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From Individual to Collective Qualities of Attention in Dynamic Work Settings: Learning Barriers to the Development of Collective Mindful Attention

Evelyne Rouby* and Catherine Thomas

Université Côte d'Azur, CNRS, GREDEG, France

Abstract

In dynamic work settings, developing a collective mindful attention is crucial but challenging. It can be achieved through learning. However, the relationships between mindful attention and learning are complex and recursive. Mindful attention is both the prerequisite and the outcome of learning. Based on a single case study of a cement plant, we build an inductive model that clarifies these relationships and highlights three learning barriers. Our paper makes two contributions to theory. First, we extend the knowledge on the complex relationships between mindful attention and learning by identifying two different learning circles. Second, by providing a better understanding of the learning barriers, we stress the pivotal role of superstitious learning in preventing the development of mindful and collective attention.

Qualities of attention refer to the various qualities which attention might assume, and how people process cues to make decisions and take action (Dane, 2013). These qualities are fundamental for studies of dynamic work settings where employees at operational levels face uncertainty (Dane, 2013; Ocasio et al., 2018; Sutcliffe et al., 2016) and are required continuously to process information related to unpredictable events (Curtis et al., 2017; Dane, 2011; Rerup, 2005). This information is needed to make real-time decisions and formulate and apply appropriate responses which deviate from prior plans (Dane, 2011; Levinthal & Rerup, 2006; Martínez-Córcoles & Vogus, 2020; Sutcliffe, 2018). Dynamic work settings require a certain type of attention, which we call mindful attention (or mindfulness) (Dane, 2013, 2021; Fraher et al., 2017; Jordan et al., 2009; Ocasio, 2011; Vogus & Sutcliffe, 2012).

Mindful attention requires detailed and nuanced attentiveness to and interpretation of an unfolding situation (Dane, 2013; Vogus & Welbourne, 2003) and is difficult to achieve. Mindful attention needs to be maintained and developed to allow management of unexpected fluctuations (Dane, 2013,

2021; Fraher et al., 2017; Martínez-Córcoles & Vogus, 2020; Rerup, 2009; Sutcliffe et al., 2016). It also requires coordination to enable collective management of complex signals and appropriate responses (Curtis et al., 2017; Fraher et al., 2017; Rerup, 2005). It requires all of the parties involved to be mindful. Individual mindful attention should be aimed at achievement of collective attention by spreading from mindful people to less-mindful ones (Sutcliffe et al., 2016).

The literature identifies experiential learning (Dane, 2013, 2021; Hutzschenreuter et al., 2014; Rerup, 2005) and learning through knowledge transfer (Levinthal & Rerup, 2006; Weick & Sutcliffe, 2006) to support mindful attention as a dynamic and collective process. Most studies focus on learning facilitators (e.g., Krieger, 2005; Martínez-Córcoles & Vogus, 2020; Orvain, 2014; Østerlie et al., 2012; Rerup, 2009; Vogus & Sutcliffe, 2012) but do not address the specifics related to how they work and interrelate. This is an area that requires more theoretical and empirical research (Sutcliffe et al., 2016).

Some scholars consider mindful attention as a prerequisite to learning rather than an outcome of the learning process (Jordan et al., 2009). The learning literature emphasises that

*Corresponding author: Evelyne Rouby Email: evelyne.rouby@univ-cotedazur.fr

complex and dynamic environments require a mindful approach to processing experience (Hutzschenreuter et al., 2014; Levinthal & Rerup, 2021). Similarly, Curtis et al. (2017) suggest that in dynamic and complex environments, mindful attention is a prerequisite for learning from indirect experience through socialisation. The attention and learning literatures generally point to the existence of complex and recursive relationships between mindful attention and learning, and there is a need for their further exploration (Levinthal & Rerup, 2021).

To address this gap, we adopt a grounded theory approach (Gehman et al., 2018; Gioia et al., 2010) to a single exploratory case study of a manufacturing department in a cement plant. Its employees operate in a dynamic work setting: to monitor a complex combustion process, they have to achieve mindful attention to enable continuous recording and making sense of a wide and unfolding range of complex signals. Since the manufacturing runtime is 24 h a day and 7 days a week, it is managed by teams of individuals rotating on 8-h work shifts. These individuals interact during handoffs when mindful attention is expected to be transferred from experienced mindful individuals to less-mindful counterparts in order to become collective mindful attention.

Based on our findings, we propose an inductive model that clarifies the relationships between mindful attention and learning and identifies three learning barriers. We provide two main theoretical contributions: we extend the knowledge on the complex relationships between mindful attention and learning by identifying two learning circles, and through a better understanding of the barriers to learning, we highlight the pivotal role played by superstitious learning in preventing the development of mindful collective attention.

This article is structured as follows. We introduce mindfulness as a required but difficult to achieve quality of attention in a dynamic work setting and discuss the learning processes needed to achieve mindful attention in such an environment. We describe the methodology used for the analysis and present a synthesis of our findings in the form of an inductive model. We conclude by discussing the contributions and limitations of our study.

Theoretical background

Achieving mindful attention in a dynamic work setting is extremely difficult and requires learning. We identify the related problems and the learning processes required to resolve them.

Mindfulness as a quality of attention

Mindfulness is a quality of attention (Dane, 2011; Hutzschenreuter et al., 2014; Langer, 1989; Rerup, 2005; Weick & Sutcliffe, 2006). Qualities of attention refer to how people direct their attention to certain cues, and how they make sense of them in order to

formulate decisions and actions (Dane, 2013; Ocasio, 2011). Attention is mindful if it relies on a 'rich awareness of discriminatory details' (Weick et al., 1999, p. 88), and rich and nuanced attentiveness to and interpretation of unfolding events (Dane, 2013; Vogus & Welbourne, 2003).

Thus, mindful attention describes present-centred attention to 'the here and now' (Sutcliffe et al., 2016). First, it entails active engagement with the present (Langer, 2000), which means actively attending to nuanced contexts (Langer, 1989), including discriminatory details (Weick & Sutcliffe, 2006), and subtle (Levinthal & Rerup, 2006; Weick & Roberts, 1993) and unanticipated cues (Weick & Roberts, 1993). Second, it entails reluctance to simplify interpretation (Fiol & O'Connor, 2003; Weick et al., 1999), which means active engagement in a continuous process of differentiation, refinement and eventually creation of categories of meanings which structure perceptions and understanding of cues (Langer, 1989, 1997; Weick & Sutcliffe, 2006). In contrast, less-mindful attention (i.e., mindlessness) means that each novel experience is automatically conceptualised with no diligent assessment of how it should be understood. It involves rigid reliance on categories and distinctions created in the past and acting on automatic pilot and precludes attention to novel information and fixation on a single perspective (Langer, 1989, 1997). An emphasis on cognitive categorisation relates mindful and less-mindful attention to the mental frames used by individuals (Langer & Moldeveanu, 2000).

