Deming's tampering revisited: definition and future research agenda

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Abstract

Purpose – How do organisations know which problems are worthy of their attention? Despite good intentions, many attempts to solve problems fail. One reason for this failure might be because of attempts to solve non-problems or to solve problems with insufficient means, a concept proposed by Deming as tampering. The purpose of this paper is to suggest a definition of tampering, outline what is currently known about possible practical implications of tampering and to suggest how to extend this knowledge by proposing an agenda for future research.

Design/methodology/approach – To fulfil the purpose, a narrative literature review was conducted.

Findings – Through this review, common aspects of what constitutes tampering are identified and the following definition is proposed: Tampering is a response to a perceived problem in the form of an action that is not directed at the fundamental cause of the problem, which leads to a deterioration of the process or the process output. In addition, recommendations are generated regarding how tampering manifests itself in practice and why tampering occurs. These recommendations could be studied in future research.

Originality/value – To the best of the authors' knowledge, this is the first paper that suggests a revitalisation of tampering. The results presented in this paper form the basis for continued studies on how tampering in organisations can be understood, managed and prevented.

Keywords Behaviour, Quality management, Literature review, Variation, Problem-solving and decision-making

Paper type Literature review

1. Introduction

Despite dedicated efforts from organisations to make process improvements, scholars continuously report about failed initiatives (McLean *et al.*, 2017; Antony and Gupta, 2019), actions not resulting in improvements and, in worst case, actions having negative impact on a process (Van Gestel *et al.*, 2015; Georgantzas, 2018). One possible reason for these undesirable results is difficulties in identifying the major root cause problems (Sunder and Prashar, 2020). Digitisation has, on the one hand, facilitated problem identification through increased access to data and customer feedback; on the other hand, the increased communication with customers has increased customers' expectations of having their specific troubles addressed very quickly (Birch-Jensen *et al.*, 2020). At a time when the

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pressure is higher than ever on organisations to respond to perceived problems, how do they know which problems are worthy of their attention?

In identifying problems, there is a need to understand whether changes in, for example, customer satisfaction (Söderlund and Julander, 2003), service quality (Roy and Mukherjee, 2018) or service failures (Tseng, 2021) are indicative that something is wrong in the process and thus needs improvement. It has been suggested that some "problems" are mere misinterpretations of deviations from a desired performance due to failure to consider the presence of *variation* (Shewhart, 1931; Deming, 1989). Deming (1993, p. 68) refers to actions taken to improve organisations without considering the presence of variation, as *tampering*. Lack of considering whether a problem is a real problem, a signal or just noise has led to solving "non-problems" and time wasted to look for non-existent root causes (Ericson Öberg *et al.*, 2017). Compared to some of Deming's other concepts as the Plan-Do-Study-Act cycle that have been studied and adapted to contemporary organisations and contexts, tampering has received scarce attention. The author of this paper argues that tampering is useful to understand why some improvement efforts do not lead to desired results.

To consider the presence of variation implies to distinguish between variations that are either due to causes that are a natural part of a system, *common causes*, or due to *special causes* that do not belong to a system (Shewhart, 1931). Misinterpretation of these may lead to overreactions or under-reactions. An overreaction could be to view any unwanted deviation as a signal and attribute it to a special cause (*type I error*), for instance, by acknowledging that service failures are common in e-commerce but still attribute failures to be due to special causes and put effort into rectifying each individual failure (Tseng, 2021). An under-reaction could be to miss signals of changes in a process or perceive that a signal is a part of the systems natural behaviour when it is not (*type II error*). An example of this is not to acknowledge and respond to signals of unanticipated and undesirable increases in waiting times in one part of the health-care system that can be attributed to changes made to improve care in another part of the system (Smeds and Poksinska, 2019). Such errors form the basis of tampering, and understanding how they affect organisations can explain why improvement efforts sometimes fail as well as provide guidance on how tampering can be prevented.

