team members, it also derived from perceptions of successful team functioning. When faced with acute adversity, team members can lose a sense of shared identity, withdraw effort from collective goals, and become more focused on self-interests (Meyer, 2017). Under such conditions, team dynamics tend to fray and performance suffers (Driskell et al., 2021).

A highly resilient team is one that can successfully address the shock of adverse events (Gucciardi et al., 2019), including the maintenance of team functions. As such, a highly resilient team should also be more satisfied with their team. Indeed, there is indication that team resilience and satisfaction have a strong association. For example, maintaining high team satisfaction was important resource in dealing with ongoing, chronic stressors as well as in preparing for future adversities (Morgan et al., 2019). In another study, team resilience positively predicted team satisfaction (West et al., 2009). As such, I hypothesize the following:

Hypothesis 3_a: All facets of the TRI will significantly predict team satisfaction.

Team potency refers to a shared belief among team members regarding their ability to perform and succeed in a variety of tasks across many situations (Gully et al., 2002; Woodley et al., 2019). Team potency is one of the most studied team constructs in the literature due to its established importance in predicting many key team functions (e.g., performance, satisfaction, and engagement; Gully et al., 2002; Stajkovic et al., 2009). This collective belief in a team's ability to overcome any challenges is an important aspect of team resilience, as adversities can come in many different forms and may not always be expected, and so highly resilient teams need to have a strong belief in their ability to handle unexpected and surprising adversities (Meneghal et al., 2016b). Highly potent teams have been found to persevere during adversity (Gully et al., 2002). As argued by Stoverink et al. (2020), team potency may act as 'motivational fuel' to power a team's goal-striving behaviour through periods of adversity, predicting the occurrence of various appraisal, communication, and performance behaviours necessary for team resilience. Moreover, team potency may operate as a feedback mechanism for team resilience whereby the repeated experience of successful resilience instances (i.e., mastery experiences) informs team members' sense of team potency in future adversities. In turn, this collective belief

in team potency acts as a resource a team can draw on to collectively respond to adversity through influencing the team's choice of strategy and motivation to persevere under duress (Hartwig et al., 2020; Meneghal et al., 2016a).

$H3_b$: All facets of the TRI will significantly predict team potency.

4.5 Method

Data for study two was formed by merging two samples. Sample 1 was collected over four time points (t1 = September, t2 = Mid-January, t3 = March, t4 = April) across the 2019-2020 academic year at a large Canadian university. Sample 2 was collected over four timepoints across the 2020-2021 academic year. The structure of the data collection was identical to dataset 1. The only difference in the context of the course was that the format of delivery was adapted to address the ongoing COVID-19 quarantine procedures. This included a shift towards a blended format of instruction, with both in-person and online components, and the participants interacted with their team members both in-person and virtually.

The participants consisted of first-year engineering design students assigned to teams of four to six members. The TRI was included as part of a larger research program throughout the academic year. In both samples, new teams were formed at the beginning of January, two weeks prior to t2. Data for the team resilience process dimensions were gathered from t2-t4, whereas data for the team resilience resources dimensions were gathered at t3. This was to ensure that the team members had sufficient time to gain a sense of their teams' resilience. T1 data collection was reserved for personality data collection as these dispositional and demographic variables (i.e., demographics and trait-narcissism) were not expected to substantially change over the academic term.

The participants were sent an email invitation to complete the questionnaire online through the course website for each time point. The teams were required to complete a variety of team-based tasks for course credit throughout the academic year. Team performance was a significant component of the course grade, including peer ratings of teamwork skills and contribution to team tasks. All participants were informed that filling out the questionnaires at each time point was voluntary and all results were completely for research purposes only. While completion did not impact the participants' grades directly, they were given a bonus .33% for completion of each time point on their end-of-term grade and a .66% bonus if they filled out the questionnaires at all four time points. In total, participants had the opportunity to earn 2% in bonus credits toward their final grade.

The engineering design course was developed to emulate a commercial engineering environment as closely as possible, whereby each team was tasked with designing a product for an organization in the surrounding community. The participants frequently interacted with each other while completing interdependent projects throughout the year, including an end-of-the-year project. Although the participants had some interactions with each other in their course during the 2019 and 2020 fall semesters, the participants were randomly assigned to their current teams at the beginning of the winter term (January), with the only caveat being that for any team with a female student, there would be at least two females on the team.

4.5.1 Participants

For Sample 1, 591 individuals enrolled in the course at the beginning of the academic year, of which 461 (k = 103, $M_{groupsize}$ = 4.66, M_{age} = 18.11, SD = 1.14, Female = 125 (22.3%), other = 2 (.36%)) participants completed the measures at t1. The participants had an average of 16.7 months of work experience (SD = 16.29) and were ethnically diverse (White = 43.7%,

Asian = 21.4%, Middle Eastern = 11.6%, East Indian = 5.5%, Hispanic = 2.50%, Aboriginal/Native = 0.7%, Multiple/Other = 10.2%). Of the 103 teams from which data were collected, 50 were Male-only teams and 53 were mixed-gender teams.

For Sample 2, 687 individuals enrolled in the course at the beginning of the academic year, of which 595 (k = 113, $M_{groupsize}$ = 4.21, M_{age} = 18.03, SD = 1.14, Female = 152 [22.1%], Other = 2 [.29%]) participants completed the measure at t1. The participants had an average of 15.4 months of work experience (SD = 17.0) and were also ethnically diverse (White = 39.7%, Asian = 18.8%, Middle eastern = 8.4%, East Indian = 7.3%, Hispanic = 2.5%, Aboriginal/Native = 0.3%, Multiple/Other = 8.4%). Of the 113 teams from which data was collected, 53 were Male-only teams and 50 were mixed-gender teams.

Across the combined samples, 1278 students were enrolled in the course, of which 1,056 individuals (representing 91.4% of the possible participants) completed the questionnaire at t1. The average age was 18.1 (SD = 1.14), 277 of the participants were Female (22.20%) and 4 indicated ‘other’ gender representation (0.32%). The participants had an average work experience of 16.04 months (SD = 16.67). The average work experience had a positive skew due to the presence of a few mature students who had significantly greater work experience. As the engineering program attracted a large international student cohort, the participants were ethnically diverse (White = 41.5%, Asian = 20.0%, Middle Eastern = 9.0%, East Indian = 6.5%, Hispanic = 2.4%, Aboriginal/Native = .5%, Multiple/Other = 9.2%). The demographic structure of the two datasets were similar, with no significant differences in age, sex, average work experience, or ethnic makeup.

4.5.2 Measures

Prior to the inferential data analyses, reliability analyses were performed for each of the measures and are included in Table 14 under the descriptive statistics section.

Team potency beliefs: Team potency (a = .91, w = .91) was measured using Guzzo et al.'s (1993) scale, which included 4 items ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

Team Satisfaction: Team satisfaction was measured using a single item *("Overall, how satisfied were you with your team?"*) anchored from -3 (*very dissatisfied*) to 3(*very satisfied*).

Psychological Resilience: Psychological resilience was measured using Campbell-Sills and Stein's (2007) 10-item version of the Connor-Davidson resilience scale. The scale range was from 0 (*not true at all*) to 5 (*true nearly all the time*). a = .89, w = .89.

Cognitive Prompt and adversity type: The instructions for the resilience processes items asked the participants to reflect on an adversity they encountered within the previous month when answering the survey. The prompt was designed to elicit reflection on collectively encountered adversities:

"Please think of a challenge or adversity your team has collectively faced within the last month. For example, this could include a missed deadline, a high workload, or a team member being unavailable. Please keep this situation in mind when responding to the following questions."

In addition, an item was included in the data collection asking the participants to select from a list of challenges (e.g., interpersonal conflict, difficulties adapting to online format, strict deadlines) that their team had experienced within the last month. These categories (see Table 13) were developed by inviting subject matter experts (i.e., the instructors and assistants for the engineering design course) to list what challenges they believed were most common for the

participant teams to experience. In addition, I reviewed narrative comments on what forms of adversity the respondents from study 1 encountered and developed themes (e.g., social loafing, interpersonal conflict). The responses from the study 1 participants and the subject matter experts were then compiled and a list of 8 adversities were identified.

Adversity Severity: Research on psychological resilience suggest there may be a significant subjective component to how the same potentially adverse event (e.g., losing a job) is interpreted and how severely its negative effects are felt (King & Rothstein, 2010). Where one individual may experience the loss of a job as a significant source of stress, another may experience little to no strain effects from the adversity (e.g., if the job itself was a significant stressor). A similar principle likely applies to team resilience (Gucciardi et al., 2019). The same potentially adverse event may be experienced by the team as more or less stressful based on their unique combination of available resources and situational context. As such, a single item measure was included to assess the participants' perception of how severely their team was affected by the adversities their team experienced that they identified: "*How severely was your team affected by these adversities?"*. The item was anchored from 1 (*not at all*) to 7 (*unable to function*).

Table 13

Frequency of Adversity Theme Reported

	t_2		t_4	
	frequency	percentage	frequency	percentage
Difficult deadlines	225	32.8	328	47.7
Social Loafing	103	15	213	31

Difficulty developing a solution to the course assignment	143	20.8	119	17.3
Interpersonal communication issues	135	19.7	154	22.4
IT issues	125	18.2	153	22.7
Interpersonal conflict	8	1.2	31	4.5
High workload	68	9.9	160	23.3
Other	21	2	23	2.1
Experienced at least 1 adversity theme in the previous month	317	46.1	339	49.3

Note: t_2 N = 687, average number of adversity themes experienced = 1.69 (SD = 1.46), average severity = 3.41 (SD = 1.16). t4 N = 687, average number of adversity themes experienced = 2.22 (SD = 1.69), average severity = 3.63 (SD = 1.19). Comments provided in the other category included unclear course instructions, mental health issues, interpersonal problems with course instructors, and difficulty with scheduling team meetings.

4.5.3 Analytic Procedure

Analysis for study 2 began with generating and reviewing the descriptive statistics for violations of assumptions. This included review for outliers in both individual and observed scores (i.e., scores aggregated to the mean), as well as skew and kurtosis values for normality. All descriptive analyses were performed in JASP, while all predictive analyses were performed in MPlus v.8.4. After this, the first step in the analysis was to assess the measurement model of the revised TRI and the individual facet scores. I used a similar format as Study 1, beginning with assessing the measurement model of the full TRI at t3 using CFA. Model fit indices guidelines were the same as Study 1 (Hox, 2015; Kelloway, 2016). A null model was specified in which all TRI items were included without any latent factors as a baseline comparison point for hypothesized models (Kelloway, 2016). CFAs were then performed for each TRI facet at each timepoint. Due to the high inter-facet correlations of the resource facets (as with Study 1), an alternative model where the resource facets were coerced to load on one factor was tested; however, this model showed a significant decrease in model fit and so was not explored further.

To test hypothesis 1 (that psychological and team resilience are separate constructs), I began by using the average variance explained (AVE) by each factor based on the sum of squared loadings divided by the sum of squared loadings plus unsquared item uniqueness (Fornell & Larcker, 1981). Raykov (2011) suggests that if the factor scores of the two hypothetically discriminant measures correlate less than $r = .3$, and the positive square root of the AVE for each of the latent variables is higher than the highest correlation with any other latent variables, then the measures reflect separate constructs. For hypotheses 2 and 3 multivariate regressions were performed wherein each factor of the TRI was entered simultaneously as predictors of team satisfaction and team potency.

4.6 Results

4.6.1 Descriptive Statistics

The descriptive statistics were assessed for each latent factor at each timepoint, the results of which are summarized in Table 14. To assess normality, the skew and kurtosis values were included. No significant outlying cases were found, and most variables had some moderate skew (i.e., greater that 1 or -1; Hox, 2015). However, this is consistent with most psychological constructs with a clear positive or negative valence and does not fall outside the acceptable range (Brown, 2006). Following this, the ICC values were calculated. ICC(1) values represent the extent to which individual ratings are attributable to team membership, while ICC(2) values represent the reliability of the team's mean rating (Hox, 2010). The range of ICC(1) values (.01 to .62) across timepoints suggests that group membership accounts for 1% to 62% of the

variance in scores depending on the variable. Descriptive statistics are also presented for the observed team scores (i.e., mean-aggregated scores for each team) in Table 15.

Table 14

Descriptive Statistics and ICC Values for Study 2.

Variable	timepoint	*N*(missing)	$k(M_{groupsize})$	*M*	*SD*	*ICC (1)*	*skew*	*kurtosis*
Affective Resources	t3	921 (327)	222 (3.73)	3.91	.53	.15	-.49	.73
Behavioural Resources	t3	921(327)	222 (3.73)	4.18	.65	.24	-.77	.63
Cognitive Resources	t3	921(327)	222 (3.73)	4.09	.65	.16	-.58	.44
Team Adaptation	t2	935(313)	222 (4.00)	3.35	1.21	.47	-.45	-1.03
	t3	928(320)	222 (3.75)	3.49	1.26	.62	-.54	-1.08
	t4	968(280)	222 (3.88)	3.38	1.29	.51	-.45	-1.14
Team Persistence	t2	935(313)	222 (4.00)	4.24	.61	.04	-.88	1.60
	t3	928(320)	222 (3.75)	4.32	.65	.09	-1.62	4.63
	t4	968(280)	222 (3.88)	4.3	.66	.01	-1.15	1.89
Team Potency	t2	929(319)	222 (3.65)	5.62	1.06	.24	-.87	.98
	t3	355(893)	221 (3.70)	5.48	1.04	.14	-.79	1.05
	t4	967(281)	222 (3.88)	5.72	1.10	.10	-.94	.80
Team Satisfaction	t2	920(328)	222 (3.93)	5.84	1.18	.07	-1.39	2.17
	t3	901(347)	222 (3.66)	5.92	1.24	.10	-1.48	2.13
	t4	960(288)	222 (3.86)	5.82	1.36	.06	-1.45	1.80
Psychological Resilience	t3	566(121)	127 (4.05)	4.19	.64	.09	-.84	.71

Table 15

Team Factor Score Descriptive Statistics for Study 2.