Weick and Sutcliffe (2006) stress the importance for achieving greater mindful attention of cultivating simultaneously high levels of stability and vividness. Stability refers to a focus solely on the objects the individual intends to monitor. A high level of stability implies deep and sustained attention and absence of disruption and/or mind wandering (Dane, 2013; Weick & Sutcliffe, 2006). Vividness describes rich interpretation of the focal object, the 'complexity of representation of issues' (Rerup, 2009, p. 878). A high level of vividness implies representations, which are 'complex, discerning, and relatively unencumbered by existing conceptual schemes or labels' (Dane, 2013, p. 48).

Mindful attention: Two main challenges to meet in dynamic work settings

In dynamic work settings which are characterised by uncertainty and complexity (Dane, 2013), individuals face unpredictable, dynamic and complex task environments. In these contexts, mindful attention is needed (Dane, 2013, 2021; Fraher et al., 2017; Jordan et al., 2009; Ocasio, 2011; Vogus & Sutcliffe, 2012) both because ongoing organisational activity often deviates from plans and expectations, resulting in 'organizational messes' and because this may reveal new not previously recognised opportunities (Levinthal & Rerup,

2006). They require individuals to pay attention to and cope with a continuous stream of unpredictable or unexpected events (Dane, 2011; Rerup, 2005) and multiple potentially meaningful weak cues which could have major consequences (Rerup, 2005; Vendelø & Rerup, 2020; Weick, et al., 1999). Insofar as cues occur not in isolation but in interactions, they constitute complex signals that the individual is required to make sense of (Curtis et al., 2017; Dane, 2011; Rerup, 2005) to inform real-time decisions and deployment of appropriate responses (Dane, 2011; Martínez-Córcoles & Vogus, 2020; Sutcliffe, 2018).

There are two major problems related to achieving mindful attention in such environments. First, mindful attention must be maintained and must grow to allow management of continuous fluctuations (Dane, 2013; Martínez-Córcoles & Vogus, 2020; Rerup, 2009; Sutcliffe et al., 2016). Thus, it involves a dynamic process (Fraher et al., 2017), which relies on the individual's ability to convert previous experience into reconfigurations of assumptions, frameworks and actions (Curtis et al., 2017; Levinthal & Rerup, 2006). As a dynamic process, mindful attention is promoted by experiential learning (Dane, 2013, 2021; Hutzschenreuter et al., 2014; Rerup, 2005).

Second, insofar as the individuals involved are responding to complex signals, fluctuations have to be managed by teams of individuals working closely and interdependently (Dane, 2011, 2013; Sutcliffe, 2018). Achieving mindful attention involves achieving 'a dynamic co-creational process among individuals' (Fraher et al., 2017, p. 241). Co-creation requires individuals to engage collectively in managing complex signals and dynamic information (Curtis et al., 2017; Rerup, 2005). It has been described as 'heedful interrelating' (Weick & Roberts, 1993, p. 361). Individuals work together heedfully if they contribute mutually to the discussion and engage in dialogue in order to share processed information, consider novel information from others, interrelate with others' comments, align their actions to meet the unfolding situation and develop a shared mental model of this situation (Weick & Roberts, 1993). In other words, it requires the individual to inquire, make sense of, frame and reframe the processes of inquiring and sensemaking, and challenge assumptions working with others (Fraher, 2011). This suggests that all those involved must be mindful. Mindful attention from one of the individuals involved will induce collective mindfulness through transfers from the experienced mindful individual to the others (Sutcliffe et al., 2016). As a collective process, mindful attention is promoted by learning by transfer; this mindful attention transfer process is worthy of further theoretical and empirical developments (Sutcliffe et al., 2016).

To sum up, achieving mindful attention in dynamic work settings requires learning whether through experience or through transfers from experienced mindful individuals. However, we need a more fine-grained view of the learning processes underpinning mindful attention.

Mindful attention and learning processes in action

Individuals, groups and organisational units learn directly from their own experience (experiential learning) and indirectly from the experience of others (learning by transfer) (Argote & Miron-Spektor, 2011; Levitt & March, 1988).

Experiential learning is a process of local search (Denrell et al., 2004), in which individuals evaluate outcomes based on aspiration levels (Levinthal & Rerup, 2006). To increase mindful attention requires conversion of individual experience into mental models used to process cues (Levinthal & Rerup, 2006); it can lead to the discovery and application of new causal laws to interpret cues and address the 'here and now' (Weick & Sutcliffe, 2006). However, in dynamic work settings in particular, a mindful approach is required to process experience or the ability to adapt by generalising and discriminating between past experience and the current situation (Hutzschenreuter et al., 2014; Rerup 2005). From this perspective, mindful attention can be seen as a prerequisite to reflection-in-action (Jordan et al., 2009).

Learning from indirect experience refers to the transfer of both tacit and explicit (or codified) knowledge (Argote & Miron-Spektor, 2011). Knowledge transfer can be achieved through socialisation which involves dialogue and knowledge sharing, or more deliberately based on codification, storage and diffusion of knowledge. Increasing mindful attention through indirect learning is facilitated by task interdependence (Vogus & Sutcliffe, 2012), which offers opportunities for exchanging lived experience (Rerup, 2009) and mutual understanding (Krieger, 2005). In addition, some authors highlight the role of professional communities to promote attention quality transfer through strong identity and a shared script of attention-action (Orvain, 2014; Østerlie et al., 2012). This echoes an insight from the learning literature that a context in which organisational units share a superordinate identity has been found to facilitate mutual learning by these units, and especially, if one unit's routines are perceived by the others as superior (Kane et al., 2005). However, in dynamic and complex environments, learning by transfer requires effective dialogue based on shared mental models or collective mindful attention (Curtis et al., 2017). Thus, mindful attention would seem to be a prerequisite for learning by transfer.

In addition, experience may not only be difficult to interpret but may also generate misinterpretation and have negative effects on learning outcomes (Hutzschenreuter et al., 2014; March, 2010). In noisy, ambiguous and changing environments, learning from experience can result in superstitious learning (Denrell et al., 2004; Levitt & March, 1988; Zollo, 2009). Noise, causal ambiguities related to misspecification of the

connections between actions and outcomes (Levitt & March 1988), outcome ambiguity (Zollo, 2009) and delay between actions and outcomes (Denrell et al., 2004) increase the emergence of superstitious learning. Zollo and Winter (2002) and Zollo (2009) suggest that deliberate learning aimed at developing both 'knowing how' and 'knowing why' through knowledge codification increases mindfulness and reduces superstitious learning.