The paper's contribution is twofold. First, to suggest an alternative view of tampering with less focus on statistical aspects. In the literature, tampering is predominantly addressed with a statistical focus by developing or applying control charts used to reduce variation (Gitlow *et al.*, 1992). However, some researchers emphasise a need to broaden the view of variation beyond focusing on statistical tools and instead to identify its practical impact on organisations and process improvement (Snee, 1990; Hanna *et al.*, 2020). This paper seeks to go beyond the traditional view by adapting the concept of tampering to contexts where statistics is not typically applied. Second, the paper contributes with illustrations of tampering and its effects in a contemporary context. The extent of tampering in organisations is unknown, and there is little empirical research on tampering and its practical implications. The purpose of this paper is to suggest a contemporary definition of tampering, to outline what is currently known about the practical implications of tampering and to suggest how to extend this knowledge by proposing an agenda for future research. Deming's (1993, p. 94) system of profound knowledge (SPK) is used as a framework to categorise and outline the findings.

This paper starts with a theoretical background (see Chapter 2) followed by a description of the method (see Chapter 3). The findings and analysis (see Chapter 4) outlines different definitions of tampering and research on tampering. The final chapter (see Chapter 5) highlights a definition of tampering and suggests a future research agenda.

2. Theoretical background

2.1 Tampering in a contemporary context

Over the years, there has been continuous development of the meaning of quality (Martin *et al.*, 2020), and a lot has happened within the quality management (QM) field since the concept of tampering was first coined. This paper argues that the underlying idea of tampering, i.e. to use knowledge about variation to identify and respond to problems, is still relevant. However, for the concept to be more applicable in a time characterised by other values than when the concept was originally developed, a revitalisation is needed. In this section, two central developments in the quality field are outlined.

First, the contexts in which quality is studied have changed and along with it the understanding of process variation. At the time when the concept of tampering was coined, efforts were directed towards manufacturing of a small variety of products, and quality was mainly considered as conformance to specification achieved through reduction of variation and standardisation of processes (Shewhart, 1931). The original conceptualisation of tampering, which still dominates our understanding, is closely related to this view and is continuously explained through Deming's funnel experiment, a popular teaching tool used to show the effects of tampering. Since, new contexts such as service production and management (Martin *et al.*, 2020) and focus on customer and societal benefits (Siva *et al.*, 2016) have influenced the quality field. Compared to the dynamic environment in many contemporary organisations, the funnel experiment, the dominant manifestation of tampering, provides a static view of a system and describes tampering actions in terms of statistical feedback rules. This view may be relatable in some contexts, such as highly standardised manufacturing processes, yet it has limited practical application in some contemporary contexts sush as in services.

The view of quality as a concept that advocates the importance of reducing variation is still valid today; however, it is no longer the only or even most important requirement to achieve high quality (McLaughlin, 1996). An increased focus on the customer has highlighted the importance of subjective quality (Martin *et al.*, 2020), customer focus, flexibility, heterogeneity and customisation (Yang *et al.*, 2015). Variation is no longer mainly viewed as negative but something that is included in the process design and is to some extent accepted. What is an acceptable level of variation depends on the process and context. It has been suggested that variations may be greater and the tolerance for deviations higher in sectors where individual assessments form the basis for various decisions, such as in health care, banking and insurance (Kahneman *et al.*, 2016). For example, health care is still largely a "craft industry" with large variations in both execution and outcome (Morton *et al.*, 2010). Although there are ambitions to reduce variations in many sectors, an understanding about the effects of tampering could further drive the ambitions to clarify what level of variation is acceptable and when improvement is necessary.

Second, the use and understanding of statistical methods has changed. Control charts are suggested as the primary tool used to identify special causes (Shewhart, 1931). Despite that they are praised by experts for their wide application (MacCarthy and Wasusri, 2002), effectiveness and simplicity to understand and adopt, their use is still limited (Grigg and Walls, 2007; Halim Lim *et al.*, 2017; Lundkvist *et al.*, 2020) especially in the service sector (Lundkvist *et al.*, 2020). Evidence points to multiple challenges and complications that arise when applying control charts both inside and outside of conventional applications such as need of statistical knowledge, demands on underlying process conditions and variable selection (MacCarthy and Wasusri, 2002; Van Gestel *et al.*, 2015). Moreover, the high level of variation in many service processes makes it difficult to isolate individual quality characteristics to measure and follow-up in a meaningful way (Ojasalo, 2019).

The next section describes the SPK that constitutes the perspective that is later used to structure the reviewed literature.

2.2 Deming's system of profound knowledge

The SPK is described as a lens through which changes faced in organisations and operations can be understood and improved and consists of four mutually interdependent and interacting parts: *appreciation for a system*, *knowledge about variation*, *theory of knowledge* and *knowledge of psychology* (Deming, 1993, pp. 94–118). The SPK has previously been recognised for its usefulness in providing a holistic view of the system (Gitlow, 1994) from a broad spectrum of disciplines that highlight different domains in management studies (Gartner and Naughton, 1988).

