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Opportunity, motivation and ability to learn from failures and errors: Review, synthesis, and the way forward.

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3 **Opportunity, motivation and ability to learn from failures and errors:**
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5 **Review, synthesis and ways to move forward**
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9
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11

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13
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23
24

25
26 **Abstract**
27

28 While organizations and individuals tend to focus on learning from success, research has
29 shown that failure can yield crucial insights in various contexts that range from small
30 mistakes and errors, product recalls, accidents, and medical errors, to large-scale disasters.
31 This review of the literature identifies three mechanisms—opportunity, motivation, and
32 ability—through which individuals, groups and organizations learn from failure, and it
33 bridges the gaps between different levels of analysis. Opportunity to learn from failure mostly
34 takes the shape of more information about errors and failures that are generated by one's own
35 and others' prior failures or near-failures. Motivation to learn from failure is hindered by
36 punitive leaders and organizations. Finally, ability to learn from failure partly relies on
37 inherent attitudes and characteristics; but can be further developed through thoughtful
38 analysis and transfers of successful routines. Our review leads us to distinguish between
39 erroneous versus correct processes and adverse versus successful outcomes to better
40 understand the full gamut of events that are faced by organizations. We identify the existence
41 of noisy learning environment, where spurious successes (when erroneous processes still lead
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3 to successful outcomes) and spurious failures (when correct processes are combined with
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5 adverse outcomes) lower the opportunity to learn. Considering noisy learning situations is
6
7 helpful when understanding the differences between slow- and fast-learning environments.
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9 We conclude our review by identifying a number of unexplored areas we hope scholars will
10
11 address to better our understanding of failure learning.
12

13 14 INTRODUCTION

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16
17 *Sometimes we may learn more from a man's errors, than from his virtues.*
18 Henry Wadsworth Longfellow
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20
21 Individuals and organizations repeatedly confront failures that range from small technical
22
23 errors and mistakes to product breakdowns to large-scale disasters. Failure can stigmatize
24
25 individual and organizational reputations, and it can be extremely costly for organizations and
26
27 society. Failure is also more noticeable than success because negative information is more
28
29 salient than positive information (Ito, Larsen, Smith & Cacioppo, 1998). As a consequence,
30
31 individuals and organizations strongly prefer success, which makes learning from failure
32
33 difficult because both the reporting of errors and other failures as well as the correct analysis
34
35 and response are risky and emotionally fraught. However, learning from failures is critical for
36
37 both operational performance and safety—failure learning is necessary for quality
38
39 improvements and efficiency gains in production processes, and systematic failure reporting
40
41 and analyses have been key for reductions in transportation accidents and adverse events in
42
43 hospitals. Because of failure's significance, the research on the topic spans many fields such
44
45 as psychology (cf. Ellis & Davidi, 2005; Hofmann & Mark, 2006), organizational studies (cf.
46
47 Reason, 1997; Zhao & Olivera, 2006), strategic management (cf. Muehlfeld, Sahib, & van
48
49 Witteloostuijn, 2012), sociology (cf. Perrow, 1999), and health care management (cf. Hoff,
50
51 Jameson, Hannan, & Flink, 2004; Kohn, Corrigan, Donaldson, 1999). Importantly, failures
52
53 provide valuable learning opportunities: individuals and organizations modify their practices
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3 to prevent similar future failures and to improve performance (Sitkin, 1992). Without
4
5 examining failure learning, our understanding of success learning is also inherently biased
6
7 (Baum & Dahlin, 2007; Denrell, 2003). Recognizing the potential of failure to improve
8
9 performance, recent studies on failure have begun to shift their focus from why and how
10
11 failure occurs in organizations to how individuals and organizations do (or do not) learn from
12
13 failure.
14

15
16 Failure learning has become a distinct area in the organizational learning literature, and
17
18 it has attracted growing attention from scholars who seek to understand the phenomenon in
19
20 various contexts such as product recalls (Haunschild & Rhee, 2004), project failure
21
22 (Shepherd, Patzelt, & Wolfe, 2011), bankruptcies (Kim & Miner, 2007), healthcare errors and
23
24 incidents (Chuang et al. 2007; Vogus & Sutcliffe, 2007), and accidents (Baum & Dahlin,
25
26 2007; Haunschild & Sullivan, 2002). The studies on failure learning cover multiple levels of
27
28 analysis and draw from a variety of theoretical frames to understand how actors do (or do not)
29
30 learn from failure. While an array of factors that affect failure learning has been identified,
31
32 there is a lack of systematic integration across levels of analysis and settings; hence, the
33
34 collective wisdom about how to best learn from failure is limited and fragmented.
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38 Importantly, the studies on failure learning borrow much from traditional learning studies, but
39
40 the links and dissimilarities are not clearly understood. Studies that have attempted to
41
42 combine success and failure learning lack conclusive findings and theory exploring how these
43
44 events are related. To that end, there is a greater divide between traditional learning studies
45
46 and failure learning studies than is currently being theorized.
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49
50 We conduct a review of failure learning studies and synthesize them to better
51
52 understand the underlying mechanisms that influence failure learning. We apply the
53
54 framework of opportunity, motivation, and ability to integrate and discuss learning factors at
55
56 the individual, group, and organizational levels. Specifically, opportunity represents a
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3 mechanism that provides information or sufficient time to analyze the cause-effect of failures;
4
5 motivation captures different actors' willingness to act on failure information and to engage in
6
7 failure learning activity; and ability represents actors' skills or knowledge base to change their
8
9 actions based on failure information (Argote, 2012; Reinholt, Pedersen & Foss, 2011).

10
11 Mapping the studies of failure learning at multiple levels of analysis with this framework can
12
13 generate new insights for future work.

14
15 We argue that it is important to clearly separate between processes and outcomes and to
16
17 acknowledge that bad processes do not always lead to failed outcomes and, conversely, that
18
19 correct processes might still result in failed outcomes. A traditional focus on "successful
20
21 processes—successful outcomes" versus "failed processes—failed outcomes" overlooks the
22
23 fact that "successful processes—failed outcomes" and "failed processes—successful
24
25 outcomes" are common. We call these last two process-outcome combinations spurious
26
27 failures and spurious successes. When they are common, these combinations produce noise in
28
29 traditional learning processes that negatively affects opportunity, motivation, and ability to
30
31 learn. A complete understanding of process-outcome relationships in organizational learning
32
33 helps to address a fundamental critical question of why we see a systematic decrease in
34
35 failures in one setting, whereas in another we do not. While the risk of dying in a car accident
36
37 has diminished by 50% over the last 25 years, and the risk of train accidents has been reduced
38
39 by 70% (NCSA, 2015; FRA, 2016), the risk of dying from a hospital error has increased by
40
41 350%¹ (Binder, 2013; Kohn, Corrigan & Donaldson, 2000).

42
43 Below, we begin our review by defining failures and failure learning as well as errors
44
45 and error learning, followed by a review of the failure and error learning literatures at three
46
47 levels of analysis, clustering mechanisms under the opportunity-motivation-ability headings.

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49 We highlight the key constructs and mechanisms that can be identified as influencing learning

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¹ Part of the increase is due to new definitions and better measurement of preventable hospital errors. The numbers are also challenged; however, overall it is clear that there is little to no improvement, which still demonstrates the contrast with transportation accidents.

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3 processes and outcomes. From there, we discuss how the four process-outcome combinations
4
5 influence the opportunity, motivation, and ability that are associated with failure learning.
6
7 Finally, synthesizing and assessing the literature as a whole, we identify the research
8
9 challenges in failure learning and discuss the promising research opportunities that may
10
11 advance our understanding of failure learning.
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14 15 16 **DEFINING SCOPE: FAILURE, ERRORS, AND FAILURE LEARNING**

17
18 There is a literature on errors and another literature on failures in organizations. They are
19
20 related, and many of the mechanisms and findings overlap. In fact, they often use the same
21
22 definition for errors and failures, that they “deviate from expected and desired goals”
23
24 (Rasmussen, 1982; Reason, 1990; Leape, 1974; Zhao & Olivera, 2003; Sitkin, 1992). The
25
26 literatures do also differ since errors are incorrectly executed tasks or routines (such as a train
27
28 engineer who drives a train over the speed limit or a nurse who gives the incorrect medication
29
30 to a patient), while failures are undesired performance outcomes (a train accident occurring
31
32 instead of the train getting from point A to point B as planned; a patient who dies after
33
34 surgery instead of leaving the hospital healthier than before entering it).
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36

37
38 With regard to errors, they have been classified by Rasmussen (1982) into rule-based
39
40 errors (breaking a known rule), skill-based errors (making a mistake or forgetting) and
41
42 knowledge-based errors (not knowing enough). Another error typology is whether the error is
43
44 action-based or related to decision-making (Lei, Naveh, & Novikov, 2016; Zhao & Olivera,
45
46 2006). Nevertheless, not all errors, mistakes or incidents necessarily lead to failure. Some
47
48 errors and mistakes can even produce positive outcomes, such as the discovery of new
49
50 organizational processes and innovation, or be too insignificant have any impact on an event’s
51
52 eventual success or failure (Cannon & Edmondson, 2005).
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3 Failures may be caused by a combination of errors such as incorrectly executed routines
4 and tasks, violations, risks, or chance factors (Frese & Keith, 2015; Hofmann & Frese, 2011).
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6 It can be avoidable or unavoidable, intentional or unintentional. It can involve human action
7 and organizational processes and arrangements (e.g., Ramanujam & Goodman, 2003; Reason,
8 1997).