In sum, the literature suggests the existence of complex and recursive links between mindful attention and learning. Mindful attention is both a prerequisite and an outcome of learning. The attention literature describes the role of learning from direct and indirect experience to increase mindful attention (Krieger, 2005; Martínez-Córcoles & Vogus, 2020; Rerup, 2009; Vogus & Sutcliffe, 2012). The learning literature outlines that in complex and dynamic environments, a mindful approach to processing and transferring experience, characterised by explicit efforts to achieve a deep understanding of the meaning of experience, is needed (Hutzschenreuter et al., 2014; Levinthal & Rerup, 2021). In line with work on superstitious learning, Levinthal and Rerup (2021) suggest that in complex and dynamic settings characterised by ambiguity, there is a need to better understand the role of interpretation, especially mindful interpretation, in learning processes. We respond to this by conducting an empirical study which explores the links between mindful attention and learning in order to better understand the development of collective mindful attention.

Methodology

This study investigates how collective mindful attention is achieved from learning in a dynamic work setting. We employ a grounded theory method (Gehman et al., 2018; Gioia et al., 2010) and a single exploratory case study.

Research setting

The study context is a cement plant manufacturing department. Cement manufacture involves three main steps: the second step consists of a very high temperature combustion process in a rotary kiln and is critical for the plant's performance.

This case was chosen following the recommendations related to sampling an exploratory single case (Einsenhardt & Graebner, 2007):

(1) Individuals operate in an unpredictable, dynamic and complex task environment: the combustion process is not programmable or predictable but is a complex physical phenomenon (Seguin et al., 2009). As in all cement factories, the complexity has increased significantly as the result of rapid and continuous changes:

(a) introduction of new techniques that complicate gas flow within the kiln and (b) use of alternative and less expensive fuels that create new emergent chemical reactions. In 2007, these changes led to the computer-expert system being abandoned and kiln monitoring becoming the responsibility of the operators (Control Supervisors – CS and Chiefs of Manufacturing – CM) who had to tune the kiln and monitor the complex combustion process. The CMs and corresponding CSs form six dyads A, B, C, D and E plus a replacement dyad F. The dyads are supervised directly by the Manufacturing Manager (MM) and Assistant Manufacturing Manager (AMM). The Plant Manager (PM) oversees all operations and works with the MM to establish performance targets for the operational teams.

(2) CSs and CMs are expected to process a wide range of cues in the form of abundant and regularly updated real-time computerised information (i.e., around **4,000 cues refreshed every 10 sec**). The cues are provided on 12 computer screens, located in a control room, which provide information on the five key parameters of kiln operations (i.e., clinker temperature, NOx, amount of raw meal, kiln rotation speed and fuel consumption) (Haspel, 2005; Järvensivu et al., 2001) and numerous peripheral ones.

(3) Since production runtime is 24/7, dyads rotate on 8-h work shifts and interact during handoffs. Handoffs take place in the control room and involve the CMs and CSs. They provide a space for socialisation: (1) handoffs between shift changes must take a minimum of 15 min, which, for wage purposes, count as working time; (2) shift work is organised that during the same month all dyads frequently handoff to each other; (3) handoffs are expected to be most oral to be conducive to real-time communication and face-to-face interaction to allow the sharing of tacit knowledge.

(4) CMs and CSs showed a sense of belonging to the same professional community and shared identity of cement workers: 'Manufacturing cement is our profession to all of us, CMs and CSs' (CS Dyad C). This promotes self-help behaviours, solidarity and mutual protection (Observations) and should facilitate learning by transfer.

Data collection

Semi-structured interviews

We conducted 22 interviews over two periods in 2008 and 2010, with 15 respondents (40 h and 512 pages of transcriptions). In 2008, we interviewed managers and some operators (five interviews), to obtain an overall picture of the

manufacturing process and its critical points. In these interviews, attention quality emerged as the cornerstone of the combustion process monitoring. In 2010, we carried out essential data collection on attention quality (17/22 interviews). We interviewed operators of the six dyads at least once and in different work situations (i.e., during day and night shifts, weekdays and weekends, critical and usual operating times, and when issues arose or not), as well as the entire hierarchical line (AMM/MM/PM). The interview protocol explored how operators process cues, make decisions and decide on actions during shifts and handoffs, and examined the underlying motivations and/or logics. Managers were asked to describe their role and how they worked with subordinates. Because the interviews with CSs and CMs were conducted during their working time, they took the form of micro-practice observations.

Findings presentation

In 2011 (January, July and September), we presented our findings to the PM (6h, 7pp), which led to rich discussion and the collection of more valuable data.

Informal conversations

After conducting the interviews, we remained in the control room to observe the operators and take notes on their daily activities. At the end of the individuals' shifts, we continued our conversation and posed some additional questions. Several individuals approached us to tell us about the most recent issues, which revealed their embedded operational knowledge. Informal conversations gave us a better understanding of how our interviewees regarded both their daily work and the work of others. We documented these conversations in detail in the field notes (45 pp).

Observations

Observations mainly involved handoffs to obtain an understanding of how individuals interacted during shift changes and how they handled attention transfer. Some observations were related to critical operating activities (e.g., preheating and starting the kiln). Detailed notes on our observations complemented and allowed triangulation with the interview data (5h, 41 pp).

Internal and external documents

We scrutinised internal documents (1692 pp) to obtain a picture of the organisational context and identify critical phases in the manufacturing process. We also used information provided by operators during interviews (e.g., computer screen shots, the 'log report' used by CMs during handoffs, which contained

12 months of data, the monitoring sheets that CSs were required to complete during their shifts and the notepad or the CSs 'pense-bête'). These materials alongside the interview data provided further insights into attentional practices and attention transfer.

External documents consulted included empirical research papers and professional journals on the cement industry, which provided information on the evolution of cement plants and the technological and organisational challenges encountered over time by employees and managers (667 pp). These materials allowed the inclusion of general data beyond strict daily work practices and enabled examination of micro practices through a spatial and temporal lens. These materials were invaluable for providing a deep understanding of the learning barriers to the development of mindful attention.

Data analysis

We followed the coding process conventionally used for a grounded theory methodology (Gehman et al., 2018; Gioia et al., 2010; Strauss & Corbin, 1998). First, we applied open coding to identify initial relevant codes, which we then grouped into increasingly abstract and conceptual categories through successive levels of abstraction. Second, these emerging conceptual categories are related to form an inductive model (Gioia et al., 2010). Our coding process involved two sequential steps: descriptive and comprehensive.

