Caught in the Middle of Causality: How the Structure of Reality Produces Incorrect and Divergent Understandings in Organizations

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INTRODUCTION

Causal inference, or determining whether observed associations reflect actual cause and effect relationships between events, is a core problem of organizational actors (Rubin, 2010; Ryall & Sorenson, 2021). In order to understand how to rectify a failure or repeat a success, employees inside organizations must observe events that have occurred and determine the causal pathways that led to them (McIver & Lengnick-Hall, 2017; Lippman & Rumelt, 1982; Schon, 1995; Ryall & Sorenson, 2021). Indeed, when organizational members share correct causal models of events, which can be represented by clear strategies, collective frames of understanding, or even shared causal narratives, they perform better (Csaszar & Laureiro-Martinez, 2018; Fiss, 2011; Nadkarni & Narayanan, 2007; Kendall, 2023).

Yet getting to a convergent and correct causal model of events in organizations is a difficult problem (see work in causal ambiguity, e.g. King, 2007; King & Zeithaml, 2000). Particularly, because organizations deal with complex tasks that exceed the informational capabilities of any one individual, they must divide work, which leads to a division of experience of events for employees (Joseph & Gaba, 2020; Levitt & March, 1988; Heath & Staudenmayer, 2000; Clement, 2023). If organizations consistently generate different event experiences for their employees, it is understandable that employees within the organization may have different causal models of these events. And yet, some organizations are nonetheless able to form convergent and correct causal understandings. Given that organizations must divide labor, and thus event experience, why is it that some are more successful than others at forming convergent and correct causal understandings?

To contextualize the importance of the convergence on correct causal understandings in organizations, consider the failure of Sony's Betamax VCR compared to the success of Toyota's expansion into the North American car market. Sony was a major player in the electronics market in the 1970s, manufacturing radios, tape recorders and TVs, when the organization decided to expand into the home video market. Sony successfully manufactured a beta product before any of their competitors had realized the market existed, yet ultimately the Betamax product failed. In post hoc analysis of Sony's strategy, researchers highlight that the organization's strategy was in most ways a great one that was ultimately "undermined when the perfectly reasonable assumptions behind those [Sony's] commitments turned out to be wrong." (Raynor, 2007).

Now consider the success of Toyota expanding into the North American car market. Toyota manufactured small, affordable, fuel-efficient vehicles, a strategic choice that appealed to their mostly regional consumer base prior to 1970. Toyota had considered expanding into other markets with their products, thinking that their strategic model would appeal to a global set of consumers. They broke into the North American market in the 1970s, where the oil crisis led American consumers to start purchasing Toyotas, and consumers who were impressed with their quality, continued to buy them after gas prices stabilized (Raynor, 2007). Thus Toyota, who bet that the global market would like to buy their small, fuel-efficient vehicles, correctly understood the assignment.

In both the case of Sony and Toyota, their respective strategies were reasonable and agreed upon within the organization, so why did Toyota succeed and Sony fail? In Raynor's

book “The Strategy Paradox”, from which both the Toyota and Sony examples are pulled, the author suggests that both organizations had to make commitments under uncertainty, and Toyota’s panned out and Sony’s did not (2007). Work in causal ambiguity would specify that the type of uncertainty that Toyota and Sony faced was that of unclear understanding of the causal relationship between events and actions that would lead to success in their respective markets (King & Zeithaml, 2000). With an uncertain understanding of the causal pathways that would lead each organization to success, both organizations had to implement strategies, which can be thought of as theories of how the world works based on a causal understanding (Lazzarini & Zenger, 2023). Sony’s assumptions about how the world worked were wrong, and Toyota’s ended up being right.

If we conceptualize the difference between Sony and Toyota’s outcomes as a function of causal understandings, with Sony coming to an incorrect causal understanding and Toyota coming to a correct causal understanding, we’re still left with the question as to why this difference in causal understanding occurred and what organizations can do to get it right. Causal ambiguity and uncertainty can explain why there is likely to be noise in determining causal understandings, but it provides a rather unsatisfactory inability to predict when an organization will achieve Sony’s failure or Toyota’s success. While organizational scholars have pointed to many different factors that can improve an organization’s ability to form successful strategy, from visionary leadership (Nanus, 1995; Parry & Hansen, 2007) to organizational learning (Argote & Miron-Spektor, 2011), if strategies are based on causal models of the world, then one factor that has been uniformly underemphasized in organizational research is the causal structure of the world.

In the research of causal induction, one of the core reasons why causal models are predicted to vary is the structure of causal reality (Pearl, 2009). In a world where causal processes cannot be directly observed, and individuals must instead observe co-occurrence of events and infer relationships between them, the structure of the true causal reality that is being observed can often predict the set of causal models formed (see d-separation, Pearl, 2009). Thus, work in causal induction might predict that Sony ended up forming an incorrect causal understanding of its market because the state of the world allowed for many different causal understandings to be consistent with Sony’s observation of events, while Toyota was able to form a correct causal understanding because the structure of the world made it easier to converge on the single, correct version of events.

Yet, the assumptions of causal induction are not so easily applied to the organizational context. Indeed, the disregard of causal reality from previous organizational research has occurred for both theoretical and practical reasons. For example, scholars in organizational learning and sensemaking have suggested that there is no true causal reality outside of experience, because employees cannot experience events outside of their interpretation of them and employees often hold causal understandings inconsistent with reality (i.e. see Levitt & March, 1988; Weick et al., 2005). Or consider the work on causal ambiguity, which concedes that there is ambiguity about the true pathways that contribute to success, but practically considers how this ambiguity can serve as an advantage to organizations, because their success will be more difficult to reproduce by their competitors (McIver & Lengnick-Hall, 2017).

I do not deny that these arguments hold weight against the necessity of considering causal reality within the organizational context. However, in forming my argument with explicit assumptions about both the nature of causal reality and the ways in which organizations shape employees’ ability to observe the nature of causal reality, I show how considering the structure

of causal reality can help predict when organizations may end up with Sony's failure or Toyota's success under causal uncertainty.

In order to illustrate the usefulness of answering this question on the structure of reality's impact on the formation of causal understandings for organizations and to introduce the findings of my theoretical model, I present the following example. Consider the case of a failing start-up, where the start-up engaged in many reorganizations to avoid failure, but these reorganizations ended up generating inefficient workflows ultimately leading to poor performance. I outline this true causal reality in Figure 1 below.

FIGURE 1: The True Causal Reality of a Start-Up Failure

Company Reorganizations →Inefficient Workflows →Poor Performance

Two employees, a manager and an engineer are attempting to form causal understandings about their start-up's failure, but their experience of the causal reality has been divided by their position in the organization. The manager, who the organization holds responsible for improving poor performance, is likely to observe this event more and more saliently than the engineer, who is focused on the recent reorganization in which she was moved to another team. How might the structure of the true causal reality of the start-up's failure interact with these two employees' experience in the organization to generate causal understandings? My theoretical model developed in the sections below would suggest that the manager and the engineer are likely to form divergent causal understandings like those in Figure 2.

FIGURE 2: Divergent Causal Understandings of Start-Up Failure

Manager: Company Reorganizations ←Inefficient Workflows →Poor Performance

Employee: Company Reorganizations →Inefficient Workflows →Poor Performance

The reason why the manager and the engineer will develop these divergent causal understandings in Figure 2 is because their observation of the causal reality in the organizational context is caught in the middle of causality. When organizations divide employee experience, such that employees only observe slices of causal reality, the divisions of causal reality observed overlap, making events in the middle of causal processes more likely to be observed than events that are at the ends of them. For example, if the manager is focused on improving poor performance and the engineer is focused on the impact of the company reorganizations, they both might be more likely to observe the closest causal relationship to their focus, inefficient workflows, but might miss the event further down the causal chain from their focus. A higher frequency of observation of events in the middle of causal processes makes these middle events look more like causes than effects, such that the manager in particular, who does not observe the root cause of the inefficient workflows frequently, might instead conclude that inefficient workflows are the root cause of the poor performance. I call this the Caught in the Middle problem of causality in organizations.

The findings of my model show that a particular type of causal reality is likely to generate incorrect and divergent causal understandings under this Caught in the Middle problem of causality in organizations. Particularly, I find that causal realities that have events in the middle of causal processes that are not root causes (like the causal reality of Figure 1) generate incorrect or divergent causal understandings. I call causal realities with this characteristic non-

middle root cause realities. To generate an intuition for what types of realities contain a non-middle root cause, I outline all possible causal realities that are not cyclical (as cyclical realities do not satisfy the conditions of having a non-middle or root cause) for three events and indicate which ones contain non-middle root cause in Table 1.

Table 1: All Possible Non-Cyclical Causal Realities Between Events A, B, and C And Whether the Reality Contains a Non-Middle Root Cause

	Example Graph	**Non-Middle Root Cause**
No Cause	A B C	No
One Cause	A->B C	No
Repeller	A<-B->C	No
Collider	A->B<-C	Yes
Linear	A->B->C	Yes

Overall, my work unites the theoretical insights of organizational research and causal induction to suggest that the structure of the true causal reality is an important factor to consider when determining whether the division of labor organizations need to get work done will be at odds with correct and convergent causal understandings. I develop a theoretical model to show how under the structured experience we expect in organizations, non-middle root cause realities are likely to generate a fundamental tension between the division of labor and the ability to form convergent understandings.