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14 We define error and failure learning as the process by which individuals, groups, or
15 organizations identify error or failure events, analyze such events to find their causes, and
16 search for and implement solutions to prevent similar errors or failures in the future. This
17 definition is consistent with the definitions of learning in the organizational learning literature
18 (Argote, 2012). The outcomes of error and failure learning can therefore include changes in
19 understanding (Huber, 1991), behaviors (Chuang & Baum, 2003; Ginsburg et al., 2009;
20 Shepherd, Patzelt, & Wolfe, 2011) or performance improvement (Cannon & Edmondson,
21 2001; Dahlin & Baum, 2007; Heimbeck, et al., 2003; Zhao, 2011).

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27 We aimed to be inclusive, if not exhaustive, in identifying studies on error and failure
28 learning and searched key management, health management and safety journals for relevant
29 studies, focusing mostly but not exclusively on the period from year 2000. All identified
30 articles were sorted by their level(s) of analysis. We reviewed the learning mechanisms in the
31 articles and categorized them according to failure learning triggers, clustering them under
32 three headings: opportunity to learn, motivation to learn, and ability to learn.

33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 **OPPORTUNITY TO LEARN FROM FAILURE**

48
49 Opportunity to learn refers to the scope of information and the time that allows actors to
50 learn from failure events. Information-based opportunity refers to the amount of information
51 that is available about similar failure events because such events can provide information
52 about failure causes (Argote, 2012). Time-based opportunity refers to the time that is given to
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3 actors to reflect upon failure events and to analyze the information that can be derived from
4
5 the events to learn from them and the time in which to execute an action that is related to a
6
7 failure learning activity (cf. Carroll, 1963). Information-based opportunities are usually
8
9 studied by quantifying the amount of available information about similar failure events
10
11 (number, frequency, recency), information access owing to group composition, organizational
12
13 members' networks and information diffusion inside or between organizations. By contrast,
14
15 time-based opportunity refers to how much time that is available to process information
16
17 and/or carrying out a task (Carroll, 1963).
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20
21 Information-based learning opportunities are often measured as one's own or others'
22
23 prior experiences with similar failure events (counted as the of number of events or the
24
25 number of cumulative events in previous time periods) and as how organizational structures
26
27 and routines influence the diffusion of failure-learning-related information. Experience and its
28
29 effect on learning are the most common empirical approach, and while this was first studied
30
31 in production settings that range from classic cases of airplane construction to that of liberty
32
33 ship builders (Wright 1936; Thompson, 2001) and learning curves, which refers to the idea
34
35 that cumulative experience affects performance at a decreasing rate, the experience and its
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37 effect on learning have come to be applied across levels of analysis, and used across a large
38
39 number of settings—among them failure learning.
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43 Two different processes convert experiences into better performance: learning-by-doing
44
45 and analytical learning. Learning-by-doing is mostly automatic and tacit, while analytical
46
47 learning involves active decision-making that uses information about a prior event to reshape
48
49 future routines (Thomson, 2012; Reason, 1990). Failure learning theories are much more
50
51 concerned with the active decision-making theory, especially on the individual and group
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53 levels, while few organizational learning curve studies separate empirical and theoretically
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3 between learning by doing and analytical learning (see Lapré, Mukherjee & Van Wassenhove,
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5 2000; or Sinclair, Klepper & Cohen, 2000 for exceptions).²
6

7 Time-based, or temporal, learning opportunities are concerned with the amount of time
8
9 that an actor has to execute a routine or to process information about a routine that has gone
10
11 wrong. Outside of the realm of student learning, relatively few studies have examined
12
13 temporal mechanisms. Exceptions in failure learning a small number of studies that analyze
14
15 the impact of *workload* and *slack* (Malone et al. 2007; Lawton, et al. 2012) and how the speed
16
17 of assimilating and analyzing relevant information affects work processes and routines
18
19 (Edmondson, et al. 2001). In addition, *autonomy* provides the mental and operational space
20
21 that can allow individuals to prioritize their tasks, allowing them the time that they need to
22
23 learn from failure (Kerr, 2009; Stern et al., 2008).
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29 **Individual and group level opportunities to learn from failure**

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31 A wide range of studies have examined how information-based and time-based opportunities
32
33 lead to failure learning. While some learning opportunities lead to automatic reduction of
34
35 errors and failures, this concerns mainly errors such as slips and mistakes. In contrast
36
37 knowledge-based errors and failures require more deliberate reflection to reduce the
38
39 likelihood of repeating them (Iedema et al. 2006). A study examining the effect cardiac
40
41 surgeons' *prior experience* had on learning, demonstrated that past surgery failures improved
42
43 a surgeon's future surgery outcomes (KC, Staats, & Gino, 2013). Moreover, other cardiac
44
45 surgeons' failures interacted with the surgeon's own prior failures to further improve the
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47 surgeon's surgery outcomes. In other words, one's own and others' failure experiences can
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49 have a joint effect on learning: any related failure provides an opportunity to reflect on what
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3 has gone wrong and how to improve procedures. Interestingly, the positive interaction effect
4
5 suggest that information-based experience can have an increasing return on failure learning.
6

7 Temporal opportunities such as working conditions affect how experiences are converted
8
9 into lower error rates. Residents with greater *work autonomy*, that is, they “perceive that they
10
11 have the freedom and discretion to plan, schedule and carry out their jobs” were found to have
12
13 higher error reduction (Stern et al., 2008, p. 1554). Task autonomy allowed the residents to
14
15 reflect on errors and learn from them by making procedural changes. When the organizational
16
17 climate was such that learning was encouraged, the residents took more time to reflect on
18
19 work processes and errors and further reduced their own errors, thus, motivation (climate) and
20
21 opportunity (time) interacted to accelerate learning (ibid.).
22
23

24
25 Teams play an important role in error learning (Edmondson et al. 2001); however, when
26
27 the environment is ambiguous and changing, team information processing becomes
28
29 complicated, which hampers learning. Individual and group levels of learning are intertwined
30
31 as individual characteristics and team composition jointly determine teams’ error reporting
32
33 (Edmondson, 1996). Good member *coordination* (Baker et al. 2006) and *common goals*
34
35 (Tjosvold, et al. 2004) enable teams to benefit from the full potential of each of their
36
37 members. In the same way, *team stability and work processes* enable the group to better
38
39 process information (Edmondson, 1996). When error *information gathering* activity is not a
40
41 part of existing team routines (Lawton, et al. 2012), or the team does not have enough
42
43 *autonomy* to allow it to collect critical information (Kerr, 2009), learning might not occur. In
44
45 other words, having neither established nor improvised ways to gather failure information
46
47 reduces opportunities to learn from failure experiences.
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51 Group characteristics can also influence information-based learning. *Group diversity*
52
53 and *intergroup linkages* are two mechanisms that provide teams with access to a wide range
54
55 of information which, in turn, reduce failure rates (Chuang, et al., 2007; Tucker &
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3 Edmondson, 2003). *Member rotation* is another way to expose teams to a greater flow of
4
5 information that can enable them to better analyze problems (Argote & Todorova, 2007). In
6
7 addition, the time aspect matters here—being exposed to many different but related
8
9 experiences in a short amount of time benefits learning. Experience also transfers across
10
11 levels: group-level success experience has been found to help individual-level failure
12
13 learning, which ultimately benefits the learning rate of the organization as a whole (Zheng et
14
15 al., 2013).
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20 **Organization-level opportunity to learn from failure**