Descriptive step

The first aim was to identify and describe individual qualities of attention performed by the individuals in the A, B, C, D and E dyads, to manage the complexity of the combustion process. Since attention is related to mental frames, we coded those that people enacted when engaging in patterns of attentional focus and interpretation. Since in dynamic work settings, mindful attention requires experiential learning, we coded how individuals learned from direct experience. Based on quotes and first-order codes, we identified six conceptual second-order codes: (1) less-mindful attention (C, D and E); (2) mindful attention (A and B); (3) enactment of a 'simple' model of activity; (4) enactment of a 'complex'' model of activity; (5) absence of experiential learning (C, D and E); (6) experiential learning (A and B).

A counter-intuitive finding emerged from this descriptive stage: mindful and less-mindful attention coexisted in the cement manufacturing department, which, in a dynamic and complex environment, was unusual and unexpected. The second descriptive step therefore focused on handoffs, designed to promote learning by transfer; we coded the interactions during handoffs and their actual outcomes in terms of learning. This resulted in four second-order codes: (7)

in-depth dialogical exchange and knowledge sharing; (8) a virtuous learning circle; (9) difficulty to initiate dialogue and absence of knowledge sharing; (10) a vicious learning circle.

Comprehensive stage

The focus of the analysis then became the two learning circles and, especially, the vicious learning circle and why it occurred. The coding process identified three learning barriers. To complement and reinforce the analysis of these barriers, we used secondary data on the cement industry. Our analysis of primary and secondary data produced three second-order codes (i.e., barriers): (11) ambiguity about the role of operational teams, (12) artificial tasks independence and (13) difficulty in assessing efficiency of routines.

Trustworthiness of data analysis

The data analysed were collected via several channels from all the people concerned. We employed iterative data analysis, involving closely coupled data analysis, data gathering and search for new and more targeted information to stabilise codes and ensure theoretical saturation.

The analytical processes involved interaction during debriefings, mutual discussions and assessments of inter-coder agreement during data collection and analysis (Clark et al., 2010; Gioia et al., 2010). Both authors analysed the data; thus, the findings do not rely on the interpretation of a single analyst. We also used the insider–outsider approach (Gioia et al., 2010) and obtained feedback from the PM and other employees to ensure that our interpretive scheme made sense to them. The PM noted: 'At each meeting, I discover many things. Thanks for your study. I realize sticking points, which enable me to clarify and understand what went wrong and develop a new perspective.' This iterative analysis helped us verify and adjust the grounded theory in order to achieve fit, relevance and workability (Glaser, 2004).

Findings

The findings take the form of a composite narrative (Jarzabkowski et al., 2014). They combine thick descriptions of work situations organised around the second-order codes and are structured as follows: the first section identifies and describes two qualities of attention coexisting in the cement manufacturing department, the second analyses handoffs and their main outputs in terms of learning and mindful attention transfer, the third identifies three learning barriers, and the fourth proposes an inductive model of the barriers that hamper development of collective mindful attention.

Less-mindful and mindful attention coexist within the manufacturing department

Less-mindful attention performed by individuals of dyads C, D and E

Members of the C, D and E dyads processed relatively few focal cues in the form of data related to the five key kiln parameters. Operators considered these data to be the most relevant information amongst the plethora of available data: 'There are too many parameters to follow so you look at the most important' (SSI CSE).

Operators observed the key parameters at regular intervals to detect any significant problems: 'I am still working with the same screen views, the main ones, to regularly monitor, like, every 5 min, that there are not major issues with the kiln's key operating parameters' (SSI CSC). They only picked up on cues if there were major deviations, that is, they attended to sounds and visual alarms: 'when an alarm occurs, it is no secret; it's time to act' (SSI CSD). By only focusing on alarms, they categorised real-time data as either normal or deviant without fine-grained distinctions within those categories: 'for key parameters, there are ranges. When values are within the range there is no problem. When they exceed, it's abnormal, we have to take care of them' (SSI CSD).

Because alarms must be attended to immediately, they act on automatic pilot. They perform standard tuning actions promptly; they interpret the specific signal applying the well-known rules related to kiln operations and do not deviate from these rules. For instance, 'high NOx [salient signal] is [only encoded as] a temperature problem … relations between major kiln control's parameters is something that goes without saying' (SSI CSE).

In summary, these individuals demonstrated attentional narrowness (i.e., a certain pattern of attentional focus) and normalised interpretation (i.e., a certain interpretative pattern), which, in combination, result in less-mindful attention.

Enactment of a 'simple' model of activity

The C, D and E dyads' monitoring of the combustion process with a less-mindful attention results in enactment of a 'simple' model of activity. They approached the combustion process as a 'simple' phenomenon: 'Drive the kiln and monitor the combustion process is still relatively easy. There are few kiln driving rules to apply' (SSI CSE). Or as the CMC put it even more succinctly: 'You put a kid in front of the console, bottom line, he drives the kiln'.

Absence of experiential learning

C, D and E dyads sustained less-mindful attention over time; there was no experiential learning: operators did not engage in any trial-and-error processes but rather reproduce mindlessly the basic rules of kiln operation, learnt in the past, in training

sessions: 'We have learnt the kiln settings [during the training period as a CS], afterwards, it is out of habit that we do things' (SSI CSD). 'In the case of a particular production, I make the same settings as those made previously for the same kind of production in the past, I look in the notebook and I reproduce' (SSI CSC).

Mindful attention performed by individuals of dyads A and B

The aim of the A and B dyads was 'to understand how the combustion is behaving in the here and now' (SSI CMB) and tune the kiln based on real-time dynamics of the combustion process, to 'improve efficiency' (SSI CMA) and 'anticipate issues' (SSI CMB). They thus engage in an active process of investigation: 'We have to be a little curious' (SSI CMA), which means they 'work with all of the information available in order to choose which information to follow, to feel the kiln, how it is behaving and will behave' (SSI CMB).

As a result, operators deal with multiple both focal and peripheral parameters in order to expand and/or deepen their scope of attention: 'Alone, cues on key parameters do not mean much … To assess the ongoing situation of the kiln, we process a wide range of other indicators to have an overview of how the combustion process is behaving' (SSI CMA).

By tracking these parameters, they actively and investigate mostly weak cues related to small amplitude phenomena: 'It is important to look at what is happening in the kiln and not just track alarms…we watch how the values are moving, we watch small changes and work with trends, trends are very important to track' (SSI CSA).

To interpret weak cues, they consider both combinative and temporal aspects: 'We must integrate different data, analyse them together and make connections between things that are occurring. What is important is their combination' (SSI CSB); 'There is an importance of monitoring various trends over time and what was occurring throughout time because they are significant indications' (SSI CSA).

