First the Chicken, Then the Egg: How Ordering Strategic Choice Helps Organizations Learn and Decision-Makers Disagree

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"There is nothing so practical as a good theory." -Kurt Lewin

ABSTRACT

Why do employees' understandings of what occurs in their organization diverge so consistently? Previous work suggests that ordering strategic choice helps decision-makers learn about their complex environments, showing a clear benefit for decision-makers to the structuring of organizational workflows in sequential chains. However, while decision-makers may observe and learn from the entire sequence of work in the organization, employees' have limited attention which is generally directed to only part of this workflow. Building on research in strategic search and organizational attention, I suggest that while sequential chains of work may improve an individual decision-maker's ability to learn from her experience, this ordering also makes it difficult for her employees whose attention is limited and differentially directed to form shared understandings. Using a formal model, I show how sequential chains of events are the structure that is most likely to generate divergent understandings between employees whose limited attention is divided. I extend these findings beyond organizational boundaries to broader social contexts where power and experience vary, like those of political and cultural ecosystems, suggesting that the ordered structure that helps those in power effectively improve their own outcomes is also the most likely structure to generate divergence in people's perceptions.

INTRODUCTION

Organizations base their strategic choices on their employees' cognitive representations, making employees' mental models a key determinant of strategic foresight and organizational performance (Gavetti & Levinthal, 2000; Csaszar & Laureiro-Martínez, 2018). But how do organizations influence the mental models that employees form about what is worth attending to? Work on attention suggests that organizations are full of structures that are likely to limit and structure the attention of their employees, and thus the observation of events for their employees (Ocasio, 1997). Most notably, the division of work by organizations means that employees are unlikely to view the entire scope of the organization's problem environment at once and are likely to view different parts of the problem at different frequencies (Dearborn & Simon, 1958; Joseph & Gaba, 2020; Levitt & March, 1988; Clement, 2023; Ocasio, 1997). If mental models are based on what employees attend to, and organizations differentially direct the attention of

their employees, it is reasonable to conclude that organizations may consistently generate divergent mental models amongst their employees about what is important.

Yet, organizations often do come to convergent theories and strategies. Previous work considers many potential structures such as hierarchy that can aggregate divergent representations and that can search for the best solution given employees' divergent representations (Rivkin & Siggelkow, 2003; Siggelkow & Levinthal, 2003). However, it doesn't necessarily explain why organizations vary in the degree to which cognitions diverge inside them (Joseph & Gaba, 2020; Thornton, Ocasio, & Lounsbury, 2012).

In fact, a recent review of information processing in organizations highlighted that while organizational scholars have acknowledged variation in the degree to which cognitions are shared in organizations, the ability for organizational structure to differentially generate divergent mental models, and thus differentially generate conflict, has been chronically underexamined (Joseph & Gaba, 2020; Gaba & Joseph, 2023). I address this gap by developing a theory for how employees form causal mental models to explain organizational problems from the observation of events in organizations, highlighting two important antecedents to the development of divergent mental models under organizational structure: the structure of the organization's problem environment and the causal strength between events in the environment.

I start by considering a significantly simplified environment, called the organization's problem environment, which I define as the ordered set of events in the organization that generate a performance outcome. I then consider the causal mental models, or causal understandings, that employees are likely to form to represent this environment. If the problem environment were easily observable, employees who were trying to represent it accurately would be likely to form the same causal understanding. However, because organizational problem

environments are ambiguous and complex (i.e. see King & Zeithaml, 2001; Levinthal, 1997), employees are likely to observe events and infer causal relationships between them to form their causal understandings.

Under the limited and divided attention expected in organizations, these organizational causal inferences are likely to be divergent when the causes closest to employees' work focus aren't shared. Specifically, the direction of attention of employees means that they only observe slices of events in their organization's problem environment. However, employees are unlikely to see independent slices of their organization's environment, the slices that employees attend to overlap. If events in the overlap of employees' focus are causes of events in both their respective focus, employees are likely to agree about their causal understandings of events in the organization. However, if events in the overlap of employees' focus are both causes and effects of events in different employees' window of attention, these employees are likely to disagree about the causal processes that generate events in the organization.

In considering which problem environments are likely to generate divergent understandings under this framework, where the causal origin of performance is located in the problem environment becomes key (i.e. the root cause). When the root cause of performance is located in the middle of a problem environment, it is likely to be at the overlap between employees' focus, and thus problem environments with middle root causes are likely to generate convergence. However, if the root cause is located at the edge of a problem environment, it is unlikely to be in the overlap of employees' divided and limited attention, which is likely to generate divergent understandings. This will be true as long as the causal strength, or how likely an effect is to occur given its cause occurs, is high enough to make the causal direction between events ambiguous.

My work ultimately suggests that the structure of the organization's problem environment and the strength of causal relationships between events in it explain when the limited and divided attention in organizations is likely to generate divergent causal understandings. Particularly, when organizations have root causes that are at the edge of their problem environments and the causal strength between events is sufficiently high, divergent causal understandings are likely under the divided and limited attention expected in organizations.

Three implications from my work follow. First, organizations should consider the structure of their problem environment when searching for explanations of and solutions to performance (i.e. Posen et al., 2018). Asking a sales manager to explain why sales are low may seem like a logical way to come up with a solution to improve sales. However, my model suggests that those employees closest to the outcome may be the least likely to have the correct explanation of the process that led to it, because their attention on the outcome is likely to limit their ability to correctly identify its causal antecedents.