Variable	timepoint	*M*	*SD*	skew	kurtosis
Affective Resources	t3	3.89	.33	-.30	-.05
Behavioural Resources	t3	4.13	.47	-.47	.07
Cognitive Resources	t3	4.05	.42	-.4	.10
Team Adaptation	t2	3.35	.97	-.50	-1.03
	t3	3.36	1.12	-.38	-1.34
	t4	3.33	1.04	-.44	-1.25
Team Persistence	t2	4.24	.33	-.71	1.63
	t3	4.29	.41	-1.33	3.61
	t4	4.28	.38	-.88	2.42
Team Potency	t2	5.63	.67	.28	.20
	t3	5.7	.67	-.92	1.45
	t4	5.71	.66	-.82	1.20
Team Satisfaction	t2	5.82	.72	-1.17	2.38
	t3	5.8	.89	-1.4	2.71
	t4	5.81	.81	-1.13	2.37
Psychological Resilience**	t3	4.21	.35	-.33	-.10
Adversities encountered**	t2	1.79	.74	.35	.32
	t4	1.96	.07	.33	.41
Severity**	t2	3.43	.65	.03	1.51
	t4	3.63	.64	.30	.42

Note: k_{t2} = 232, k_{t3} = 232, k_{t4} = 233. * Variable included only in dataset 1, ** variable included only in dataset 2.

Table 16

Study 2 Correlation Table

	Timepoint 2								Timepoint 3						Timepoint 4			
Variable	Persist	Adapt	T.Coord	T.Sat	T.Pot	TR-A	TR-B	TR-C	T.Coord	Persist	Adapt	T.Sat	T.Pot	P.Res	Persist	Adapt	T.Coord	T.Sat
t2 Persistence	.86																	
t2 Adaptation	.14**	.93																
t2 Team Coordination	.27**	-.54**	-															
t2 Team Satisfaction	.43**	.11**	.37**	-														
t2 Team Potency	.54**	.22**	.22**	.64**	-													
t3 Affective	.36**	.25**	-.06	.46**	.50**	.82												
t3 Behavioural	.33**	.34**	-.16*	.48**	,51**	.76**	.84											
t3 Cognitive	.40**	.26**	-.06	.50**	.57**	.79**	.81**	.90										
t3 Team Coordination	.21**	.13*	.05	.21**	.25**	.29**	.35**	.33**	-									
t3 persistence	.44**	.15**	-.07	.35**	.41**	.47**	.53**	.56**	.39**	.88								
t3 Adaptation	.06	.69**	-.55**	.10*	.17**	.29**	.37**	.29**	.17*	.29**	.96							
t3 team satisfaction	.32**	.14**	.10	.62**	.50**	.61**	.67**	.62**	.40**	.45**	.16**	.88						
t3 team potency	.37**	-.13*	-.05	.41**	.57**	.57**	.61**	.70**	.67**	.58**	-.14*	.65**	.93					
t3 P. Resilience	.34**	.33**	.09	.23**	.37**	.38**	.37**	.45**	-.13	.24**	.27**	.21**	.17	.89				
t4 Persistence	.43**	.10*	.05	.36**	.43**	.41**	.46**	.49**	.22**	.47**	.09*	.37**	.45**	.27**	.88			
t4 Adaptation	.06	.67**	-.52**	.13**	.21**	.27**	.36**	.30**	.11	.17**	.70**	.17**	-.27**	.30**	.20**	.90		
t4 Team Coordination	.16*	-.46**	.53**	.35**	.13	.05	.01	.06	.14	.15*	-.41**	.23*	.05	.10	.19*	-.45**	-	

t4 Team Satisfaction	.26**	.12**	.10	.51**	.40**	.46**	.51**	.51**	.26**	.39**	.15**	.65**	.50**	.15**	.47**	.19**	.35**	-
t4 Team Potency	.34**	.18**	.01	.46**	.54**	.48**	.56**	.56**	.31**	.42**	.18**	.53**	.62**	.28**	.56**	.24**	.30**	.62**

Note: * p <.05 ** p <.001 N = 1281. Cronbach's a reliability index is presented in the diagonal.

4.5.2 Factor Structure and Internal Relationships

The 5-factor (Affective, Behavioural, and Cognitive resources, Persistence, and Adaptation) CFA showed acceptable model fit for the TRI at t3 ($\chi^2(485) = 1300.102$, RMSEA = .043, CFI/TLI = .959/.956, SRMR = .033) and is summarized in Table 17. The determination of model fit was based on comparison of the model fit indices obtained from the CFA with suggested cutoff values frequently suggested in the literature (Hox, 2015; Kelloway, 2016). Although the chi-square test of model fit was significant, the chi-square value divided by the degrees of freedom was less than 5, which some suggest as a benchmark for interpreting the chi-square test of model fit with larger samples (e.g., Schumacker & Lomax, 2004). The model also showed significant improvement in model fit compared to the unconditional model (χ^2 difference = 17,765.006 p <.001). The item loadings for this measurement model are presented in Table 18.

Because of the high Pearson's *r* correlation coefficients between the latent team resilience resource facets (see Table 19), two alternative measurement models were tested. First, exploratory structural equation modeling (E-SEM; van Zyl & ten Klooster, 2022) was used to assess the model fit that allows for crossloadings of items. This approach differs from traditional CFA in that rather than assuming 'purely' discreet latent factors where factor crossloadings are constrained to 0, E-SEM allows for crossloading of items between factors within the framework of *a priori* specified factor structures. The E-SEM model showed improved model fit, suggesting that there are some crossloadings between the TRI factors, and that accounting for these improved both the model fit and parsimony. Second, as with study 1, a model was performed that had all resource items loaded onto one factor. Review of the model fit indices indicated that the three resource facets had better model fit and so the univariate latent resource model was rejected. This was repeated with multilevel CFA, where an alternative model with a univariate

resource factor was hypothesized, and again this showed worse model fit. The modification indices did not suggest any outstanding sources of ill fit or changes that would significantly improve the model fit and so no modifications were made to the TRI measurement model. Overall, the measurement model suggested that while the resource facets had large inter-correlations, they are still best viewed as three distinct yet related factors.

Table 17

Study 2 Model Fit Indices for the TRI Measurement Models

	χ^2 (df)	RMSEA (90% CI)	CFI/TLI	SRMR/between	AIC	BIC	aBIC
Unconditional Model	19065.108 (1056)**	.145	0/0	.331/.662	71351.45	71817.31	71502.92
total CFA (5 factor)	**1300.102 (485)****	**.043 (.040, .046)**	**.959/.956**	**.033**	**61722.56**	**62247.1**	**61900.93**
total ESEM	614.001 (373)**	.027 (.023, .030)	.983/.976	.017	61438.56	62502.09	61800.22
total CFA (3 factor)	1132.102 (492)**	.038 (.035, .041)	.956/.952	.036	61910.82	62401.68	62077.74
Within model	2291.420 (1013)**	.039 (.037, .040)	.929/.926	.153/.690	55920.53	56588.73	56137.8
Between model	19511.229 (1013)**	.150 (.141, .159)	0/0	.332/.234	65938.6	66606.8	66155.87
MCFA (5 & 5)	**1767.335 (970)****	**.032 (.030, .034)**	**.956/.952**	**.039/.154**	**55502.62**	**56373.17**	**55785.68**
MCFA (3& 3)	1943.857 (984)**	.035 (.032, .038)	.947/.943	.043/.172	55651.59	56456.26	55913.23
CFA (Team Means)	843.324 (485)**	.056 (.050, .063)	.930/.924	.049	8410.053	8785.747	8440.275

Note: Model fit indices are reported for t3, as this was the only timepoint to include all five facets of the TRI. ** $p < .001$, $N = 812$, $k = 222$. Within Model refers to a measurement model where the level 2 parameters are saturated. Between model refers to a measurement model where the level 1 parameters are saturated. The 5 & 5 model refers to a multilevel measurement model where all 5 hypothesized TRI facets are specified at each level of analysis. The 3 & 3 model refers to a multilevel measurement model where adaptation and persistence are distinct factors at each level, with a global factor for team resilience resources.

Table 18

Item Loadings for the 5-factor TRI

Factor	Total	Within	Between
Affective Resources			
TRA_1 “Our team sees things positively”	.77	.75	.94
TRA_2 “Our team members support one another emotionally”	.67	.68	.73
TRA_3 “Our team ensures all members feel safe speaking up in team discussions”	.67	.63	.98
TRA_4 “Our team members are able to control their emotions”	.62	.57	.98
TRA_5 “Our team members feel good about being on this team”	.82	.81	.94
TRA_6 “Our team members trust one another to support them”	.80	.79	.96
TRA_7 “Our team is easily frustrated”	.28	.26	.51
Behavioural Resources			
TRB_1 “Our team can perform well in the absence of any team member”	.52	.44	.98
TRB_2 “Our team shares the workload in a fair way”	.70	.66	.82
TRB_3 “Our team is quick to respond to changes”	.77	.73	.99
TRB_4 “Our team cooperates to accomplish our goals”	.82	.78	.96
TRB_5 “Our team ensures each member is up to date on what we are doing”	.69	.65	.98
TRB_6 “Our team expects one another to do their best”	.70	.68	.99
Cognitive Resources			
TRC_1 “Our team can handle vague goals and tasks”	.65	.62	.91
TRC_2 “Our team seeks input from every member before making decisions”	.63	.59	.96
TRC_3 “Our team sees challenges as opportunities for learning”	.73	.73	.88
TRC_4 “Our team all understand our roles”	.75	.73	.99
TRC_5 “Our team plans how to respond to challenges we may face in the future”	.70	.70	.93
TRC_6 “Our team is quick to think of a new approach if something does not work”	.69	.65	.99
TRC_7 “Our team has a variety of expertise we can draw upon”	.71	.67	.99
TRC_8 “Our team is always thinking of ways to improve”	.78	.78	.98
TRC_9 “In our team, mistakes are openly discussed to learn from them”	.68	.66	.98
Persistence			
TPP_1 “Our team persists through challenges”	.84	.83	.99
TPP_2 “Our team is able to endure the challenges we are currently facing”	.83	.82	.98

TPP_3 "Our team continues to work toward our goals, even when it is difficult"	.78	.78	.85		
TPP_4 "When our team experiences a setback, we try even harder than before"			.70	.70	.97
TPP_5 "If a team task turns out to be quite difficult, we just persist in our efforts"			.73	.73	.81
Adaptation					
TPA_1 "Our team adapts to respond to challenges"			.93	.82	1
TPA_2 "Our team develops new plans to overcome challenges"			.94	.84	1
TPA_3 "Our team tries new approaches to deal with challenges"			.90	.80	1
TPA_4 "Our team finds opportunities for new ways of doing things in unexpected situations"			.90	.80	.99
TPA_5 "Our team modifies its strategy to adapt to challenges"			.92	.83	.99
TPA_6 "Our team modifies its composition to adapt to challenges"			.74	.63	.99

Note: N = 812, k = 222. All items loaded at $p < .001$

Table 19

Within and Between Correlation Matrices for Study 2

	Affective	Behavioural	Cognitive	Persistence	Adaptation
Affective		.95**	.98**	.99*	.62*
Behavioural	.94**		.99**	.88*	.81**
Cognitive	.90**	.92**		.93*	.75**
Persistence	.53**	.59**	.56**		.55**
Adaptation	.16*	.12*	.18*	.30**	

Note: N = 817, k = 222 ($M_{groupsize}$ = 3.68). Lower diagonal refers to within-teams correlation matrix. Upper diagonal refers to between-teams correlation matrix.

4.5.3 Discriminant Validity Testing

H_1 stated that psychological and team resilience are distinct constructs. As this hypothesis essentially posits that team members can reliably separate their perception of their own psychological resilience and their perception of their team's resilience, multilevel modeling was not used. To test this hypothesis, I began with examining the correlation matrix between the TRI

facets and psychological resilience. Psychological resilience had a significant moderate, positive correlation with each factor of the TRI as expected. Second, I performed an average variance explained (AVE) test. Using the AVE as an analysis for discriminant validity tests if the square root of each AVE value belonging to each latent construct is larger than the correlation between the target and comparison latent constructs (Zait & Bertia, 2011). For each factor of the TRI, the square root of the AVE score was substantially larger than the factor's correlation score with psychological resilience (see Table 20), suggesting that the participants reliably separated psychological and team resilience, and supporting H_1.

Table 20

Study 2 Discriminant Validity Testing for Team and Psychological Resilience

	Correlation	AVE	square root AVE
Affective	.45**	.41	.64
Behavioural	.44**	.48	.69
Cognitive	.52**	.50	.71
Persistence	.31**	.59	.77
Adaptation	.18	.80	.90

Note: Model fit: χ^2 (845) = 1453.862, RMSEA = .028 (.026, .031), CFI/TLI = .965/.962, SRMR = .047, N = 412, k = 115

4.5.4 Multivariate Regressions

Table 21 summarizes the results of the multivariate regression models of the TRI predicting team satisfaction (R^2 = .69, p <.001) and team potency (R^2 = .57, p <.001). Regarding team satisfaction the Behavioural resources (b = .61, p <.001) and Adaptation (b = -.17, p = .002) were both significant predictors. Interestingly, Adaptation was a negative predictor, the opposite of the hypothesized relationship. H_{3a} was partially supported. For team potency, Affective

resources (b = .26, p = .011) and Persistence (b = .31, p <.001) were both significant predictors, partially supporting h*3b*.

Table 21

Study 2 Multivariate Regressions for Timepoint 3 Team Satisfaction and Team Potency

Variable	Team Satisfaction			Team Potency		
	estimate	s.e.	*p*	estimate	s.e.	*p*
Affective	.04	.20	.546	**.26**	.21	.011
Behavioural	**.61**	.18	<.001	.14	.19	.292
Cognitive	.06	.21	.535	.09	.22	.513
Persistence	.05	.12	.344	**.31**	.13	<.001
Adaptation	**-.17**	.04	.002	-.01	.05	.927
R^2	.69		<.001	**.57**		<.001

Note: * p <.05 ** p <.001 N = 1281

4.6 Summary and Conclusions

Using a series of multilevel regressions and longitudinal MSEMs, the objectives of study 2 was to further investigate the validity and reliability of the TRI, and to explore the nomological network of team resilience. The current study evaluated the extent to which team resilience resources (i.e., Affective, Behavioural, & Cognitive) and team resilience processes (i.e., Persistence & Adaptation) are empirically distinct and relate to theoretically important outcomes. Overall, the results showed further support for the measurement model of the TRI, showed good model fit, and was consistent with the results of study 1. The results further confirmed the relatively better model fit of the 3 resource factors (affective, behavioural, and cognitive) over the single resource factor, although an exploratory SEM model was performed, and the improved fit of this model suggests that there were significant item crossloadings and accounting for this improved model fit.