These interpretations are unique and elaborated according to local circumstances: 'Everything is partly in interpretation of the moment' (SSI CMB). Thus, interpretation refers to deployment of an interpretative scheme, which does not ignore previous categories and relationships, but enriches them continuously with new ones, based on the unfolding combustion process. An important example was the way the different individuals encoded information on NOx: 'Even if in most cases high NOx means high temperature, in some cases high NOx can mean something else, we find what it means by combining several parameters and make sense from them' (IC CMB).

In summary, the individuals adopted a broad focus and a vivid interpretation, which, in combination, led to mindful

attention and allowed improvisation and innovative practices: 'there is not much of a procedure in what we do…we can tune the kiln in a very original way…we try stuff and attempt small adjustments that are written nowhere to improve effectiveness' (SSI CMB).

Enactment of a 'complex' model of activity

When dyads A and B monitor the combustion process with mindful attention, they enact a 'complex' model of activity: 'With the combustion process, there are many uncertainties; we cannot predict all situations we encounter … variables are not interrelated in one way' (IC CSA); 'There is no one tuning method, not a known solution for a known problem or situation … it is very complex … what is happening in the kiln is too complex' (SSI CSB).

Experiential learning

Individuals process experience mindfully: they are curious, track multiple relevant parameters, investigate weak cues, interpret them in a vivid way and perform innovative responses. In so doing, they engage in a trial-and-error process from which they learn: 'we try new settings, we make adjustments, we search, we try things, we play with the parameters and then, with what we experience, we know if it is relevant or not to pursue and reproduce' (SSI CMB). They usually delimit the boundaries to the trial-and-error process by making selected gradual incremental adjustments:

> 'We do not act on all fronts otherwise we do not know what is moving in relation to what; we delimit the number of new parameters to deal with and the new actions to be performed, we decide on a particular thing we want to play with, generally we integrate one new parameter to deal with, and then another one and so on' (IC CMB).

These practices show how processing experience mindfully is intertwined with learning.

Transfer of mindful attention during handoffs

This section describes handoffs and their outputs in terms of learning and attention transfer. They provide an opportunity to explore the relation between learning by transfer and experiential learning.

Effective mindful attention transfer between A & B

In-depth dialogical exchange and knowledge sharing
Knowledge sharing and learning by transfer occurred when the individuals of dyads A and B handed over. Oral handoffs

generally lasted for at least 20 min. Information is passed on about trial-and-error activities, and dialogical exchange allows knowledge sharing and learning from others:

'With B, we discuss trials we have attempted ...We can say: ''We worked with such and such a tuning. It may seem a little quirky, but the kiln operates better...We tried this and that alternative tuning and tracked such and such parameters'' ... and during handoffs we exchange a lot and share our views … we exchange on our experience of situations, we progress, we learn' (SSI CMA).

A virtuous learning circle

During handoffs between mindful individuals (in dyads A and B), a virtuous learning circle is set up: through in-depth dialogue and interaction, individuals transfer to their counterparts what they have learnt during their shift, from their mindful processing of experience. This allows their mindful counterparts who take over, to continue the experiment during their shift. This allows them to learn from what they themselves experience and allows them to keep their mindful colleagues informed about their actions through dialogue with them. Thus, learning from indirect and direct experience is related in a virtuous way:

'We continue kiln regulation carried out by them [A] during their shift work, thus we can see if the direction is good or not, and then we discuss it again with them so that they continue to see what happens' (IC CMB).

No mindful attention transfer between dyads (A or B) and (C, D or E)

Difficulty to initiate dialogue and absence of knowledge sharing

Knowledge sharing and learning by transfer do not occur between mindful individuals (A or B) and their less-mindful colleagues (individuals of C, D and/or E). Handoffs do not give rise to dialogical exchanges. A and B inform their counterparts about the weak cues they have proceeded and the fine tunings attempted, in order to maintain the flow of fine diagnosis and action from one shift to the next. However, no in-depth discussions occur:

'We continue to inform them on emerging issues or new tunings we have attempted even though we know that it will go over their heads and they will not take care of them … they are not interested in what we say … It is completely useless we cannot discuss with them' (SSI CMB).

C, D and E do not understand much of what A and B discuss and tend to ignore what they are told:

'He [CSA] informs me about a lot of things – trends tracked; parameters watched – . He said, ''I watched this, and this, and that, and even that, and then we did this and that''. But I do not care about what he says. I see no value in saying all of this and I do not pay attention!' (OH CSA/CSE). CMA confirms: 'Unfortunately, with them [operators of C, D and E], there are lots of things we cannot share...they do not understand what we do and what we are saying to them'.

A vicious learning circle

The virtuous learning circle is broken when C, D or E takes over from A or B. C, D and E do not appropriate knowledge from A and B, do not learn from them and do not continue the trial-and-error processes enacted by A or B during their shifts:

'We make trial and find that it works better that way. We hope that what we experiment can continue with the next team. With some [C, D or E], it is not just for hope!' (SSI CSA); 'With them [C, D or E], we cannot follow our trial over time' (IC CMB).

As a result, C, D and E continue to be less-mindful: 'In my shift, I monitor alarms…I always do like that, I do as I used to do' (SSI CSE); they do not learn from local circumstances and are unable to benefit from experiential learning and a vicious learning circle prevails. In the absence of learning from mindful counterparts' indirect experience, less-mindful people remain less-mindful and are unable to process experience mindfully, which results in no experiential learning.

Barriers to learning

Our results outline three main learning barriers. The first hinders experiential learning; the second and third hinder learning by transfer.

Ambiguity about the role of operational teams

Both operators and managers are unclear about the role of operational teams, and operators have different visions of their role. A and B emphasise improvisation, autonomous behaviours and distributed decision-making power to members of the operational teams:

'We are responsible for kiln operations, kiln monitoring is our initiative, our job. It's up to us to decide' (IC CMB); 'cement is us and it's up to us to manage kiln operations; we have a very greater responsibility for decision making' (IC CMA).

They justify this based on the practical knowledge they have gained through experience: 'We know what we have to do, and we can always justify and argue our autonomous decision-making' (IC CMB). This reinforces their propensity to engage in trial-and-error to gain expertise: 'we want to maintain

our expertise' (IC CMA). In contrast, C, D and E adhere strictly to the instructions provided by managers: 'I'm obedient and disciplined. I do what my superiors told me to do. The hierarchy is the hierarchy. It's her decision and if the decisions are not good, if the kiln is going badly or well, never mind' (SSI CSE). If managerial instructions are inconsistent, an alarm will be set off: 'instructions are untenable, oh well, never mind, there will be an alarm to signal, that's all' (SSI CSE). This does not encourage engagement in active investigation and, thus, does not result in learning from direct experience.