Second, to generate convergent causal understandings of events that reflect the true organizational problem environment, organizations should direct their employees' attention to the causal origin. To the extent that organizational leadership has a clear idea about the events leading to performance but is struggling to get their employees to agree on the causal explanations for this performance, my model suggests that the easiest way to generate convergence in causal mental models is to have employees over sample on the root cause of organizational performance.

Third, to the extent that employees hold divergent understandings of performance and organizational leadership does not know the pathway that led to outcomes, my work suggests

that having a theory about the causal origin of performance, and sampling from the explanations of employees whose attention is directed to this event due to their divided work, is the most likely way for organization's to generate the correct understandings, and thus strategies, about what to do next.

Overall, my work generates a theory for how employees form causal understandings of their organization's problem environment, showing the role of the structure and strength of the problem environment for determining when the divided attention expected in organization's is likely to generate divergence. In addition to generating two hypotheses for when divergent understandings are likely in organizations, this theory provides several practical propositions for what organizations can do to mitigate divergence and help their employees reach correct understandings of the problem environment, which ultimately is likely to lead to more successful strategy formation and performance.

MODEL

The previous discussion introduces employees' causal understandings as representations of the organization's problem environment. But how can the ordered selection of events made in the organization that generate a performance outcome and employees' mental models of this process be represented? Consider what it means for there to be an ordered set of events that generate a performance outcome and for an employee to observe a set of events and infer causal relationships between them. For both the environment and the employee's representation of it, there are events that are causally related that generate an outcome (i.e. an end state). In causal modeling, series of events that are causally related and that have an end point are called directed acyclic graphs (DAGs; i.e. see Pearl, 2009). I thus formalize both the organization's problem environment and the employees' causal understandings of it as directed acyclic graphs, and

model when employees' inferences of their organization's problem environment are likely to diverge.

Motivating Example

To contextualize the model parameters in an organizational context, I provide the following motivating example of an organization considering its advertising and sales pipeline, where the true problem environment of the organization is that product improvements generate clicks on the organization's advertisements, which in turn generates sales.

Figure 1: Organization's Problem Environment

A product manager and a sales manager are both forming causal understandings of the organization's problem environment above. Through the development of my model below, I will show how this structure of problem environment, under sufficiently high causal strength between events and division of attention for the product and sales managers, is likely to generate divergent causal understandings.

Event Occurrence vs. Event Observation

The core distinction in my model of causal understandings is that because organizations divide attention, event occurrence and event observation are not equivalent. An event occurrence means that an event has been generated by the organization's problem environment. An event observation means that an employee has observed an instance of the event. Because organizations limit and structure the attention of employees, events can occur in the organization without being observed by an employee. For example, the organization can have chosen to make

product improvements, but the sales manager need not have observed any of the product improvements occurring. Thus, my general equation for the probability of an event (e_n) for a given employee (i) in an organization is the likelihood of the occurrence of the factor $P(c_{e_n})$ times the sum of the likelihood that the event is observed occurring $P_i(b_{e_n})$.

$$P_i(e_n) = P(c_{e_n}) * P_i(b_{e_n}) \quad (1)$$

In the below sections I break down how I calculate the likelihood of both event occurrence and event observation.

Event Occurrence: The Likelihood of an Event Given an Organization's Problem Environment and a Probabilistic Causal Strength

Event occurrence in an organization is a function of the structure of the organization's problem environment. One way to understand event occurrence is to conceptualize the possible worlds that an organization's problem environment could create at any given time. For all directed acyclic graph data-generating processes with three events (A,B,C) for example, there are eight possible worlds that could occur ranging from all three events not yet occurring (A:0, B:0, C:0) to all three events co-occurring (A:1, B:1, C:1). I outline all possible worlds for three event problem environments in column 1 of table 1. However, for any specific organizational environment with three events, the likelihood of each possible world differs.

For example, consider the organization's problem environment being a linear graph, as in the motivating example, where Product Improvement→Advertising Clicks → Sales (A→B→C). If I assume, that effects cannot occur without their causes, which is consistent with a strict definition of what it means for something to be a cause and an effect (see Gale, 1965; footnote 1), then for a linear problem space, some possible worlds will not be possible, because B

occurring without its cause A is not possible. In column 2 of Table 1, I identify which of the 8 possible worlds are possible for the linear graph.

Footnote 1: 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.

Table 1: Likelihood of Event Occurrence for 3 Event Linear Graph (A→B→C) in the Possible Worlds Framework

Possible Worlds	Possible for Linear Graph	Likelihood of World for Linear Graph	Likelihood for Linear Graph at S = 0.9
A:0, B:0, C:0	Yes	(1-S)	0.1
A:1, B:0, C:0	Yes	S*(1-S)	0.09
A:0, B:1, C:0	No	0	0
A:0, B:0, C:1	No	0	0
A:1, B:1, C:0	Yes	S*S*(1-S)	0.081
A:0, B:1, C:1	No	0	0
A:1, B:0, C:1	No	0	0
A:1, B:1, C:1	Yes	S*S*S	0.729

After understanding which worlds of event occurrence are possible, the next step of my model is to calculate how likely each world of events is to occur. I assume that the strength of causality in organizations varies, which means how likely effects are to occur after their causes occurs varies as a function of a variable I call causal strength (S). Causal strength is how likely an effect is to occur given its cause occurs. I use the variable causal strength (S) to identify the amount that a cause increases the probability of its effect occurring by. For example, if the causal strength (S) of the relationship between a product improvement and advertising clicks is 0.9, then improving the product increases the likelihood of advertising clicks by 90%. Using this framework, the likelihood of an event occurring given its cause has occurred is S, and the likelihood of an event not occurring given its cause has occurred is 1-S. I assume that the likelihood of an independent cause occurring is also S, which can be interpreted as an

unobserved cause of the independent cause occurring. I use this basic logic to generate the likelihood of each possible world for the linear graph in column 3 of Table 1.