21
22 In our review of the literature, it emerged that information-based opportunity is the most
23
24 studied organizational learning mechanism. To summarize across the organizational
25
26 opportunity studies: experience matters in most cases and across a wide array of settings;
27
28 however, it does so somewhat differently in different settings and organizations. The nature of
29
30 an experience event, its outcome, rareness, and complexity, influence its learning impact. A
31
32 trend in organizational-level studies is to separate one's own versus others' experiences and to
33
34 focus on in which case one matters more than the other and when (Baum & Dahlin, 2007;
35
36 Chuang & Baum, 2003; Kim & Miner, 2007; Madsen & Desai, 2010; Madsen, Dillon &
37
38 Tinsley, 2016).
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43 *Prior failure events* provide opportunities to learn. Over time, as many problems are
44
45 resolved or better managed, we would expect a diminishing return to experience, which yields
46
47 a learning curve that is similar to that in production learning. In fact, there is rich empirical
48
49 support that shows that learning curves have a similar shape with regard to failure reduction.
50
51 Train, mining, and airline accidents have been found to reduce future accident propensity on
52
53 the industry and firm levels (Baum & Dahlin, 2007; Desai, 2016; Madsen, 2009; Haunschild
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55 & Rhee, 2004). The failure-reducing effect is strongest for *recent* accidents (Haunschild,
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3 Polidoro & Chandler, 2015), accidents of *larger magnitude*, which are measured in terms of
4
5 accident cost and level of injuries (Madsen, 2009), and events of high *visibility* (Desai, 2011),
6
7 which are measured in terms of the media scrutiny of the accidents. There are two
8
9 mechanisms that can induce organizations to learn from highly visible failures: in such cases,
10
11 the information about causes and remedies is more available; however, the motivation to
12
13 counteract accidents may also increase when outsiders pay more attention and reputations are
14
15 at stake. When there is more press attention to an accident or a product recall, organizations
16
17 invest more in activities that can reduce the risk of future accidents, such as a train line
18
19 installing new track (Desai, 2011).
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22
23 The effect of *recency*, that more recent events have greater impact than older events on
24
25 failure reduction, can also have multiple explanations. For instance, there is the proposition
26
27 that new routines and practices make past experiences less relevant as time passes, or, as
28
29 suggested by Haunschild et al. (2015), that an adverse event attracts an organization's
30
31 attention and motivates the organization to reduce the risk of future accidents; however, this
32
33 motivation weakens over time as other important organizational goals take precedence.
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35

36
37 *Complex problems* provide a greater opportunity to learn. A notable study supporting
38
39 the argument that complex challenges trigger faster and more efficient learning is an
40
41 investigation of British IVF clinics, which demonstrates how opportunity affects learning
42
43 (Stan & Vermeulen, 2013). The key performance metric of IVF clinics is live births per
44
45 treatment cycle, and a key aim is to lower the number of failed cycles. Whereas private clinics
46
47 could choose to accept only patients with good prognoses, which meant fewer failures, public
48
49 clinics were not allowed to screen patients and therefore had higher failure rates at the start of
50
51 their activities. However, working with more difficult cases enhanced the information-based
52
53 learning of the public clinics, and they increased their ability to successfully treat any patient,
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55 which resulted in higher learning rates than those of private clinics. Working on complex
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3 problems provided greater opportunity to find solutions to difficult problems and led to faster
4 failure reduction across problems. The concept that complex failure situations provide richer
5 information is in line with the finding that airlines learned more from complex accident
6
7 information is in line with the finding that airlines learned more from complex accident
8
9 causes than from simpler ones (Haunschild and Sullivan, 2002) and that this was especially
10 true for specialist airlines. Complex problems offered more venues for learning and
11
12 counteracted simplified cause-effect analyses (e.g., simplifying failure attributions to factors
13
14 that are beyond the organization's control such as patient age in hospital cases or to pilot error
15
16 in the case of airlines).
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20
21 *Whose experiences matter.* Not only do failures that are experienced by an individual
22 organization provide opportunities to learn, but the failures that are experienced by other
23 organizations provide information for learning. Airlines learn both from their own and other
24 airlines' accidents (Haunschild & Sullivan, 2002). Based on the behavioral theory of firm
25 logic, which states that organizations are more likely to look further for better solutions when
26 their peers outperform them, train companies that had more accidents compared to their peers
27 were found to learn more from such peers rather than from their own accidents (Baum &
28 Dahlin, 2007). Ontario nursing home chains learned from both their own and others'
29 businesses with respect to naming their units. The learning effect, or willingness to change
30 was dampened when the chain had followed a strategy for a long time (Chuang & Baum,
31
32 2003).
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46 *Learning from near misses.* It is not only failure events that provide information-based
47 opportunities to learn, but such information can also be gleaned from events that are neither
48 purely successful nor wholly failures (Rerup, 2006). Most attention has been given to near
49 misses—when there is almost a failure but there are no direct negative consequences
50
51 (Kessels-Habraken, et al. 2010). The opportunity to learn from near misses (especially those
52 of others), or what is also known as latent errors (Reason, 1997; Ramanujam, 2003), is only
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3 possible if such actions are recorded or easily observed. Kim and Miner (2007) used the
4
5 ratings of banks to capture whether they were close to failing and found that near failures
6
7 affected learning more than actual failures did. Building on industry insiders' quotes, they
8
9 found that near failures have greater informational content—whereas failed firms disappear
10
11 from the industry and are forgotten, near failures remain and can tell their story and at the
12
13 same time they also remind others of their survival. Perhaps more importantly, near failures
14
15 combine bad performance with remedies for restoring performance after a period of trouble.
16
17 Rather than telling a story of how to fail, they tell a story of redemption when one is close to
18
19 failure. The greater informational content of the near failures means that there is a greater
20
21 opportunity to learn from them. However, the reporting of near-misses and thus the
22
23 information gathering process is more difficult because of the challenges in defining the scope
24
25 of such events (Kessels-Habraken, et al. 2010).
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32 **MOTIVATION TO LEARN FROM FAILURE**

34 Motivation is the desire or willingness to act in a certain way and, in the context of error and
35
36 failure learning, the desire or willingness to invest in reducing adverse event frequency.
37
38 Motivation to learn from failure therefore refers to the resource levels that are devoted by
39
40 individuals and organizations to failure learning activity; such resources include attention and
41
42 operational investments (Kanfer and Ackerman, 1989). Effective learning processes require
43
44 individuals and organizations to allocate cognitive resources to (i) correctly identify and
45
46 analyze error and failure causes and (ii) search for and implement solutions that prevent
47
48 similar errors or failures in the future. Failure learning studies concerning motivation address
49
50 contextual factors such as safety climate, psychological safety, leadership style and attitudes;
51
52 cognitive and emotional barriers such as attribution errors (internal versus external);
53
54 information processing in groups and, for organizational-level studies, factors that trigger
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3 motivation such as high visibility events and public attention. Other organization-level
4
5 motivation triggers include threats to ones' reputation, social comparisons (doing worse than
6
7 the competition), the recency of an event, and climate variables.
8
9

10 11 **Individual and group level motivation to learn from failure.** 12

13
14 Most individual-level studies on error and failure learning study motivational factors. In two
15
16 laboratory studies, using a computer simulation task, Zhao (2011) found a positive association
17
18 between participants' self-reported *motivation to learn* from errors and their actual failure
19
20 learning. In a field study of an Australian hospital, employees' *safety motivation* had a
21
22 positive effect on their safety participation, which was measured as behaviors that promote a
23
24 safety-oriented environment (Neal & Griffin, 2006). While individual motivation affects
25
26 learning behavior in both the lab and inside organizations, organizational factors affect
27
28 individual motivation to learn from failure. For example, *safety climate*, which is defined as
29
30 "perceptions of policies, procedures, and practices related to safety" (Neal & Griffin, 2006;
31
32 956), plays an important role in motivating individual learning. *Group-level safety promotion*
33
34 is positively associated with *individual safety motivation* and *safety participation* in hospitals
35
36 (Buljac-Samardzic et al., 2012). There are both bottom-up and top-down processes between
37
38 individuals and groups that help to produce a safety climate (Neal & Griffin, 2006). *Group*
39
40 *climate* has been found to affect both individual motivation and individual behavior, and in a
41
42 study of 33 organizations, individuals were more likely to report accidents when supervisors
43
44 enforced safety policies (Probst, 2015). Adding the organizational level of analysis, *individual*
45
46 *attitudes* to safety affects organizational learning by promoting a safety climate at the group
47
48 level (Zohar & Luria, 2005). Individual *safety motivation and engagement* in failure learning
49
50 activities both affect and are affected by group, managerial and organizational attitudes.
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3 Motivation to learn from failure is also driven by individuals' *causal attributions*
4
5 concerning failures. In attribution theory, individuals cope with outcomes by making causal
6
7 attributions to guide their future behaviors (Ilgen and Davis, 2000; Nisbett and Ross, 1980).
8
9 Causal attribution involves how an individual allocates causes for a certain outcome, which,
10
11 in turn, influence his or her motivation to learn. Specifically, individuals tend to attribute
12
13 success to internal causes such as ability and effort, and failure to external causes such as
14
15 environmental factors and luck (cf. Jones & Harris, 1967). At the same time, individuals often
16
17 turn this around and attribute others' successes to external causes and others' failures to
18
19 internal causes. Such attributions affect individual motivation to engage in failure learning
20
21 activity (Chuang et al., 2007; Zhao and Olivera, 2006). Attribution theory helps us to better
22
23 understand the previously discussed result that surgeons' cumulative number of successful
24
25 cardiac procedures had a greater impact on their future success rate than failed procedures
26
27 had, while other surgeons' cumulative number of failed procedures significantly helped to
28
29 improve a cardiac surgeon's subsequent success rate (KC et al., 2013). One can argue that
30
31 surgeons attributed the prior successes to their own effort and actions, while the prior failures
32
33 were attributed to uncontrollable factors. Thus, the surgeons assumed that there was little to
34
35 learn from own failed procedures. In contrast, other surgeons' failures were attributed to their
36
37 efforts and actions, which made the focal surgeon more willing to review and learn from
38
39 others' failure causes. In a similar vein, individuals who work in teams attributed failure to
40
41 actions that are taken by other individual team members rather than by the team when they
42
43 experience poor team performance in a laboratory setting (Naquin and Tynan, 2003).
44
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48 However, this tendency decreased as subjects' *knowledge of teamwork* increased. Another
49
50 sign that attribution biases can be alleviated is a study in which individuals were better able to
51
52 make internal attributions after failing in a task when they received *after-event reviews* that
53
54 helped them to understand what contributed to their performance (Ellis, Mendel, and Nir,
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3 2006). Individuals who made more internal than external attributions improved their
4
5 performance more. In a study of CEO attributions and organizational performance, Salancik
6
7 and Meindl (1984) found an even stronger learning effect from internal attributions: when
8
9 CEOs attributed poor firm performance to internal causes even when the low performance
10
11 was clearly caused by an external factor, their firms performed better in subsequent periods.
12
13 Internal attributions are clearly important for behavioral change.
14
15