At the same time, managers 'do not send a coherent message and have to reach an agreement on what is expected from operational teams' (IC PM). MM highlighted the power of hierarchy: 'the responsibility to monitor the kiln and optimize the kiln operation' belongs to him. It is for him 'to decide, define instructions and kiln operating procedures; operators are executors, they have to strictly apply instructions.' His propensity to favour hierarchical authority rather than deference to the expertise of his subordinates is common in cement factories. For instance, (Zermane & Mouss, 2017) show that when control of the cement manufacturing process is centralised in a control room and automated using a computer-expert system, the traditional division of labour in cement factories can be maintained. Decision-making will continue to be centralised in managers over time (Zermane & Mouss, 2017). Path-dependence in the division of labour in cement factories is not neutral in how the trade-off between 'hierarchical authority and deference to expertise' was envisioned by the MM.

The PM was more inclined to value the merits of the positive role of improvisation, dialogue and co-construction with operators:

'MM gives the settings and kiln regulations. I'm more in the recognition of improvisation in teams. No one knows everything. Nobody can say "this is how the kiln has to be monitored, with only such parameters and operating rules". Kiln monitoring is very empirical. There is much to be learned from team's initiative and dialogue with them' (SSI PM).

However, his expectations were not clear: 'what the managers expect of us, it is not clear' (SSI CMF). Even for A and B, with whom the PM shares this positive autonomy, there is some lack of understanding about what he expects from them:

'Okay, he [PM] comes to discuss with us, he asks us questions, but that's a joke. I think he is just coming to see if objectives are met. Sometimes I have the feeling that like us [A and B], he [PM] values trial-error and experimentation of innovative settings, but it's not clear what he wants' (SSI CMB).

As a result, it seems to be difficult for the PM to value the merits of improvisation, especially when managerial ambiguity dominates. Ultimately, managerial ambiguity about the benefits

of improvisation prevents the entire line management from providing the conditions conducive to experiential learning. In particular, it prevents managers from conveying cultural values related to improvisation and deference to expertise rather than to hierarchical authority. To sum up, ambiguity about the positive role of autonomy and improvisation, at all organisational levels, constitutes a major barrier to learning from direct experience.

Artificial tasks independence

As in any 24-7 runtime complex work setting, the actions of operators are highly temporal interdependent and the interdependence amongst the tasks performed by operators who rotate will be especially high. However, our data provide contrasting evidence: artificial independence of tasks from an organisational logic based on temporal task segmentation (i.e., chronological time segmented into three 8-h shifts in a work day), reinforced by a tacit shift sovereignty rule; no one interferes with work performed by another shift worker: 'Each team is sovereign during its 8 h' (SSI CMA); 'To each his 8 h, each is responsible for his 8 h' (SSI CSE).

As a result, even if A and B disagree with how C, D and E monitor the combustion process, they do not express this openly or engage in open conflict or negotiation. This results in no sharing of knowledge with less-mindful counterparts:

'With them [C, D and E], work and handoffs are rotten! They do not inform on subtle things because they do not see them during their shift, or they think they [subtle things] are not important enough. This annoys us a lot. We are exasperated! But it stops there, we say nothing, we do not discuss, it's a pity' (SSI CMB).

Ultimately, A and B are prevented from engaging in the role of experienced mindful individuals responsible for the learning of less-mindful counterparts through dialogue during interactions. Artificial tasks independence constitutes a major barrier to learning from indirect experience.

Difficulty in assessing efficiency of routines

Operators in the C, D and E dyads and managers found it difficult to assess the efficiency of dyads A's and B's mindful way of working. The operators in dyads C, D and E recognised A and B as competent individuals and able to monitor the combustion process efficiently: 'Everyone in the department [including C, D and E] sees him [CMB] as a competent person, and so does the team A' (SSI CMF). If they were working at night or over a weekend and in the absence of instructions from the MM, they would routinely phone members of A or B at home to ask how they should resolve the problem, which indicates a sense of belonging to the same professional

community. However, C, D and E did not recognise the greater efficiency of A and B and their mindful way of working. CSC is emblematic of this difficulty. Whilst he stated repeatedly that 'members of B are good elements that work well … they often leave the kiln in very good condition, a kiln without major issues', he also thought that when discussing what he considered to be non-salient issues and alarms during handoffs, A and B were 'overzealous': 'they like to say lots of things, but it's because they like to show off' (IC CSC). He could not see any benefit from deferring to A and B and learning from their expertise. The resulting difficulty related to assessment of routine efficiency by less-mindful people prevented them from indirect learning from their mindful counterparts.

Managers found it difficult to evaluate the greater efficiency of A's and B's mindful way of working. MM recognised implicitly that A and B were more efficient than C, D and E. However, he often attributed this to management of technical failures: 'Some teams [C, D or E] leave significant potential technical failures to those who take over because they do not see the problem happening; at the opposite, some others [A and B] are able to detect and respond to a minor problem that could later have big consequences'. On A's and B's monitoring of the combustion process, his opinion was mixed. He believed that 'they sometimes make mistakes because they manage in their own way and take risks' (IC MM). For his part, the PM was aware that 'teams are not homogeneous in terms of outcomes; A and B are able to perform fine tunings and that is good', but he did not really understand why: 'I state that some are more competent than others but without really explaining the underlying reasons and explaining why' (IC PM). Only the MMA who is closer to the operational activities and worked previously as a CM was able to understand that mindful kiln monitoring was more efficient:

'Certain people [C, D and E] are less efficient than others according their ability to analyse and fine tune the kiln… others [A and B] are more effective in terms of fine tunings; they do not perform an abrupt kiln's driving which is good in terms of CO2 production, raw meal cooking and thus cement quality' (SSI MMA).

The problems involved in assessing and comparing the efficiency of routines are a major barrier to the transfer of mindful attention from A or B to C, D or E. Its link to outcome ambiguity promotes the emergence of superstitious learning.

Similar to other complex task environments, outcome ambiguity is significant and is related to two other factors that increase the emergence of superstitious learning, that is, causal ambiguity and delay between action and outcomes. First, the connections between actions and outcomes are mis-specified: 'Variables are not interrelated in one way, it depends on local circumstances' (II CSA). Second, causal ambiguity is reinforced by high temporal interdependence amongst actions over time:

'there is inertia in the system and the results of actions taken are not always immediate, so, what's going on at some particular point in time has an influence on what happens after, even hours or days later' (IC CMB). As a result, it is difficult to attribute particular outcomes to particular dyads and to assess which individual during which shift made accomplished specific kiln tunings: 'evaluation is difficult to operate … the effects of actions performed by a team often have to be managed by next teams several hours later, next teams have to manage what a previous has done or not upstream' (SSI PM).