Table 1 shows the general intuition that event occurrence in an organization is a function of the structure of the organization's problem environment and the causal strength between related events. While I show the calculations for a linear graph with three events above, this framework can be generalized to any number of events and problem environments, as I formalize in equation 2 below, where the probability of any possible world (w) is a function of the causal strength of the relationship between events (S), the number of events that occur in the possible world (j), the number of independent causes that do not occur in the possible world (i.e. events that do not have a cause in the world, k), and the number of effects of events j that do not occur in the possible world (m).

$$P(w) = S^j * (1-S)^k * (1-S)^m \quad (2)$$

With equation 2 formalized to give the likelihood of a possible world given a causal strength (S) and problem environment data-generating process (which determines the values of j, k, and m), to find the likelihood of an event occurring $P(c_{e_n})$, I only need to sum all possible worlds where event e_n occurs, which I formalize in equation 3, where d is the number of possible worlds.

$$P(c_{e_n}) = \sum_0^d w_d[e_n] * P(w_d) \quad (3)$$

I can also calculate the probability of any two events (e_1, e_2) co-occurring together, $P(c_{e_1 \& e_2})$, by summing possible worlds where both events occur, as formalized in equation 4.

$$P(c_{e_1 \& e_2}) = \sum_0^d w_d[e_1] * w_d[e_2] * P(w_d) \quad (4)$$

The above formalization of my model of possible worlds gives me a way to measure the likelihood of event occurrence in an organization $P(c_e)$ given an organization's problem environment and strength of causal relationship (S). This portion of the model is similar to work developed in causal modeling (i.e. see Pearl, 2009), but adapted to an organizational setting. In equation 2, I also find a calculation supporting our intuition for why problem environments that contain a causal origin at the edge of them may generate divergent causal understandings. Edge root cause problem environments are more likely to generate a smaller number of possible worlds, and when causal strength is high, these graphs are most likely to either generate complete co-occurrence or no occurrence of all events. This uncertainty creates the opportunity for errors in causal mental models, which limited and structured attention is likely to produce.

However, the key assumption about organizations, that they limit and structure attention for their employees, is not incorporated into the occurrence of events, but rather into the observation of events that have occurred $P_i(b_{e_n})$, thus I turn to formalizing the observation of events next.

Event Observation: The Likelihood of an Employee Observing an Event Occur Given the Limited and Divided Attention in the Organization

Event observation in an organization is a function of the degree to which attention is limited and directed in the context. For example, if the product manager in the motivating example is tasked with developing product improvements, the organization can be said to have limited and structured the attention of the product manager to focus on this event. This means that the product manager is both more likely to see the product improvement event, but it also means that she is more likely to see this event not occur. What the structuring of attention functionally means in an organization is that employees are focused on observing specific sections of the organization's problem environment more than others. One nice metaphor to

consider this concept through is the tale of the inebriated man searching for his keys only where the lamp had lit up the street, because it was the only place that he could see. Organizations allow for selective observation of events by 'turning on the streetlight' for certain people on certain events across time, creating variance in the observation of events given a set of occurrences of events.

To formalize this idea of limited attention in organizations, my model assumes that organizations limit the attention of employees to observe pairs of related events only (see footnote 2 below). This means that the likelihood that an employee observes a pair of events (e_1, e_2) occurring in an organization is simply the likelihood that the employee's (i) attention in this organization focuses them on observing this pair ($f_{i,e_1\&e_2}$).

$$P_i\left(b_{e_1\&e_2}\right) = f_{i,e_1\&e_2} \tag{5}$$

Footnote 2: The model formalizes the set of events an employee can observe as a pair of related events only. However, as long as the scope of events remains smaller than the number of causes, the argument holds.

In order to find the likelihood of observing any particular event (e_n) given the siloed, pairwise focus of events in organizations, I can simply sum all the pairwise focuses that include event (e_n), giving equation 6 below.

$$P_i\left(b_{e_n}\right) = \sum_{y=0,y\neq n}^{N} f_{i,e_n\&e_y} \tag{6}$$

This event observation portion of my model formalizes the idea that organizations limit the attention of their employees (Ocasio, 1997), where the event focus variable ($f_{i,e_n\&e_y}$) is a limited observation window for employees to observe events within the organization. To operationalize the idea that organizations structure employees' attention, such that the product

manager and the sales manager for example, are likely to observe different events, different employees can be said to have different focuses on events (i.e. $f_{i,e_n\&e_y} \neq f_{r,e_n\&e_y}$).

In Table 2 I summarize the parameters of my model that I can vary to generate different likelihood of events for employees.