16 Failures often generate strong negative emotions (Paget, 1988) as individuals
17
18 experience feelings of guilt, embarrassment or fear when they are involved in failures or make
19
20 errors (Edmondson, 1996; Paget, 1988). *Negative emotions* prompt individuals to become
21
22 more risk averse (Loewenstein et al., 2001), affect judgment (Forgas, 1995), and lower
23
24 engagement in failure learning. In general, failure-induced negative emotions should lower
25
26 individuals' motivation to learn. However, in a laboratory study, negative emotions were
27
28 instead positively associated with the motivation to learn (Zhao, 2011). The author explains
29
30 this effect by suggesting that the strength of emotions matters, not just whether an emotion is
31
32 negative, and negative emotion only affects learning above a relatively high threshold. If the
33
34 strength of emotion matters, the finding that *managerial error intolerance* increases negative
35
36 emotions suggests that managers' attitudes can push staff into non-learning (Keith & Frese,
37
38 2005).
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43 There are individual differences in the emotional response to failure and individual
44
45 differences in *coping orientations* that help to explain the different emotions that are
46
47 generated by failure as well as differences in the motivation to learn from failure: Individual
48
49 *affective organizational commitment*—how loyal they feel towards their organizations—
50
51 decreased with negative emotions about failure (Shepherd et al., 2011); however, this link
52
53 between negative emotions and failure was moderated by coping orientations when dealing
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3 with failure. Negative emotions also decrease when individuals perceive that failure is a
4
5 normal occurrence in their work environment (Shepherd et al. 2011).
6

7
8 Individuals' motivation to learn from failure is affected by *psychological safety*. Not to
9
10 be confused with safety climate, psychological safety refers to the perception that it is safe to
11
12 take interpersonal and professional risks in the workplace (Edmondson, 1999; Edmondson and
13
14 Lei, 2014). Psychological safety has been found to positively influence failure learning by
15
16 increasing an individual's motivation to engage in failure learning activity (reporting failures
17
18 and errors; willingness to discuss possible solutions) because the fear of negative
19
20 consequences to self-image, status, or career are lower when psychological safety is high
21
22 (Edmondson, 1996; Tjosvold, et al. 2004). Surveying three firms in the software, electronics
23
24 and finance industries, Carmeli and Gittell (2009) found that psychological safety was
25
26 positively associated with failure-based learning behaviors.
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28

29
30 At the group level, *group norms* shape learning from failure: compliance with norms
31
32 motivates individuals to identify and record failures and to act to prevent them (e.g., Katz-
33
34 Navon et al., 2009; Vogus & Sutcliffe, 2007; Zohar, 2002). When studying groups in different
35
36 functions in the same organization, *sharing the same beliefs* about how to cope with failure
37
38 exerted great influence on failure learning (Cannon & Edmondson, 2001).
39

40
41 Information sharing and interpersonal relationships within groups is another key
42
43 element impacting how motivated teams' are to learn from failures. Teams with *cooperative*
44
45 rather than competitive goals learn more (Tjosvold, et al. 2004). *Trust* between the members
46
47 of a team affects learning motivation (Carmeli et al. 2012). Comparing hospitals with similar
48
49 characteristics but different failure learning rates, Edmondson et al., (2001) found that team
50
51 member error *information sharing* affected the learning rate. In a similar fashion, *managerial*
52
53 *safety practices* also affect the motivation to learn—managers who demonstrate that safety is
54
55 important positively affect error reduction (Katz-Navon et al. 2009). *Lack of information*
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3 *sharing* depends on the routines, awareness of others' knowledge and status dynamics within
4
5 groups: a study found that slower-learning groups had team members that did not bring
6
7 attention to errors since they assumed, often incorrectly, that other team members are already
8
9 aware of them (Cannon & Edmondson, 2001; Edmondson, et al. 2001).

11
12 According to Gersick & Hackman (1990), *routines* are double-edged swords: on the one
13
14 hand, they can prevent team members from addressing failure by reducing their motivation to
15
16 learn because change would upset the routine; however, on the other hand, routines create
17
18 comfort within a group and lead to a climate where group members are more comfortable
19
20 sharing what went wrong.
21

22
23 A high *team workload* not only decreases the opportunity to learn, it also considerably
24
25 reduces team motivation to learn from failure (Lawton et al. 2012), and it may ultimately
26
27 affect the ability to change because the team might be unaware of the need to improve
28
29 existing routines (Edmondson, et al. 2001). Team's *ability to manage its workload* is also
30
31 important, and teams that do better at this were found to improve their error rate faster
32
33 (Lawton, et al. 2012). To reduce errors and failures routines often need replacing, but
34
35 renewing routines is cumbersome, with preexisting routines being obstacles to change; thus,
36
37 unless there is a clear rationale for why routines must change, groups are likely to resist
38
39 change and may even implement defensive strategies with respect to learning processes, for
40
41 example, by shifting responsibility and finding arguments to *defend failing mechanisms*
42
43 (Hodgkinson & Wright, 2002). Workload is a time-dependent opportunity but also impacts
44
45 motivation to learn since decisions that are made under time pressure may require individuals
46
47 and groups to focus on a shorter-term horizon (Malone et al. 2007).
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54 **Organization-level motivation to learn from failure.**
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3 A majority of the studies on how motivation affects error and failure are conducted in
4 the health care context. There is a very real concern that hospitals are not reducing their error
5 rates and are causing patient harm at a high rate (Leape, 1994; Kohn et al., 2000). The focus is
6 often on how individual motivation to report errors is affected by organizational factors. The
7 problem of non-reporting is high (Zhaou & Olivera, 2006; Ramanujam, 2003), which renders
8 the analysis of error causes incomplete. The reason for an individual to not report an error that
9 he or she made, or which was made by someone close, is often a lack of trust that responsible
10 managers in the organization will conduct proper analyses to determine the true causes. It is a
11 common and simple solution for organizations to blame an error on an individual (Hofmann
12 & Stetzer, 1998; Rathert & May, 2007). The belief that organizations prefer to blame
13 individuals rather than to find organizational causes is supported by data: Perrow (1999)
14 reported that a re-examination of industrial accident causes where 70% to 80% were
15 attributed to operator errors, in contrast found that operators had caused less than half of the
16 accidents they were blamed for, or that 30% to 40% of accidents were caused by operator
17 errors.

18
19 In line with the tendency to blame the person who is closest to an error, factors that
20 impede error reporting and analysis at the organizational level can be linked to the culture of
21 *blaming individuals* rather than exploring other error causes (Khatri et al., 2009), *ward*
22 *climate* (Lawton et al. 2012), whether health care work units are *patient-centered* (work is
23 planned around the patient's needs) (Rathert & May, 2007) and that when greater *distance*
24 *between professional groups* in health care reduces the willingness of orderlies and nurses to
25 admit to or discuss errors with doctors (Khatri et al., 2009). Organizational climate is a
26 determinant that trickles down to affect both group and individual-level learning from failure.