Beginning with H_1, the results supported the discriminant validity of team and psychological resilience. Though correlated, the AVE square root extracted for each TRI factor was larger than its corresponding correlation with the PsyCap resiliency scores, suggesting that these are distinct concepts. This is consistent with the notion that the psychological resilience of individual team members may be a resource teams can draw from in response to collective adversity, and that, in turn, a team's resilience may be a protective factor for its members. Further discriminatory work may consider EFA approaches and exploration of what outcomes are similarly or differentially predicted by psychological and team resilience both at the within-team (i.e., how psychological and team resilience may similarly or differentially relate to team states) and between-team levels (i.e., how aggregate perceptions of psychological and team resilience relate to other constructs in the nomological network of team resilience) as further areas of exploration.

Regarding H_2, that the team resources factors would positively predict Persistence and Adaptation, the results showed that the behavioural and cognitive resource factors significantly predicted Persistence, but not Adaptation. This may be due to a complicated relationship between beneficial team resources and processes and team adaptation (Maynard et al., 2015). Although teams may require resources to adapt effectively, access to beneficial resources may preclude adverse situations that necessitate teams to adapt. In other words, teams that score highly on the resource facets may not indicate that they had to adapt, may not have identified adaptation as a viable strategy, or that they had to dedicate significant resources to adapting well because they are able to mitigate adversities before they become large enough to require adaptation. Conversely, teams that indicate they had to adapt may only have needed to do so due to an adversity overwhelming their existing resources. This is consistent with a punctuated-

equilibrium view of adaptation (Gersick, 1991), wherein adaptation only occurs when an entity is disrupted enough to surpass the threshold at which the entity can no longer continue the status quo in the face of the adversity. In the context of teams, this may take the form of teams with significant resources are able to use those resources to address adversity before it significantly threatens their equilibrium and requires adaptation. Conversely, teams that lack resources may not have the capacity to adapt, even when required and may continue in a dysfunctional trajectory (Gucciardi et al., 2018). These competing explanations may make it difficult to isolate a clear, linear relationship between team resilience-related resources and team adaptation as teams with few or many resources available may both have their reasons to engage in adaptation, though the reasons may be very different. Future research may benefit from a more controlled setting in which the presence of an adversity is standardized while the resources are left to vary so each team must adapt more or less effectively.

Team persistence, however, may have a more straightforward relationship with resilience-related resources. Continued team functioning inherently requires some degree of persistence, though the strength of that persistence depends in large part on the resources that the team can funnel into maintained effort. As such, teams with more resources available to them should show higher persistence and the results of study 2 support this.

H_3 posited that each facet of the TRI should predict team satisfaction and team potency. In review of partial correlations, each facet of the TRI positively, significantly correlated with both team satisfaction and team potency as predicted with the exception of Adaptation and team potency. While this correlation was significant, it was a small negative effect, contrary to H_3. In multivariate regressions it was found that the Affective resources and Persistence both predicted team potency. Both behavioural resources and Adaptation predicted team satisfaction, however

Again, Adaptation's effect was negative. Although the relationships found largely supported hypothesis 3, the exception of Adaptation is interesting. It may suggest that rather than being a net positive process for a team, high potential teams may not need to engage in Adaptation in the first place. In other words, high functioning teams may report low Adaptation scores as they may not need to adapt in the first place.

5. Study 3: Trajectories of Resilient Team Performance

Team resilience capacity is what many researchers have in mind when defining team resilience as a whole and is implicitly operationalized and measured as the sum total of resources and processes a team has available to them. Emergent team resilience, however, is the *demonstration* of this capacity through the maintenance and/or recovery of functioning following exposure to adversity. Following Ratcliffe et al.'s (2019) model, four components need to be operationalized and measured in order to capture emergent team resilience: 1) a baseline level of performance on an outcome to compare against; 2) the incursion of an adversity occurs with the potential to disrupt the functioning of the outcome; 3) the degree to which the functioning of the outcome departs from the baseline; and 4) the time it takes for the outcome function to return to the baseline. This way of conceptualizing team resilience takes as its focal point a relevant team function outcome (e.g., performance) that can vary across time around a baseline level of performance. While this distinction of team resilience into capacity and emergent forms appears unique in the team resilience literature, it has emerged as a useful approach in other areas of resilience research (Britt et al., 2016; Degbey & Einola, 2020) as an entity can possess the capability of being resilient to an adversity (i.e., team resilience capacity) without necessarily having opportunity to demonstrate it (i.e., emergent team resilience). This distinction also has the potential to significantly reduce the trait/process/outcome debate in team resilience literature that has undermined faith in the specificity and utility of the construct.

Research on team resilience to date has been largely piecemeal and focused almost

exclusively on identifying characteristics of a highly resilient team (Hartwig et al., 2020). Gucciardi et al. (2019) attempted to remedy this situation by introducing their theoretical model of team resilience to promote the "systematic, coordinated, and accumulative efforts to studying and theorizing about team resilience" (2019, pp. 730). Of interest to study 3 is the emergent resilient performance component of their model, which suggests team resilience is best conceptualized as an emergent property of an outcome variable that results from the sharing of individual resources through person-person and person-situation interactions and is manifested in trajectories of team performance over time. Although the authors provide a brief description of what these performance trajectories may look like (i.e., a resistant, bounce-back, or recovery trajectory) based on how teams respond to adversity, they do not go into depth regarding how to operationalize these performance trajectories, or what indices may be used to measure them. This limitation is highlighted by the authors as an area of possible future research.

In the current study, I expand on Gucciardi et al.'s (2018) framework by drawing from interdisciplinary theory on resilience to position resistance (the ability of a team to resist disturbance from an adverse event) and recovery (how well a team recovers from the disturbance of an adverse event) as the two formative concepts in a bivariate model of emergent team resilience. To demonstrate this bivariate model using team performance, I use a within-subjects longitudinal design with participant teams to demonstrate resistance and recovery in action and how it may be operationalized, as well as overall resilient team performance.

Study 3 has two key objectives. First, to demonstrate a way of operationalizing resilient trajectories of team performance over time. To accomplish this, I used the Area of Resilience to Stress Event (Arse; Ratcliffe et al., 2019) a novel approach that measures the area of a graph bounded by the lines representing a baseline norm, and deviations from the norm that result from an adversity being introduced. This provides the area of the polynomial which varies based on the deviation between the norm score and the initial post-adversity timepoint (i.e., the resistance

to the negative effects of the adversity), and the deviation of subsequent timepoints before the baseline level of performance is recovered (i.e., recovery). In other words, the Arse score can be viewed as a function of a team's resistance and recovery following an adverse event and as an operationalization of a team's resilient performance.

Second, I expand on studies 1 and 2 by assessing the measurement model of the TRI with non-acquainted teams performing different tasks and assessing the ability of the TRI to predict trajectories of resilient performance over time. Teams with larger pools of resiliency-related resources, that are more persistent in their efforts, and more successfully adapt to an adversity should show stronger resistance to adversity and faster recovery of any lost performance. Therefore, each facet of the TRI should predict better resilient performance. As such, I predicted that: (H_1) the TRI factors (including affective, behavioural, and cognitive resources as well as Adaptation & Persistence) will predict a more resilient trajectory of performance.

Although the Arse score can be used to operationalize team resilience as a function of resistance and recovery, it cannot assess either independently. However, resistance and recovery are best viewed as related but separate constructs as it is entirely possible for a team to demonstrate high or low resistance independent of their ability to recover and vice versa. A team may show only minimal performance loss following an adversity but take considerable time to recover (i.e., the high resistance, low recovery trajectory) or could show significant loss and relatively quick recovery of performance (i.e., low resistance, high recovery trajectory). That said, they are not independent, as how well a team resists any function loss clearly affects how quickly they recover and return to their pre-adversity baseline. Building on this, the resiliency-related resources a team has available to them and the strategy processes they choose to engage in to address the adversity may differentially predict resistance and recovery. For example, a team's collective emotional regulation may be more important in weathering the initial shock of an adversity (i.e., resistance) than its long term recovery; while their collective grit may be more

important in predicting their long-term commitment to recovery. With this in mind, the TRI facets may also differentially predict resistance and recovery, so the following hypotheses were made.

H_{2a}: The team resilience factors (including affective, behavioural, and cognitive resources as well as Adaptation & Persistence) *will predict less decrement in performance following the adversity event (i.e., higher resistance).*

H_{2b}: The team resilience factors (including affective, behavioural, and cognitive resources as well as Adaptation & Persistence) *will predict less decrement in performance between the baseline performance and performance in t4 (i.e., higher recovery).*

The approaches taken to operationalize and measure resistance, recovery, and overall resilience (i.e., the Arse score) trajectories requires specific outcomes of relevance that can be easily delineated and measured consistently across timepoints to provide an objective measure of a team's resilience. However, consistent, objective performance indicators are often difficult to achieve in research outside of contrived laboratory settings. Through repeated experiences together, team members will form a shared subjective perception of their team's ability to be resilient (Gucciardi et al., 2019; Stoverink et al., 2020). Such subjective perceptions are substantially easier and more convenient to measure as a potential stand in for objective indicators of resistance and recovery. It is unclear, however, how accurate such shared perceptions could be. Research suggests that correlations between objective and subjective ratings of team performance vary considerably based on the complexity of the task(s) and the ability to observe performance outcomes (e.g., Prewitt et al., 2009). Meta-analysis shows that, in general, objective and subjective performance indicators have moderate overlap (Bommer et al., 1995). The design of study 3 was such that the team members received immediate feedback on their performance after each level, and thus had a clear idea of their team's performance trajectory, how well they maintained performance following the adversity manipulation (i.e.,

resistance), and how well they eventually recovered performance level (i.e., recovery).Therefore, for study 3, I also developed a short measure for shared perceptions of the teams' resistance and recovery to test how well these shared perceptions may actually reflect their objective performance. It is expected that the team members' performance perceptions should be relatively accurate and there should be a large degree of overlap. I predicted that:

H_{3a}: The subjective perception measure of resistance will correlate positively with the objective performance indicator of resistance.

H_{3b}: The subjective perception measure of recovery will correlate positively with the objective performance indicator of recovery.

Building on this, if these subjective perceptions of team resilience are accurate to the teams' true resilient performance, they should also be predicted by the same antecedents, such as the resource and process factors of the TRI. As such, I also predicted that:

H_{4a}: The TRI resource factors, adaptation, and persistence will predict subjective perceptions of resistance.

H_{4b}: The TRI resource factors, adaptation, and persistence will predict subjective perceptions of recovery.

5.1 Study Procedures

To test my hypotheses, I designed a pre-post-treatment within-subjects design with two conditions: 1) Pre-adversity (team performance prior to the introduction of the adversity); and 2) Post-adversity (team performance after exposure to the adversity). Participants consisted of first-year undergraduate students from a large Canadian university. The participants came from a variety of disciplines, but all were enrolled in an introductory Psychology course and completed the study in return for research participation credits administered by the Psychology department as part of their course curriculum. A total of 175 participants were included in the study,

representing 45 teams ($M_{groupsize}$ = 3.9). The average age was 18.24 (*SD* = 1.18), 42.9% of the participants were Male, 56.6% of the participants were female. Only one participant indicated they were gender non-binary. The participants were also ethnically diverse, with 1.5% of the participants indicating they were of Indigenous American descent, 25.7% of East-Asian descent, 2.3% indicating Black/Afro-Caribbean, 21.7% indicating South-Asian, 8.6% indicating Middle-Eastern, 30.9% indicating White/European, and 11% indicating an ethnicity not covered by the choice options.

The sample consisted of a total 45 teams. The participants signed up for study timeslots, which were limited to four available spots for each timeslot. The participants enrolled in each timeslot were then grouped as a team. The teams were formed specifically for this study and as such the participants had little to no familiarity with each other. The participants completed the study task in-person with a shared video game console. Upon arriving at the lab, the participants were directed to fill out the demographic questionnaire—including the videogame experience items—and to make their way to the video game console. The majority of participants indicated no experience with the videogame chosen for the study task (153/175 participants indicated "no experience with Overcooked!2") and only moderate experience with team-based video games in general (*M* = 3.14 out of a possible 5).

Once all participants had completed the demographic questionnaire, they were given an overview of the study and instructions for how to play the videogame. The participants were told that they were expected to play a total of 8 rounds of the videogame "OverCooked! 2", a commercial kitchen simulator which has the participants complete all the tasks necessary to receive, prepare, and serve meal orders. The more orders they complete and more accurate they are, the higher the 'tip' they receive. The tip received was how the team's performance was operationalized for the study (i.e., the more and better orders they completed, the higher their performance score). Each round lasted 3 minutes, and the participant teams all completed 8

rounds (i.e., t_1-t_8). The participants were told that the team with the highest score on the 8th, final round would receive $200 in gift cards, and that the first 7 rounds were for practice. They were advised to make use of their practice rounds to strategize and improve, and that they can communicate and organize themselves in any way they prefer.

This videogame in particular was chosen as a good context to demonstrate team resilience for a few reasons. First, the game tasks are highly interdependent. The game requires a significant degree of team coordination, communication, and planning for success. Second, each round of the game is short and the same level can be played multiple times. Across trials, this allowed me to exert significant control over the task context (e.g., no new challenges from the design of the game) and to have the multiple timepoints required to measure resilient performance over time. It also allowed for the teams to repeat the same task multiple times and compare performance across trials without any extraneous effects. As such, I could be confident that any variance in scores between trials was largely due to changes in the team's skill and ability to work together.