Table 2: Model Parameters

Parameter	Name	Description	Possible Values	Category of Variance
S	Causal Strength	Given that the cause is selected, the likelihood of also selecting the effect.	[0,1)	Strength of Causality
$f_{i,e_1\&e_2}$	Event Focus	The proportion of employee i's focus that is directed by the organization onto events e1 and e2.	[0,1]	Direction of Employee Attention
j	Events, Occurring	Number of events that occur in a possible world.	[0,N]	Problem Environment
k	Independent Events, Non-Occurring	Number of events that do not have causes that do not occur in a possible world.	[0,N]	Problem Environment
m	Effect of Events j, Non-Occurring	Number of effects of events j that do not occur in a possible world.	[0,N-1]	Problem Environment

Forming a Causal Understanding of Events from Event Observation

Employees observe events occurring, but in order to form a causal understanding of events, they need to infer the causal relationships between events. Assuming the employees are not motivated to generate causal understandings that are inconsistent with the organization's problem environment, employees are likely to rely on general causal inference principles about how causality should work to form their understandings. One such principle is that a cause can occur without its effect, but an effect cannot occur without its cause.

Functionally, this principle suggests that for an employee observing a set of events, causes should be more likely than effects. To the extent that there is not motivated reasoning or situated interpretation (see sense-making literature, i.e. Weick et al., 2005), this means

employees will select more likely events as the causes of less likely events in their causal understandings. Thus, if event 1 is observed occurring more than event 2, then an employee (i) will conclude that event 1 causes event 2. I formalize this logic into equation 7 below.

$$\begin{gathered} if\ P_i(e_1) > P_i(e_2)\ \ then\ e_1 \rightarrow e_2 \\ if\ P_i(e_1) < P_i(e_2)\quad then\ e_2 \rightarrow e_1 \\ if\ P_i(e_1) = P_i(e_2)\quad then\ e_1 \rightarrow e_2\ or\ e_2 \rightarrow e_1 \end{gathered} \tag{7}$$

This provides a clear way that employees go from observing event co-occurrence to forming causal mental models of these events. In equations 8 and 9, I formalize how the probabilities in equation 7 can be derived from the event probabilities that I calculate in equations 1 through 6.

$$P_i(e_1) = P_i\left(b_{e_1}\right) * \sum_0^d w_d[e_1] *\ P(w_d) \tag{8}$$

$$P_i(e_2) = P_i\left(b_{e_2}\right) * \sum_0^d w_d[e_2] *\ P(w_d) \tag{9}$$

When Employees Form Divergent Causal Explanations: High Causal Strength Problem Environments with an Edge Root Cause

A divergent causal understanding occurs when some employees see e_1 as more likely than e_2 in the problem environment, but other employees see e_2 as more likely than e_1. Consider employee (i) and employee (q) observing events in a problem environment and differentially concluding that $e_1 \rightarrow e_2$ and $e_2 \rightarrow e_1$ respectively.

Divergent Causal Understandings of Events for Employees i and r

$$P_i\left(b_{e_1}\right) * \sum_0^d w_d[e_1] *\ P(w_d) >\ P_i\left(b_{e_2}\right) * \sum_0^d w_d[e_2] *\ P(w_d), \text{ concludes } e_1 \rightarrow e_2 \tag{10a}$$

$$P_q\left(b_{e_1}\right) * \sum_0^d w_d[e_1] *\ P(w_d) <\ P_q\left(b_{e_2}\right) * \sum_0^d w_d[e_2] *\ P(w_d), \text{ concludes } e_2 \rightarrow e_1 \tag{10b}$$

Equations 10a and 10b formalize the relative probabilities of events e_1 and e_2 necessary to drive divergence of causal understandings for two employees observing the same problem environment. The question then becomes, which elements of event occurrence and event

observation are likely to generate this divergence? Two core features of variation are likely to matter.

First, consider the impact of causal strength in the inequalities above. Both employee i and q are observing the same organizational problem environment, such that either $e_1 \rightarrow e_2$ or $e_2 \rightarrow e_1$. This means that the actual relative occurrence of event e_1 and e_2 is set by the organization's problem environment for both employees. However, the closer the rate of occurrence between events e_1 and e_2, the more differences in observation are likely to drive differences in causal understandings. Returning back to the calculation of different possible worlds ($P(w_d)$), as the causal strength (S) approaches 1, the likelihood of occurrence of effects approaches the likelihood of occurrence of causes. Thus, as causal strength increases, the rate of occurrence of effects gets closer to the rate of occurrence of causes, making it more likely that the direction of causality will be impacted by differences in attention. This generates hypothesis 1 below:

Hypothesis 1: Employees will be more likely to diverge on causal understandings when there is a higher causal strength between events.

Second, consider the impact of the structure of the problem environment on whether employees form divergent causal understandings, particularly whether the problem environment contains an edge root cause. Edge root cause environments are environments where there exists an event with no causes, and this 'root' cause is contained in the event set. Such that if $l_{e_{rootcause}} = z_{e_{rootcause}} + t_{e_{rootcause}}$, where $z_{e_{rootcause}}$ is the number of causes of the root cause and $t_{e_{rootcause}}$ is the number of effects of the root cause, then $z_{e_{rootcause}} = 0$. In addition, edge

root cause environments have an effect that has more relationships with other events than the root cause, such that $l_{e_{effect}} > l_{e_{rootcause}}$. I formalize this definition in equation 11 below.