Practically, in considering the implication of my findings for the divergent understanding formation between the manager and engineer in the start-up as detailed in Figure 2, my work suggests that in order to understand why these two individuals disagree on causal understandings and how best to resolve this disagreement in order to form a successful strategy, it is essential to think about both the underlying process generating events and the underlying organizational division of work influencing their experience of events. My work ultimately provides a set of theoretically grounded propositions for how the division of experience in organizations is likely to matter for the divergence of causal understandings and provides a theoretical framework for more rigorous research of causal understandings in organizations.

THEORY

A Roadmap for Where We Are Going Together

In this theory section I develop my argument for how the systematic division that organizations place on the observation of reality for their employees interacts with the true causal reality to determine whether causal understandings correctly converge. The argument is structured such that I develop the intuition for a series of assumptions I make, and then show that the result of my argument follows directly from my assumptions. The theory section progresses by answering a series of questions in order generate this argument, which I provide in a list below to give you (the reader) a sense for where we are going together.

- What is a causal understanding and why is it important for organizations?

- What is the nature of the true causal reality and an individual's ability to form a causal understanding of it?
- How do individuals form causal understandings from event observation?
- How do organizations impact the observation of causal reality for their employees?
- How does organizations' division of the observation of events impact the causal understanding formed by their employees?
- When does this incorrect causal understanding generated by an organization dividing the observation of events generate divergence in causal understandings amongst their employees?

What is a causal understanding and why is it important for organizations?

A causal understanding is an individual's cognitive representation of the true causal relationships that exist between events (Carey, 1995); or, in other words, a causal understanding is an explanation for why events happened the way they did (Juarrero, 2011). In addition to being core to psychology and cognitive science's work on human reasoning (see Carey, 1995; Goodman et al., 2011), causal understandings are central to the function of organizations. This is because forming a successful organizational strategy requires a correct causal understanding of events.

One way to view a strategy is as a proposed set of causal relationships between events, where a strategy is really a theory of how the world works based on a causal understanding (Lazzarini & Zenger, 2023; Carroll & Sorensen, 2021). For example, consider the manager in our motivating example above, who is responsible for resolving the poor employee performance in her organization. If the manager's strategy is to improve the efficiency of workflows in order to increase employee performance, then implicit to this strategy is the causal understanding that inefficient workflows are causing poor performance. Thus, forming a strategy of what to do next relies on a causal understanding of what has happened previously.

If we accept that strategy formation is based on a set of causal understandings, then forming a successful strategy will be contingent on employees having a correct causal understanding. Continuing with our example, the manager's strategy to increase the efficiency of workflows in order to improve employee performance will only be effective if inefficient workflows are a part of what caused the poor employee performance. If the manager's causal understanding of the relationship between events is incorrect, the strategy formed is unlikely to be effective. This conceptualization of strategies as theories based on causal understandings is consistent with research that finds that managers that have a correct causal understanding of events are more successful at resolving problems when they arise (Milgrom & Roberts, 1992; Ryall & Sorenson, 2021).

Finding the correct causal understanding in order to generate successful future strategy for an organization may sometimes be a straightforward task. For example, returning to Toyota's expansion into the North American market, Toyota's causal understanding that small, fuel-efficient cars sell was developed from its regional market strategy and continued to be effective and collectively agreed upon by the organization (Raynor, 2007). However, if there are consistent factors that generate either incorrect or divergent causal understandings, and these causal understandings are core to the formation of successful strategies, then organizations ought to be uniquely concerned with uncovering these determinants.

Indeed, work in organizations has addressed several possible antecedents to incorrect and divergent causal understandings. For example, under causal ambiguity, where causal relationships are difficult to infer, trustworthiness is likely to matter for how much information and understandings are shared (Szulanski et al., 2004). Hidden events and factors may also make it difficult for managers to reach a correct causal understanding (Ryall & Sorenson, 2021). And while not necessarily directly based in causal relationships, a large body of work addresses how differences in mental representations may make the search for and formation of strategy less than ideal (Csaszar & Levinthal, 2016; Santos et al., 2021).

However, in considering the broad set of factors that might impact the ability for employees to converge on correct causal understandings, organizational scholars have yet to study in detail the structure of the true causal reality. To the extent that causal reality has been considered in work on organizational understandings, it has often been dismissed, with work citing that employees' interpretations and true events can never be disentangled, and that employees can even hold understandings that are in direct contrast to their experience (Weick et al., 2005; Levitt & March, 1988). While there are no doubt pathways of motivated reasoning and interpretation that generate causal understandings (i.e. see Tappin et al., 2020), work in causal induction suggests that one of the central reasons that causal models diverge when being inferred from observation is because of the underlying structure of the causal reality (see d-separation, Pearl, 2009).

In the next section I turn to this work in causal induction, introducing the structure of true causal reality and a series of assumptions about this reality, which I will build into a theoretical argument for why and how the structure of true causal reality is likely to matter for the inference of causal understandings in organizations.

What is the nature of the true causal reality and an individual's ability to form a causal understanding of it?

A true causal reality is the underlying process that generates the events that individuals, such as employees within an organization, experience. If there is a true causal reality that generates events, then an employee's causal understanding of the world can be defined as this individual's cognitive representation of the underlying true causal reality. While some work within organizations has asserted that there is no true causal reality (i.e. see Skoldberg, 1994; Rhodes & Brown, 2005), the argument in this research generally relies on the fact that humans can never observe the true causal reality independent from their interpretation or perception of this reality (see Weick et al., 2005). While I also assume that the true causal reality cannot be observed, it is analytically useful in my argument to distinguish between the existence of a true causal reality and the ability to observe it. These two first assumptions of the existence, but unobservability, of the true causal reality are formalized below.

Assumption 1: There is a true causal reality, i.e. there is a true causal process that generates events.
Assumption 2: The true causal reality is unobservable to individuals.

It follows from these two assumptions that individuals can seek to find the true causal reality but must infer the true causal relationship between events based on their observation of the events, and not the observation of the process directly. Thus, the act of an individual forming

a causal understanding, or a cognitive representation of the true causal reality, is an act of inference from the observation of events.

Proposition 1: When an individual forms a causal understanding, she uses her observation of a set of events to infer the causal relationship between them.

How do individuals form causal understandings from event observation?

If individuals must form causal understandings through inferring the true causal relationships between events based on their observations of them, the natural next question is how individuals perform this inference. To start, I differentiate between event occurrence and event observation. An event occurring means that an event has been generated by the true causal reality. An event observation means that an individual has observed the event that has occurred. While I differentiate between event occurrence and event observation, crucial to my argument is that individuals who are observing events do not differentiate between the occurrence of events and their observation of them. This is a simplifying assumption, but it is consistent with work on theories of causal induction, where inference of causal relationships based on the observation of even small sets of data is a uniquely human endeavor (Griffiths & Tennenbaum, 2009).

Assumption 3: An employee forming a causal understanding assumes that event occurrence is consistent with her observation of events.

With assumption 3 in hand, that individuals assume that their observation of events is consistent with actual event occurrence, I now turn to how individuals go from observing events to inferring relationships between them. General causal inference proceeds with basic principles about how causality should work. One such principle is that a cause can occur without its effect, but an effect cannot occur without its cause. While this is in some ways a strict assumption in our multi-modal complex world, it is also an assumption ingrained in the definition of the terms cause and effect. Simply put, a cause must occur before its effect, or else the labels of cause and effect are not analytically useful or correct (Gale, 1965). However, effects need not occur with their causes. For example, consider the relationship that a cloud causes rain. A cloud must be present in the sky for it to rain, but it need not be raining for a cloud to appear in the sky. I formalize this assumption below:

Assumption 4: A cause can occur without its effect, but an effect cannot occur without its cause (or causes).

The above assumption helps individuals who are seeking to form causal understandings, but cannot observe the true causal reality directly, make correct inferences about the causal relationships between events. However, we are not just interested in individuals forming causal understandings generally, but in employees forming causal understandings in the structured context of organizations. In considering what causality is like in organizations, and what principles of inference might help employees converge on correct causal understandings, I make one further assumption about the nature of causality. Specifically, while much work in causal induction thinks about deterministic causality, I suggest that the causality in organizations is most likely to be probabilistic.

Deterministic causality means that if A causes B, when A happens B happens. Probabilistic causality means that if A causes B, A occurring increases the likelihood that B occurs. In the context of organizations, we generally say that effective coordination is likely to increase performance (Okhuysen & Bechky, 2009) or that complex problems generally require more coordination (Heath & Staudenmayer, 2000). In fact, much organizational research has come to the conclusion that while there are things we generally believe to be the case, the complexity and variation in organizations yields very few absolutes and very many 'it depends'. Thus, when considering causality in the context of organizations, I assume that employees, consistent with the body of organizational research, will form causal understandings of causal processes that are probabilistic. I formalize this assumption below.

Assumption 5: If a cause occurs the likelihood of its effect occurring is S, where S<1.
(Note: S denotes the causal strength of the relationship between a cause and its effect)

Two propositions about the formation of causal understandings by employees follow from these assumptions. First, since an effect cannot occur without its cause (assumption 4), an effect must occur at a rate lower than its cause (assumption 5), and employees assume that their observation of events is consistent with the occurrence of events (assumption 3), it follows that causes should be observed occurring more often than effects.

Proposition 2: For an employee forming a causal understanding consistent with causal inference principles, causes should be observed occurring more often than effects.