Upon completing t_4, the participants were asked to take a break and complete the second questionnaire, which included the self- and team performance and confidence items. After this, they returned to the video game console. Before beginning t_5, a member of the team was chosen at random and removed. This was the adversity manipulation for the study. The removed participant was asked to remain and watch their team as they would be asked to fill out the last questionnaire on their team's resilience, but to otherwise remain silent and avoid offering help to their team. The remaining participants would then complete the second half of the rounds (t_5-t_8) and complete the last questionnaire. The manipulation was successful, with 94% of the participant teams showing a performance decrement following the removal of one of their members. At each timepoint, their score was recorded and all gameplay was retained using video capture. Lastly, after the participants completed the final round (t_8), they were asked to fill out

the third questionnaire (i.e., the TRI). All questionnaires were filled out online and can be found on my OSF page.

5.1.1 Adversity Manipulation

The adversity event (i.e., the manipulation) for the study was that in timepoint four out of eight, a member of the team was removed, creating a significant adversity as the team both lost a contributor to performance and had to substantially adapt the structure of their team and work processes.

5.2 Measures

Demographics: At the beginning of the study, the participants were asked to fill out a brief demographic questionnaire that included their age, gender identity, and ethnic background.

Experience: Participant experience was measured in two ways. First an item was included asking participants if they have (yes/no) "… ever played the video game "Overcooked!" or "Overcooked!2" before?" Second, another item was included asking their general familiarity with team-based video games (i.e., *"How familiar are you with team-based video games?"*). The scale ranged from 1 "Not at all" to 5 "Extremely".

Self- and team-performance and confidence ratings: At t_4, to measure participants' perceptions of their own and their team's performance, a 1-item question ("Overall, how well do you think you/team are performing so far?). Participants were also asked, "*Overall how much confidence do you have in yourself/your team moving forward?".* The Likert scale ranged from 1 (not at all) to 5 (a lot).

Team Resilience Capacity: Team resilience capacity was measured using the TRI developed in studies 1 and 2. The measure included 5 factors (affective, behavioural, and cognitive team resilience resources as well as Adaptation & Persistence). The measure consisted of 34 items (affective = 7, behavioural = 6, cognitive = 9, Persistence = 6, Adaptation = 6). Reliability statistics for each factor can be found in Table 27. The team resilience resource

factors (Affective, Behavioural, & Cognitive resources) were administered during the break between timepoint 4 and 5, while Adaptation & Persistence were administered at the end of the session following timepoint 8.

Resistance and Recovery: Six new items developed to assess the participants' subjective perception of their team's resistance (i.e., *"Our team was able to resist the negative effects of the challenge"*) and recovery *("Our team was able to bounce back from the challenge").* These 3-item scales showed good reliability (w = .91, .90, respectively).

Severity: As a measure for the magnitude of the adversity intervention, at the end of the session participants were asked to rate the severity of the adversity *("After the fourth round, we removed a member of your team. How severely did this affect the performance of your team?")* from 1 (*not at all*) to 5 (*my team was unable to function*).

Emergent Team Resilience: The emergent trajectory of resilience was measured using the Arse method (for an in-depth explanation, see Ratcliffe et al., 2019). This approach uses the area created from deviations of a given baseline following an adversity across timepoints (i.e., the area under the curve). A resilient outcome can be quantitatively assessed by measuring the relative degree to which a function negatively deviates from the baseline (i.e., resistance) and the timepoints required to recover the baseline function (recovery) using XY cartesian coordinates. The area of the shape created by the Cartesian points as a perimeter is then operationalized as a resilience score (i.e., the Arse score) and can be used in comparison between entities and to track resilience over time. Lower resilience scores indicate a more efficient resilience process where there was either: a) less deviance from the baseline performance; and/or b) a quicker recovery.

The Arse score only works with a minimum of three time points. Ideally, a continuous measurement of the outcome function is used to capture fluctuations in functioning over time. However, the method also works with multiple discrete timepoints in a longitudinal,

approximately continuous process (for example, repetitive performance of a team task in close succession). The authors of the Arse method suggest at least four timepoints, with one being prior to the adversity event. With 5 timepoints used in the analysis (t_1-t_3 being practice rounds to avoid practice effects contaminating the data), study 3 meets these criteria. The arse scores were assessed using the accompanying 'arse' R package. Specifically, I used the $Arse_{ts}$ scores, which subtracts any positive deviations (i.e., improvements in performance across time) from any negative deviations (i.e., loss of performance over time). This approach was taken rather than the basic 'arse' score as the basic arse score only measures the area under the curve prior to the first time point where the performance meets or exceeds the baseline (i.e., completes the resilience cycle). In the case of team performance, this may attenuate variation in the performance scores if the performance over time is non-linear (e.g., improves in the timepoint immediately following the adversity, but decreases thereafter). The basic arse score also removes the possibility of post-adversity growth (e.g., through redoubling efforts, successful adaptation, removal of detrimental team members), which could be observed and may be explained by variation in the team's resilience capacity (i.e., available human resources, strategizing, adaptability, persistence, etc.).

Team performance: Team performance was measured as the score the teams received for each round of the videogame. Performance scores ranged from 0 to 1080. The baseline level of performance against which timepoints were compared was operationalized as the score the team received at timepoint 4 prior to the introduction of the adversity manipulation. The team's performance at timepoints 5 and 8 were used as the team's scores to operationalize resistance and recovery.

5.3 Results

5.3.1 Descriptive Statistics

Analyses for study 3 began with a review of the descriptive statistics and correlations for each of the study variables. The results are summarized in Table 27. The participants, on

average, appeared to have little experience with the team task, and a moderate amount of experience for team-based video games in general. The participants also indicated that the manipulation (i.e., the adversity) had a moderately severe impact on their ability to perform; that it was a challenge, but not debilitating. Overall, the participants indicated a high level of resilience resources and engagement in persistence and adaptation, though they noted this was only moderately effective in resisting and recovering from the adversity. ICC(1) scores for each variable are included in Table 22 and show a large degree of variance explained by group membership in each.

Table 22

Study 3 Descriptive Statistics, ICC values, and Correlations

Variable	***M***	***SD***	**ICC(1)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1. Videogame Experience	3.12	.55	.05	—											
2. Team task Experience	1.6	2.8	.02	.07	—										
3. Severity	3.06	.62	.39	.06	.13*	—									
4. Affective resources	4.23	.45	.48	.37*	-.09	.14	.92								
5. Behavioural resources	4.10	.37	.35	.41*	-.11	-.12	.74**	.80							
6. Cognitive resources	4.02	.45	.41	.34*	-.04	.14	.77**	.75**	.91						
7. Persistence	4.39	.45	.65	.41*	.11	.08	.65**	.70**	.60**	.94					
8. Adaptation	4.19	.56	.56	.30*	-.06	.20	.68**	.72**	.82**	.74**	.94				
9. Resistance (subjective)	2.98	.96	.35	.05	-.00	-.71**	.13	.37*	.14	.19	.03	.84			
10. Recovery (subjective)	3.65	.75	.67	.09	-.03	-.50**	.24	.52**	.28	.40*	.32*	.71**	.94		
11. Resistance (objective)	-144.07	149.55		-.03	-.23	-.35*	-05	.09	.14	-.12	-.09	.36*	.18	—	
12. Recovery (objective)	-25.17	148.26		-.17	-.32*	-.65**	-.14	.07	-.05	-.18	-.09	.59**	.59**	.45*	—
13. Emergent Team Resilience	400.14	617.25		.10	.22	.51**	.02	-.16	-.14	.14	.06	-.55**	-.55**	-.83**	-.78**

Note: $N = 147$, $k = 46$ * $p < .05$ ** $p < .001$.

5.3.2 Measurement Model

Following the descriptive analysis, a series of CFAs were performed to assess the measurement model of the TRI (see Table 23 for the results). The results indicated acceptable model fit, with the main 7-factor CFA indicating good fit on each index except the SRMR ($\square^2$ (681) = 1389.324, p <.001, RMSEA = .078, CFI/TLI = .821/.806, SRMR= .101). Following the CFA models, MCFAs were conducted to establish the multilevel measurement model. The MCFA model also showed good model fit (χ^2 (1362) = 1728.83 (1362), RMSEA = .039, CFI/TLI = .910/.902, SRMR (between) = .107(.347). Review of the multilevel models indicates that, as with study 1 and 2, the level-2 covariance matrix may be affected by non-positive definiteness, affecting the covariance matrix and subsequently the model fit at level 2. In particular, when the level 1 covariance matrix was saturated, the between-teams only covariance matrix had significant model misfit. Additionally, the relatively smaller amount of teams (46) may have affected the model fit relative to the higher-powered studies 1 and 2. In addition to the CFA models, Table 24 summarizes the factor loadings for the 7-factor model.

The factor scores generated from the MCFA were saved to be used for all future analyses for study 3. Factor scores are standardized scores with a mean of 0 that indicate a person or team's relative standing on a latent factor. Although the model solution was non-positive definite, factor scores generated from the model are still viable (Lorenzo-Sava & Ferrando, 2021). Using factor scores as predictors gives unbiased regression slope and helps account for multicollinearity among the predictors (DiStefano et al., 2018). In specific, the factor scores generated for the between level variance were retained, as this represented standardized variance

between teams on each factor and circumvents potential problems with the between-level covariance matrix.

Table 23

CFA Results for study 3

	χ^2 (df)	RMSEA	CFI/TLI	SRMR(between)	AIC	BIC	aBic
Null Model (7 factors)	8145.046** (1482)	.161		.344(.486)	18692.87	19061.81	18691.32
CFA (5 factor)	984.862** (485)	.077 (.070, .084)	.840/.826	.078	12432.32	12776.03	12430.88
CFA (7 factor)	1389.324** (681)	.078 (.072, .083)	.821/.806	.101	15146.67	15581.83	15144.84
MCFA (between saturated)	1769.395** (1209)	.052	.862/.831	.111 (.484)	15470.84	16700.63	15465.67
MCFA (within saturated)	5537.113** (1482)	.109	.386/.248	.333(.366)	17398.3	18628.08	17393.12
MCFA (7 factors)	**1728.83 (1362)**	**.039**	**.910/.902**	**.107(.347)**	**15123.73**	**15871.06**	**15120.59**

Note: N = 173, k = 46 ($M_{groupsize}$ = 3.84)

Table 24

Study 3 Factor Loadings for the TRI

Item	Loading	ICC	Item	Loading	ICC
TRA_1	.762	.21	TPP_1	.849	.23
TRA_2	.749	.19	TPP_2	.817	.20
TRA_3	.770	.30	TPP_3	.854	.17
TRA_4	.614	.22	TPP_4	.689	.12
TRA_5	.873	.26	TPP_5	.798	.15
TRA_6	.907	.24	TPA_1	.650	.17
TRA_7	.353	.23	TPA_2	.840	.17

TRB_1	.428	.26	TPA_3	.861	.16
TRB_2	.746	.17	TPA_4	.782	.19
TRB_3	.715	.14	TPA_5	.881	.21
TRB_4	.839	.18	TPA_6	.588	.21
TRB_5	.652	.20	TRes_1	.484	.17
TRB_6	.547	.12	TRes_2	.869	.19
TRC_1	.558	.12	TRes_3	.901	.20
TRC_2	.539	.25	TRec_1	.874	.19
TRC_3	.586	.17	TRec_2	.867	.33
TRC_4	.662	.17	TRec_3	.770	.39
TRC_5	.642	.27			
TRC_6	.781	.21			
TRC_7	.600	.12			
TRC_8	.813	.30			
TRC_9	.696	.29			

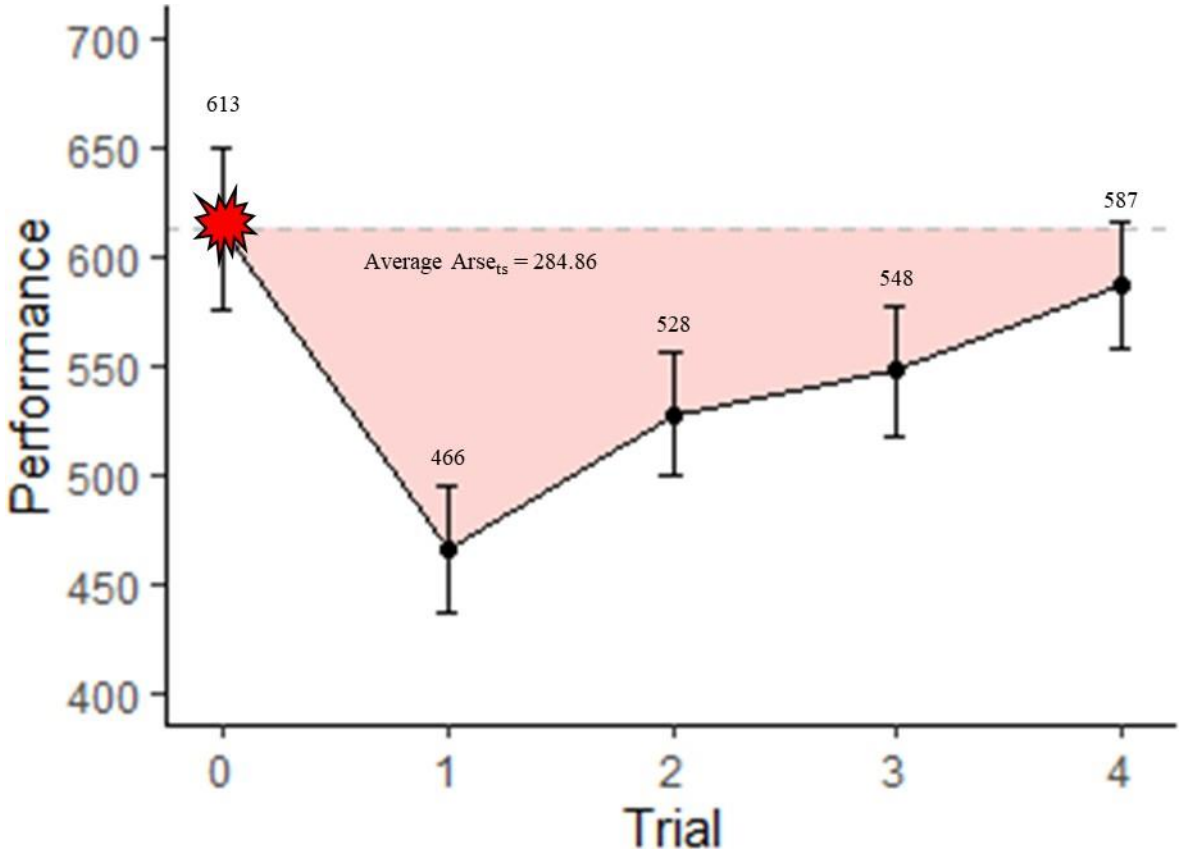
N = 175

5.3.3 Hypothesis Testing

Figure 4 visualizes the average trajectory of performance for the teams following the adversity manipulation. The dotted line represents the baseline performance prior to the adversity event (t_0) while the black line represents the trajectory of performance over time. At each timepoint included in the analysis (i.e., t_0-t_4) the average performance is indicated by the black dot and the bars indicate the confidence interval. The red-shaded area represents the area of resilience and this is captured by the average $arse_{ts}$ score. The average $Arse_{ts}$ score was 284.86 with a standard deviation of 491.49. The average trajectory of performance indicated that the adversity manipulation had the intended effect as team performance drastically decreased following its introduction.