Formal Definition of Edge Root Cause Environments: Equation 11

$$l_{e_{rootcause}} = z_{e_{rootcause}} + t_{e_{rootcause}} \quad (11)$$
$$z_{e_{rootcause}} = 0$$
$$l_{e_{effect}} > l_{e_{rootcause}}$$

Where $z_{e_{rootcause}}$ is the number of causes of the root cause and $t_{e_{rootcause}}$ is the number of effects of the root cause.

Edge root cause environments are likely to satisfy equation 10 and generate divergent understandings amongst employees who have limited and divided attention. This is because employees are unlikely to share a common cause under divided attention in an edge root cause problem environment. Equation 12 and 13 formalize the focus on a focal vs. non-focal set of events.

$f_{i,focal}(e_1 \& e_2)$, where events e_1 and e_2 are the events that employee (i) are focused on (12)

$f_i(e_n \& e_y) = \frac{(1 - f_{i,focal}(e_1 \& e_2))}{k_r - 1}$, where events n and y are any events but the focal pair (13)

Such that the likelihood of observing event e_n is formalized in equation 14, as a function of whether the event is in the focal event for employee i or not.

Where if factor e_n is in the focal pair with factor e_x then:

$$P_i(b_{e_n}) = f_{i,focal}(e_n \& e_x) + \sum_{y=0, y \neq n,x}^{N} f_{i,e_n \& e_y}$$
$$= f_{i,focal}(e_n \& e_x) + (l_{e_n} - 1) * \frac{(1 - f_{i,focal}(e_n \& e_x))}{k_r - 1} \quad (14a)$$

And if factor e_n is not in the focal pair, but another factor e_y is, then:

$$P_i(b_{e_n}) = l_{e_n} * \frac{(1 - f_{i,focal}(e_y \& e_x))}{k_r - 1} \quad (14b)$$

Consider employees i and q having the majority of their attention on different focal sets of events, such that they share one event in common in their focus, event e_2, but each uniquely

focus on e_1 and e_3 for their other focal event. In plugging in this situation to equation 10, we get the following equation 15 below:

$$f_{i,focal}(e_1\&e_2) + \left(l_{e_1} - 1\right) * \frac{\left(1 - f_{i,focal}(e_1\&e_2)\right)}{k_r - 1} * \sum_0^d w_d[e_1] * P(w_d)$$

$$> f_{i,focal}(e_1\&e_2) + \left(l_{e_2} - 1\right) * \frac{(1-f_{i,focal}(e_1\&e_2))}{k_r-1} * \sum_0^d w_d[e_2] * P(w_d), \text{ concludes } e_1 \rightarrow e_2 \quad (15a)$$

$$\left(l_{e_1}\right) * \frac{\left(1 - f_{q,focal}(e_2\&e_3)\right)}{k_r - 1} * \sum_0^d w_d[e_1] * P(w_d) <$$

$$f_{q,focal}(e_2\&e_3) + \left(l_{e_2} - 1\right) * \frac{(1-f_{q,focal}(e_2\&e_3))}{k_r-1} * \sum_0^d w_d[e_2] * P(w_d), \text{ concludes } e_2 \rightarrow e_1 \quad (15b)$$

When is equation 15 likely to be satisfied? First consider when equation 15b is likely to be satisfied, such that an employee q that is focusing her attention on events e_2 and e_3 will conclude that event e_2 is the cause of event e_1. Because employee q observes event e_1 occurring some, but is mostly focusing her attention on events e_2 and e_3, as long as the base rate of event occurrence of events e_2 and e_3 is sufficiently high (high enough causal strength S), she is likely to see event e_2 occur more than event e_1. Since the basic principle that employees are using to infer whether an event is a cause or an effect is the relative likelihood of the events, where causes are observed more than effects, employee q will likely conclude that $e_2 \rightarrow e_1$.

Consider now when employee i, who is focusing on events e_1 and e_2, will come to a different understanding than employee q about the causal relationship between events e_1 and e_2, satisfying equation 15a. Employee i is determining a relationship between two events in her focal pair, events e_1 and e_2.

If employees i and q do not share the same focal pair of events:

$$f_{i,focal}(e_1 \& e_2) \neq f_{q,focal}(e_2 \& e_3) \quad (16a)$$

And if the event overlap for focal events of employees (i.e. event e_2):

$$e_{overlap} = f_{i,focal}(e_1 \& e_2) \cup f_{q,focal}(e_2 \& e_3) \quad (16b)$$

Is not a root cause:

$$z_{e_{overlap}} \neq 0 \quad (16c)$$

Then employees i and q will form divergent causal understandings.

This is because equation 15b shows that employee q focusing on events e_2 and e_3 will always be likely to think that e_2 causes e_1. However, employee i who focuses on events e_1 and e_2 will only be likely to think that e_2 causes e_1 if e_2 actually causes e_1 in the problem environment. If the overlap event is not the cause of the two other events being observed by these employees (i.e. is not the root cause of the two other events), employees will have different causes that are most proximate to the work the organization is focusing them on. Both employees will think the proximate cause to their work is the root cause of the organization's problem, and this will generate divergence in causal understandings between employees. Which problem environments are likely to generate this situation between employees consistently?