Second, our assumptions 3, 4 and 5 actually provide a specific probability of observing effects given the observation of causes. Under our assumption 3, observation and occurrence of events should be consistent, under assumption 4, effects cannot occur without their cause (or causes), and under assumption 5, effects occur at a rate of S when their cause occurs. It follows from this that the probability of observing an effect is S to the power of the number of causes of S.

Proposition 3: For an employee forming a causal understanding consistent with causal inference principles, the probability of observing an event is $S^{i_{e_n}}$, where i is the number of causes of event e_n.

Equation 1 below details the probability of observing event e_n, ($P_{ob}(e_n)$) under assumption 1-5, as a function of the causal strength (S) of the relationship between events, and the number of causes of event e_n (i_{e_n}).

$$P_{obs}(e_n) = S^{i_{e_n}} \quad (1)$$

Note that this works for calculating the probability of observing event e_n whether it is an effect of another event or is a root cause. Because if event e_n is a root cause, the number of causes of event e_n, i_{e_n} is equal to 0, which makes the probability of observing root cause events $P_{obs}(e_{rootcause}) = 1$.

How do organizations impact the observation of causal reality for their employees?

With a series of propositions developed for how employees might infer a causal understanding based on their observation of events, I now turn to how organizations might impact these employees' observation of the true causal reality. A key element of organizations is the division of labor; in order to complete the complex and information intensive tasks of an organization, work must be divided between employees (March & Simon, 1958; Mintzberg, 1989). While the division of labor improves an organization's ability to complete its necessary tasks, work on modularity and organizational design frequently points to the potentially unintended consequence of this division: the division of event experience in the organization (Clement, 2023; Dearborn & Simon, 1958; Joseph & Gaba, 2020).

In considering how to specifically operationalize the way in which organizations divide the event observation of their employees, I rely on Simon's seminal work on this topic which states that "structural boundaries and the division of labor reflect how the organization represents its problems and affect how individuals filter information" (Dearborn & Simon, 1958; Joseph & Gaba, 2020). The structure of the organization then, which limits the scope of work to a small set of tasks, may also limit the scope of events that an employee is likely to see at any given time, which in turn serves to create this employee's causal understanding of events in the organization as a whole. Thus, the core feature that I consider in operationalizing the way that organizations impact the observations of events for their employees, is the way in which organizations limit employees from getting a bird's eye view of the organization, limiting observation of events at any time to related events only. I formalize this assumption below:

Assumption 6: Organizations divide the scope of observation of the true causal reality for their employees, such that while many events may occur in the organization, employees in the organization will only ever observe pairs of related events occurring.

This is the strongest assumption of my work, and it is also the most consequential. To consider why this assumption may be accurate for organizations, I return again to the motivating example. A manager and an engineer are trying to form causal understandings of their start-up's failure. The problem that both employees face in trying to understand the organization's failure is that they cannot see the whole set of events occurring at once. Because the organization silos experience (whether by time, role, or department), neither the manager nor the engineer is likely to observe the company reorganization directly occurring with the poor performance. This could in some ways help the manager and the engineer form correct causal understandings, because they are unlikely to identify spurious relationships between events, like the company reorganization directly causing poor performance (a common problem in the divergence of causal models, see d-separation in Pearl, 2009). However, it also means that when observing pairs of events in the organization, the manager and the engineer will both have the difficult task of connecting their observation of pairs of events into a larger model of causal reality to generate their own causal understandings.

From this assumption it is possible to see how organizations may impact the formation of correct causal understandings for their employees, because if limiting the scope of experience to related events only generates event observation for employees that is inconsistent with event occurrence of the causal reality, it is likely that employees will form incorrect causal understandings of events. To understand when assumption 6 may lead to assumption 3 being

inaccurate, which may lead to incorrect inferences being made based on assumption 4 & 5, consider the following.

Employees who form causal understandings from the observation of pairs of related events only, which is how their organizations' divide their ability to observe events, will observe events at a frequency different from their occurrence. Specifically, because events are observed with their directly related events, and events in the middle of causal processes are related to more events, occurrence of events in the middle of causal reality is more likely to be observed by an employee than occurrence of events at the ends of causal reality. I label this problem the Caught in the Middle problem of causality. To formalize the exact likelihood of employees observing an event, I start with a conservative, but potentially unrealistic, assumption in the organizational context, that employees are equally likely to observe any slice of causal reality. This assumption could represent organizations who have more generalists in their structure or who have high transparency across the organization (i.e. Ferreira & Sah, 2013; Ball, 2014).

Assumption 7a: Employees in an organization are equally likely to observe any pair of related events.

It follows from assumption 6 and 7a, that employees who form causal understandings from the observation of pairs of related events only will observe events at a frequency different from their occurrence, where because events are observed with their directly related events and events in the middle of causal processes are related to more events, occurrence of events in the middle of causal reality is more likely to be observed by an employee than occurrence of events at the ends of causal reality. Specifically, since all pairs of related events are equally as likely to be observed under assumption 7a, the likelihood of observing an event will be a function of the number of relationships the event is a part of. I formalize the implication of assumption 6 and 7a to the proposition 4a below:

Proposition 4a: Under the assumption of equal observation of the divided pairs of events (7a), an employee will observe an event occurring at a probability of:

$$P_{obs}(e_n) = S^{i_{e_n}} * \frac{i_{e_n} + j_{e_n}}{k_r} \quad (2)$$

Where equation 2 above details the probability of observing event e_n ($P_{obs}(e_n)$) under assumption 1-7a, as a function of the causal strength (S) of the relationship between events, and the number of causes of event e_n (i_{e_n}), the number of effects of event e_n (j_{e_n}), and the total number of relationships in the causal reality r (k_r).

How does organizations' division of the observation of events impact the causal understanding formed by their employees?

To unpack the implications of the division of observation of events by organizations outlined in assumption 6 for the causal understandings formed by employees, I provide two additional propositions that follow from my assumptions above and that show how the implications of proposition 4a for the formation of incorrect causal understandings by employees vary by the structure of the true causal reality.

Proposition 4a suggests that the frequency of the observation of events for employees in organizations may be different than the frequency of occurrence of events. This may cause a

problem for assumption 3, where employees assume that their observation of events is consistent with the occurrence of events, and the subsequent inferences of causal relationships based on this assumption, but only if the employee's observation of events ends up being inconsistent with event occurrence, such that the implication of assumptions 3, 4 and 5, that causes should be observed more than their effects (proposition 2) is violated.

So, the goal of this portion of the argument then is to identify under what conditions will the division of experience in organizations, that leads to a modification of the frequency of observation of events as outlined in proposition 4a, violate the necessary implication of our causal inference assumptions that causes should be observed occurring more than their effects. When this violation occurs will be a function of the structure of the true causal reality, captured in the variables of proposition 4a: the number of causes of event e_n (i_{e_n}), the number of effects of event e_n (j_{e_n}), and the total number of relationships in the causal reality (k_r).

To understand why this is the case, consider when an effect will be observed occurring more than a cause under proposition 4a. Returning to our motivating example, imagine the true causal reality is like that of Figure 1, reproduced below for ease of viewing.

FIGURE 1: The True Causal Reality of a Start-Up Failure
Company Reorganizations →Inefficient Workflows →Poor Performance

Company reorganizations are the root cause of the true causal reality, but this event is only present in one causal relationship. Inefficient workflows are both an effect of company reorganizations and a cause of poor performance; this event is present in two causal relationships. Under our division of observation and equal likelihood of event slices assumptions (6 and 7a) using proposition 4a, when employees incorrectly see inefficient workflows occurring more than company reorganization, and thus make the incorrect inference of the relationship between them, because according to proposition 2, causes should be observed occurring more than effects.

To calculate when an employee might observe the event inefficient workflows (e_{iw}) more than the event company reorganizations (e_{cr}), and thus make the incorrect inference about the relationship between the two, I calculate when equation 2 of the probability of observing inefficient workflows will be greater than the probability of observing company reorganizations under the true causal reality of Figure 1.

Given true causal reality of Figure 1(f_1) company reorganizations (e_{cr})→ inefficient workflows (e_{iw}) → poor performance (e_{pp}), incorrect causal understandings would be expected when:

$$S^{i_{e_{iw}}} * \frac{i_{e_{iw}} + j_{e_{iw}}}{k_{f1}} > S^{i_{e_{cr}}} * \frac{i_{e_{cr}} + j_{e_{cr}}}{k_{f1}}$$

Where the number of relationships in the true causal reality $k_{f1} = 2$, the number of causes of inefficient workflows $i_{e_{iw}} = 1$, the number of effects of inefficient workflows $j_{e_{iw}} = 1$, the number of causes of company reorganizations $i_{e_{cr}} = 0$, the number of effects of company reorganizations $j_{e_{cr}} = 1$. Therefore, we can calculate the following for our motivating example:

$$S^{1} * \frac{1+1}{2} > S^{0} * \frac{0+1}{2}$$

Which simplifies to:

$$S > \frac{1}{2}$$

Thus, when the causal strength (S) of the relationship between events is greater than 0.5 in our motivating example, employees will form an incorrect causal understanding under the division of event experience in organizations between company reorganizations and its related cause. I formalize this insight into proposition 5a below.