Figure 4

Average Trajectory of Resilient Performance Following the Adversity Manipulation.



To assess the ability of the TRI to predict emergent team resilience, two approaches were taken. First, using the between-teams factor scores I conducted a series of univariate regression analyses (see Table 30). Negative regression scores indicate a reduced Arse$_{ts}$ score and thus higher emergent resilience as the team has less performance loss over time. Only the behavioural resources factor was found to predict the Arse$_{ts}$ score (b = -.33, p <.001). Following this, I then entered each of the five factors into a multivariate regression (see Table 31). Behavioural resources continued to significantly, negatively predict the Arse$_{ts}$ score (b = -.48, p <.001) and

the model overall accounted for 19% of the variance (R^2 = .19, p = .046). Overall, the results partially supported Hypothesis 1.

Table 25

Univariate Regression Results Predicting Emergent Team Resilience

	estimate	S.E.	*p*
Affective	.08	.16	.638
Behavioural	**-.33**	.09	<.001
Cognitive	-.04	.14	.745
Persistence	-.10	.12	.420
Adaptation	.03	.12	.827

Note: Estimates are standardized regression coefficients. Predictive variables are standardized factor scores. k = 45.

Table 26

Multivariate Regression Results Predicting Emergent Team Resilience

	estimate	S.E.	*p*
Affective	.17	.18	.352
Behavioural	**-.48**	.13	<.001

Cognitive	-.32	.17	.064
Persistence	-.03	.11	.787
Adaptation	.06	.15	.681
R^2	**.19**	.10	.046

Note: Estimates are standardized regression coefficients Predictive variables are standardized factor scores. *k* = 45.

To assess the hypotheses regarding resistance (i.e., the decrement of performance between t_0 and t_1), I used a multivariate autoregression model, wherein the t_1 performance score was regressed onto the baseline performance score as a control, while the three TRI resource factors, adaptation, and persistence were added afterwards. As expected, the baseline performance significantly predicted resistance (*b* = .67, *p* <.001). In addition, the behavioural (*b* = .24, *p* = .025) and cognitive (*b* = .25, *p* = .43) resources factors also predicted resistance, partially supporting hypothesis 2a (see Table 25). The same procedure was then repeated with recovery as the outcome. Again, the baseline performance score was a significant predictor (*b* = .69, *p* <.001) however of the TRI factors only the behavioural resources were predictive (*b* =.32, *p* = .06) (see Table 27).

Table 27

Multivariate Regression Results for Resistance

Variable	estimate	S.E.	*p*
Baseline	**.67**	.11	<.001
Affective	-.11	.15	.484
Behavioural	**.24**	.11	.025

Cognitive	**.25**	.13	.043
Persistence	.01	.11	.911
Adaptation	-.06	.12	.597
R^2	**.46**	.14	.002

Note: Estimates are standardized regressions, $k = 45$.

Table 28

Multivariate Regression Results for Recovery

Variable	estimate	S.E.	p
Baseline	**.69**	.08	<.001
Affective	-.08	.15	.601
Behavioural	**.32**	.17	.006
Cognitive	.20	.14	.147
Persistence	.07	.12	.576
Adaptation	-.05	.12	.664
R^2	**.50**	.10	<.001

Note: Estimates are standardized regression coefficients, $k = 45$

For hypothesis 3 regarding the accuracy of team members' perceptions of their team's resistance and recovery, full support was found. The subjective and objective resistance and recovery scores correlated at $r = .36$ ($p = .016$) and $r = .59$ ($p < .001$), respectively. Further, both the resistance and recovery subjective perception scores correlated with the $arse_{ts}$ score at $r = -.55$ ($p < .001$), with the negative correlation indicating the construct is associated with higher emergent team resilience.

5.4 Summary & Conclusions

The primary objective of study 3 was to outline a method of operationalizing and measuring emergent team resilience and to assess the ability of the TRI to measure this. Factor

analyses of the TRI with the addition of Resistance and Recovery showed continued support for the measurement model of the TRI with good model fit. In addition, increasing control over the study context (e.g., having only one team task for participants to focus on, the much-reduced timeframe and complexity of the teams' task) appeared to resolve the issue of low perceptual sharedness among team members (i.e., low ICC scores).

I demonstrated and found support for the ability of the TRI to predict emergent team resilience as operationalized through the Arse analysis. Regarding hypothesis 1, that the TRI factors will predict emergent team resilience as represented through the $Arse_{ts}$ score, I found partial support as only the behavioural resources factor was a significant predictor. A similar theme was found for hypothesis 2a and 2b as only the behavioural and cognitive resources factors were found to be significant predictors of resistance and recovery. Although I hypothesized Affective, Behavioural, and Cognitive resources as well as Adaptation and Persistence would predict emergent team resilience, the results may suggest that different resources and processes are important for demonstrating emergent resilience in different team performance tasks. It is likely that in other team tasks and contexts, different resources and processes may become more important.

A secondary objective for Study 3 was to investigate the utility of team members' subjective perceptions of their team's resistance and recovery as stand-ins for more objective indicators. This was assessed through the correlation of the perception scores with the deviation scores between t0 and t1 (resistance) and t0 and t4 (recovery). Hypothesis 3 was that the subjective and objective measures of Resistance and Recovery would significantly correlate and this was supported. With moderate correlations, the subjective perception measures of Resistance and Recovery may be used as stand-ins for objective measures where that is not available. Future

researchers are cautioned however that the participants in this study were able to track their performance themselves and that the task was relatively simple. In more ambiguous situations, participants may not be able to accurately judge their team's emergent resilience and thus future researchers should carefully consider the team context when using these subjective measures and where they are appropriate.

6. General Discussion

Whether in response to the growing threat of climate change and ecological shocks or the increasing complexity of social systems and potential for failures, recent decades have seen a marked interest in the concept of resilience; how to develop it, and how it manifests under adverse conditions (Hodgson, 2015; Moser et al., 2019). This theme includes the organizational psychology literature, where the resilience of employees and of organizations has been a prolific topic (Bardoel et al., 2014). However, research on resilience in the context of small groups such as workplace teams has been under-represented. In part, this is due to a lack of clear conceptualization of what resources make for a resilient team, what characteristics define a team as 'resilient', and what sorts of outcome indicators are required to demonstrate that a team was indeed resilient in response to an adversity.

This dissertation project responds to several recent calls for: 1) greater clarity on what defines a resilient team; and 2) a well-validated, comprehensive measure that can be used to further empirical research in the area (Brykman & King, 2021; Chapman et al., 2020; Hartwig et al., 2020). The results of a literature review across the organizational psychology and small group dynamics literatures suggested that team resilience research is characterized by compartmentalization into trait, process, and outcome perspectives of team resilience. Further,

there may be a pre-occupation with identifying and listing characteristics of a resilient team to the detriment of clear theorizing of how team resilience emerges. This issue is compounded by the lack of a psychometrically sound measure of team resilience as researchers rely largely on *ad hoc* measures of team resilience that limit the generalizability of results. To address these conceptual issues, in the present dissertation project I developed a conceptual model of team resilience and a measurement tool—the TRI—as well as conducted initial research to support its reliability and validity. To provide a comprehensive test of the TRI as a measure of team resilience capacity, the present research included: 1) the development and evaluation of a 40-item measure designed to measure the resiliency-related resources a team holds and the use of persistence and adaptation as strategies to respond to the adversity; 2) an initial examination of the construct's nomological network; and 3) the validity of the TRI in predicting emergent team resilience as demonstrated in the trajectory of team performance over time.

Given the conceptual confusion regarding team resilience and the general lack of supporting evidence for current measures of team resilience, I aimed to stringently test my model and measure of team resilience to meet best practice criteria for measure development (Podsakoff, 2016). As such, the first component of my research project was to develop a definition of team resilience following best practice guidelines for improving content validity (Podsakoff et al., 2016). Based on a review of previous definitions of team resilience, including where they do or do not meet operational criteria for a high-quality definition, I ultimately defined team resilience as:

> An emergent state and outcome that reflects a team's ability to resist or recover from a collectively experienced adversity. It emerges through the interactions between team

> members as they invest resources into persisting through and/or adapting to adversity in pursuit of maintaining or recovering a point of equilibrium on a relevant team-level outcome (e.g., team performance).

Based on this definition, I began developing the initial domain areas for the TRI, beginning with a close review of the literature to identify what factors, antecedents, processes and outcomes were also considered as part of the nomological network of team resilience. From this review, I developed two domain facets that represent a team's resilience capacity: Resiliency-related resources (including Affective, Behavioural, and Cognitive resource factors) and Resilience-related processes (including Adaptation and Persistence process factors). These domains were used as the basis to form the initial item sets in conjunction with a close review of the literature. Next, I surveyed a panel of subject matter experts for their feedback on the domain definitions and the items I developed. Participants were asked to rate the relatedness of each item to each domain area and to provide feedback on the clarity of the domains and items as well as thoughts on the conceptual model. Based on the results of this expert panel review some items were removed and others were changed to reflect the feedback. Overall, the ratings from subject matter experts indicated that the items reflected their intended domain and did not have substantial overlap between the domains.

In Study 1, I evaluated the psychometric properties of the three resource factors of the TRI (Affective, Behavioural, and Cognitive). Item-level analyses from Study 1 demonstrated adequate means, standard deviations, skewness, kurtosis, item-total correlations, and ICC scores. At the latent construct level, the TRI resource facets as well as the overall scale were shown to have good reliability as demonstrated through acceptable Cronbach's alpha coefficient scores.

Factor analysis that did not account for team membership showed adequate model fit. Expanding on this, I analyzed the measurement structure at both the within- and between-teams levels of analyses. The within-teams model showed good model fit; however, at the between-teams level it appears that the complexity of the model along with small variances in scores between teams led to difficulties with non-positive definite matrices and subsequent difficulties with model convergence. In addition to assessing the measurement model of the resource facets, exploratory analyses were performed to investigate the criterion-validity of the TRI and develop some initial insight into the nomological network of team resilience through assessing the resource facets' ability to predict team-level outcomes (i.e., team satisfaction team conflict, status conflict and conflict management strategies). The results indicated that the TRI resource facets did indeed predict these outcomes and offer an initial look at some relations with team resilience.

Study 2 expanded on the results of Study 1 by introducing the Persistence and Adaptation factors to the TRI model and by assessing the TRI's nomological net with hypothesis testing. As with Study 1, descriptive analyses of the TRI showed good item-level results and reliability and multilevel factor analyses supported the hypothesized model structure. However, at the between-teams level of analysis, the difficulty of low between-team variance and the complexity of the model again led to difficulties with non-positive definite matrices and model convergence.

To offer an initial look at the validity of the TRI two approaches were taken. First, to test its criterion validity I used level 2 (i.e., between-team) factor scores derived from the M-CFA model to assess the ability of the TRI to predict team satisfaction and team potency. The results were largely supportive of the TRI's criterion validity as each facet of the TRI was predictive of at least one outcome. To test the TRI's discriminant validity from a team-aggregate score of

psychological resilience, I assessed the AVE of each TRI facet against psychological resilience. Each facet was below the .30 correlation threshold. In addition, the TRI facets and psychological resilience showed differential prediction of team satisfaction and team potency, and the TRI facets showed incremental prediction beyond psychological resilience as demonstrated in the R^2 change in hierarchical regressions predicting team satisfaction and team potency. Overall, Study 2 built on the results of Study 1 by further establishing the reliability of the TRI's measurement model and its validity as a distinct construct that predicts relevant outcomes while using a larger sample size.

In Study 3, I used the TRI to predict emergent team resilience as demonstrated in a team's trajectory of performance over time. Beginning with another assessment of the TRI's measurement structure, the factors again showed adequate model fit and item statistics, further supporting the reliability of the measurement model, this time with a different sample group and task context. In this study, I introduced emergent team resilience as a function of resistance and recovery that is manifested in the trajectory of a team's performance over time and operationalized using the Arse score (Ratcliffe et al., 2019). The study used a within-subjects, lab-based design wherein contrived teams competed to get the highest achievement score on a video game task over a series of eight rounds. Halfway through the sessions, I removed a team member at random, inserting a severe adversity the remaining team members would need to overcome then tracked their performance scores over time. The better a team was able to resist (i.e., had a minimal deviation from their pre-adversity score) and/or recover from (i.e., eventually returned to their baseline score), the more 'resilient' they were. This novel approach may facilitate the team resilience literature to move beyond identifying resources thought to predict team resilience (i.e., team resilience capacity) to be able to directly measure emergent team

resilience. Further, developing a single score for emergent team resilience allows for its relationships with other variables to be quantifiably established. For example, in the current study I tested the ability of the TRI to predict emergent team resilience as measured by the $Arse_{ts}$ score, as well as its constituent factors resistance and recovery. The results were only partially supportive as only the behavioural and cognitive resources facets were predictive of the teams' $Arse_{ts}$, resistance, and recovery scores. This was somewhat unexpected, and opens up questions for future research on when, how, and why different team resilience capacities are important in predicting emergent team resilience.

A secondary objective of Study 3 was to investigate how accurately team members can assess their team's emergent resilience. To this end, I developed two 3-item scales to measure the team members' perceptions of their resistance and recovery. The item statistics and reliability analysis of these scales were adequate although no factor analyses were performed as there were too few items leading to just-identification. Subjective evaluations of resistance and recovery exhibited moderate-to-strong positive correlations with performance-based indices of resistance and recovery, as represented by the deviation between the baseline timepoint score and the initial post-adversity timepoint score for resistance, and the deviation between the baseline timepoint score and the final timepoint score for recovery. The size of the correlations suggest that the subjective perceptions measures may be an appropriate stand-in for objective performance metrics-at least when team members are able to monitor their performance and the task is relatively simple. Future researchers should be mindful that this approach may introduce concerns of common method bias as well.