Traditionally, the tampering concept has a strong focus on knowledge about variation. The SPK compliments the focus on variation with the aspects psychology, system thinking and knowledge, aspects that could help inform the tampering concept by shifting focus from being mainly statistical to also include softer values such as having a holistic mindset and acknowledge the individuals acting in the system. In this paper, each of the four parts of the SPK represents a different perspective and acts as a category for structuring current research on how tampering manifests in organisations and its practical implications. In the following paragraphs, the concepts in the SPK are further described.

2.2.1 Knowledge about variation. Variation is the result of everything and everyone involved in any system (Shewhart, 1931). "Everything and everyone" was, especially in Japan, made understandable by using the "4M Fish-Bone cause-effect diagram" where the 4M was the name of the main causes of variation: Men, Methods, Machines and Materials. The emphasis on *knowledge of variation* arose from observations of managers' insufficient understanding of data, trends and true levels of performance, which ultimately leads to bad outcomes (Shewhart, 1931). Knowledge about variation enables managers to make fact-based decisions by appropriately identifying, interpreting and reacting to variation encountered in figures, performance and output (Joiner and Gaudard, 1990).

2.2.2 Theory of knowledge. Theory of knowledge emphasises the importance of using theory from which to draw meaningful conclusions about a system and building knowledge to be used for learning. Deming (1993) stresses the need for outspoken theories to be used to predict the outcome of actions, and for comparing the actual outcome with the prediction. Consequently, agreement between predictions and outcomes either verifies or refutes the theory, and the new knowledge gained calls for revision or extension of the theory, or abandoning it for novel theories (Deming, 1993).

2.2.3 Appreciation for a system. Deming (1993) describes a system as a network of multiple interdependent parts striving to achieve a shared aim. To understand how organisations operate, there is a need to look at a process from start to end and understand the interdependencies, interactions and integrations between its constituent parts. Due to the interdependencies, there is a need to consider how changes made in one part of the system will affect other parts (Deming, 1993). Further, value should be understood from a customer perspective, and where there is a variety in demand, there is a need to acknowledge and manage this demand.

2.2.4 Knowledge of psychology. Knowledge of psychology emphasises an understanding of individuals' behaviour, their interactions with the system, their interactions with each other and their motivations (Deming, 1993). The importance of behaviour guided by internal achievements – intrinsic motivation as opposed to extrinsic – and empowerment is emphasised in particular.

3. Method

Based on the above outlined purpose, this paper is based on a literature review that aims for a conceptual contribution in terms of revising and suggesting an alternative view (MacInnis, 2011) of the tampering concept as well as suggesting a future research agenda. In broad terms, a literature review can be described as a method for collecting and synthesising previous research (Tranfield *et al.*, 2003) and is useful for advancing knowledge (Webster and Watson, 2002) and uncovering areas in need of further study (Snyder, 2019). This literature review followed the four phases described by Snyder (2019): designing the review, conducting the review, analysis and writing the review.

Following the steps in the design phase (Snyder, 2019), a narrative literature review was chosen due to its usefulness when outlining the current state of knowledge and establishing a future research agenda (Tranfield *et al.*, 2003; Snyder, 2019). For a topic with scarce research on a specific term, this review process is suitable as it allows for a more open search, which matches the conceptual aim. This study does not aim for a comprehensive review, but for a representative selection sufficient to demonstrate the tampering concept (Wong *et al.*, 2013). If the conceptual aim would be to provide a complete overview of an area, a systematic literature review would have been more feasible (Tranfield *et al.*, 2003).

The literature search was conducted in two steps. First, a search was conducted in the Scopus database that was selected due to its broad coverage of academic disciplines and global outreach. The search terms used were: "Deming* funnel", "funnel experiment", "Nelson* funnel", overadjust*, overcontrol* and tamper*. The inclusion criterion was papers that in some way were related to tampering as described by Deming or highlighted process variation in terms of challenges of practice variation or customer variation as well as practice failure related to variation. Another inclusion criterion was peer-reviewed articles written in English. Papers on, for example, digital tampering, fraud, manipulation of, e.g. food, other types of funnel experiments, papers merely outlining the concept of the funnel experiment or variations thereof and statistical applications of the funnel's feedback rules were excluded.