27
28 Motivational factors that have been studied outside health care are different. Based on
29 the behavioral theory of firms, which states that organizations are more motivated to act and
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3 change when they perform worse than they did in the past or when they perform worse than
4 their competitors or peers (Cyert & March, 1963), Baum and Dahlin (2007) found that train
5 companies that have *higher accident costs than their peers* learn faster but mainly from
6 others' experiences. Learning from others' and not one's own experiences might be due to
7 poor failure performance: the organization might need external ideas of how to change
8 behaviors. Another motivation study found that when an automobile manufacturer were
9 forced to recall products and thus its *reputation* was challenged, the likelihood of future
10 recalls was lowered (Haunschild & Rhee, 2004; Rhee, 2009). The effect in the auto recall case
11 was curvilinear: low- and high-reputation car companies reduced recalls less than companies
12 with medium reputations did. In a study that focused on how motivations change over time,
13 Haunschild et al. (2015) found that a *recent failure* (in their case, a pharmaceutical product
14 recall) made the organization work to reduce future such events; however, as time passed,
15 other performance metrics, such as profits, reclaimed the organization's attention and lowered
16 the focus on failure reduction.
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34 Some findings on how attention impacts motivation contradict one another. While *more*
35 *media coverage* after an accident motivates greater investment in infrastructure for train
36 companies, thus reducing accident risks (Desai, 2011); more media coverage of the near-
37 misses involving air traffic controllers instead reduced the effect of prior near-misses on
38 learning (Desai, 2014). This divergence could be explained by near- misses looking alarming
39 to outsiders since an actual failure (airline accident) would have catastrophic consequences,
40 while organizational members, in contrast, see a near-miss as a success since an error was
41 rectified and a failure was avoided (Kessels-Habraken, et al. 2010; Dillon & Tinsley, 2008) .
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ABILITY TO LEARN FROM FAILURE

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3 Ability to learn from failure concerns the capacity to identify and report failure;
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5 understanding failure leads to finding and implementing solutions to prevent future failures.
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7 Individual and group level studies are concerned with training, emotional responses, shared
8
9 goals and managerial style, as well as the interaction between ability and motivation.
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11 Organization-level studies rarely measure directly ability but rather conclude that the
12
13 unobservable variances across units or organizations are due to differences in ability. In health
14
15 care, where geography makes competition between hospitals less of an issue, checklists are
16
17 used for the transfer of best practices across units, which raises the ability to learn in
18
19 organizations.
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25 **Individual- and group-level ability to learn from failure**

26
27 The question of how to improve individuals' ability to learn from their errors and failure
28
29 experiences has led to a series of studies that focus on comparing different training methods
30
31 and the role of post-event reviews. Keith and Frese (2005) compared *error management*
32
33 *training*, which explicitly addresses individuals who make errors during training and uses
34
35 these errors as learning exercises and *error avoidance training*, which instead focuses on
36
37 preventing participants from making errors. Error management training enhanced individuals'
38
39 capacity to cope with, and generate solutions to, new problems. Error management training
40
41 also led to better emotion control and metacognitive activity, which in turn improved
42
43 individuals' ability to cope with new problems. *Individual differences* interact with training
44
45 method so that individuals with better *cognitive ability* and *higher openness to experience*
46
47 were found to perform better during error management training than if they had received no
48
49 training or only training with a focus on error avoidance situations. Error management
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51 training not only provides trainees with opportunities to make errors but also to receive
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53 informative feedback; overall, these programs increase an individual's ability to learn from
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3 failure. Thus, the ability to learn from failure can be actively developed, and such training is
4
5 more effective when it is paired with high motivation to learn from failure (Katz-Navon, et al.
6
7 2005).

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9
10 A laboratory study on how to enhance individuals' ability to draw lessons from previous
11
12 experiences found that *after-event reviews* of both successful and failed events had a positive
13
14 impact on individual learning (Ellis and Davidi, 2005). The after-event reviews followed a
15
16 similar but more extensive process than that of *error management training* because it also
17
18 included successful events. While the participants' mental models of failure events were
19
20 richer than those of success events, the performance improvements were greater when the
21
22 after-event reviews focused on both failures and successes. In a follow-up study, *any type of*
23
24 *after-event review* (success, failure or both types of events) was found to lead to better
25
26 performance compared with no after-event review. Interestingly, for individuals who
27
28 experienced successful events, the after-event reviews that focused on the failure factors that
29
30 led to the greatest performance improvements had a greater impact than no reviews, reviews
31
32 that focused on success factors, or on both success and failure factors (Ellis et al., 2006).

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36 Individual differences in how failure is processed has an impact on failure learning.
37
38 Studying three types of *coping orientations*: loss, restoration, and oscillation, Shepherd and
39
40 colleagues (2011) analyzed how these orientations affected (self-reported) learning. Loss
41
42 orientation refers to the explicitly processing of a failure to break the emotion that is
43
44 associated with the failure (a failed project). Restoration orientation refers to suppressing
45
46 feelings of loss and instead proactively focusing on the tasks that arise as a consequence of
47
48 the failure rather than preventing future failures. An oscillation orientation refers to moving
49
50 back and forth between loss and restoration orientations. Individuals who have stronger loss
51
52 and oscillation orientations reported a better ability to learn from previous project failure than
53
54 those with a restoration orientation. Apparently, the necessary element is the capacity to
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3 emotionally disconnect from the failure, which suggests that effective learning involves
4
5 managing the emotions that are evoked by a failure.
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7 An individual's ability and motivation to learn from failures are affected by *emotional*
8 *states*. The ability to learn is enhanced when the *environment is emotionally supportive*:
9
10 Individuals must feel comfortable applying their knowledge and acquiring new knowledge to
11
12 learn from failures. An individual's perception of *psychological safety* and the quality of his
13
14 or her relationships with others in an organization are positively associated with failure
15
16 learning (Carmeli and Gittell, 2009). *High-quality relationships*, which are manifested in
17
18 shared goals, shared knowledge, and mutual respect, not only promote psychological safety
19
20 but also enhance information processing and coordination capacity, which in turn have
21
22 positive effects on the capacity to learn from failure.
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27 Individuals can also encourage failure learning at the group level with a positive
28
29 *leadership style*, which includes clear direction and effective coaching (Cannon &
30
31 Edmondson, 2001; Katz-Navon et al., 2009): leadership style can motivate learning; however,
32
33 it also reflects the group's ability to learn and a leader's ability to enhance group learning. For
34
35 example, when a CEO fosters *psychological trust* in a top management team (between the
36
37 CEO and the team, and within the team), the team is more likely to engage in failure learning
38
39 and to produce high quality strategic decisions (Carmeli, et al. 2012).
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43 Because individuals in organizations are embedded in groups, studies have stressed
44
45 teamwork to be an important factor for failure learning (Baker, et al. 2006; Morey, et al.
46
47 2002). Many studies of ability involve overlapping and interactive effects between motivation
48
49 and ability, and some determinants are related to both mechanisms. Efficient teamwork relies
50
51 on *coordination and communication*, which can be actively promoted (Baker et al. 2006)
52
53 using *formal training* to improve team collaboration (Morey et al. 2002). Ability to foster
54
55 cooperative goals also triggers failure learning (Tjosvold, et al. 2004). Most ability-type
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3 factors can be taught, and they can, in turn, nurture group motivation to learn. Other group-
4
5 level factors that improve group learning ability are *group member stability*, *understanding of*
6
7 *team processes*, and *training to reduce attribution biases* (Buljac-Samardzic, van Woerkom,
8
9 & Paauwe, 2012; Morey, et al, 2002; Naquin & Tynan, 2003).

11 A process study of how ability is developed focuses on Israeli fighter crews (Ron,
12
13 Lippschitz & Popper, 2006). To reduce errors in flight procedures, crews not only relied on
14
15 their own learning based on flying more missions and thus learning through direct observation
16
17 and experience; rather, because they knew that subjective perceptions are incomplete and
18
19 sometimes faulty, given the intensity and massive information processing that is required
20
21 when piloting a fighter jet, after each mission the entire cadre held a debriefing. In the
22
23 debriefing crews watched footage from aircraft cameras while talking through their
24
25 perceptions of what had occurred. The review process allowed them to compare their
26
27 perceptions with the footage, clearly see how imprecise real-time perceptions are, which
28
29 helped them to make corrections, and convert subjective experiences to objective ones. The
30
31 review process and the debriefing are imposed by the organization, it enhanced the teams'
32
33 abilities and also increased information-based opportunities since the debriefing sessions
34
35 provided the crews with additional information.
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43 **Organization-level ability to learn from failure**

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45 We found fewer studies on organizational-level ability than on organizational-level
46
47 opportunity or motivation. A study analyzing failure reduction across clinics that use a new
48
49 heart surgery method used an indirect measure of clinic ability (Pisano et al., 2001). Carefully
50
51 establishing that given the same opportunity (cumulative number of procedures, which had a
52
53 large impact on learning) and motivation, organizations differed in how well they converted
54
55 experience into higher performance: the 16 clinics in the study demonstrated different
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3 learning curve slopes. After ruling out other opportunity-based explanations, the conclusion
4
5 was that differences across clinics must be due to (unobserved) ability. A paper argues that
6
7 organizational form, whether an airline is a specialist or generalist, can influence its ability to
8
9 learn from failure (Haunschild and Sullivan, 2002). Generalists have a more complex
10
11 organizational structure with the potential to complicate information processing and
12
13 coordination, which in turn hampers learning. In the airline industry specialists compared to
14
15 generalists were better able to learn from failures with heterogeneous, that is, more complex
16
17 causes. Similarly, smaller hospitals (more specialized), compared to large hospitals (more
18
19 generalists), have been found to engage in more learning behaviors related to major adverse
20
21 events and near-misses (Ginsburg et al, 2010).
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26 More detailed measures of ability demonstrate that ability affects the absolute number
27
28 of errors as well as the reduction of errors: hospitals achieve faster learning and fewer errors
29
30 by *implementing protocols and checklists* developed from best practices across the industry
31
32 (WHO, 2017; Thornlow & Merwin, 2009; Thomassen et al., 2-13). Checklists were originally
33
34 introduced in aviation, where they have been partly credited with the rapid decline in
35
36 accidents (Clay-Williams & Colligan, 2015). Hospitals with *patient-centered units* were better
37
38 at processing and reporting errors and near misses, which suggests that the *organization of*
39
40 *work* matters for an organization's ability to manage failures (Rathert & May, 2007).
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46 47 **SYNTHESIS ACROSS LEVELS OF ANALYSIS**