In sum, the weight of available evidence from the team resilience literature as well as the TRI's acceptable psychometric properties supported three separate resilience-resource factors (Affective, Behavioural, and Cognitive) as well as two separate resilience-processes (persistence and adaptation) that together represent the capacity of a team to be resilient. Two further factors consisting of subjective perceptions of a team's Resistance and Recovery were included in study 3 and appear to be effective stand-ins for objective measures of emergent team resilience. Critically, the TRI was shown to be distinguishable from psychological resilience to participants and to have differential prediction; supporting the argument that though related and mutually supportive, team resilience is a distinct construct from psychological resilience. The TRI offers an effective survey of the resources and processes involved in building team resilience capacity and is able to predict various relevant team-level outcomes.

6.1 Future Directions and Limitations

6.1.1 Team Resilience and its Relation to COR Theory

Review of the team resilience literature highlighted the potential role of COR theory (Hobfoll, 1989) as a guiding framework to understand the emergence and function of team resilience (e.g., Brykman & King, 2021; Stoverink et al., 2020). Drawing from COR theory, I posited an IPO-based model of team resilience wherein team members invest beneficial resources (affective, behavioural, and cognitive) into response processes meant to address the collectively-faced adversity (persistence and adaptation) with the ultimate purpose of maintaining or recovering a status quo level of function (resistance and recovery). The TRI was developed to reflect both *team resilience capacity* (i.e., the team resilience resources and processes that contribute to a team's potential to successfully respond to an adversity) and its *emergent demonstration* (i.e., the team's demonstrated ability to resist and recover from the

negative effects of adversity). In general, the results of my study supported the argument that the capacity for team resilience develops from the accrual of resiliency-promoting resources within the team, and the team's ability to invest those resources into effective responding to an adversity.

Throughout the three studies included in my dissertation, the resource facets of the TRI consistently predicted theoretically relevant team level outcomes, including team satisfaction, potency, and performance. Teams with more resilience capacity resources expended those resources to continue efforts towards striving to maintain key functions, and to perform any adaptations of strategy, group structure, work processes, etc. required to respond to the adversity. Multivariate regression models in Study 2 supported this notion such that resiliency resource factors each predicted one of the team outcomes. These results highlight the importance for teams to leverage the unique resources they can contribute to the team's resilience. In particular, the findings suggest that building a team's capacity for resilience benefits not only from the accrual of generally beneficial resources (e.g., human capital, financial resources, logistical capacity), it would also benefit from developing structures for resource mobilization and exchange that can fully capitalize on the team's resources (Brykman & King, 2021; Meneghal et al., 2016a). Building communication and coordination systems that foster the team's ability to recognize, make sense of, and coordinate a response ultimately funnel their resources into the team's collective response to adversity in a more effective way. Improving these systems allows teams to more effectively invest their resources and translate it into resilient performance.

Overall, the results of my dissertation project suggest that teams develop a capacity for team resilience through building their reservoir of resources, which can be subsequently invested

into responding to an adversity. This is in line with previous team resilience literature drawing from COR and Crossover theory (e.g., Hartmann et al., 2021; Stoverink et al., 2020) and supports COR theory as a multilevel foundation for research in team resilience, how it relates to resilience in other levels of analysis such as the individual or organizations (Hartmann et al., 2020), and how it emerges through the investment of resources into collective action to respond to shared adversity.

6.1.2 Defining Emergent Team Resilience

Research on psychological resilience to date has focused quite strongly on identifying the characteristics of a resilient person and by extension what resources act as a protective or risk factor that make an individual vulnerable in the face of adversity (Fletcher & Sarkar, 2013). Research in the team resilience field seems to have largely adopted this approach as well. How team resilience emerges as a trajectory of functioning over time (i.e., emergent team resilience) is a largely untouched perspective. However, a team's trajectory of functioning over time and whether it can be described as resilient is what defines team resilience as a construct rather than a collection of generally good resources for a team to have.

Although in the current dissertation project I treated team resilience as a latent construct wherein measurement items reflect team resilience, future researchers may consider an alternative of team resilience as a second-order, formative construct that unfolds over time and consists of *team resilience capacity*, and *emergent team resilience*. Rather than being reflective of a single latent structure, the contributing constructs of team resilience may be better viewed as three stages of an IPO model (Ilgen et al., 2005) forming the second-order construct of team resilience (Bowers et al., 2017). In a traditional reflective latent construct, each facet of the TRI would be assumed to represent one aspect of the higher-order latent construct, however in the

case of team resilience, there appears to be a difference between the various characteristics that go into the capacity to be resilient if required, and the demonstration of resilience as it emerges over time in the trajectory of a relevant outcome. Further, an alternative approach to modeling team resilience is to take a team-centric approach through the use of profile analysis to identify variation in within-team patterns of resilience qualities.

In addition to identifying the relevant outcomes in team resilience, there are considerations future researchers should keep in mind on the operationalization side as well. For example, when using the Arse method of measuring emergent team resilience, it can be conceptually difficult to specify when a team has demonstrated resilience sufficiently to be characterized as 'resilient'. In the current study, I elected to avoid a categorical approach to defining resilience, and instead treated the Arse score as a continuous outcome where teams could be more or less resilient without a qualitative distinction between resilient or not. Should future research choose a more categorical approach (e.g., by comparing resilient or not resilient teams), identifying cutoff points could be somewhat arbitrary. Is a team resilient only if they recover their baseline score by the final timepoint? What if it is close? What if performance recovers soon after the final timepoint? What if it recovers the baseline score, but then drops off again? What if one team eventually recovers with a large Arse score, while another team never returns to baseline but has a low Arse score? Which is more resilient? Does the relative process-loss, even though the team eventually bounced-back, outweigh the non-resilient but more efficient team's performance? Again, I reiterate here the importance of clearly identifying the: a) the nature of the adversity; b) the task; c) how good/bad functioning is operationalized; and d) what context-specific criteria needs to be met to identify a team as performing well as these considerations will help specify the resilience context and inform how it will be measured

in situ. The TRI was developed to be an inventory of ‘generic’ predictors of emergent team resilience. It is effective as a diagnostic tool to assess a team’s general capacity to be resilient if required and would be best used in conjunction with an in-depth review of what idiosyncratic resources/processes are likely necessary for effective resilience within an adversity situation. However, when using the Arse method there are some helpful suggestions. For example, if specifying team resilience as the complete maintenance or return to a baseline score, a margin of acceptance could be established (e.g., the 95% confidence interval, the margin of error, or the standard deviation) which, if at the endpoint of the study the team falls within the region, signals successful demonstration of resilience. Resilience could also be inferred by comparison of function trajectories to a control group where the function is measured across all timepoints free from the strain of the adversity manipulation. In such cases, resilience could be inferred if the experimental team stays within or returns to a pre-defined margin of comparability to the control condition. Lastly, in the event that a team does not return to the baseline, the slope of the trajectory could be used to extrapolate when, if at all, a team is likely to cross the baseline. In these instances, the extrapolated slope could be used to calculate the Arse score as well. Future researchers are also encouraged to consider when a return to baseline is not the most appropriate criterion for resilience as well. For example, in some situations a better measure may be growth beyond the baseline function (Gucciardi et al., 2018), a reduction in deviations over time indicating equilibrium is restored (Gucciardi et al., 2021), or a ‘normal’ trajectory of performance is returned to.

In general, caution should be taken when attempting to define resilient and non-resilient cases or comparing resiliency across teams and situations as what defines ‘resilient’ is highly contextually specific. This applies to both team resilience capacity (e.g., are the resources

available to the team relevant to the adversity? Are the response options available to the team capable of addressing the adversity?) and emergent team resilience (e.g., what outcomes are likely relevant to the impact of the adversity? How do we measure its change over time?). While a team with more available resources (i.e., higher scores on the resource facets of the TRI) may have a higher global capability to deal with a variety of adversities, it does not guarantee better performance in responding to any specific adversity. For instance, how does the strength of the stressor impact the interpretation of a team's resilience? A significant stressor like the loss of a team member may show a less efficient Arse score than a relatively minor stressor like the adoption of a new chat platform but the response to the major stressor may be 'good' considering the context. The answer to this question may be critical when attempting to compare resilience between teams or adversities. Researchers may even wish to control for these differences by weighing the severity of the adversities. For example, in Study 3, I included a subjective measure of the severity of the adversity manipulation that asked participants to rate how severe the adversity was from 'Not at all' to 'My team was unable to function". This subjective perception report may quantify the strain felt by the team, though the team members' perceptions of how greatly they were impacted may not be separate from how well they were able to respond to the adversity as the question was asked at the end of the study session. In future research, others may wish to use subject matter expert ratings or observer ratings of how severe an adversity is to better standardize and therefore control for the impact of the adversity on the interpretation of a team's resilience.

6.1.3 Relationship Between Psychological and Team Resilience

Another question I aimed to address with this dissertation project is the relationship between psychological and team resilience. Some previous empirical studies have operationalized team resilience as an aggregate of psychological resilience (e.g., West et al.,

2009). Others have argued that as a global construct team resilience does not have a lower-level analog and is distinct from individual resilience (Dove-Steinkamp, 2017; Hartwig et al., 2020), with the rationale that aspects of team resilience such as the coordination of resources and behaviour do not exist at a lower level. In other words, because teamwork emerges from interdependencies among team members, understanding the individual-level contributors is insufficient to understand a team-level phenomena and we should be careful not to assume isomorphism across levels of analysis.

Building off COR and Crossover theory (Hobfoll et al., 2015; 2018; Westman, 2001), I argued that team resilience capacity emerges when team members invest their resources into a collective response to an adversity with psychological resilience being one such resource that can be invested and shared. In turn, team resilience may act as a protective factor for its members, mitigating the potential adversities and stress they experience. In Study 2, I tested this argument and the results support the notion that psychological and team resilience capacity are related yet distinct constructs as shown in their small to moderate relationships and differential prediction of team outcomes. As far as I am aware, this is the first attempt to test the discriminant validity of these two constructs. The main takeaways for future research are that a simple aggregate of psychological resilience is insufficient to adequately represent team resilience (Hartwig et al., 2021) and that team resilience is a distinct construct (Molenaar et al., 2022).

6.1.4 Objective and Subjective Measures of Emergent Team Resilience

When looking at emergent team resilience, a point of conceptual confusion in the literature is a disconnect between the assumption that resilience is in part an emergent property of some outcome function and its measurement as a shared perceptual construct (Chapman et al., 2020; Gucciardi et al., 2019). This was another area I attempted to address in this dissertation

project. Measuring team constructs using sharedness perceptions among team members (i.e., a compilational construct; Kozlowski & Klein, 2000) appears to be the default approach for a variety of reasons, including ease of use and convenience. It is often significantly easier to ask participants or their supervisors to rate their team's performance than it is to identify and measure objective indices of performance. However, perceptual sharedness measures may not always be the most appropriate approach to operationalizing a team construct such as emergent team resilience as it is not always clear that participants have a shared idea of what the construct is, how to rate it, or if the ontology of the construct is compatible with perceptual reports (Kozlowski & Klein, 2000).

To test the appropriateness of a shared perception measure of emergent team resilience, I included a short questionnaire in Study 3 that measured the team members' evaluation of their team's resistance and recovery regarding their performance over time. I tested the internal reliability of these two perpetual sharedness measures using McDonald's *w* as a measure of internal reliability. The results were encouraging, and in addition to the standard psychometric internal reliability I also tested how these subjective measures of resistance and recovery correlated with the objective measures of resistance and recovery (i.e., a discrepancy score between the initial and last post-adversity timepoint scores and the baseline score). The subjective and objective measures had a moderate correlation, and the subjective measures both significantly correlated with the overall emergent team resilience score ($arse_{ts}$). Overall, this supported the notion that team members are capable of accurately identifying their team's demonstrated resilience and that subjective measures of emergent resilience (e.g., questions such as "how resilient was your team to this adversity?") are potentially valid as an index for emergent team resilience. Scholars who wish to use these Resistance and Recovery measures are

cautioned, however, that the use of self-report formats may introduce issues associated with the use of self-report measures and that the accuracy of these self-reports will likely vary drastically based on the complexity and visibility of team performance.

6.1.5 Evaluating and Building a Team's Resilience

Another area of conceptual confusion in the team resilience literature is the degree to which it can be developed through intentional cultivation versus an innate property of the team (Hartwig et al., 2020). The current study could contribute to the resolution of this issue in two ways. First, by embedding team resilience capacity in COR theory as the product of the resources available to the team and their successful investment in the resilience processes, my conceptual model of team resilience suggests that team resilience capacity can be fostered through the accrual of generic team resilience resources that likely apply to a variety of common adversities faced by teams. This was supported in my dissertation by the significant variation between the Study 2 teams in their resilience capacity and their variation in resources over time. In the psychological resilience literature, COR theory, with its emphasis on the development, maintenance, and protection of resources has often been drawn on in the context of post-traumatic growth. Specifically, following exposure to adversity and eventual recovery individuals often engage in sense-making activities to understand the adversity and ultimately develop their resource pool to better guard against resource loss from future, similar adversities (Hobfoll, 2001). Indeed, a large literature suggests successfully managing an adversity builds psychological resilience to future adversity (Bonanno, 2015; Bonanno et al., 2010; Kuntz et al., 2016; Levine et al., 2011). When people successfully manage adversity, it may strengthen their resilience to future adversity through enhanced self-efficacy and mastery experiences (Brown & Westaway, 2011; Luthar et al., 2000).

A similar effect is likely to take place in the team context as well. In the conceptual model introduced in the current study, I suggest that mastery effects (e.g., knowledge, skills, and attitudes learned through successfully addressing the adversity, continuous improvement of resilience processes through iterations) may serve to bolster the resources available to the team in future adversity situations. For example, in Study 3 nearly every team, following an initial loss of performance, was able to recover their performance. If their removed member was reunited with the team, we would likely expect performance growth to spike and continue to grow as the teams applied their learning with new labour resources. While the potential for mastery experiences to promote future team resilience capacity was not directly addressed in my dissertation, the role of mastery effects as a feedback loop input in the team resilience cycle may be a direction of future research.