Second, a directed search was conducted. This search strategy was chosen when using predefined specific keywords failed to capture the tampering concept and searches using broader keywords resulted in samples deemed too extensive to analyse within the scope of the study. One reason for the difficulties in finding suitable articles using keywords may be that relevant concepts are not always listed as keywords (Dereli *et al.*, 2011). Instead of using keywords, a search strategy previously applied in reviews of quality literature was used (Dereli *et al.*, 2011; Carnerud, 2018; Wawak *et al.*, 2020), namely, to scan journals dedicated to QM. Selection criteria for the journals were peer-reviewed articles, with a broad scope of QM research covering a wide selection of contexts. The journals *International Journal of Quality and Service Science* (IJQSS) and *Total Quality Management and Business Excellence* (TQM-BE) were judged to provide a fair representation of literature in the field of QM. Because the IJQSS dates back to 2009, both journals were scanned through the years 2009–2021. To ensure that no obviously related articles were missed, a directed search on the terms tamper*, overcontrol*, overadjust* varia*, fail and error was conducted for all volumes in TQM-BE (from 1990 to 2021). The inclusion criteria were the same as in earlier stages.

In the conduct phase, the review was carried out (Snyder, 2019). The final selection consisted of 30 articles. An overview of the selection process can be seen in Figure 1 and an overview of the selected articles in Table 1.

In the analysis phase, the analysis method was selected, and the analysis was conducted (Snyder, 2019). In this study, the analysis was a qualitative thematic analysis. The thematic analysis was carried out in two steps. First, all the selected articles were read through to

conceptualise the central learnings of each paper. Research topics such as causes of variation, behavioural aspects and examples of tampering were compiled in an Excel spreadsheet. Next, the learnings were categorised and synthesised in accordance with the concepts in the SPK. The writing phase (Snyder, 2019) is the result of this method section. The results and analysis following this review are presented in the following sections.

4. Findings and analysis

4.1 Tampering – a brief overview

Many scholars have conceptually repeated Deming's view of tampering and have provided anecdotal examples (Latzko, 1989; Joiner and Gaudard, 1990; Davis, 2000). Articles in the review presenting practical implications of tampering focus on manufacturing (Van Gestel *et al.*, 2015; Georgantzas, 2018; Davis, 2000), business and economics (Roberts, 1990), education (Coleman, 1999), forest management (Bednar and Shainsky, 1996), health care (Schiff, 1994; Fisher and Welch, 1999; Deyo, 2002; Morton *et al.*, 2010; Smeds and Poksinska, 2019), public sector (Gerst, 1995) and service sector (Gal *et al.*, 2021). More specifically, the articles link tampering to the fields of health-care policy (Gerst, 1995), knowledge management (Van Gestel *et al.*, 2015), product development (Blumstein, 1995), decision-making (Latzko, 1989; Roberts, 1990), system dynamics (Georgantzas, 2018) and quality assessment programmes (Davis, 2000).

Not seldom, scholars express examples of tampering in terms of the rules applied in Deming's funnel experiment (e.g. Davis, 2000; Kwon and Woo, 2018). However, these examples are often anecdotal and not supported by empirical data or cases (e.g. Davis, 2000). The setting for the funnel experiment is traditionally used in engineering (Blumstein, 1995); other applications are in teacher education (Coleman, 1999) and in business education (Kwon and Woo, 2018).