48
49 A large body of literature finds that individuals, groups and organizations learn from prior
50
51 failure experience. Information opportunities positively affect learning rate. The richer the
52
53 information, the faster the reduction in errors and failure. Failure experiences generally
54
55 contain more information than successful experiences (Kim & Miner, 2007). Most successes
56
57 are "business as usual" contributing to learning by doing and other automatic responses, thus
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2
3 enforcing existing routines. In contrast, failures trigger analyses and have greater potential to
4
5 improve routines (Stan & Vermuelen, 2013). A lack of routines for error and failure
6
7 management stops the information from passing through an organization (Gersick &
8
9 Hackman, 1990; Kim & Miner, 2007). Larger-magnitude, more frequent and salient errors
10
11 have greater information content and, hence, learning opportunities (Baum & Dahlin, 2007;
12
13 Chuang & Baum, 2003; Madsen, 2009; Desai, 2011). Near misses also provide information
14
15 about how to recover from a bad situation, which increases opportunities to learn (Kim &
16
17 Miner, 2007). In general, studies find that “more is better” in regard to information-based
18
19 learning opportunities; however, we would expect an overload when failures and errors are
20
21 too frequent (Dahlin & Roulet, 2014). Information overload that leads to limited failure
22
23 learning can hamper the ability to learn from failure. Accepting frequent errors due to
24
25 information overload, that is, not learning from them, can also be a sign of low motivation to
26
27 learn. These two factors—low ability and low motivation to learn—may be difficult to
28
29 distinguish (Baum & Dahlin, 2007; Dahlin & Roulet, 2014).
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34 Time-based, or temporal, learning opportunities operate in the same direction and in a
35
36 similar fashion as information-based learning opportunities: a lower work load leads to fewer
37
38 errors and failures since work load reduces the time that is available for learning (Malone et
39
40 al. 2007; Lawton, et al. 2012). Nevertheless, some groups are able to analyze and process
41
42 information faster, taking advantage of temporal learning opportunities to enhance their future
43
44 performance (Edmondson, et al. 2001). Whether temporal opportunities can trigger learning
45
46 also depends on whether individuals in organizations have autonomy to process and reflect on
47
48 the errors and failures that they encounter (Kerr, 2009; Stern, et al., 2008). To that end,
49
50 organizational design (e.g., workload, task autonomy) has the potential to lead to latent failure
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52 that hampers learning opportunities.
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3 Even when opportunity to learn from failure—whether information- or time-based—is
4 high, learning may not occur. While opportunity studies are more concerned with what
5 enables learning, motivation studies focus on why learning does not happen. Conditions under
6
7 which individuals attribute the causes of errors and failures to other factors, groups attribute
8 the causes of errors and failures to factors other than the group collective, and organizations
9 attribute the causes of errors and failures to individuals rather than organizational factors,
10 reduce the motivation to learn, which leads to low error and failure reporting and lower
11 learning rates (Chuang et al., 2007; Ellis et al., 2006; KC, Staats & Gino, 2013). A cost-
12 benefit model that is proposed by Zhou and Olivera (2006) offers an overarching explanation
13 to this problem: the unbiased reporting of errors is only expected when the perceived
14 reporting cost is low to both an individual and his or her organization, and the perceived
15 benefits for reporting is high to both as well as to any victim(s) who are associated with the
16 errors. All other combinations of costs and benefits distort the motivation to report and what
17 will be reported, which in turn affects the opportunity to learn from failure. In empirical
18 studies, climate or psychological safety can be thought of as a reporting cost. Patient-centered
19 climate (Rathert & May, 2007), low hierarchical distance, non-blaming cultures (Kathri et al.
20 2009) and high psychological safety (Tjosvold et al. 2004) lead to better reporting and
21 learning. The perception of the benefits to reporting are affected by the same factors;
22 however, this side of the explanation for failure learning is less investigated.

23
24
25 On the organizational level, conflicting goals, often safety and profitability, affect the
26 motivation to learn from failure: A recent failure highlights safety goals for employees;
27 however, as time passes, the focus reverts to financial performance metrics (Haunschild et al.,
28 2015). This highlights the risk of taking failure reduction for granted, assuming that learning
29 is irreversible. Unless learning is embedded in physical artifacts (better brakes, a new IT
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3 trading system) or it becomes a part of organizational routine, there is always the risk that
4
5 error and failure rates will reverse.
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7 Ability studies show that training programs and after-event analyses can improve
8
9 individual and group abilities to correctly analyze situations (Keith & Frese, 2005). It is clear
10
11 that such training is quite common, with checklists being used in different industries, such as
12
13 aviation and health care, to enhance organizational safety work (Clay-Williams & Colligan,
14
15 2015).
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20 21 **Integration across mechanisms**

22 Most studies focus on one or (at most) two mechanisms, either opportunity, motivation or
23
24 ability, and we know that they all matter for failure learning. We know less about how the
25
26 mechanisms affect one another. While some studies have considered moderating effects (KC,
27
28 et al., 2013; Madsen & Desai, 2010; Shepherd et al., 2011), mediation is more seldom
29
30 mentioned. If opportunity to learn sets the stage (providing information for failure analysis
31
32 that can improve routines and failure responses), motivation causes actors to be willing to
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34 attend to such information, and ability is the conversion of opportunity into higher
35
36 performance. What we do not clearly know is how, and whether, these three mechanisms
37
38 jointly affect failure learning.
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43 Theoretical arguments about how to combine the different mechanisms argue for a
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45 three-way interaction (Blumberg & Pringle, 1982; Reinholt et al., 2011). However, it may just
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47 as well be a moderation-mediation process where the opportunity to learn interacts with the
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49 motivation to learn, and such interaction is mediated by the ability to learn, which results in
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51 failure learning. The empirical research focuses on one or two of the mechanisms, at most
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53 testing two-way interactions (for instance, how ability and motivation jointly determine
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55 learning). The notion that reality is complex is illuminated by different findings, some of
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3 which find interactions between factors, others of which find that one factor affects learning
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5 but is mediated by a second factor. Motivation is thus found to affect ability, but ability also
6
7 affects motivation (Lawton et al., 2012; Hofman & Stetzer, 1998) with both paths leading to
8
9 learning. Further, motivation and opportunity jointly lead to learning (Haunschild et al. 2015),
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11 opportunity affects ability, which leads to learning (Stan & Vermuelen, 2013) and opportunity
12
13 and motivation interact to produce learning (Baum & Dahlin, 2007). It is clear that the
14
15 interplay between the mechanisms is more complex than we originally thought, and this
16
17 promises many different ways to stimulate failure learning.
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20 21 **MOVING BEYOND THE THREE FAILURE LEARNING MECHANISMS**

22
23 The papers in the review section covered both error and failure reduction. While there are
24
25 many similarities between them, errors and failures are different types of events (Zhao &
26
27 Olivera, 2006). Errors are mistakes, slips or violations of procedures, and they might or might
28
29 not lead to an adverse outcome (Rasmussen, 1982; Reason, 1990). Failures are adverse
30
31 outcomes³, such as accidents, unexpected patient deaths or bankruptcies (Tucker &
32
33 Edmondson, 2003). While reducing errors should reduce failures, in this section we will
34
35 discuss how these two types of events have a complex relationship; through a better
36
37 understanding of this relationship, we can also better understand the differences in learning
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39 rates.
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46 **Differentiating process and outcomes**

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48 When we study failures, that is, adverse outcomes such as product recalls, accidents,
49
50 bankruptcies or unexpected hospital deaths, we assume that the cause of an adverse outcome
51
52 is an erroneous process. Correspondingly, when we study traditional learning with successful
53
54 outcomes, we assume that processes that lead up to the outcomes are correctly executed.
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57
58 ³ We use the terms adverse outcomes, failures and undesirable outcomes interchangeably.
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3 Questioning the strong link between the correctness of processes and outcomes, there is an
4 increasing interest in situations in which erroneous processes can still result in good
5 outcomes, such as near-misses (cf. Kim & Miner, 2007) and latent errors (Ramanujam, 2003;
6 Reason, 1990). It is also possible, but rarely discussed, that a correct process can lead to an
7 adverse outcome, such as a patient dying, even after well-executed surgery⁴. We propose that
8 to better understand failure learning we must decouple **processes and outcomes**, or, more
9 precisely, independently assess whether a process is correctly performed and whether an
10 outcome is desirable. We also argue that different settings have different frequency
11 distributions for the process-outcome pairs and that opportunity, ability and motivation to
12 learn from failures (and successes) depend on this distribution, which explains why lessons in
13 failure learning in one setting can be difficult to translate to another.

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27 If we regard processes as either correct or erroneous, and outcomes as successes or
28 failures, we end up with four possible process-outcome combinations (see Table 2).