Proposition 5a: Under the division of experience to related events only and the equal observation of pairs of related events, an employee will come to the incorrect causal understanding of the causal relationship between event A (e_A) and event B (e_B), where A causes B, when:

$$S^{i_B} * \frac{i_{e_B} + j_{e_B}}{k_r} > S^{i_{e_A}} * \frac{i_{e_A} + j_{e_A}}{k_r} \quad (3)$$

Where equation 3 above details when an employee will conclude B→A even though A→B, under assumptions 1-7a, as a function of the causal strength (S) of the relationship between events, and the number of causes of event A (i_{e_A}) and event B (i_{e_B}), the number of effects of event A (j_{e_A}) and event B (j_{e_B}), and the total number of relationships in the causal reality r (k_r).

As equation 3 shows, whether the condition of proposition 5a that allows for incorrect causal understandings to be formed by employees will be possible will be contingent on the structure of causal reality. Specifically, two features of causal reality matters, the relative number of causes of event A and B, represented by i_{e_A} and i_{e_B} respectively, and the relative number of effects of event A and B, represented by j_{e_A} and j_{e_B} respectively. When A causes B and this inequality is satisfied, an employee will form an incorrect causal understanding. This equation of 5a, generalizes to all sets of causal reality, and I now consider how both the relative number of causes of A and B and the relative number of effects of A and B matter for the satisfaction of this inequality when A→B.

In this explanation, first remember the major intuition for why employees will form incorrect causal understandings from observation of events under the division of event experience of organizations (assumption 6): the Caught in the Middle problem of causality. Events in the middle of causal reality have more relationships with other causal events, which makes them more likely to be observed than other events under the organization's division of experience. Because employees use causal inference principles that lead them to believe that causes should be observed more than effects (proposition 2), seeing middle events more makes these middle events look more like causes. Middle events looking like causes will not be a problem if the middle events are causes, but if the true causal reality contains middle events that are effects, the over observation of middle events compared to occurrence is a problem. Now we turn to the individual components of equation 3 that formally outlines this Caught in the Middle intuition.

In considering how the relative number of causes and effects of A and B matter for the formation of incorrect causal understandings by satisfying equation 3, first consider how event B having more causes than event A i.e. $i_{e_B} > i_{e_A}$, impacts the equation. When event B has more causes than event A, there is a greater likelihood that $\frac{i_{e_B} + j_{e_B}}{k_r} > \frac{i_{e_A} + j_{e_A}}{k_r}$, which generally

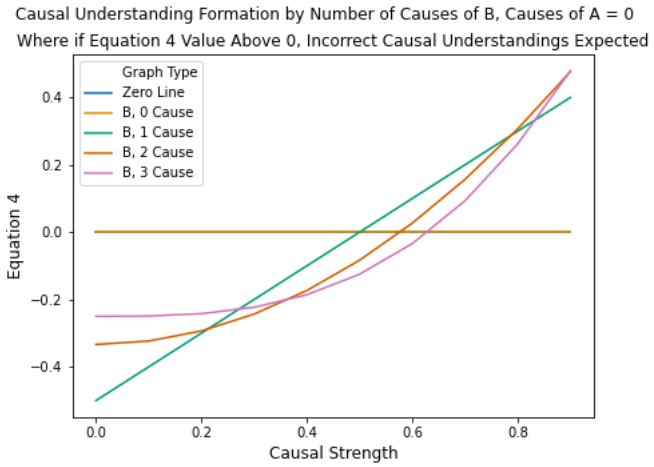
should make equation 3 more likely to be satisfied and thus incorrect causal understandings between A and B may be formed. However, it is also important to note that the number of causes of events A and B are included in two positions in equation 3, and changes in the relative number of causes of A and B end up being calculated in such a way to offset themselves some.

For example, consider a causal reality where A has fewer causes than B ($i_{e_B} > i_{e_A}$), but the number of effects of both are the same ($j_{e_B} = j_{e_A}$). This does makes $\frac{i_{e_B} + j_{e_B}}{k_r} > \frac{i_{e_A} + j_{e_A}}{k_r}$ more likely and thus incorrect causal understandings potentially more likely, however, this also means that $S^{i_B} < S^{i_A}$ which makes equation 3 being satisfied, and incorrect understandings, less likely. Because of this offsetting nature of relative number of causes in the equation, having relatively similar number of causes between A and B, with A for example having 1 fewer cause than B, is as likely to generate incorrect causal understandings as larger differences in number of causes across causal strengths. To make this tradeoff clearer, I reformulate equation 3 into equation 4 below.

$$S^{i_{e_B}} - S^{i_{e_A}} * \frac{i_{e_A} + j_{e_A}}{i_{e_B} + j_{e_B}} > 0 \quad (4)$$

To visualize why this is the case, Figure 3 graphs the lefthand side value of equation 4 (a reformulated version of equation 3), holding the number of effects of A and B constant at 1 ($j_{e_A} = j_{e_B} = 1$) and causes of A constant at 0 ($i_{e_A} = 0$), where the x-axis is the causal strength (S), and the y-axis is the number of causes of B (i_{e_B}).

FIGURE 3



Equation 3 thus shows us that as long as B has one more cause than A ($i_{e_B} = i_{e_A} + 1$), the relative number of causes between A and B is not likely to make a difference for when employees form incorrect causal understandings, which are likely to occur as long as the causal strength between events is high enough, controlling for equal number of effects. Since I have needed to control for the relative number of effects in producing these results, before formalizing this finding into a proposition, I will need to consider the relative number of effects in causal reality.

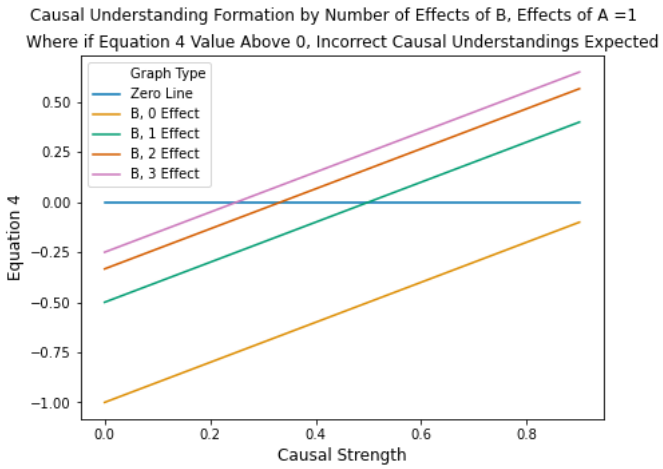
Equation 3 also formalizes the Caught in the Middle of causality intuition for how the relative number of effects between A and B (j_{e_A} *and* j_{e_B}) impacts the formation of incorrect causal understandings. The problem with Caught in the Middle of Causality for the true

relationship of A causes B, is that because B is in the middle of causality, it tends to be observed more and look more like a cause than an effect. In considering the relative number of effects between A and B, if B has more effects than A, this means that B is actually more 'causy' than A overall, and this is likely to exacerbate the problem of B looking like the cause of A.

The way that equation 3 quantifies this intuition is that when B has more effects than A ($j_{e_B} > j_{e_A}$), but A causes B, employees are uniformly more likely to form an incorrect causal understanding. However, it's not necessarily that B needs to have more effects than A to drive incorrect understandings. If we consider a special case, where A is the root cause of the true causal reality, and thus must have at least one fewer cause than B, thereby satisfying the $i_{e_B} \geq i_{e_A} + 1$ from our consideration of the relative number of causes of A and B, then even A and B having equal numbers of effects will lead employees to form incorrect causal understandings at high causal strengths, with larger differences in effects leading to more likely formation of incorrect causal understandings at even low causal strengths.

To visualize the impact of relative number of effects between A and B when A causes B for employees forming incorrect causal understandings, Figure 4 graphs the value of the lefthand side of equation 4 holding the number of causes of A constant at 0 ($i_{e_A} = 0$), the number of causes of B constant at 1 ($i_{e_B} = 1$), and the number of effects of A constant at 1 ($j_{e_A} = 1$), where the x-axis is the causal strength (S), and the y-axis is the number of effects of B (j_{e_B}).

FIGURE 4



This section above has developed the intuition for which types of causal realities are likely to lead employees to form incorrect causal understandings. Using equation 3 I first uncovered that causal realities where A causes B, but where B is caused by at least one more event than A ($i_{e_B} \geq i_{e_A} + 1$), are likely to generate incorrect causal understandings under an organization's division of experience, controlling for the number of relative effects of these events. I then showed that in causal realities where A causes B, but B has more effects than A overall ($j_{e_B} > j_{e_A}$), under the division of experience in organizations, incorrect causal understandings are likely controlling for the relative number of causes of these events. I can now combine these two findings to make a broader statement about the types of causal realities, both in terms of relative number of causes and effects between events, are likely to generate incorrect causal understandings, which I do below in proposition 6a:

Proposition 6a: If A is the cause of B, but A is caused by fewer events than B ($i_{e_B} \geq i_{e_A} + 1$), then if B has at least an equal number of effects as A ($j_{e_B} \geq j_{e_A}$), incorrect causal understandings are expected at high enough causal strengths (where 'high enough causal strengths' is determined by equation 3).

Through this entire argument, I have returned to the problem of being "Caught in the Middle" of causality, suggesting that non-middle root causes are going to be particularly likely to generate incorrect divergent understandings due to this problem. True causal realities that have 'non-middle root causes', are a special type of true causal reality, in that these realities are assumed to contain the root cause of the event, where $i_{e_{rootcause}} = 0$. I formalize this as an additional assumption below:

Assumption 8: The root cause of the true causal reality is in the event set, such that if event A is the root cause in the true causal reality, the number of causes of event A is equal to 0 ($i_{e_A} = 0$).