Resilience research has grown against the backdrop that our abilities to quantify, mitigate, and control risk is limited and increasingly more difficult as our organizations, institutions, and climate becomes more complex (Talib, 2007). Increasingly, that risk, uncertainty, and surprises are the norm rather than the exception is becoming the dominant perspective in organizational dynamics. As such, resilience has developed as an organizing construct and strategic approach for addressing adversities that emerge from an increasingly complex world. Resilience perspectives often emphasize the development and strengthening of new and existent capacities (i.e., resources and processes) that are thought to increase the likelihood of beneficial outcomes for the entity (i.e., the maintenance and/or recovery of functioning). Indeed, identifying and building this resilience capacity appears to be the main driver in resilience research across all fields of study (Hartwig et al., 2019; Hodgson et al., 2015). Those systems that have developed their resilience capacity are thought to be better able

to resist or recover from adversity and thus viewed as ‘more resilient’ (Welsh, 2014). In other words, resilient teams are those who have significant resource pools and are able to deploy these resources through resilience processes to resist strain induced by adversity and maintain function, or quickly recover from any loss of function.

This opens the question then of what, exactly, can be considered as a contributing factor to a team’s capacity to be resilient? Indeed, this appears to be the main line of questioning in team resilience research with most primary research conducted attempting to identify these contributing factors (e.g., Carmeli et al., 2013; Meneghal et al., 2016a; 2016b; 2021; Morgan et al., 2013; 2015; Stoverink et al., 2020). However, team resilience is not an absolute. It is highly specific to the context of the team, including its task(s), the adversity faced, the team’s baseline of functioning, its laterality for deviations in performance, and what outcome-indicators are chosen to measure its resiliency. As such, a team’s resilience capacity may be well-suited for some adversities and not others, and the same team may be described as resilient in some challenging situations but not others. It is the hope that the resources and processes included in the TRI represent generic resilience capacities that will operate as protective factors against a wide variety of adversities likely faced by teams. Future research may wish to explore the boundary conditions of the TRI, particularly to how these capacities may effectively protect against some adversities but not others.

As such, just as with resilience research in other disciplines, it appears that the list of contributing factors to resilience capacity is extensive and may be synonymous with factors that predict performance in general (Chapman et al., 2020; Hartwig et al., 2020). In the current dissertation, I took the approach of surveying the existing literature at the time to identify constructs thought to characterize a resilient team and looking for themes across sources. Given

the variety of constructs identified and that few had been supported in more than one study, I took a broad approach to identifying categories of resources a team can draw from (Affective, Behavioural, and Cognitive) and focused on the strategic decisions to continue exerting effort and/or adapt in response to the adversity (Persistence and Adaptation). These factors were designed to be a high-level survey that lightly touches on the many factors that characterize a resilient team. It is possible that the TRI is not an exhaustive list of factors that may compose team resilience capacity and that future research is likely to identify other factors not sufficiently covered by the TRI as predictive of emergent team resilience. However, as a general inventory of resiliency capacity the TRI is useful in diagnosing a team's capacity to be resilient and has both good internal reliability and is a valid predictor of resilient team performance.

Operationalizing team resilience capacity and emergent team resilience this way and the development of the TRI and Arse method allows for evaluative statements of a team's resilience as 'strong', 'weak', 'quick' 'slow' 'prepared' 'vulnerable', etc., and for comparisons between teams such as rank ordering. However, such evaluations and comparisons may not be as simple as they initially seem. For instance, an evaluation of strong or weak resilience is inherently relative to the strain induced by the adversity and the team's normal range of function. Resilience is adversity and outcome specific; what makes a team resilient to one adversity (e.g., internal team conflict) may not be helpful when exposed to a different adversity (e.g., loss of funding). In other words, a team may develop resilience to adversity A and B, but not to adversity C, and what makes a team resilient to A may actually come at the expense of their resilience to C (Orbist et al., 2010). As team members invest their resources into responding to one adversity, it may tax their resources to the point they are not as resilient to a separate adversity (Dove-Steinkamp, 2017). On the other hand, there may be spillover effects wherein successful

resilience in one domain supports resilience to another adversity by building up the resource pool that can be used to buffer potential strain from other adversities, such as the case of mastery effects and experience gained (Ungar, 2013). Resources and processes that are beneficial in building resilience capacity to one adversity may not necessarily help outside of that context, which can make it challenging to know if and where study results can be synthesized across research contexts. Within the team resilience literature, this problem is exacerbated by the ubiquity of sources suggesting potential contributing resources and processes, without empirical validation (Chapman, 2020). Assuming relationships, such as what resources define a resilient team based on theoretical presumptions leads to a myriad of presumed contributors without support. Future research may benefit from the empirical study of which resilience resources and processes are most useful in the context of different potential adversities and across different populations and contexts (Hartwig et al., 2020).

Training designed to promote team resilience would be successful to the degree that teams are able to apply the human capital resources gained in training to successfully respond to unexpected adversity in new environments (i.e., transfer generalization; McKeough et al., 2013). Development through resource accrual would likely take the form of pre-emptively developing the human capital of a team that is applicable to a wide variety of potential adversity. For example, Pavez et al. (2021) found that building team trust and team potency prior to the beginning of a challenging project through clear and thorough project planning and consensus-based decision-making promoted the speed at which teams adapted to adversity and reduced performance loss. Alternatively, another way such practical interventions could be designed is to introduce adversities into work process simulations that force teams to respond. For example, in an experimental control setting, naval officer cadet teams that participated in adversity-event

simulation exercises performed significantly better in live training exercises than their counterparts who did not receive such training; even when the adversities encountered in the simulation and live training were not similar (Mjelde et al., 2016). The authors suggest that one way of designing team resilience training is through the development of a diversity of realistic adversity simulations that reflect naturally occurring adversities the team may be faced with. Such simulations build both the human capital resources a team can draw from (e.g., through the development of knowledge and skills learned in the training) and the effectiveness of resilience processes (e.g., more readily able to coordinate a response and adapt if required).

Though not named as team resilience capacity building, that team functioning can be built through a scaffolded approach of introducing progressively more challenging adversities (e.g., a change in management, budget cuts, supply chain problems) is well recognized (e.g., Staw et al., 1981). In Study 3, the participants iteratively developed their knowledge, skills, coordination, team structure, etc. and showed increased performance in each consecutive round. This process closely reflected active learning and offered a means for the participants to try out various strategies for addressing the adversity manipulation. Through this trial and error approach, the teams were able to apply and see the results of various strategies and derive insight through what is successful or not. In a similar vein, Duchek et al (2021) found in the context of student teams that active play scenarios where students must work as a team to overcome a collective adversity built up important team resilience resources such as problem-solving skills, positive intrateam relationships, and creative thinking, which in turn predicted observer ratings of team resilience. Interestingly, the effects of these active play interventions appeared to generalize to unrelated adversity scenarios, supporting the validity of active learning approaches in the design of team resilience training. Thus, attempts to develop team resilience capacity

through learning new resources or processes may not alone be enough to develop team resilience; rather, it requires concrete experiences of confronting and overcoming collective adversity. Though active play designs may not be the preferred method of training in organizational settings, the principle that repeated exposure and successful mastery of a variety of collective adversities promotes team resilience can be extended to other contexts, such as case-studies and work simulations. An important condition to be met for the development of team resilience capacity, however, is that participants have the opportunity to debrief and reflect on what was learned throughout the process of addressing the adversity and learn from it (Alliger et al., 2015). Such reflection allows team members to identify root causes of the adversity, when and where similar adversities may occur, what resources are needed to address it, and what strategies are effective, to better respond in future situations Degbey & Einola (2020).

Overall, the results of my study suggest that team resilience capacity can indeed be developed and that the higher the capacity, the better able a team is to demonstrate resiliency through trajectories of performance. The question then is what exactly are the factors that build this capacity and if identified, can resilience capacity be developed through intervention? While specific suggestions for building team resilience capacity is outside the scope of the current study it is the hope of the researcher that the TRI forms the basis for rigorous assessment of team resilience capacity and in turn supports the design of effective interventions for team resilience.

6.1.6 Resilience: The good, the bad, or the Just is?

Though the TRI was designed with the assumption that team resilience is a positive process that occurs to prevent the negative outcomes of an adversity, future research may consider when and where a team's resilience may be unwelcome. Team resilience is typically treated as a positive phenomenon that focuses on the prevention or mitigation of negative

outcomes from adversity. In other words, successfully bouncing back from adversity. This normative evaluation of resilience as positive is ubiquitous (Fletcher & Sarkar, 2013; Martin-Breen & Anderies, 2011; Meerow et al., 2016). However, team resilience is not necessarily positive or negative (Bene et al., 2012; Dove-Steinkamp, 2017), and instead a framework for understanding how a team handles disruptions. Such disruptions can be negative as is commonly thought of but could also be intended as beneficial. For example, it is entirely possible for a team to be resistant to an intervention to introduce a new, more efficient work process that would improve performance and thus show little to no performance gain as a result. It is also possible for a team, having adopted a new mode of working, to then slowly revert back to old habits and we would see a recovery of a previous, lower baseline of performance. Though resilience is often portrayed as inherently good in the organizational psychology and behaviour literature, this does not extend to other domains of research. For example, 'poverty traps' are a highly undesirable social system and state that is widely recognized as resilient (Martin-Breen & Anderies, 2011). Further, drawing from research on allostatic load (McEwen, 1998; Ong et al., 2006) and ego depletion theory (Baumeister, 2002) a team may be resilient in one function (e.g., team performance) at the expense of resources that could be dedicated to another (e.g., team wellbeing). In other words, if team resilience resources are finite, investment into dealing with one adversity leaves less resources to deal with another. Future research on team resilience may consider breaking with this implicit positive evaluation to explore if and when a team's resilience may be detrimental to the performance of the team.

6.1.7 What Outcomes Should be Used to Infer a Team as 'Resilient?

In Study 3, I used a contrived team task that was repetitive and relatively simple to evaluate performance as a means of clearly exemplifying emergent team resilience. However, team performance is rarely so easily defined and measured. In complex systems, there may be no

one best way to be resilient or to measure it. What optimal outcome indicators a researcher chooses should ideally be those that are most conceptually related to the collective adversity encountered. For example, the absence of psychological distress is a sensible measure for psychological resilience (Fletcher & Sarkar, 2013). At the team-level, various outcomes may be a reasonable medium for measuring the resilience of a team; however, Gucciardi et al. (2019) argued that team performance may be the best fit for a couple reasons. It is the core function of a team, and it is a point through which all other team outcomes are funneled.

6.1.7 The Resilience of Team States

In the current study, I took an outcome-focused approach wherein the construct presumed to change over time is the end product (e.g., team performance). This is not the only way to operationalize team resilience, however. An alternative approach could be to define resilience as reductions in fluctuations of a function over time as the system stabilizes. Reduced fluctuations in an indicator outcome could infer that the system is stabilizing into a new equilibrium (e.g., Gucciardi et al., 2021). Indeed, the focal construct for team resilience doesn't necessarily need to be an outcome at all. For example, resilience can be viewed as the propensity to maintain or recover a state or structure such as a specific biome (Hodgson et al., 2015) or a state of trust within a team (Brykman & King, 2021). From this approach, resilience is not measured by how closely a system maintains or recovers a pre-adversity function, instead it is how stable the state of a system is before it is thrown into disequilibrium by an adversity (Hodgson et al., 2015). Future research may expand the nomological network of team resilience by exploring these alternative ways of conceptualizing emergent resilience.

Another point of future contention is the role of qualitatively different functioning as a result of exposure to an adversity, whether it be through the direct effects of the adversity or the

team's attempts to adapt. For instance, if a production team is directed to shift to a new product that requires significant retooling of their equipment, retraining of their team members, and a restructuring of their teams, the nature of both their team performance and team structure is qualitatively different. In this scenario, a team which has adapted in response to the adversity is one that has found a new, acceptable point of equilibrium that may look significantly different than their previous status quo. Viewing team resilience in this 'renewal' perspective presents significant challenges for both the theory and measurement of team resilience and may be an important conceptual challenge for future research to address.

The Relationship Between Team Resilience and Performance Growth

Psychological resilience and post-traumatic growth (the notion that some individuals emerge stronger following successfully overcoming a traumatic event) are deeply connected constructs (Lepore & Revenson, 2006) and the role of resilience in learning and growing from the experience of adversity is well-documented. For example, individuals who experience a moderate amount of adversity over their lifetime report being more resilient than those who have experienced little or too much adversity as successful addressment of adversity enabled individuals to develop effective coping skills and gain a sense of mastery (Seery et al., 2010; 2013).

A similar phenomenon may occur in the context of team resilience as well. Team resilience appears to be promoted by successful mastery of previous adversity situations, presumably as an effect of enhanced mastery beliefs (Menghal et al., 2016a). When teams successfully manage an adversity, they learn from the experience, feel more confident, and thus are better able to handle future adversities of a similar nature. Several organizational scholars have also described learning and other mastery effects as an outcome of successful team

resilience. Barton and Kahn (2018) suggest that teams go through a reflection period after addressing an adversity wherein they review the adversity and their strategy, its success, and what changes could be put in place to mitigate the adversity in the future. Alliger et al. (2015) argue that this reflection period is a core part of the team resilience process while Stoverink et al. (2020) suggest that when teams engage in thoughtful reflection it aids in sensemaking and preparation for future adversity.

In some instances, a team may even show eventual performance growth following adversity as they are challenged to find new and better ways of performing. Though not directly addressed in this dissertation, the potential for such growth trajectories can be investigated through the use of the Arse method. When a team's level of functioning surpasses the baseline, this may be interpreted as growth is occurring, and a new, higher baseline of functioning may be established. Scholars may be interested in extending on the results of this dissertation in the future, by further investigating the potential for post-adversity growth in teams and if/when this growth is a separate construct from team resilience.