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TABLE 2 TO BE INSERTED HERE

Success and failure learning. A correct process with a favorable outcome represents traditional learning in which the outcome motivates actors who continuously improve and/or exploit the process to further enhance the outcome. This is what we expect from production learning curves (box 1 in Table 2). A faulty process with an undesirable outcome represents the “normal” failure learning case—an error is made, which yields a bad result (a train driver falls asleep, ignores a signal, and collides with another train; box 4). The main thrust in success learning is on how to improve existing processes to enhance the number of successful operations per time unit and thus lower the cost per unit produced (Argote, 2012; Yelle,

⁴ Over time the number of different health interventions has greatly increased, many of which have been directed towards terminally ill patients (Maile, 2012).

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2
3 1979). The main thrust in failure learning is the analysis of how to improve the processes,
4
5 reduce errors, and thereby lower the risk of failure or reduce the number of failed operations
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7 per time unit (or as a share of all operations) (Reason, 1997).
8

9
10 The assumption is that box 4 is a good representation of failure situations: if there is a
11
12 failure outcome, there must be a preceding error. As a consequence, failures should be
13
14 reduced when errors are reduced, and this approach of error reduction lies behind much
15
16 successful failure reduction (Reason, 1997; Van Dyck et al. 2005). Similarly, the assumption
17
18 is that successful outcomes are due to an error-free process. However, there are two other
19
20 possibilities in the matrix that complicate learning: the off-diagonal combinations where (1)
21
22 an error has no effect on the outcome, that is, does not lead to a failure (Ramanujam, 2003), or
23
24 (2) when there is a failure outcome without an error that has been committed (e.g., an “act of
25
26 God”). The very existence of the off-diagonal combinations weakens the link between a
27
28 process as being either correct and not, and its outcome as being either successful or not. We
29
30 label the off-diagonal combinations *spurious successes* and *spurious failures*. An increase in
31
32 spurious events leads to noisier learning processes because the cause-effect analysis becomes
33
34 more complex, which in turn introduces difficulty in learning from both successes and
35
36 failures. We expect that both spurious successes and failures complicate learning in general
37
38 and failure learning in particular. Spurious successes and failures are likely to shift the
39
40 attention of individuals and organizations away from the “true” causal-effects of failure,
41
42 making failure learning challenging. Because successes tend to be vastly more common than
43
44 failures,⁵ we failure learning should be more sensitive to the occurrence of spurious events.
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50 ***Spurious success.*** Not all errors lead to bad outcomes. We expect that both the
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52 motivation and ability to learn from an erroneous process is lower when an organization
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54 experiences a spurious success, that is, there is no negative outcome (Table 2, box 3). Further
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3 lowering learning ability, many process errors are unreported (and sometimes also
4
5 unobserved) and unreported errors are known as latent errors (cf. Ramanujam, 2013; Reason,
6
7 1997). Latent errors can lower failure reduction because a near-failure without an adverse
8
9 outcome can strengthen an erroneous behavior.. The lower the likelihood that an error will
10
11 lead to a failure, the more the error is accepted and the lower the motivation to correct the
12
13 error or to learn from it is (Dillon & Tinsley, 2008; Banja, 2010). The motivation to reduce
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15 errors is also compromised because risk perception changes when actors experience errors
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17 without negative effects (a train driver falls asleep but wakes up before missing the signal, or,
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19 if the driver misses the signal, no other train is on the line, thus, there is no collision—the
20
21 conclusion is that being tired on the job is not such a dangerous thing). Japanese nuclear firms
22
23 did not learn from other firms' errors without adverse outcomes when these errors were
24
25 similar to non-adverse outcome errors the focal firm had experienced itself (Mitsubishi,
26
27 2012). This suggests that spurious success also lowers the motivation to learn from others'
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29 errors: Knowing that other firms in the industry experience similar errors without adverse
30
31 consequences signals that these errors pose no real risk and thus require little attention. When
32
33 latent errors start being accepted by organizational members as not leading to adverse events,
34
35 we obtain what is called *normalization of deviance* (Banja, 2010; Vaughan, 1996).
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37 Normalization of deviance involves accepting errors and rule breaking. Deliberate rule
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39 breaking is usually a dismissal of rules that are considered to be ill-conceived or overly
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41 complex. It is a gradual process (Vaughan, 1996) and in the majority of cases, normalized
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43 deviance has no negative outcome.
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50 Normalized deviance is often exposed after a dramatic failure event leads to patient
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52 death (Maxfield, Grenny, Patterson, McMillan, & Switzler, 2005), nuclear meltdown
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54 (Dekker, 2011), spectacular trading losses (The Economist, 2014) or the crash of a space
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56 shuttle (Vaughan, 1996). Normalized deviance means that there is an implicit or explicit
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3 agreement among organizational members to ignore certain safety procedures or regulations.
4
5 One effect of normalized deviance is that it complicates cause-effect analyses when a failure
6
7 strikes: it is easy for analysis to focus on the deviance behavior, which might not be the main
8
9 cause of the failure. After all, some procedures or regulations are probably outdated or
10
11 ineffectual and ignored for good reasons. In health care, normalized deviance often involves
12
13 the violation of safety rules that impede work flow and signal a lack of trust in operators
14
15 (Banja, 2010). Normalized deviance can also come from institutional logics that became
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17 dominant over time inside an industry despite their clashing with broader order values and
18
19 beliefs that lie outside of the industry (Roulet, 2015; Shymko & Roulet, 2017).
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23 Despite a weak link between latent errors and failure outcomes (cf. Dekker, 2011),
24
25 some settings still exhibit strong learning under such circumstances (airline safety, automobile
26
27 safety), and it would enhance learning if we can determine factors that trigger learning from
28
29 latent errors. First, the human error and safety literature is focused on errors regardless of
30
31 outcomes, with a clear acceptance that adverse outcomes are quite infrequent; however,
32
33 despite the low probability of an error that leads to a failure, there is nevertheless a link
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35 (Reason, 1997). When the focus is on errors rather than outcomes, both motivation and ability
36
37 to learn should be enhanced. Creating agencies whose mission is error detection and
38
39 reduction, such as the NTSB in transportation, leads to a low tolerance for errors. Some
40
41 agencies have the power to close down or fine error-prone organizations with the aim of
42
43 limiting such trade-offs in organizations, thus enhancing the organizations' motivation to
44
45 engage in failure reduction. Organizations' and their members' ability to reduce errors is also
46
47 improved as regulators help with cause-effect analyses and recommend or regulate safer
48
49 behaviors (FRA, 2016).
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54 ***Spurious failures.*** The fourth process-outcome combination is the case where a faultless
55
56 process produces an adverse outcome (Table 2, box 4). For instance, well-executed surgery
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3 can still lead to a patient dying, or correct driver behavior can produce an accident. We call
4
5 this a spurious failure, and this particular outcome is problematic for failure learning for a
6
7 number of reasons. A failure outcome often triggers a search for causes even if there is none.
8
9 Such a search risks misattributing the process as faulty, and there is a risk that the
10
11 organization will replace a good routine with a worse one or make inefficient changes, and
12
13 thus the ability to learn is compromised. The good-process-bad-outcome option is fairly rarely
14
15 studied; however, it is likely to be frequent in complex settings where many processes co-
16
17 occur and involve many different actors. Because organizations are twice as likely as an
18
19 impartial observer to assign blame to an operator after a failed event (Perrow, 1999), spurious
20
21 failures are risky for individuals who might be unfairly blamed for adverse outcomes when
22
23 the organization looks for failure causes. Thus, spurious failures can lead to lower trust and
24
25 lower reporting of actual errors, which lowers the motivation to learn (Hofmann & Stetzer,
26
27 1998).
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32 Health care is an obvious case where we expect frequent spurious failures because very
33
34 sick patients eventually tend to die regardless of treatment. Staff is acutely aware that many
35
36 failures (such as death) occur for reasons that are unrelated to any procedures that they
37
38 perform, and this leads them to accept bad outcomes as an unavoidable part of everyday
39
40 activities. While the acceptance of adverse outcomes is necessary, there is a risk of acceptance
41
42 spilling over and allowing errors and latent errors to be forgiven. Because death is an
43
44 expected and even unavoidable outcome for many patients, even when the cause of death is
45
46 an error instead of an underlying disease and the outcome should be recorded as a failure, the
47
48 high incidence of spurious failures might mean that errors are not detected. In addition, even
49
50 if an error is detected, it might be ignored and therefore not corrected (Kohn, Corrigan &
51
52 Donaldson, 2000). In other words, normalized deviance can be affected by spurious failures
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54 as well as by spurious successes.
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3 In summary, the more frequent spurious learning and failure, or *bad-good*
4 combinations, there are (boxes 2 and 3), the more difficult it is to perform a correct causal
5 analysis. The combination of process error—good outcome is probably more common than
6 that of the process error—bad outcome. An analysis of airline crews found that an error was
7 made in the cockpit during a flight at least every four minutes but that very few incidents or
8 accidents resulted (Bird, 1969; Reason, 1997). Similarly, nurses commit errors once every
9 hour; however, this rarely leads to bad outcomes (Tucker & Spear, 2006). In contrast, we
10 have almost no information about how often a correct process results in an adverse outcome.
11 Learning motivation is low when the off-diagonal events are frequent, as is the opportunity to
12 learn given the noisy information.
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25 When there are many processes that can simultaneously go wrong, attending to all
26 potential errors becomes cumbersome and this also makes cause-effect analyses difficult.
27 Simulations are well suited to investigating these trade-offs as well as experimenting with the
28 complexity of tasks, the number of involved parties, risk levels and how these factors affect
29 motivation and ability to learn (cf. Denrell, 2003).
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39 **The impact of spurious successes and spurious failures on slow- and fast-learning** 40 **settings**