Figure 4 shows this special case and an implication of assumption 8, where when A is a root cause ($i_{e_A} = 0$), as long as A and B have equal number of effects ($j_{e_B} = j_{e_A}$) incorrect causal understandings are expected. This is where the non-middle part of causal reality comes in. Event A is considered a non-middle event in causal reality compared to event B, when event A has fewer relationships to other events than event B, I formalize this in equation 5.

$$i_{e_B} + j_{e_B} > i_{e_A} + j_{e_A} \tag{5}$$

From this equation 5 defining what a non-middle root cause is and assumption 8, there is one additional proposition that can be made, because as long as there exists one relationship in a causal reality where a root cause event A co-occurs with another event that satisfies the equation $i_{e_B} + j_{e_B} > i_{e_A} + j_{e_A}$, (i.e. the root cause A is a non-middle root cause), an employee is likely to form an incorrect causal understanding at high enough causal strengths.

Proposition 7a: An employee will form an incorrect causal understanding at high causal strengths if the true causal reality contains a non-middle root cause.

Any causal reality that contains a non-middle root cause at a suitable causal strength, as outlined in proposition 7a, will under the division of event experience and equal observation of pairs of events (assumption 6 and 7a), lead to employees forming incorrect causal understandings. On the other hand, realities with a middle root cause are unlikely satisfy this proposition, and thus will allow employees to form correct causal understandings. In Table 1, I introduce all possible non-cyclic true causal realities between 3 events, A, B, and C, and label whether these graphs are non-middle root cause realities or not. I reproduce this Table 1 below to show which graphs have non-middle root causes, and thus likely to satisfy proposition 7a under high causal strengths, generating incorrect causal understandings under our assumption set.

Table 1: All Possible Non-Cyclical Causal Realities Between Events A, B, and C And Whether the Reality Contains a Non-Middle Root Cause

	Example Graph	Non-Middle Root Cause	Equation Used
No Cause	A B C	No	NA
One Cause	A->B C	No	4
Repeller	A<-B->C	No	4b
Collider	A->B<-C	Yes	4
Linear	A->B->C	Yes	4

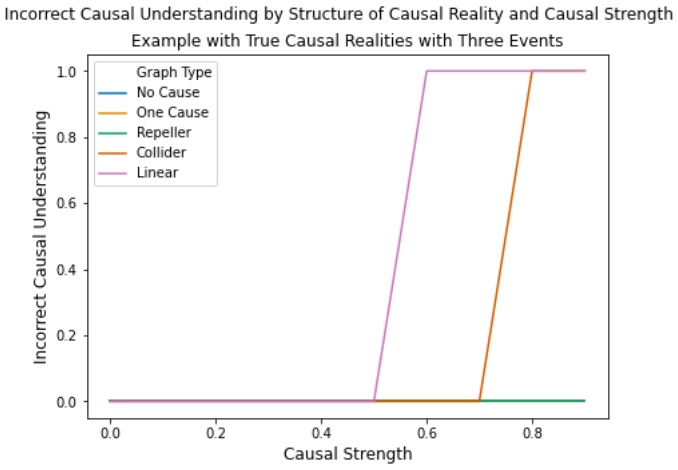
(A note on true causal realities with more than 2 relationships. If we assume as we do in assumption 7a that employees see all pairs of relationships in the true causal reality equally, then adding an additional relationship between events makes it easier for individuals to form correct causal understandings because it will require a higher causal strength between relationships to generate differences between the equation of Proposition 5a).

To visualize proposition 7a, I calculate the equation 4 for all possible true causal realities where A causes B, and equation 4b for causal realities where B causes A, as outlined in Table 1 and present this as Figure 5. In realities where A→B, equation 4 represents when employees will form incorrect causal understandings of B→A. In realities where B→A, equation 4b represents when employees will form incorrect understandings of A→B. Column 4 is added to Table 1 to denote which equation is used for which true causal reality.

$$S^{i_{e_B}} - S^{i_{e_A}} * \frac{i_{e_A} + j_{e_A}}{i_{e_B} + j_{e_B}} > 0 \qquad (4b)$$

In Figure 5, on the x-axis is the causal strength of relationships between events (S). On the y-axis, if the value is 0, employees converge to the correct causal understanding of the true causal reality, if the value is 1, employees converge to the incorrect causal understanding of the true causal reality.

FIGURE 5



While the causal strength at which each non-middle root cause causal reality leads to incorrect causal understandings differs, Figure 5 shows how non-middle root cause realities can lead to the formation of incorrect causal understandings by employees at high causal strengths.

My theory development suggests that successful strategies are those that are constructed from correct causal understanding, making proposition 6a and 7a problematic for organizations. Non-middle root cause realities under the division of experience in organizations (assumption 6) and under the equal experience of all pairs of events (assumption 7a) will lead to employees converging on the incorrect causal understandings at high causal strengths. However, as hinted about in the formation of assumption 7a about the equal observation of pairs of related events in organizations, while this assumption may represent some forms of transparent, generalized organizations, the specialization of employees on particular tasks that tends to occur in many organizations (see Thompson, 1961) means that employees may be unlikely to see all parts of the true causal reality equally. In the next section, I turn to the implications of this assumption, labeled 7b.

When does this incorrect causal understanding generated by an organization dividing the observation of events generate divergence in causal understandings amongst their employees?

Because organizations are likely to not only limit the scope of experience of events by dividing work, but also the frequency of experiences of events by assigning divided work in a specialized manner (Dearborn & Simon, 1958; Heath & Staudenmayer, 2000), different employees are likely to experience different pairs of events at different frequencies. Returning to our motivating example, the manager and the engineer are responsible for different tasks in the organization, which likely leads them to experience different sets of events at different frequencies. The manager may be responsible for resolving poor performance, and thus may experience this event and its causes more frequently than the other events in the organization. The engineer, on the other hand, may have moved teams in the recent company reorganization, and thus may experience the company reorganization and its effects more and more saliently than other events.

If we continue to assume that organizations structure the scope of experience to related events only (assumption 6), the implication of differences in the frequency of observation of events in an organization is that employees have different focuses on different pairs of events, where each employee sees their focal event and its related events more than other events in the true causal reality. I formalize this alternative assumption to 7a as assumption 7b below.

Assumption 7b: Employees in an organization will observe the pair of events that they are responsible for at a rate higher than that of all other pair of related events, where the focus pair of events e_A and e_B, for an employee is observed at a rate $F(e_A \& e_B)$ and all other events are observed at a rate $\frac{(1-F(e_A \& e_B))}{k_r - 1}$, such that focus on all pairs of events sums to 1.

With a new assumption 7b about the frequency of the observation of events in the organization, we will now need to reformulate the implications of the organization's division of experience for how employees will form their causal understandings. To start, now that employees have differential focus on events, the likelihood of observing events occurring that we formulated in proposition 4a will be a function of how much the organization focuses the employee on a particular pair of events. Thus, I reformulate proposition 4a as 4b below to match with assumption 7b:

Proposition 4b: Under the assumption of unequal observation of the divided pairs of events (7b), the probability an employee (m) will observe event (e_n) occurring is:

$$P_{obs,m}(e_n) = S^{i_{e_n}} * \sum_{y=0,y\neq n}^{N} F_{m,e_n\&e_y} \quad (6)$$

Where equation 6 above details the probability of observing event e_n ($P_{obs}(e_n)$), under assumption 1-6 and 7b, as a function of the causal strength (S) of the relationship between events, the number of causes of event e_n (i_{e_n}) and the sum of the focus ($F_{m,e_n\&e_y}$) that the organization places on all pairs of events that contain event e_n for employee (m) from a set of N possible total events in the causal reality.

Proposition 4b, much like proposition 4a, suggests that the frequency of the observation of events for employees in organizations may be different than the frequency of occurrence of events. However, unlike proposition 4a, proposition 4b suggests that when employee observation of events will be inconsistent with actual occurrence of events will be a function not only of the structure of causal reality, but also how frequently the employee's division of labor leads them to observe certain events and not others. I return once again to the motivating example to identify what is likely to occur between the manager and engineer forming causal understandings.

While the causal reality is still that of Figure 1, a linear graph where company reorganizations cause inefficient workflows cause poor employee performance, this time the development of our theory will explain why the manager and the engineer's causal understandings are likely to diverge into the understandings of Figure 2 (reproduced below for ease of viewing).

FIGURE 2: Divergent Causal Understandings of Start-Up Failure

Manager: Company Reorganizations ←Inefficient Workflows →Poor Performance

Employee: Company Reorganizations →Inefficient Workflows →Poor Performance

Say that the manager, who is responsible for improving poor performance, is more focused on poor performance (e_{pp}) and inefficient workflows (e_{iw}), meaning that $F_{manager,e_{pp}\&e_{iw}} > F_{manager,e_{cr}\&e_{iw}}$. While the engineer, who has been moved in the company reorganizations is more focused on company reorganizations (e_{cr}) and inefficient workflows (e_{iw}), meaning that $F_{engineer,e_{pp}\&e_{iw}} < F_{engineer,e_{cr}\&e_{iw}}$. When will the manager or engineer come to incorrect causal understandings under their divided frequency of event experience (assumption 7b)? An incorrect causal understanding is likely to arise when an employee observes an effect occurring more than a cause (violating proposition 2). For example, when the manager observes inefficient workflows occurring more than company reorganizations, she is likely to form an incorrect causal understanding. I formalize this with our focus parameter introduced in assumption 7b below.