Edge root cause problem environments are likely to generate divergent causal understandings under this division of attention because in these environments, as long as there are at least three events, there exists two pairs of events, such that employee i focuses on a pair of events with the root cause ($f_{i,focal}(e_{rootcause} \& e_{effect})$) and employee q focuses on a pair of events with the effect, but not the root cause ($f_{q,focal}(e_{effect} \& e_{other})$). Because the overlap for these employees is the effect event e_{effect}, and this event by definition in equation 11 has $z_{e_{effect}} \geq 1$, edge root cause problem environments are very likely to satisfy equation 15 and generate divergent causal understandings. I formalize this into hypothesis two below:

Hypothesis 2: Employees will be more likely to diverge on causal understandings of problem environments that have a root cause at the edge of them.

RESULTS

A Three Event Example: Causal Understandings as a Function of Limited and Divided Attention, the Structure of the Problem Environment, and Causal Strength

The mathematical model above generates the intuition for why problem environments that have high causal strength and have a root cause at the edge of them are likely to generate divergent causal understandings under the divided and limited attention in organizations. Below I solve the equations above for all possible directed acyclic graph problem environments with three events, and show that for edge root cause problem environments at high causal strengths, the division of attention is likely to generate the division of understandings. Table 3 outlines all possible problem environments with three events below.

Table 3: All Possible Directed Acyclic Graph Problem Environments for Three Events

	Example Graph	**Number of Graphs in Type**	**Number of Arrows in Graph**	**Edge Root Cause**	**Figure 1 Equation**	**Figure 2 Equation**
No Cause	A B C	1	0	No	NA	NA
One Cause	A->B C	6	1	No	10b	10a
Repeller	A<-B->C	3	2	No	10a	10b
Collider	A->B<-C	3	2	Yes	10b	10a
Linear	A->B->C	6	2	Yes	10b	10a

Consider the motivating example, where product improvements (A) cause increases in advertising clicks (B) which results in higher sales (C). My results below will speak to when the product manager and the sales manager are likely to agree on a causal understanding of this problem environment, and when their differential focus might lead them to divergent and potentially inaccurate representations of their organization's environment. My results overall suggest that organizations should consider the structure and strength of the problem environment when trying to help their employees reach convergent understandings of it.

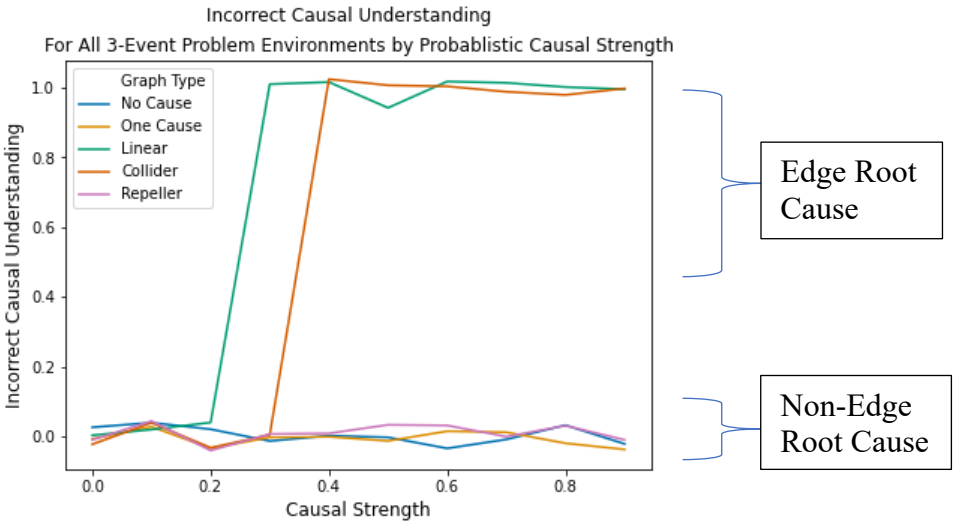
Finding 1: Employees Closest to the Outcome are Likely Represent the Problem Environment Incorrectly When It Contains and Edge Root Cause and has Sufficiently High Causal Strength

Asking the sales manager to explain why sales are low may seem like a logical way to come up with a solution to improve sales. However, my model suggests that those employees closest to the outcome may be the least likely to have the correct explanation of the process that led to it, because their attention on the outcome is likely to limit their ability to correctly identify its causal antecedents. This is because in problem environments that are strongly causal and contain an edge root cause, the sales manager's focus on the outcome of sales precludes her from observing the root cause and generates an incorrect representation of the process that led to sales. For example, if the true problem environment is that product improvement → advertising clicks → sales, the sales manager's focus on the sales outcome might lead her to conclude that advertising clicks are what is driving sales, not the product improvements, leading her to generate strategy suggestions that optimize advertising clicks instead of product releases.

In Figure 1, I plot the results of equation 10 to show that for employees whose majority focus is on a pair of events A and B, when the pair of events does not contain the unique root cause, at high causal strengths, employees are likely to generate incorrect understandings of the organization's problem environment. On the x-axis is the causal strength of relationships between events (S), which is how likely an effect is to occur given the cause has occurred. On the y-axis, if the value is 0, employees focusing on the non-edge root cause slice of the problem environment (with $f_{i,focal}(e_B \& e_C) = 0.75$) come to the correct causal understanding of the problem environment. If the value is 1, these employees come to the incorrect causal understanding of the problem environment. To calculate the 0 and 1 values of the y-axis for each problem space, I use either equation 10a or 10b (specified in column 6 of Table 3) depending on

whether the true relationship is either A→B or B→A. If equation 10 is satisfied, employees reach an incorrect causal understanding for the true problem space at that causal strength, meaning a value of 1 on the y-axis.