6.2 Strengths, Limitations, and Future Directions

Despite the valuable contributions of my dissertation project, several limitations should be noted. First, the complexity of the measurement and structural models in conjunction with the low between-team variance of the TRI scores found in studies 1 and 2 led to difficulties with the between-team covariance matrix and subsequently the model fit. Although the single-level factor analyses showed acceptable model fit, this was not the case at the between-teams level of analysis. Due to the complexity of the model and the large number of parameters typically

estimated in multilevel studies, researchers may wish to consider other approaches that reduce the model complexity and to consider closely how their research design may affect the sharedness of participant perceptions.

Throughout my review of the team resilience literature, significant confusion appeared to be caused by researchers using the term ‘team resilience’ to refer to different constructs that involved subtle but key ontological differences. Morin et al. (2019) summarized these differences based on whether team resilience was conceptualized as a trait/capacity, process, or outcome. Research into team resilience from each of these perspectives is necessary. However, researchers are encouraged to explicitly outline their conceptualization of team resilience upfront to better inform the reader and the wider literature what their perspective is and hopefully better facilitate generalization across studies and ultimately theorization. In this dissertation, I separated team resilience as a higher-order construct that is formed by a team’s resilience capacity (i.e., the resources they possess and the processes they are capable of performing to address adversity if required) and emergent team resilience (i.e., the demonstration of resilience manifested in the trajectory of functioning over time). This separation may be a useful organizing framework for future research in that it neatly separates the tools a team requires to be resilient from the demonstration of that resilience itself. I also defined team resilience as dynamic, multilevel, and inherently a longitudinal construct including team resilience capacity as teams are likely to gain new resources, lose others and develop their skills through repeated adversity. However, in all studies, I measured team resilience capacity at only one or two timepoints and thus cannot assess changes in team resilience capacity over time. This area of research would benefit from studies that measure team resilience capacity longitudinally and particularly how changes in team resources and the use of adaptation and persistence leads to changes in valued outcomes. Future research may extend the notion that mastery effects increase resilience in future adversity situations through testing for reciprocal relations among team resilience capacity and the

experience of adversity over time.

Although the current dissertation largely addressed the team level of analysis, how team resilience interacts with the resilience of entities both above (e.g., organizational resilience and community resilience) and below (e.g., psychological resilience) may be a fruitful area of research. The results of Study 2 suggested that, though separate constructs, psychological and team resilience may be mutually reinforcing.

Psychologically resilient team members may promote the resiliency of their team simply through being better able to handle the cascading stress of collective adversity, however this relationship is likely deeper. Resilient individuals may better support other members of their team or they may be able to promote the resilience of others through modelling behaviour or social support mechanisms. Similarly, how team resilience plays into the resilience of the larger organizations they are constituents of is largely unexplored (Hartmann et al., 2021). For example, it would be interesting to investigate how resilient teams can support a more resilient organization and which team resilience resources may also be modeled at the organizational level (Pavez et al., 2021).

A comprehensive investigation of the nomological network of team resilience requires establishing not only what constructs are related to it, but also those that should not be. In this dissertation project, to support the construct and criterion validity of the TRI, I hypothesized relationships only with constructs that should be related to team resilience, whether as a somewhat overlapping construct or as an outcome of it. Indeed, separating out team resilience capacity from other broadly beneficial team constructs may be difficult as any factor which may benefit either the maintenance or quick recovery of team functioning may be viewed as a contributing factor to a team's resilience capacity. In the future, researchers might seek to address this issue by examining what other constructs (e.g., team trust) may be related to team resilience capacity and under what conditions.

Lastly, research on team resilience is in its nascent stages and in addition to the conceptual confusions outlined in my literature review, there is also the challenge of a relative lack of diversity in research methodologies and samples. In the current dissertation, I used multiple independent sample groups that although all comprised of students, had a marked distinction in the nature of their team tasks and context. Further, I used two separate methodological approaches, with Studies 1 and 2 using self-report surveys whereas Study 3 used a mix of self-report surveys and objective performance criteria. The purpose of Studies 1 and 2 was the development and initial validation of a measure, and thus self-report survey designs were appropriate, while the purpose of Study 3 was to investigate how this measure predicted emergent team resilience and thus used a mixed-methods approach. To my knowledge, Study 3 may represent the first empirical study of team resilience in a lab setting. However, this only scratches the surface, and there is a wealth of other samples, methodological, and team contexts that could be employed to further our understanding of team resilience. For example, extant empirical studies on team resilience have largely relied on single timepoint, self-report survey approaches that provide limited insight into the dynamics of team resilience as it unfolds over time. More diversity in participant samples and research methodology-if sufficient details about the team context and operationalization of team resilience is provided-should benefit the ability to draw inferences across empirical studies. As of yet, however, few studies specify these particulars with intermittent mention of contextual factors like team size, tasks, tenure, or performance indicators and measurement factors like item descriptions or reliability statistics. Thus, in the future, team resilience researchers should take care to not only diversify the samples and methodologies they employ, but also be diligent in communicating these details to the reader.

6.3 Concluding Remarks

In conclusion, in this dissertation I present and demonstrate support for a conceptual

model of team resilience as a formative construct consisting of team resilience capacity and emergent team resilience. Grounded in COR theory, I developed the TRI to survey a team's resilience capacity as represented by the Affective, Behavioural, and Cognitive resources they possess and the Persistence and Adaptation processes they engage in to address an adversity. Drawing widely from the resilience literature, I introduced and supported the concept of emergent team resilience as manifested in a trajectory of team functioning over time and demonstrated how this construct may be operationalized and measured. In addition, I provide some initial insight into the nomological network of team resilience on which others may continue to expand.

As the pace and complexity of adversities in the workplace continues to grow, the potential of team resilience as an approach to risk preparation mitigation, and management becomes only more important. This work calls on researchers to continue identifying what resources and processes build a team's resilience capacity and how and when this resilience capacity is employed to demonstrate emergent resilience in the face of adversity. It is the hope that the conceptual model, measure, suggestions, and insight in this dissertation project provide clarity within this domain and a solid foundation for future research to build on.

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Appendices

Appendix A

Team Resilience Inventory Item List

Team Resilience Resources

Questionnaires and responses are collected anonymously. Please respond to the following items as honestly as possible. Please read the following statements, beside each statement you will find five numbers, ranging from 1 – Strongly Disagree (on the left) to 5 – Strongly Agree (on the right). Please indicate which number you believe best describes your team overall.

TC-A - Team Resilience Resources – Affective (Resources and protective factors of the team that facilitate members' sense of emotional well-being and self-esteem; the content of this domain includes the abilities to maintain a sense of optimism, feeling safe to voice opinions around other team members, a positive regard for other team members, and being able to identify, reason with, and understand team members' emotions.)

1. TCA_1 Our team sees things positively
2. TCA_2 Our team members support one another emotionally
3. TCA_3 Our team ensures all members feel safe speaking up in team discussions
4. TCA_4 Our team members are able to control their emotions
5. TCA_5 Our team members feel good about being on this team
6. TCA_6 Our team members trust one another to support them

8. TCA_7 Our team is easily frustrated

TC-B - Team Resilience Resources – Behavioral (Resources and protective factors of the team that contribute to the team's capacity to coordinate team behavior to either adapt to, or persist despite changing environmental constraints and opportunities. The content of this domain
includes remaining united while pursuing goals, monitoring members' task focus, cooperation, and being competent and capable of dealing with challenges.)

1. TCB_1 Our team can perform well in the absence of any team member
2. TCB_2 Our team shares the workload in a fair way
3. TCB_3 Our team is quick to respond to changes
4. TCB_4 Our team cooperates to accomplish our goals
5. TCB_5 Our team ensures each member is up to date on what we are doing
6. TCB_6 Our team expects one another to do their best

TC-C - Team Resilience Resources – Cognitive (Resources and protective factors of the team that provide a sense of coherence and coordination to the team; the content of this domain includes learning orientation and seeking out new experiences and encounters, the ability to deal with uncertainty, strategy development, problem
solving, discretionary communication, as well as being open-minded and attentive to different sources of information.)

1. TCC_1 Our team can handle vague goals and tasks
2. TCC_2 Our team seeks input from every member before making decisions
3. TCC_3 Our team sees challenges as opportunities for learning
4. TCC_4 Our team all understand our roles
5. TCC_5 Our team plans how to respond to challenges we may face in the future

6. TCC_6 Our team is quick to think of a new approach if something does not work
7. TCC_7 Our team has a variety of expertise we can draw upon
8. TCC_8 Our team is always thinking of ways to improve
9. TCC_9 In our team, mistakes are openly discussed to learn from them

Team Resilience Processes – Persistence: Persistence refers to the persistence of effort in the face of adversity.

At the current moment…

1. TPP_1 Our team persists through challenges
2. TPP_2 Our team is able to endure the challenges we are currently facing
3. TPP_3 Our team continues to work toward our goals, even when it is difficult
4. TPP_4 When our team experiences a setback, we try even harder than before.
5. TPP_5 If a team task turns out to be quite difficult, we just persist in our efforts
6. TPPe_6 Our team is not discouraged by setbacks.

Team Resilience Processes- Adaptation: Adaptation refers to a strategy in which teams respond to a collectively shared adversity by modifying their team structure, processes, and/or strategy.

At the current moment…

1. TPA_1 Our team adapts to respond to challenges.
2. TPA_2 Our team develops new plans to overcome challenges
3. TPA_3 Our team tries new approaches to deal with challenges
4. TPA_4 Our team finds opportunities for new ways of doing things in unexpected situations

5. TPA_5 Our team modifies its strategy to adapt to challenges.

6. TPA_6 Our team modifies its composition to adapt to challenges.

Appendix B

Ethics Approval for Studies 1 & 2

Western Research

Date: 5 September 2019

To: Dr. Alex Benson

Project ID: 112318

Study Title: Understanding engineering project teams

Application Type: NMREB Amendment Form

Review Type: Delegated

Full Board Reporting Date: 04/Oct/2019

Date Approval Issued: 05/Sep/2019 15:46

REB Approval Expiry Date: 13/Aug/2020

Dear Dr. Alex Benson,

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the amendment, as of the date noted above.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
EngMaterials2019-2020_V2_20190827	Online Survey	27/Aug/2019	1
EngMaterials2019-2020_V2_20190827	Paper Survey	27/Aug/2019	1
Letter of information ENG 2019 Sep implied consent version	Implied Consent/Assent	04/Sep/2019	1
Letter of information ENG 2019 Sep implied consent version clean	Implied Consent/Assent	04/Sep/2019	1
Letter of information ENG 2019 Sep written consent version clean	Written Consent/Assent	04/Sep/2019	1

REB members involved in the research project do not participate in the review, discussion or decision.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Katelyn Harris, Research Ethics Officer on behalf of Dr. Randal Graham, NMREB Chair

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).

Western Research

Date: 5 September 2019

To: Dr. Alex Benson

Project ID: 112318

Study Title: Understanding engineering project teams

Application Type: NMREB Amendment Form

Review Type: Delegated

Full Board Reporting Date: 04/Oct/2019

Date Approval Issued: 05/Sep/2019 15:46

REB Approval Expiry Date: 13/Aug/2020

Dear Dr. Alex Benson,

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Documents Approved:

Document Name	Document Type	Document Date	Document Version
EngMaterials2019-2020_V2_20190827	Online Survey	27/Aug/2019	1
EngMaterials2019-2020_V2_20190827	Paper Survey	27/Aug/2019	1
Letter of information ENG 2019 Sep implied consent version	Implied Consent/Assent	04/Sep/2019	1
Letter of information ENG 2019 Sep implied consent version clean	Implied Consent/Assent	04/Sep/2019	1
Letter of information ENG 2019 Sep written consent version clean	Written Consent/Assent	04/Sep/2019	1

REB members involved in the research project do not participate in the review, discussion or decision.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Katelyn Harris, Research Ethics Officer on behalf of Dr. Randal Graham, NMREB Chair

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).

Western Research

Date: 8 September 2020

To: Dr. Alex Benson

Project ID: 112318

Study Title: Understanding engineering project teams

Application Type: NMREB Amendment Form

Review Type: Delegated

Full Board Reporting Date: 02/Oct/2020

Date Approval Issued: 08/Sep/2020 10:10

REB Approval Expiry Date: 13/Aug/2021

Dear Dr. Alex Benson,

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the amendment, as of the date noted above.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
Letter of information ENG 2020 January implied consent version	Implied Consent/Assent	18/Aug/2020	1
Amendment EngMaterials2020-2021__Aug 19	Online Survey	19/Aug/2020	1

REB members involved in the research project do not participate in the review, discussion or decision.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Katelyn Harris, Research Ethics Officer on behalf of Dr. Randal Graham, NMREB Chair

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).

Appendix C

Ethics Approval for Study 3

Date: 14 October 2021
To: Dr. Alex Benson
Project ID: 119585
Study Title: Resilient Team Dynamics
Short Title: Resilient Team Dynamics
Application Type: NMREB Initial Application
Review Type: Delegated
Full Board Reporting Date: November 5 2021
Date Approval Issued: 14/Oct/2021 16:53
REB Approval Expiry Date: 14/Oct/2022
Dear Dr. Alex Benson
The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the above mentioned study, as of
the date noted above. NMREB approval for this study remains valid until the expiry date noted above, conditional to timely submission and acceptance of NMREB
Continuing Ethics Review.
This research study is to be conducted by the investigator noted above. **All other required institutional approvals and mandated training must also be obtained**
prior to the conduct of the study.
Documents Approved:
Document Name Document Type Document Date Document Version
Questionnaire_Trajectories of Team Resilience Online Survey 17/Aug/2021 1
ParticipantInvitation_TeamResilienceStudy_update Recruitment Materials 23/Aug/2021 1
DebriefingLetter_TeamResilienceTrajectories_Clean Debriefing document 05/Oct/2021 2
LOIC_TeamResilienceTrajectories_Clean_05102021 Implied Consent/Assent 05/Oct/2021 2
No deviations from, or changes to the protocol should be initiated without prior written approval from the NMREB, except when necessary to eliminate immediate
hazard(s) to study participants or when the change(s) involves only administrative or logistical aspects of the trial.
The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario
Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as
Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered
with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.
Please do not hesitate to contact us if you have any questions.
Sincerely,
Kelly Patterson , Research Ethics Officer on behalf of Dr. Randal Graham, NMREB Chair
Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).