Proposition 5b: Under the division of experience to related events only and the unequal observation of pairs of related events, an employee (m) will come to the incorrect causal understanding of the causal relationship between event A (e_A) and event B (e_B), where A causes B, when:

$$S^{i_{e_B}} * \sum_{y=0,y\neq B}^{N} F_{m,e_B\&e_y} > S^{i_{e_A}} * \sum_{y=0,y\neq A}^{N} F_{m,e_A\&e_y} \quad (7)$$

Where equation 7 above details when an employee will conclude B→A even though A→B, under assumptions 1-6 and 7b, as a function of the causal strength (S) of the relationship between events, the number of causes of event A (i_{e_A}) and event B (i_{e_B}), and the sum of the focus ($F_{m,e_n\&e_y}$) that the organization places on all pairs of events that contain event e_n for employee (m) from a set of N possible total events in the causal reality.

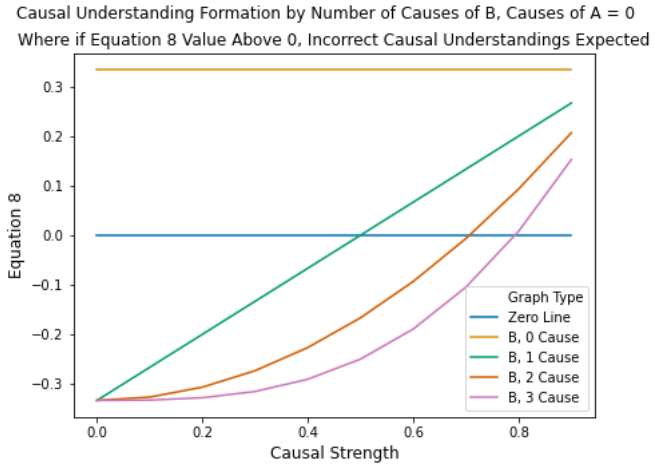
As equation 7 shows, whether the condition of proposition 5b that allows for incorrect causal understandings to be formed by employees will be possible will be contingent on the structure of causal reality and the way the organization is differentially focusing employees on certain parts of causal reality. Specifically, both the relative number of causes of event A and B, represented by i_{e_A} and i_{e_B} respectively, and the relative focus on pairs of events that contain event A vs. those that contain event B, represented by $\sum_{y=0,y\neq B}^{N} F_{m,e_B\&e_y}$ and $\sum_{y=0,y\neq A}^{N} F_{m,e_A\&e_y}$respectively, drive when an employee is likely to form an incorrect conclusion.

In considering the structure of causal reality, specifically the relative number of causes of event A (i_{e_A}) and event B (i_{e_B}), since S is always less than 1, from equation 7 we can see that when B has relatively fewer causes than A, even though the true relationship between event A and event B is that A causes B, that employees are more likely to form incorrect causal understandings. In checking our calculation with our Caught in the Middle of causality intuition, the issue with organizations dividing event experience is that middle events tend to be observed more, and thus look more like causes as opposed effects. When event B is caused by fewer things, event B is the effect of fewer events, making B look less like an effect, and feeding into the Caught in the Middle problem of causality. I transform equation 7 into equation 8 below to codify this relationship and for the graph of Figure 6 below.

$$S^{i_{e_B}} * \sum_{y=0,y\neq B}^{N} F_{m,e_B\&e_y} - S^{i_{e_A}} * \sum_{y=0,y\neq A}^{N} F_{m,e_A\&e_y} > 0 \quad (8)$$

To visualize the impact of the relative number of causes of event A and event B under assumption 1-6 and 7b, Figure 6 graphs the lefthand side value of equation 8 (a reformulated version of equation 7), holding the focus on pairs of event with event B and pairs of events A constant at baseline rate of observation of pairs (such that $\sum_{y=0,y\neq B}^{N} F_{m,e_B\&e_y} = 0.66$ and $\sum_{y=0,y\neq A}^{N} F_{m,e_A\&e_y} = 0.33$), holding the number of causes of A constant at 0 ($i_{e_A} = 0$), where the x-axis is the causal strength (S), and the y-axis is the number of causes of B (i_{e_B}).

FIGURE 6

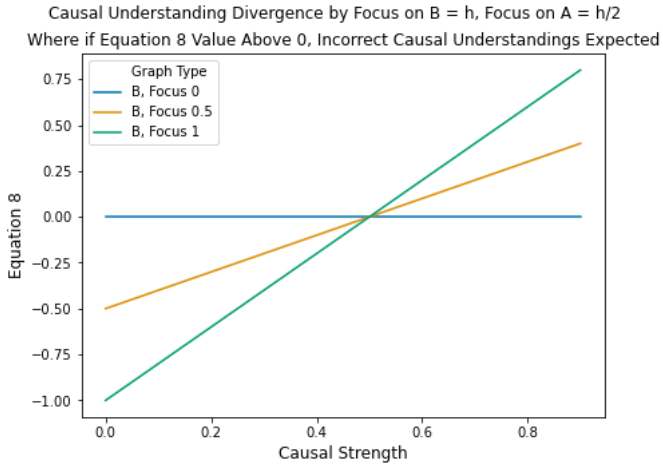


Equation 8 shows us that the most likely structure of causal reality to generate incorrect causal understandings is one where B has relatively fewer causes than A ($i_{e_B} < i_{e_A}$). Incorrect causal understandings can even occur when B has one more cause than A ($i_{e_B} = i_{e_A} + 1$) if the difference in focus is large enough, but the relative number of causes of B being lower than A increases the likelihood of incorrect causal understandings for a given causal strength and focus on events.

Next I consider the second portion of equation 7 that is likely to generate incorrect causal understandings, the relative focus on pairs of events with event A and event B in them, represented by $\sum_{y=0,y\neq B}^{N} F_{m,e_B\&e_y}$ and $\sum_{y=0,y\neq A}^{N} F_{m,e_A\&e_y}$ respectively. This portion of equation 7 and Proposition 5b formalizes the intuition from our motivating example, that the manager, who is focused on events that do not include the root cause of company reorganizations such that $F_{manager,e_{pp}\&e_{iw}} > F_{manager,e_{cr}\&e_{iw}}$, will be more likely to form the incorrect causal understanding in Figure 2. More generally, when the true causal reality is that A causes B, but when an employee focuses on pairs of events that contain event B but do not contain event A, such that $\sum_{y=0,y\neq B}^{N} F_{m,e_B\&e_y} - \sum_{y=0,y\neq A}^{N} F_{m,e_A\&e_y} > 0$, the employee is likely to form incorrect understandings. This is because focusing on events that contain an effect (event B) without observing this effect's cause (event A) is likely to break the causal inference principles outlined in assumption 3,4, and 5, such that proposition 2, that causes are observed more than effects, will be untrue, which will lead to incorrect inferences between A and B.

To visualize this relationship between focus on event pairs containing event A and event B and incorrect understandings, Figure 7 graphs the value of the lefthand side of equation 8 holding the number of causes of A constant at 0 ($i_{e_A} = 0$), the number of causes of B constant at 1 ($i_{e_B} = 1$), and the focus on pairs of events that contain event B at $\sum_{y=0,y\neq B}^{N} F_{m,e_B\&e_y} = h$ and the focus on pairs of events that contain event A at $\sum_{y=0,y\neq A}^{N} F_{m,e_A\&e_y} = h/2$, representing events containing B being focused on twice as much as events containing A. Where the x-axis is the causal strength (S), and the focus on pairs of events that contain event B is $\sum_{y=0,y\neq B}^{N} F_{m,e_B\&e_y} = h$, where h = 0, 0.5, and 1.

FIGURE 7



Now I have developed the intuition for which types of causal realities are likely to lead employees to form incorrect causal understandings under our new assumption 7b, that organizations divide labor such that some employees see certain slices of reality more than others. Equation 7 jointly showed that for causal realities where A causes B, but where B is caused by one more event than A ($i_{e_B} = i_{e_A} + 1$) and for employees whose experience is divided such that they focus sufficiently more on pairs of events that contain B than those that contain A ($\sum_{y=0,y\neq B}^{N} F_{m,e_B\&e_y} - \sum_{y=0,y\neq A}^{N} F_{m,e_A\&e_y} >> 0$), incorrect causal understandings are likely to be formed. I formalize these insights into proposition 6b below:

Proposition 6b: If A is the cause of B, but B is caused by relatively few events compared to A ($i_{e_B} < i_{e_A}$), then if organizations sufficiently focus employees on observing events containing B more than events containing A ($\sum_{y=0,y\neq B}^{N} F_{m,e_B\&e_y} - \sum_{y=0,y\neq A}^{N} F_{m,e_A\&e_y} > 0$) incorrect causal understandings are expected at high enough causal strengths (where sufficient focus and 'high causal strengths' are determined by equation 7).

In considering tangibly which types of causal realities will satisfy proposition 6b, I focus us again on a specific case of causal realities, non-middle root cause realities, which will be particularly likely to exhibit the properties of causal realities outlined in 6b. I restate assumption 8 below, where the root cause of the true causal reality is in the event set, a necessary condition for identifying what a root cause reality is.