INSERT FIGURE 1 HERE



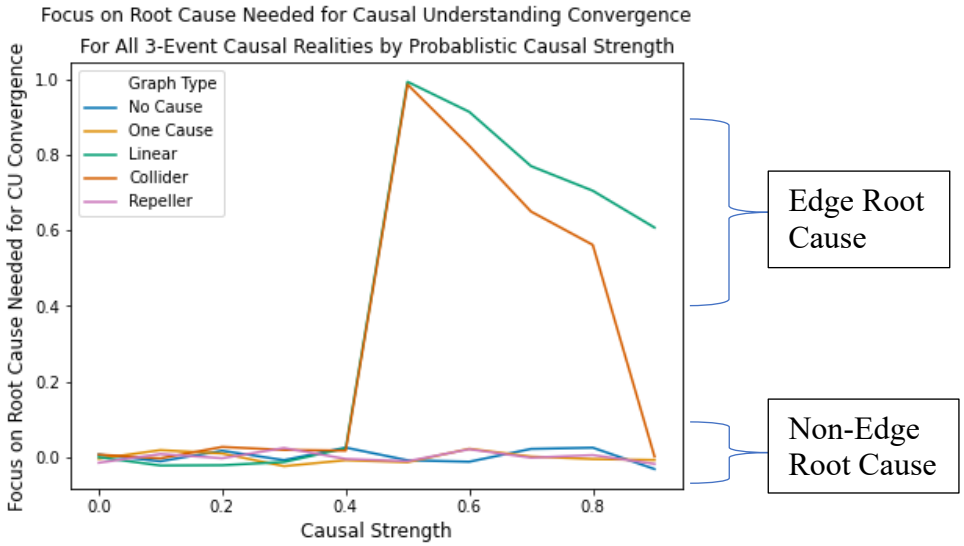
Finding 2: Oversampling on a Slice of the Problem Environment that Contains the Root Cause Generates Convergence on Correct Representations of the Problem Environment

Employees' whose organizations direct their attention to the causal origin of organizational performance are likely to generate a causal understanding of events that reflect the true organizational problem environment. To the extent that organizational leadership has a clear idea about the events leading to performance but is struggling to get their employees to agree on the causal understandings of this performance, my model suggests that the easiest way to generate convergence on correct causal mental models is to have employees over sample on the root cause of organizational performance. This is because over-sampling on the root cause of a

problem environment generates observation of events that is consistent with actual event occurrence.

In Figure 2 I plot the results of equation 10 to show the amount of attention employees need to direct to the pair of events that contain the root cause in order to generate correct and convergent understandings by structure of the problem environment and causal strength. A and B, when the pair of events does not contain the unique root cause, at high causal strengths, employees are likely to generate incorrect understandings of the organization's problem environment. On the x-axis is the causal strength of relationships between events (S), which is how likely an effect is to occur given the cause has occurred. On the y-axis, is the focus on a pair of events that includes the root cause $f_{i,focal}(e_{rootcause}\&e_x)$ above which convergence in causal understandings for employees is likely, i.e. to satisfy either equation 10a or 10b (see Table 3, column 7).

INSERT FIGURE 2



Finding 3: Having a Theory About Who is Closest to the Root Cause Can Help Organizations Select the Understanding that Represents the Problem Environment Accurately

In the debate between whether a top-down or theory-driven approach for information processing is better (see Walsh, 1995; Galambos et al., 1986; Nisbett and Ross, 1980), my model suggests that for the context of causal understandings specifically, a theory-driven approach that considers where the root cause is likely to be located in the problem environment will perform better. When employees hold divergent understandings of performance and organizational leadership does not know the pathway that led to outcomes, sampling from the explanations of employees whose attention is directed to what is likely to be the origin of performance outcomes due to their divided work, is the most likely way for organizations to identify the correct understandings, and thus strategies, about what to do next. For example, the product manager whose work clearly precedes the sales manager's work in the organization's workflow may be more likely to observe the true causal antecedents of low sales of the product.

Under any problem environment, the product manager holds the correct causal understanding because she samples the root cause of the organization's sales performance, which is shown in the results of Figure 2. The sales manager will hold the incorrect understanding when the problem environment is causally strong and contains an edge root cause, which is shown in Figure 1. In considering an organization trying to form strategies based off of their employee's causal understandings is that it is better to have a theory about the employee who is closer to the root cause, because these employees will be likely to hold the correct understandings, and that is where the organization should search for understandings to base its strategies on.

Why do edge root cause problem environment generate divergence in causal understandings at high causal strengths? Event Observation is Inconsistent with Event Occurrence

To better understand the mechanism for why the problem environments with edge root causes lead to divergent understandings at high causal strengths, I graph the event observation and event occurrence for employees across different structured problem environments. What the results of Figure 3a-e show is that for problem environments that contain an edge root cause, employees whose attention is not directed to this edge root cause will end up observing events in a way that is inconsistent with event occurrence, leading to incorrect understandings. For each of the problem environments I generate the observation of events A and B for employees vs. the actual occurrence of events A and B over time for employees across causal strengths (S) and report them in Figure 3a-e. When the observation and occurrence line remain on the same side of zero to each other, this means that employee observation in the organization is consistent with event occurrence. However, for the edge root cause problem environments 'Linear' and 'Collider', above causal strength of 0.5, employee observation and occurrence are no longer consistent, which leads to incorrect causal understandings.