The difficulty related to assessing efficiency of routines is especially severe for managers and linked to causal ambiguity and delays between actions and outcomes. It results in the persistence of the two following barriers: ambiguity in terms of the role of operational teams and artificial tasks independence. The persistence of these barriers indicates the occurrence of superstitious learning. Managers are unable to identify which work organisation (e.g., autonomous behaviours, task interdependences) is likely to favour mindful combustion process monitoring.

Difficulties related to assessing the efficiency of routines decreased during the period of analysis, which provided opportunities for individuals to reflect on their actions. Our findings and discussions with the PM caused him to explore 'why' A's and B's outcomes were in line with expectations about the complex combustion process. The PM told us: 'Your study opened my eyes. I now realize how so precisely different the kiln tuning practices are and why, and I begin to understand why A and B are more competent than other; I fully realize that everyone has to learn from their experience' (II PM). However, this was a small step, and the effect was confined to the PM. It did not raise awareness amongst the whole team or clarify and codify the 'why' more collectively, throughout the hierarchy. It did not promote organisational changes to support implementation of both mindful routines and learning from direct and indirect experience.

Inductive model: Barriers to the development of collective mindful attention in dynamic work settings

Our in-depth data analysis allows us to propose an inductive model of the barriers to learning from direct and indirect experience, and how their interaction becomes a barrier to the development of collective mindful attention.

The first barrier (Figure 1a) is ambiguity about the role of operational teams. In the case of managers, this is rooted in path-dependent centralised decision-making and hierarchical working and makes it difficult for all those involved to share and diffuse knowledge about what is expected from the operators. This reinforces the ambiguity experienced by the operators
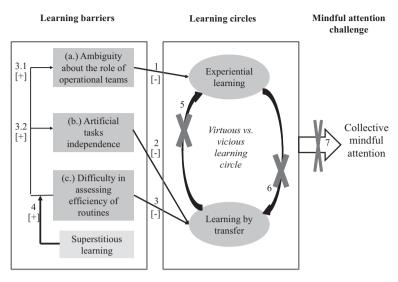
Figure 1. Inductive model: Barriers to the development of collective mindful attention in dynamic work settings.

about their role and the propensity for less-mindful operators to continue working in the same way. Less-mindful individuals are not encouraged to perform autonomous behaviour, improvise or engage in trial-and-error processes, and all of this prevents their learning from direct experience (sign [-] arrow 1).

The second barrier (Figure 1b) is artificial tasks independence. In a 24-7 runtime context, temporal modularity emerges and results in fragmentation of chronological work times. Temporal modularity then promotes artificial organisational fragmentation and makes it difficult for individuals to depart from the sovereignty shift team rule, as it is in cement plants. Artificial tasks independence emerged and handoffs failed to involve in-depth dialogue. This applied, especially, amongst individuals with different mental models. It resulted in the mindful operators being unable to embrace their role of experienced individuals responsible for sharing knowledge and mutual understanding. They were prevented from transferring their experience to their less-mindful counterparts even though all were members of the same professional community. This barrier was an obstacle to learning by transfer (sign [-] arrow 2).

The third barrier (Figure 1c) was difficulty related to assessing routine efficiency. Since less-mindful individuals were unable to recognise mindful ways of working as superior, they did not question their less-mindful ways of working or the assumptions underlying expectations about their task environment. Therefore, they saw no reason to learn from the experience of their mindful counterparts. This was a major obstacle to learning by transfer (sign [-] arrow 3).

In the case of managers, the difficulty in assessing the efficiency of routines did not allow them to change the organisational context, which reinforced barriers (a) and (b) (signs [+] arrows 3.1 & 3.2). In this case, outcome ambiguity, combined

with causal ambiguity and delay between actions and outcomes, generated superstitious learning, which explains managers' inability to change the organisational context. By highlighting the direct impact of superstitious learning on barriers (a) and (b) (sign [+] arrow 4), our model shows its significance for promoting learning barriers and transfer of mindful attention.

Our model identifies two learning circles in which experiential learning and learning by transfer are self-reinforcing (arrows 5 & 6). When learning barriers are moderate, as in the case of dyads A and B, this promotes a virtuous learning circle (arrows 5 & 6 not crossed out). Mindful individuals are able mindfully to process experience and to learn from experience; this expands the scope of their attention and allows sensemaking of complex signals; mindful attention increases with direct experience; during the in-depth dialogue in handoffs, experienced mindful interactants frame and reframe the processes of enquiring and sensemaking, which allows learning from others' experience and, in turn, increases mindful attention, and so on. High barriers to learning (dyads C, D and E) promote a vicious learning circle (arrows 5 & 6 crossed out). Less-mindful people do not learn from direct experience because they are unable to process it mindfully; they also do not learn from indirect experience of their mindful counterparts due to barriers (b) and (c), handoffs do not provide opportunities for increased mindfulness, and so on. This vicious learning circle hampers the development of collective mindful attention (arrow 7 crossed out). In the absence of interactions between the two types of learning (arrows 5 and 6 crossed out), the virtuous circle is blocked and is replaced by the vicious circle, which spreads over time and space. It prevents the achievement of collective mindful attention, including between A and B if the less-mindful C, D and E dyads take over between A's and B's shifts.

To break the vicious learning circle requires more distance from the ongoing operations, which involves reflection-on-action. We saw this beginning in the case of the PM. It allows a space for operators and managers to identify the most efficient ways of working (the how) and why they are efficient (the why). This allows a prominent learning barrier (c) to be demolished. Deliberate learning allows co-construction and formalisation of shared mental models related to the nature of the task and expectations about appropriate ways of working.

Discussion and conclusion

Our study highlights the complex interrelationships between learning from direct and indirect experience, and development of mindful attention. We identified three barriers to learning, which reveal the core role of superstitious learning. Our findings and our inductive model should be useful for managers and contribute to the theory.

Theoretical contributions

Our study responds to a recent call for further empirical investigation of qualities of attention in dynamic work settings and amongst individuals at operational levels (Dane, 2013; Sutcliffe et al., 2016; Ocasio et al., 2018). In these contexts, mindful attention must be collective (Curtis et al., 2017; Fraher et al., 2017; Rerup, 2005). We highlighted the need for a better understanding of the learning processes involved, in order to develop collective mindful attention (Levinthal & Rerup, 2021; Sutcliffe et al., 2016). We provide three main contributions to the literature on the relationship between mindful attention and learning.