Assumption 8: The root cause of the true causal reality is in the event set, such that if event A is the root cause in the true causal reality, the number of causes of event A is equal to 0 ($i_{e_A} = 0$).

Root cause realities where event A is the root cause may be less likely to satisfy the front portion of proposition 6b, in that event B has relatively fewer causes than event A ($i_{e_B} < i_{e_A}$), since when $i_{e_A} = 0$, given that the true relationship is that A causes B, the smallest that i_{e_B} can be is 1. However, I make one additional assumption about organization's distribution of focus across all employees, that generates a consistent issue with non-middle root cause realities and the focus component. Specifically, organizations, while specializing individual employees on

each slice of causal reality, on average have employees focus equally across all pairs of reality, formalized as assumption 9.

Assumption 9: Organizations, while focusing individual employees (m) on slices of causal reality, on average, focuses all of its employees on slices of events equally, such that across all employees M, the average focus on any pair of events ($F_{M,e_A\&e_B}$) is equal to $\frac{1}{k_r}$, where k_r is the number of relationships in the causal reality.

$$\frac{\sum_{m=0}^{M} F_{m,e_A\&e_B}}{M} = \frac{1}{k_r} \tag{9}$$

The implication of assumption 9 is that on average across the organization, there will be more focus on event B as opposed to event A if event B has more causal relationships (whether as a cause or an effect, than event A, equation 10 shows this below:

$$\sum_{y=0,y\neq B}^{N}\sum_{m=0}^{M} F_{m,e_B\&e_y} = \sum_{y=0,y\neq B}^{N}\frac{1}{k_{r,y,B}} = \frac{i_{e_B}+ j_{e_B}}{k_{r,y,B}} \tag{10}$$

The result of equation 10 should look familiar, as this is probability of observing events under assumption 7a of equal observation of event slices. Thus, if organizations, while specializing individual employees on divided labor, still keep the average distribution of focus on events equal across the organization, the problem of root cause realities remains the same. Even though root cause realities may start with a disadvantage in satisfying proposition 6b because given that the true relationship is that A causes B and that A is the root cause, meaning that $i_{e_A} = 0$, and $i_{e_B} = i_{e_A} + 1 = 1$, as long as A is considered a non-middle part of causal reality compared to event B, when event A has fewer relationships to other events than event B (recall equation 5 $i_{e_B} + j_{e_B} > i_{e_A} + j_{e_A}$), on average incorrect causal understandings are likely to be formed in the organization.

However, not all employees in the organization will form an incorrect understanding. As proposition 6b suggests only employees whose focus on events contains the non-root cause of the true causal reality ($\sum_{y=0,y\neq B}^{N} F_{m,e_B\&e_y} - \sum_{y=0,y\neq A}^{N} F_{m,e_A\&e_y} > 0$), will end up with an incorrect causal understanding. Thus, I formalize:

Proposition 7b: An employee will form an incorrect causal understanding at high causal strengths if the true causal reality contains a non-middle root cause and the employee focuses on the part of the true causal reality that does not contain the root cause.

The implications of proposition 7b are larger than just an employee forming an incorrect causal understanding. Returning to our motivating example of the engineer and manager forming divergent causal understandings of the same events as in Figure 2, proposition 7b explains why this is likely to be the case, and tells us when this divergence is likely to happen as a function of the structure of the true causal reality. When the true causal reality contains a non-middle root cause, and the engineer observes the part of causal reality that that does contain the root cause, focusing on the company reorganization, the implication of proposition 7b is that the engineer will form the correct causal understanding of events. However, when the manager observes this same non-middle root cause reality, but observes the part of causal reality that does not contain

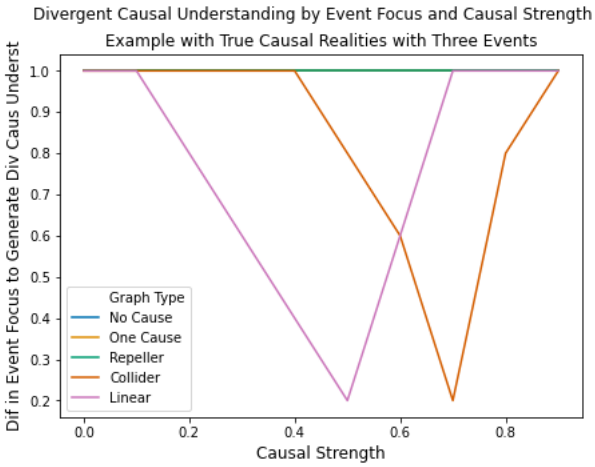
the root cause, focusing on poor performance, the manager is likely to form the incorrect causal understanding. Thus, a major implication of proposition 7b is that under the division of event experience in organizations, both in terms of scope (6) and frequency (7b), non-middle root cause realities are likely to generate divergence in causal understandings.

Once again, I visualize this implication of these propositions by graphing the relationships developed for all the true causal realities with three events as outlined in Table 1. Figure 8 graphs the amount of difference in focus on the pair of events with the root cause vs. the pair of events without the root cause necessary to generate divergence in causal understandings between employees with those different focuses. On the x-axis is causal strength (S) varying from 0 to 1. On the y-axis is the difference in the amount of focus on the root cause pair for two employees ($\sum_{y=0,y\neq rootcause}^{N} F_{employee1,e_{rootcause}\&e_y} - \sum_{y=0,y\neq rootcause}^{N} F_{employee2,e_{rootcause}\&e_y}$), necessary to generate differences in evaluation of equation 8 (or equation 8b below for the repeller graph where B→A).

$$S^{ie_A} * \sum_{y=0,y\neq A}^{N} F_{m,e_A\&e_y} - S^{ie_B} * \sum_{y=0,y\neq B}^{N} F_{m,e_B\&e_y} > 0 \quad (8b)$$

For each type of true causal reality, the line represents how much difference in focus on pairs of events (as specified in assumption 7b) would be necessary for two employees to disagree on causal understandings.

FIGURE 8



Overall, my work in this section suggests that when the true causal reality contains a non-middle root cause and is causally strong, and organizations divide work such that employees observe different events at different frequencies, it is likely that employees will diverge on causal understandings. Furthermore, this work suggests that when employees do diverge on causal understandings, the employee that observes the slice of reality that contains the root cause most often is the most likely to have formed the correct causal understanding. This is because of the Caught in the Middle problem of causality, where middle events end up being observed occurring more than end events, making a systematic non-observation of the root cause of true causal reality extremely problematic for forming the correct causal understanding.

A Summary of the Argument

In the below table 2 and 3, I outline the series of assumptions and propositions that follow from them respectively. Overall, this argument suggests that when the true causal reality has a non-middle root cause, like that of the linear reality in Figure 2, employees are likely to form either incorrect or divergent causal understandings, depending on how work is divided in the organization.

Table 2: Assumptions

Number	Assumption
1	There is a true causal reality, i.e. there is a true causal process that generates events.
2	The true causal reality is unobservable to individuals.
3	An employee forming a causal understanding assumes that event occurrence is consistent with her observation of events.
4	A cause can occur without its effect, but an effect cannot occur without its cause (or causes).
5	If a cause occurs the likelihood of its effect occurring is S, where S<1. (Note: S denotes the causal strength of the relationship between a cause and its effect)
6	Organizations divide the scope of observation of the true causal reality for their employees, such that while many events may occur in the organization, employees in the organization will only ever observe pairs of related events occurring.
7a	Employees in an organization are equally likely to observe any pair of related events.
7b	Employees in an organization will observe the pair of events that they are responsible for at a rate higher than that of all other pair of related events, where the focus pair of events e_A and e_B, for an employee is observed at a rate $F(e_A \& e_B)$ and all other events are observed at a rate $\frac{(1-F(e_A \& e_B)}{k_r - 1}$, such that focus on all pairs of events sums to 1.
8	The root cause of the true causal reality is in the event set, such that if event A is the root cause in the true causal reality, the number of causes of event A is equal to 0 ($i_{e_A} = 0$).
9	Organizations, while focusing individual employees (m) on slices of causal reality, on average, focuses all of its employees on slices of events equally, such that across all employees M, the average focus on any pair of events ($F_{M,e_A \& e_B}$) is equal to $\frac{1}{k_r}$, where k_r is the number of relationships in the causal reality.