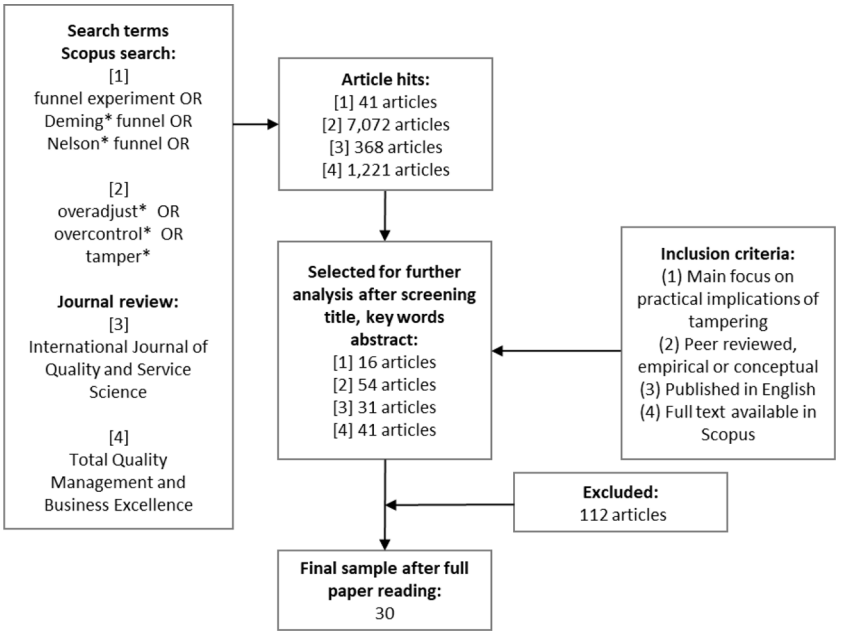

Figure 1.
Overview of paper selection process

This overview shows that tampering has been disseminated into multiple contexts and fields of study. The next section presents different meanings of tampering. Based on this, a modified contemporary definition is proposed at the end of this paper.

4.2 Different meanings of tampering

In Deming's earlier writings, the term "over-adjustment" is used (Deming, 1982, 1989); however, this term is substituted for "tampering" in later writings (Deming, 1993). This study shows that both terms are still frequently used. A proposed synonym is overcontrol (Kwon and Woo, 2018). Even though tampering has been discussed for decades, no clear definition has yet been established. Descriptions provided by Deming are:

In Deming (1982, p. 125):

- *Over-adjustment [. . .] The operator tests a few items now and then, and adjusts his machine on the basis of ups and downs.*

In Deming (1989, p. 318):

- *Overadjustment is a common example of mistake No. 1.*

Main topic	Author (year)	Author (year)
Scopus search		
	Keywords: funnel experiment or Nelson funnel or Deming* funnel*	*Keywords: tamper* or overadjust* or overcontrol**
Behavioural aspects	Coleman (1999)	Stepanovich (2004)
Learning/statistical thinking	Blumstein (1995), Kwon and Woo (2018)	Roberts (1990)
Conceptual paper on variation/statistical thinking	–	Latzko (1989), Joiner and Gaudard (1990); Bednar and Shainsky (1996), Davis (2000)
Examples in health care	–	Schiff (1994), Gerst (1995); Fisher and Welch (1999), Deyo (2002); Morton (2010)
Examples in manufacturing	–	Van Gestel *et al.* (2015), Georgantzas (2018)
Journal review		
	Total Quality Management and Business Excellence journal	*International Journal of Quality and Service Science*
Causes of service failures	Chiu *et al.* (2020), Koc *et al.* (2017)	Tseng (2021)
Causes of variation	Soltani *et al.* (2004)*; Söderlund and Julander (2003)*; Yang *et al.* (2015)	Smeds and Poksinska (2019), Gal *et al.* (2021)
Statistical thinking/ organisational learning	Grigg and Walls (2007)*; Tort-Martorell (2011), Kobo Greenhut *et al.* (2017); Halim Lim *et al.* (2017), Luo and Lee (2015)	–
Variation in service quality	–	Ojasalo (2019)

Note: References marked with an * were identified when searching for articles in the *Total Quality Management and Business Excellence* journal published between the years 1990 and 2008

Table 1. Overview of included articles

In Deming (1993):

- *[. . .] an example of tampering (Ch. 9) – action on the system without action on the fundamental cause of the trouble* (p. 68).
- *[. . .] tampering (Ch. 2) – management by results* (p. 194).
- *To take action on the process in response to production of a faulty item or a mistake is to tamper with the process* (p. 204).
- *Gadgets that hold product to specification are only tampering* (p. 205).
- *In the experiment with the Red Beads, were we to halt the line and try to discover what happened on appearance of some high or low number of Red Beads, we would be tampering* (p. 205).

The ambiguity surrounding the definition has led researchers to interpret the concept differently. Some authors view it as a type of *cause* (Joiner and Gaudard, 1990) or a type of *variation* (Davis, 2000); however, these descriptions seem to be uncommon. The majority of the reviewed literature refers to tampering as unnecessary *actions* taken to respond to variation. Some examples are as follows:

- reacting to common cause variation as if it was special cause variation (Fisher and Welch, 1999);
- adjusting a stable system (Stepanovich, 2004), or process in which only common cause variation occurs (Davis, 2000), or a process while it is still within control limits (Van Gestel *et al.*, 2015); or
- actions taken to improve errors despite no knowledge of the cause of the errors (Kwon and Woo, 2018).