Clarification of the recursive relationship between mindful attention and learning

The attention literature suggests that mindful attention is a dynamic process of co-creation amongst individuals (Fraher et al., 2017), promoted by both experiential learning (Dane, 2013, 2021; Hutzschenreuter et al., 2014; Rerup, 2005) and learning by transfer (Sutcliffe et al., 2016). It highlights the role of learning to increase mindful attention at the individual and collective levels. The learning literature emphasises that complex and dynamic environments require a mindful approach to processing experience (Hutzschenreuter et al., 2014; Levinthal & Rerup, 2021). These two conditions suggest a recursive relationship between mindful attention and learning: mindful attention is both a prerequisite and an outcome of learning. However, we need to know more about this recursive relationship (Levinthal & Rerup, 2021). Our study provides a finer-grained understanding of how it emerges and develops within a virtuous learning circle. It also demonstrates the importance of learning by transfer for this virtuous learning circle to be initiated.

The difficulty to achieve the relationship between mindful attention and learning in dynamic work settings

Our identification of a vicious learning circle adds to the literature in three ways. First, it shows that, whilst it is assumed that learning by transfer will occur through socialisation in dynamic work settings (Dane, 2021), transfer of tacit knowledge is not automatic even if the actors belong to the same professional community. This contrasts with the findings from previous empirical research on mindful attention (e.g., Fraher et al., 2017; Orvain, 2014; Østerlie et al., 2012). Second, it shows that mindful attention transfer is not obvious. It takes a different perspective from work that focuses on facilitators rather than barriers (e.g., Joseph & Ocasio, 2012; Levinthal & Rerup, 2006; Orvain, 2014; Østerlie et al., 2012; Vogus & Sutcliffe, 2012; Weick et al., 1999) and/or approaches learning by transfer as automatic and enabled by close work-related interactions in real-time, and exchanges of data based on lived experience (Krieger, 2005; Rerup, 2009; Vogus & Sutcliffe, 2012). Third, by identifying the difficulty involved in assessing the efficiency of routines as a major barrier that promotes a vicious learning circle, our study adds to the stream of work (Kane et al., 2005) that considers that the routines of a group perceived by others as superior facilitates learning from that group. In particular, our study stresses the central role of superstitious learning in preventing managers from understanding effective ways of working and adapting the organisational context to promote the development of mindful attention. This finding is consistent with the literature on learning in complex environments (Denrell et al., 2004; Levitt & March, 1988; Zollo, 2009). It also contributes to the attention literature, which, so far, neither emphasises nor anticipates superstitious learning and the difficulties this raises for increasing mindful attention. In the case studied, the inability of the entire hierarchy to assess mindful ways of working as superior (outcome ambiguity) promoted the emergence of superstitious learning, which prevented managers from breaking down artificial tasks independence, which was a major obstacle to learning by transfer. It prevented managers from acknowledging the superiority of experienced mindful individuals, which resulted in problems related to valuing the merits of improvisation and deference to expertise. Ambiguity about the role of operational teams subject to organisational path-dependency persists and acts as an organisational obstacle to experiential learning. By focusing on learning barriers and their relationships, we showed that deference to expertise was essential for the development of collective attention in a dynamic work setting (Joseph & Ocasio, 2012; Vogus & Sutcliffe, 2012; Weick et al., 1999), and how this could be biased by superstitious learning.

Increasing mindful attention in dynamic work settings: The role of deliberate learning

Our finding related to superstitious learning suggests that decreasing superstitious learning and increasing collective mindful attention in a dynamic work setting require deliberate learning. Zollo and Winter (2002) assumed conceptually that deliberate learning is useful for reducing superstitious learning and increasing mindful attention. Our empirical study demonstrates why deliberate learning is critical for reducing the direct and indirect impacts of superstitious learning on the development of mindful attention. Since managerial ambiguity, regarding both the role of operational teams and efficiency of routines, persists over time, our study suggests that in the absence of reflection-on-action, which induces deliberate learning (Jordan et al., 2009) from knowledge codification, efficient learning cannot take place. Our study, which constitutes a first step to codifying the 'how' and 'why' questions, helps to reduce these ambiguities.

We suggest that the role of managers needs more investigation. The previous literature considers managers to be facilitators, with the power to impose changes to organisational activities to foster learning (Hernes & Irgens, 2013) and to create the conditions for those lower down in the hierarchy, to engage in learning through interaction with others (Martínez-Córcoles & Vogus, 2020; Rerup, 2009; Vogus & Sutcliffe, 2012). A focus on reflection-on-action, through intentional and systematic efforts outside of ongoing operations (Jordan et al., 2009) considers managers to be stakeholders in a deliberate learning process. In contexts affected by ambiguity, interpretation of why a routine is efficient is impossible and will not capture the entire phenomenon. The reasons why routines are efficient involve multiple interpretations and shared meaning amongst a disparate collection of actors (Levinthal & Rerup, 2021). Co-creation of shared meaning requires close interaction amongst managers and operators, in a space that is distant from the ongoing activity. The manager role becomes one of initiator rather than facilitator, making managers a stakeholder in a deliberate learning process.

Practical implications

In dynamic work settings, managers are expected to create the conditions to allow those individuals at lower hierarchical levels to manage real situations in the here and now, that is, to be mindful. In the case of 24-7 runtime contexts, two major actions are needed. First, handoffs must become spaces for socialisation and knowledge sharing. This implies deviation from the tacit rule of shift sovereignty and the need to train people how to monitor complex processes. Second, managers must be able to implement deliberate learning, based on reflection-on-action, in order to codify the 'how', that is,

how to perform attention in line with the expectations of the task environment, and the 'why', that is, why some ways of performing attention are superior for meeting these expectations.

Limitations and directions for future research

Our use of a single case study limits the generalisability of our findings to other contexts (Einsenhardt & Graebner, 2007). Future work should extend our inductive model to other environments for an analytical generalisation through reproduction and/or refinement (Tsoukas, 1989). It is possible that the relationship between mindful attention and learning processes might vary amongst firms with different characteristics and in different settings. We studied the particular context of a cement plant, which, though distinct, we consider, is representative of other dynamic settings that require mindful attention (e.g., petroleum production, nuclear power facilities and steel production). Cement manufacture is a well-established industry that has had to cope with rapid technical evolutions, which have increased the complexity of the combustion process. Few of the individuals involved, including managers, have been able to fully assess and internalise the impact of these fast changes on the overall complexity of the manufacturing process or to identify the consequences of this complexity and the effect on manufacturing process monitoring, work and team management, organisational tools (e.g., handoffs) and organisational practices (e.g., HR practices such as training, information technology implementation and design).

Two other limitations of our work suggest new research questions. First, our emphasis on the usefulness of deliberate learning calls for some redefinition of the manager's role in promoting learning processes. However, this contrasts with what Hernes and Irgens (2013) suggest and needs further investigation. Second, when attention depends on the use of digital artefacts, we need to understand how these artefacts affect virtuous or vicious learning circles. Few empirical studies identify artefacts and their role of facilitators of learning (e.g., Orvain, 2014; Østerlie et al., 2012). Future work might consider artefacts in terms of barriers.

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