Table 3: Propositions

Number	Proposition	Necessary Assumptions
1	When an individual forms a causal understanding, she uses her observation of a set of events to infer the causal relationship between them.	1, 2
2	For an employee forming a causal understanding consistent with causal inference principles, causes should be observed occurring more often than effects.	1, 2, 3, 4, 5
3	For an employee forming a causal understanding consistent with causal inference principles, the probability of observing an event is $S^{i_{e_n}}$, where i is the number of causes of event e_n.	1, 2, 3, 4, 5
4a	Under the assumption of equal observation of the divided pairs of events (7a), an employee will observe an event occurring at a probability of: $$O_{1,2,3,4,5,6,7a}(e_n) = S^{i_{e_n}} * \frac{i_{e_n} + j_{e_n}}{k_r}$$	1, 2, 3, 4, 5, 6, 7a
4b	Under the assumption of unequal observation of the divided pairs of events (7b), the probability an employee (m) will observe event (e_n) occurring is: $$O_{1,2,3,4,5,6,7b}(e_n) = S^{i_{e_n}} * \sum_{y=0,y\neq n}^{N} F_{m,e_n\&e_y}$$	1, 2, 3, 4, 5, 6, 7b
5a	Under the division of experience to related events only and the equal observation of pairs of related events, an employee will come to the incorrect causal understanding of the causal relationship between event A (e_A) and event B (e_B), where A causes B, when: $$S^{i_B} * \frac{i_{e_B} + j_{e_B}}{k_r} > S^{i_{e_A}} * \frac{i_{e_A} + j_{e_A}}{k_r}$$	1, 2, 3, 4, 5, 6, 7a
5b	Under the division of experience to related events only and the unequal observation of pairs of related events, an employee (m) will come to the incorrect causal understanding of the causal relationship between event A (e_A) and event B (e_B), where A causes B, when: $$S^{i_{e_B}} * \sum_{y=0,y\neq B}^{N} F_{m,e_B\&e_y} > S^{i_{e_A}} * \sum_{y=0,y\neq A}^{N} F_{m,e_A\&e_y}$$	1, 2, 3, 4, 5, 6, 7b
6a	If A is the cause of B, but A is caused by fewer events than B ($i_{e_B} \geq i_{e_A} + 1$), then if B has at least an equal number of effects as A ($j_{e_B} \geq j_{e_A}$), incorrect causal understandings are expected at high enough causal strengths (where 'high causal strengths' is determined by equation 3).	1, 2, 3, 4, 5, 6, 7a
6b	If A is the cause of B, but B is caused by relatively few events compared to A ($i_{e_B} < i_{e_A}$), then if organizations sufficiently focus employees on observing events containing B more than events containing A ($\sum_{y=0,y\neq B}^{N} F_{m,e_B\&e_y} - \sum_{y=0,y\neq A}^{N} F_{m,e_A\&e_y} > 0$) incorrect causal understandings are expected at high enough causal strengths (where sufficient focus and 'high causal strengths' are determined by equation 7).	1, 2, 3, 4, 5, 6, 7b

7a	An employee will form an incorrect causal understanding at high causal strengths if the true causal reality contains a non-middle root cause.	1, 2, 3, 4, 5, 6, 7a, 8
7b	An employee will form an incorrect causal understanding at high causal strengths if the true causal reality contains a non-middle root cause and the employee focuses on the part of the true causal reality that does not contain the root cause.	1, 2, 3, 4, 5, 6, 7b, 8, 9

DISCUSSION & CONCLUSION

Below I summarize the findings of my theoretical model, suggest a wide set of contexts that this type of model can apply to, and suggest directions for future research on causal understandings in organizations.

What do we gain from considering causal reality in the formation of causal understandings in organizations?

Organizational research has previously ignored causal reality for reasons both theoretical and practical (i.e. Levitt & March, 1988; Weick et al., 2005; McIver & Lengnick-Hall, 2017). While there are arguments against the consideration of causal reality, my model nonetheless suggests that examining the interaction between an organization's division of work and causal reality provides a powerful way to predict when employees within an organization will reach incorrect or divergent causal understandings. Specifically, when true causal reality contains a non-middle root cause, employees will either converge on incorrect causal understandings or reach divergent causal understandings, depending on the division of work in the organization.

The application of this model to real world organizations, however, may be stymied by a particularly troublesome and necessary assumption of it, which is assumption 2, that individuals cannot observe the true causal reality. My model provides a proof of concept for how the true causal reality is important, but in order to identify situations where causal understandings are likely to be incorrect or divergent, knowing the structure of causal reality is essential. So how can a model showing that the structure of true causal reality be useful when it assumes that the structure of true causal reality is unobservable?

Practically, my model is likely to be most useful for organizations in three ways. First, in ex post analysis of organizational failures and success, my model suggests that considering the structure of causal reality might help distinguish why Sony converged to the incorrect causal understanding and Toyota converged to the correct causal understanding, even though both held a reasonable set of assumptions ex ante (Raynor, 2007). My model would provide the hypothesis that the reality that Sony faced was not only uncertain, but also structured in such a way that converging on the correct assumptions in order to form the right strategy may have been a near impossible task.

Second, my model may be particularly useful to organizations when they are attempting to select the most successful strategy from a set of divergent causal understandings. While motivated reasoning and other factors may be at play in divergent causal understandings, another consistent reason employees in an organization reach divergent understandings of event is because of the division of work, and thus experience in organizations (Dearborn & Simon, 1958; Joseph & Gaba, 2020). However, only certain structures of causal reality are likely to generate

divergent understandings from division of labor, non-middle root cause realities. In the case where the structure of causal reality is generating divergent understandings in organizations, my model provides a clear prediction for whose causal understanding will be correct, the employee who observes the root cause and its associated events more.

Because the true causal reality cannot be observed, it may be difficult to directly identify the root cause. However, my model suggests that having a theory for who is most likely to observe the root cause, may help organizations make more principled decisions in choosing a strategy from divergent causal understandings. For example, some work suggests that managers may be closer to the root cause of events, making manager's causal understanding of root cause events more likely to be correct, but potentially generating myopia to the trickle-down effects of higher-order decisions (Hannan et al., 2003). While in other instances, employees on the ground who are doing the work and are closer to the action, may observe the root causes of issues in the organization more saliently, and thus soliciting input, especially divergent input, from employees may generate more successful strategy (Tegarden et al., 2005).

Finally, my model suggests a rather counterintuitive, but hopeful implication for the division of work and divergent causal understandings in organizations. Traditional accounts of modularity in organizations point to how the division of work drives divergence and disagreement, harming coordination and performance (i.e. Clement, 2023; Santos et al., 2021; Heath & Staudenmayer, 2000). This research has an often unified story that, when it comes to making collective decisions, divergence in understandings decreases collective outcomes. While it's likely that the processes to reach a convergent decision will be more difficult under the divergent causal understandings that are formed in my model, the results of division of experience for the likelihood of coming to the correct causal understanding in an organization are uniformly positive.

This is because in non-middle root cause realities, if employees were not differentially focused on different parts of this causal reality, employees would converge on causal understandings, but they would agree on an incorrect understanding. In this light, divergence in causal understandings due to division of work can be seen as a positive outcome of organizational processes. When employees see different slices of reality, then even for non-middle root cause realities in which it is extremely difficult to infer correct understandings, there is a chance that organizations can reach the correct causal understanding, because some employees do hold this understanding.

Ultimately, while the true structure of causal reality is unobservable, my work suggests that having a theory about the structure of the true causal reality may help organizations consider how to better select which causal understanding to form strategy on when causal understandings diverge. In addition, in ex post analysis of organizational failure and success based on causal understandings, perhaps considering the structure of causal reality can provide a more tangible input to the uncertainty and causal ambiguity that can generate differences in outcomes for organizations (Raynor, 2007; King, 2007).

Where else do the results of the interaction of division of experience and causal reality apply?

While the work above uniformly focuses on the organizational context, my theory on causal reality applies to any context that consistently divides individual scope and frequency of experience. Societal structures, such as the sociodemographic features of race, gender, and income, may also be likely to systematically structure individuals' experience of event (Healey & Stepnik, 2009). Expanding my model to this wider set of social structures, my theory provides

a potential explanation for why, for example, low-income and high-income parents may disagree on causal understandings of raising children (Lareau, 2018). Or even why democrats and republicans, whose experience is often stratified by many social features, may observe the same set of political events and come to different understandings on them (Cutler, 2003; Basta, 2017). Thus, while I believe that organizations are particularly likely to exhibit the particular division of experience outlined in my model above, future work might well consider how other societal groups whose experience of events is also structured, may also reach divergent causal understandings as a function of the division of experience and the structure of causal reality.

Where do we go from here?

The goal of the theory developed in the paper is to help future work in organizations and social science research better identify why incorrect and divergent causal understandings occur. I suggest an additional and often overlooked source of this variance in causal understandings, which is the structure of true causal reality. While the structure of true causal reality is not readily observable to researchers and practitioners alike, my work suggests that having a theory of what the structure of true causal reality is may help us better understand the antecedents of division and make principled selections of causal understandings when divergence exists. Several pathways for future work follow.

First, while the propositions above are developed by following the set of assumptions, the first test of my theory is, in a controlled experimental setting, to see whether under this assumption set, individuals form incorrect and divergent causal understandings. Work on causal narratives in economics has run models and sets of experiments that generally support the idea that the observation of co-occurrence of events generates the types of causal inference errors I identify in my theory above (i.e. Spiegler, 2016; Eliaz & Speigler, 2020). However, this work does not test the set of assumptions about how organizations divide work and event experience, thus future work should explore how the formation of causal understandings under the specific set of divided work we expect to see in organizations is likely to generate the theoretical insights developed here.

Second, a major contribution of this work in organizational contexts is that it may help organizations make principled decisions about which causal understandings may generate successful strategy when there is divergence of causal understandings in the organizations. Future work should explore this theoretical insight by specifically examining organizational context where division in causal understandings arise, testing whether forming a model of the structure of causal reality and which set of stakeholders are most likely to observe the root cause of events, may help organization select better strategies and ultimately perform better.

Finally, organizations' division of experience represent similar division of experience that occurs in many different parts of our society. For any social science scholar who studies populations that diverge on causal understandings, from work on polarization to work on class differences in parenting, considering the structure of causal reality and division of experience of individuals may help explain the divergence of individuals who may ostensibly observe the same reality.

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