Apart from the differences, a shared view is that tampering results in a worse output than if the process was left alone, which is in line with both Deming (1993) and Merriam Webster's Dictionary, which defines tampering as "to interfere so as to weaken or change for the worse" (Merriam-Webster's Dictionary, Tampering).

4.3 Tampering and the system of profound knowledge

In the following sections, current research on tampering identified in the reviewed literature will be structured according to the four parts in the SPK. At the end of each section, recommendations are formulated that constitute the basis for a future research agenda.

4.3.1 Tampering and knowledge about variation. In the literature, the view of tampering is strongly associated with responses to variation in manufacturing processes such as overreactions to small shifts in performance (common cause variation) through, for example, unnecessary adjustment to machine settings (Van Gestel *et al.*, 2015; Georgantzas, 2018). Similar examples occur in health care in terms of making unnecessary adjustments to medicine dosage whenever there is a change in a parameter (Schiff, 1994; Fisher and Welch, 1999) and unnecessary changes in operative routines because of sporadic adverse outcomes of treatment (Morton *et al.*, 2010). Overreactions to special causes, on the other hand, occur when atypical patient cases or suboptimal outcomes of a treatment in one case act as a guide for treating other cases (Schiff, 1994). An example in service is service providers' response to different customer behaviours, which if unsuccessful may lead to service disruptions or even service failure (Gal *et al.*, 2021). Deyo (2002) calls the chain of unnecessary activities following such overreaction a cascade effect. The author further states that such chains of activities create unnecessary suffering for patients and high costs for a system. Another

reported consequence of tampering is decreased end-product quality (Van Gestel *et al.*, 2015; Georgantzas, 2018).

To gain knowledge about process variation, there is a need to understand how a process varies over time, short- and long-term (Ojasalo, 2019), and what causes this variation (Yang *et al.*, 2015). Roy and Mukherjee (2018) state that traditional service research focuses too much on customers' experience of the finished service process and suggest that more knowledge about variation could be gained by studying intermediate stages, peak experiences as well as end experience. Some suggested causes of variation in service are factors belonging to the customer, such as preferences, expectations and level of cooperation with a service provider, as well as factors belonging to the service provider, such as knowledge, method and efforts (Söderlund and Julander, 2003; Yang *et al.*, 2015). From a customer's view, service failure is a consequence of an unsatisfactorily performed service process. Research on this topic focuses on how customers perceive and react to service failures (Koc *et al.*, 2017), recovery strategies and the handling of complaints (Tseng, 2021) as well as causes of service failure (Chiu *et al.*, 2020). Rectifying service failures seems to be a common advice (e.g. Söderlund and Julander, 2003; Tseng, 2021). However, problems and errors occur in all processes; to take ownership of any problem perceived by the customer, even those that the organisation is not accountable for risk leading to tampering.

Recommendation 1: Empirical examples of tampering from a wide range of contexts such as the service and public sector are needed to further understand how the concept of variation and tampering differs between contexts and to be able to conceptualise and further develop the tampering concept.

4.3.2 Tampering and a theory of knowledge. QM advocates that decisions should be based on facts and that organisations should strive to improve by learning from past experience (Tort-Martorell *et al.*, 2011). Roberts (1990) argues that basic statistical reasoning is necessary because of the many informal statistical applications encountered in contemporary organisations. Statistical thinking is a mindset emphasising that application of a holistic view of a system and its processes and understanding variation are the keys to making relevant decisions (Roberts, 1990; Grigg and Walls, 2007; Halim Lim *et al.*, 2017). However, the literature indicates that this mindset is not widely applied (Roberts, 1990; Grigg and Walls, 2007; Halim Lim *et al.*, 2017).