INSERT FIGURE 3A-E HERE

FIGURE 3A: No Cause Environment

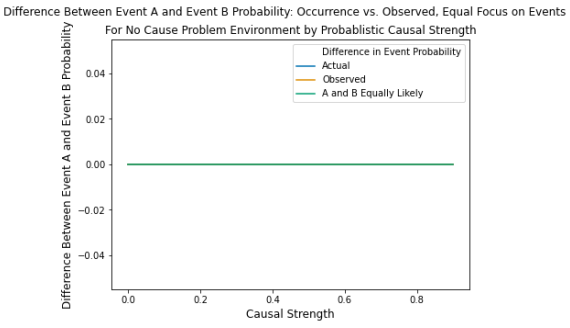


FIGURE 3B: One Cause Environment

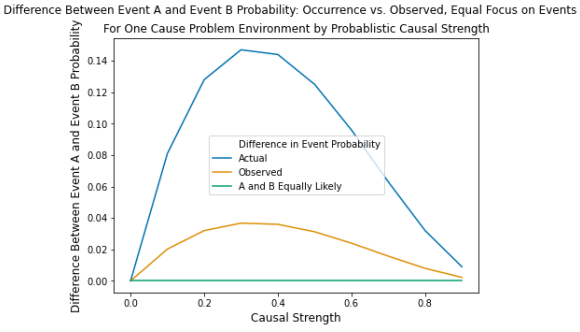


FIGURE 3C: Linear Environment

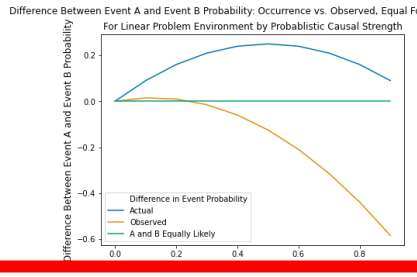


FIGURE 3D: Collider Environment

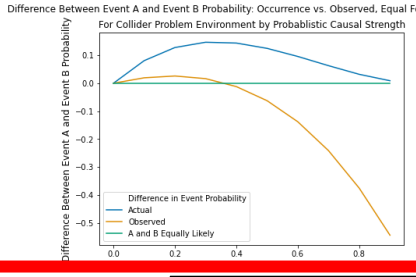
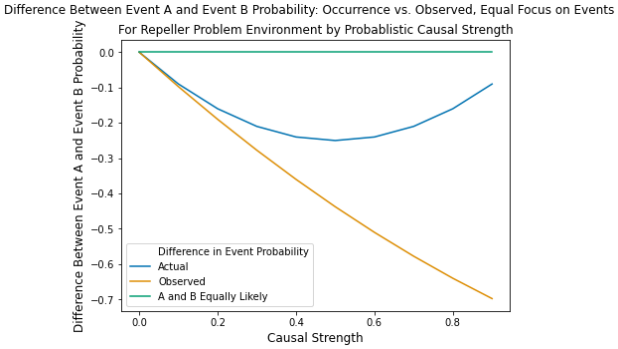


FIGURE 3E: Repeller Environment



Problem environments containing an edge root cause generate factor observation that is inconsistent with factor occurrence at sufficiently high causal strength.

DISCUSSION & CONCLUSION

The structure of the organization's problem environment and the causal strength between events in it are important determinants of when employees' causal understandings with diverge under the structured and divided attention of organizations. When causal strength between events is high and when the problem environment contains a root cause of performance at its edge, employees are likely to disagree on why performance outcomes have occurred. I suggest three managerial implications to my model.

First, because employees closest to the outcome may be the least likely to have the correct explanation of the process that led to it, organizations should consider when searching for solutions further away from the outcome and asking employees who are further down the workflow for their understandings may lead to better outcomes. Second, because divergence in causal understanding can come from employees focusing on different causes due to the

organization's direction of attention, when organizational leadership is trying to generate convergent and correct causal understandings of performance, directing employees to over-sample on the root cause of organizational performance is likely to be effective. Third, when organizational leadership is unsure about what causal understanding of their performance to base their strategy on, having a theory about who is closest to the root cause of organizational performance may help them select the correct causal understanding. Several extensions and directions for future work follow.

Where else do the results of the interaction of direction of attention and problem environments apply?

While the work above uniformly focuses on the organizational context, my theory on problem environments applies to any context that consistently divides and limits individual attention. Societal structures, such as the sociodemographic features of race, gender, and income, may also be likely to systematically structure individuals' attention and experience (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 why certain parenting methods lead to success or failure (Lareau, 2018). Or even why democrats and republicans, whose attention 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 division of attention 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 explanations as a function of the limited and structured attention and the strength and structure of the problem environment.

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 the problem environment. While the structure of the organization's problem environment may not be readily observable to researchers and practitioners alike, my work suggests that having a theory of what the structure of the environment is may help us better understand the antecedents of divergence and make principled selections of explanations when divergence exists. Several pathways for future work follow.

Of the first order is a series of experimental tests that combine the structure of the problem environment with the limited and divided attention expected in organizations to see if the causal strength and structure of the problem environment do generate the expected divergence in 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 how these inferences are impacted by the divided and limited attention expected in organizations. 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 contexts where division in causal understandings arise, testing whether forming a model of the structure of the problem environment and identifying 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 attention represents 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 the problem environment and division of attention of individuals may help explain the divergence of individuals who may ostensibly observe the same reality.

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