Grigg and Walls (2007) relate statistical thinking to organisational learning and propose that the level of learning (i.e. loops of learning) depends on the action taken based on the knowledge gained (Grigg and Walls, 2007). Zero learning and single-loop learning are both relevant in regard to tampering, as zero learning implies that problems remain unidentified or that no action is taken to address a problem, and single-loop learning implies identifying a problem and correcting it without tackling its underlying causes (Grigg and Walls, 2007). Sometimes, deciding on an appropriate action is difficult given the present knowledge. If, in the light of new knowledge, an obvious gap between the expected and the actual results is observed, there is a need to search for or change to an alternative action (Kobo Greenhut *et al.*, 2017). If no efforts are made to change action or efforts are conducted too late, undesirable results are unescapable, a phenomenon called *frozen action mode* (Kobo Greenhut *et al.*, 2017). Pursuing double-loop learning, i.e. changing a process to eliminate the fundamental causes or preventing its recurrence, or triple-loop learning, i.e. radically changing a process, may thus facilitate improvement and hamper tampering. Retrospective study of failures is widely used to gain additional knowledge to be used for learning and improvement (Luo and Lee, 2015; Koc *et al.*, 2017; Chiu *et al.*, 2020; Tseng, 2021).

Recommendation 2: Study whether applying a statistical thinking mindset decreases the risk of making decisions leading to tampering.

Recommendation 3: Study whether the use of single-loop learning processes or zero learning processes promotes tampering and whether double- or triple-loop learning prevents tampering.

4.3.3 Tampering and appreciation for a system. It is a widely accepted view that system factors (common causes) account for most of the variation in a process and that such causes are difficult to distinguish (Shewhart, 1931). Difficulty of grasping these factors may explain why individuals overestimate their understanding of (Van Gestel *et al.*, 2015) and oversimplify the complexity of a system (Coleman, 1999; Georgantzas, 2018), which leads to tampering. When comparing operators with more experience with novice operators with less experience, Van Gestel *et al.* (2015) discovered that the novice operators were making complex, and as it turned out incorrect, analyses by analysing variables that were irrelevant for achieving high end-product quality (Van Gestel *et al.*, 2015). The novices were misled by their intuition about the system and their decisions made operations less efficient compared with their senior colleagues. Georgantzas (2018) reports that oversimplification caused management to pursue a special cause action to a common cause problem, which further decreased end-product quality. Smeds and Poksinska (2019) report about a nationally introduced large-scale health-care improvement that achieved its aim to decrease waiting times for one patient group, but at the unintended expense of the quality and waiting times of other groups.

Soltani *et al.* (2004) question the emphasis on system factors as the main source of variation in organisations and raise the question of individuals' role as a source of variation. The same authors propose that even though individual's actions cannot be separated from the system, many have discretion and authority to act in and affect a system (Soltani *et al.*, 2004). In manufacturing, it has been suggested that individuals executing a process should not be blamed for its faults and that the system should be held accountable for as much as 96% of problems (Deming, 1993). These figures are unconfirmed for other contexts, but it is likely that they are not the same for contexts such as service or public sectors where process variations generally are higher. Service performance depends on the personal involvement of service providers and, thus, it is likely that causes of variation to a higher extent stem from factors associated with individuals in such contexts. For example, a recent study by Chiu *et al.* (2020) shows that human error caused the majority of medical service failures in a hospital.

Recommendation 4: Study whether tampering is promoted by different types of system structures and, if so, which system factors counteract or promote tampering.

4.3.4 Tampering and knowledge of psychology. It is widely agreed that interpretations and decisions should be based on facts and data rather than intuition (Van Gestel *et al.*, 2015; Georgantzas, 2018; Tort-Martorell *et al.*, 2011). Nevertheless, research shows that individuals who have access to the same information respond differently because they weigh the information differently (Van Gestel *et al.*, 2015). To be able to improve individuals' ability to make "correct" interpretations and thereby reduce the occurrence of tampering, an understanding of the mechanisms behind these flawed interpretations is needed. In literature, some suggestions are given for which motives and behaviours cause tampering.

One suggested mechanism is failed logical reasoning (cognitive bias) (Coleman, 1999; Stepanovich, 2004), i.e. systematic errors in judgement due to limitations in human cognition. One example is availability bias, where judgements rely on examples that are top of mind, as illustrated by physicians giving undue weight to experiences of recent patients (Schiff, 1994). Further, Coleman (1999) highlights that understanding variation, or randomness, does not seem to be intuitive and that some even regard "randomness" as unrealistic. Some authors suggest that lack of understanding of randomness may explain

why individuals believe that they can figure out "the pattern" in random data (Coleman, 1999; Van Gestel *et al.*, 2015) or that every shift above or below a target value is a signal (Georgantzas, 2018).

From another perspective, Van Gestel *et al.* (2015) suggest a motivating factor where novice operators tended to make more comfortable and unintentionally faulty decisions to be able to return to the more "comfortable environment of the control room" as quickly as possible.

Another suggested mechanism stems from external pressure. Georgantzas (2018) suggests that a perceived pressure triggers a behaviour in management of acting without having the time, knowledge or resources to do so, also known as muddling through. Further, for first-line workers, the pressure to act is suggested to come from an obligation to follow routines established by management. In addition to the mechanisms presented here, a lack of systems understanding, highlighted in a previous paragraph, may be another mechanism.

Recommendation 5: Study of internal and external mechanisms that influence individuals' interpretation leading to tampering.

5. Conclusions and future research agenda

So far, this paper has outlined how tampering is manifested in and its implications for organisations. In addition, recommendations have been given as to what is in further need of studying. In this last chapter, a definition of tampering is proposed and an agenda for future research is presented.

5.1 Proposing a contemporary definition of tampering

In this paper, variation in the terminology and definition of tampering was elucidated. In line with this paper's intention to revitalise the tampering concept, a definition is needed that is viable in a variety of contemporary contexts. The reviewed literature implies that the term tampering is a suitable concept as it, to some extent, has disseminated to multiple research fields. The advantages of using this term compared to, for example, overcontrol are the distance of the term from the topic of quality control and the distinctiveness from other management concepts such as statistical control and excessive management control.

Based on the present study, the author of this paper expects that tampering may be widespread in organisations, even if the term itself is not commonly used. The identified disagreement on and the different interpretations of the term suggest that there is a need for a single, common definition to form a common ground upon which managers and researchers can build. The aim is not to reinvent the wheel by developing a new definition but instead to revitalise and highlight a description that is more useful and relevant but perhaps not as widespread or well-used. The proposed definition is based on the description of tampering as "action on the system without action on the fundamental cause of the trouble" (Deming, 1993, p. 68). By clarifying that tampering is a response to a problem and adding the missing aspect about tampering leading to process deterioration, a proposed contemporary definition of tampering is:

> *A response to a perceived problem in the form of an action that is not directed at the fundamental cause of the problem, which leads to a deterioration of the process or the process output.*

The arguments of why this definition is more suitable than other descriptions are, firstly, that it adheres to the criticism raised against the concept (Van Gestel *et al.*, 2015; Hanna *et al.*, 2020). Secondly, it is easy to comprehend because it is written in an everyday language without terms such as stable process and special and common cause variation that require clarification or knowledge in statistical process control. Thirdly, it moves away from the

statistical and mathematical aspects and thus the need to quantify the problem. Thus, it opens up to new interpretations and applications as well as use of other, both qualitative and quantitative, methods. Fourth, this definition is not limited to describing tampering examples such as management by results, which makes it approachable in a wider range of situations and contexts such as in service operations and service management. This definition and the previously presented recommendations constitute the basis for the proposed future research agenda outlined in the next section.

5.2 Suggestions of a future research agenda

In this last section, a future research agenda is proposed based on the previously presented recommendations.

First, it is important to further explore when tampering occurs and how it manifests itself in practice, with the proposed definition in mind. With more tampering examples, new insights could be gained into specific situations where problem identification and rectification fail in organisations. In particular, it would be interesting to study contexts with high variation and contexts where statistical reasoning is not traditionally applied, such as service.

Second, comparative studies of similarities and differences between different contexts such as service and manufacturing or service and public sector could further deepen knowledge about how tampering manifests itself in a specific context and could provide opportunities for shared learning. In addition, different systems should be studied to gain knowledge on whether certain systems or system factors promote or counteract tampering.

Third, applying a statistical thinking mindset has been suggested as useful to be able to consider the presence of variation in daily work. The question is whether use of this mindset decreases the risk of making decisions leading to tampering. Studying the decisions made that are guided by this mindset could provide valuable insight to its suitability for problem-solving.

Fourth, organisations have different approaches to problem-solving and learning. The loops of learning constitute an interesting framework for studying whether any of the loops promote or prevent tampering.

Given the key role that individuals play in situations that result in tampering, studying their motivations and behaviours is highly relevant for understanding why tampering occurs and how it can be prevented. Fifthly, it would be interesting to study internal and external mechanisms that influence individuals' problem identification and rectification leading to tampering, such as those suggested in the reviewed literature: action based on incomplete understanding of the system, judgements based on cognitive bias, comfort and organisational factors.

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