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43 Noise and uncertainty in the process-outcome relationship help to explain learning-rate
44 differences across settings. In settings with more off-diagonal outcomes (boxes 2 and 3), we
45 expect lower learning rates since both ability and motivation to learn are lowered, and causal
46 inferences are more difficult to draw. Spurious success (box 3), for example, is more likely to
47 occur in situations in which tasks are easy and the rate of success is naturally high, while
48 spurious failures (box 2) will, by contrast, be more common when tasks are complex, the
49 chance of making an error is high and the risk of failure is also high. In the health care sector,
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2 relatively routine procedures would be expected to lead to a higher rate of spurious success.
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4 By comparison, complex and high-risk surgical operations are more likely to lead to spurious
5
6 failures. Those contexts offer fewer opportunities to learn because there is less information on
7
8 which to draw for further success. The learning process is also hampered by the difficulty in
9
10 assessing and taking stock of ability: the more spurious failures there are, the greater the
11
12 doubt about current abilities will be. We also expect that motivation to learn will be lower in
13
14 settings with high rates of spurious failure and success given the ambiguity with regard to
15
16 cause and effect.
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23 **FUTURE RESEARCH DIRECTIONS**

24
25 How can organizations best learn from errors and failures? We will suggest a number of
26
27 approaches that are based on the ideas of maximizing the triad of learning mechanisms,
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29 opportunity, ability and motivation while taking into account the role of spurious failures and
30
31 spurious successes.
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36 **Opportunity to learn from failure**

37
38 *Using multiple sources of event information and the role of regulations.* What can
39
40 organizations do when they experience few failures but still want to reduce future failure risk?
41
42 There is an increasing emphasis in learning studies on vicarious learning in the form of
43
44 organizations' learning from similar others' failures, successes and near-miss experiences
45
46 (Baum & Dahlin, 2007; Haunschild & Sullivan, 2002; Kim & Miner, 2007; Madsen & Desai,
47
48 2010), and thus one way to increase learning opportunities is to learn from others. Moreover,
49
50 information about events is also provided by an array of industry stakeholders such as the
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52 press, unions, regulators, industry associations, insurance companies, equipment
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54 manufacturers, trade press and academics. All of these groups have an interest in failure
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3 reduction, and some are mandated to collect data, investigate accidents and issue
4
5 recommendations. They provide information, analysis and suggestions on how to reduce
6
7 failures, and some of them are very active. However, management scholars have mostly
8
9 ignored these stakeholders and the role that they play in identifying, analyzing and suggesting
10
11 remedies for failures. As a consequence, there is an omitted variable bias in many studies,
12
13 which overestimate the effect of one's own or others' ability to learn from failures (Dahlin &
14
15 Roulet, 2014). In addition, it would be interesting to examine the relative impact of different
16
17 learning sources on failure learning to better understand stakeholder roles. We call for future
18
19 studies in management to include more industry stakeholders, or at least to control for their
20
21 actions to better understand the sources of learning. While policy studies are engaging with
22
23 this question to study the effect on an entire industry (Silbey, 2009; Dekker, 2011) they rarely
24
25 analyze firm-level factors.
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30 Some key questions to ask when investigating the role of multiple parties are: Given
31
32 different learning rates across industries: are there fewer sources of learning in slow-learning
33
34 settings? Can a slower learning rate be explained by a lower opportunity to learn?
35

36
37 Noise also lowers opportunity to learn: If slow-learning settings are more likely to
38
39 combine a high failure volume and a high spurious failure volume, is it possible that lower
40
41 failure learning rates are due to the difficulty to learn from spurious failures? Spurious failures
42
43 create a great deal of noise, which makes cause-effect analyses complicated and makes more
44
45 common failure cases (erroneous process—adverse outcome) difficult to analyze. Exploring
46
47 these questions can further advance our understanding of the differences in failure learning
48
49 across settings.
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52 ***Opportunity and the transfer of learning.*** One way to transfer best practices developed in a
53
54 high-performing organization or industry to a lower-performing organization or industry is to
55
56 use checklists (Degani & Wiener, 1993; Thomassen, Storesund, Søfteland, & Brattebø, 2014).
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3 Checklists are required in aviation and their success has led to their adoption in health care.
4
5 They are, for example, increasingly used in surgical procedures. Checklists have been
6
7 effective in accelerating learning, with more rapid failure reductions in units that use surgery
8
9 checklists than in units that do not use surgery checklists (Walker, Reshamwalla & Wilson,
10
11 2012). However, in a meta-analysis of checklist studies, Thomassen et al. (2014) reported
12
13 either improvement or no effects in the use of checklists. When some non-learning situations
14
15 were more closely analyzed it was found that the checklists were not properly implemented—
16
17 some surgeons have resisted their use (Leape, 2014).
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21 Checklists are also used for data collection and analysis by US transportation safety
22
23 agencies, such as the National Transportation Safety Board when they investigate accidents
24
25 and has helped to reduce airline and train accidents (NTSB, 1998). Since the transportation
26
27 sector is heavily regulated, all agencies are tasked with safety interventions and trained in
28
29 using systematic tools while it is not clear if enforced checklists use by external agencies
30
31 would be as effective in the health care setting. Maybe health care is too complex (different
32
33 professional groups, hierarchical structures that complicate communication between groups, a
34
35 large number of diagnostic and treatment options, complex information flow), thus requiring
36
37 different tools to facilitate failure learning beyond learning on the procedural level? At the
38
39 same time there are few other tools to facilitate information transfer that have been as
40
41 extensively developed and whose impact is as well understood as the learning effects of
42
43 checklists (Leape, 2014). We wonder what other methods and/or tools could be used to
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45 increase learning opportunities in general and which methods and/or tools might be effective
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47 for slow-learning environments in particular.
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54 **Ability to learn from failure**
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3 Ability is the learning mechanism that is most difficult to investigate, and we find a
4 large gap in our understanding of how to improve ability. While there are case studies that
5 conclude that failure learning is difficult, with many factors that are used to explain when
6 learning will not occur (cf. Baumard & Starbuck, 2005), there are fewer studies that explain
7 high learning rates (i.e., a better ability to learn from failure).
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13 *Can ability to learn from failure be improved?* After-event analysis and error management
14 are ways to improve failure learning. Our review revealed that psychological safety and non-
15 hierarchical environments with good communication and coordination within and between
16 teams also lead to more learning from errors and failures. This result then begs the question
17 for organizations that lack good communication and have low psychological safety: how can
18 they increase their failure learning ability? Can psychological safety be promoted by the same
19 manager who pushes the norms of non-reporting? What types of action are necessary for
20 organizations that wish to adopt the climate and norms of more successful failure learning
21 organizations? Conversely, in organizations with good managerial support for error reporting
22 and psychological safety, how can learning ability be further enhanced?
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3 *How much of learning is automatic? How does ability evolve?* Some performance
4
5 improvements in the learning-curve literature are virtually automatic; learning-by-doing is
6
7 played out at the individual level (Thompson, 2012), and learning-by-doing implies that
8
9 individuals' abilities increase by themselves (but plateau after fairly few experience cycles,
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11 *ibid.*). How important is automatic learning in the context of failure learning? We expect
12
13 some types of errors to diminish as operators gain experience. For instance, car drivers lower
14
15 their accident risk within the first five years of driving, and we tend to ascribe this to success
16
17 experiences. However, the failure learning studies have ignored the automatic learning effect.
18
19 A general assumption is that performance improvements are due to active learning attempts.
20
21 One of the most studied groups in the error research is nurses (e.g., Edmondson, 2004; Tucker
22
23 & Spear, 2006); however, we see little discussion with regard to whether nurses' error rates
24
25 go down with tenure in the profession. Surgeons demonstrate failure reduction over time, thus
26
27 it would be surprising if we would not see the same for nurses with respect to errors.
28
29 However, if the link between errors and failures is weak, the effect of professional tenure may
30
31 not be a reduction in errors but a reduction in errors that result in failed outcomes, that is, in
32
33 converting potential failures into near-miss events.
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39 Again, considering the difference between settings, is there less room for automatic
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41 learning in slow-learning settings, thus requiring more deliberate learning for failure
42
43 reduction? Examining these questions is both theoretically and practically meaningful. These
44
45 questions help to advance our understanding as to how different types of learning occur. The
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47 answers to these questions have implications for practices as they help to develop intervention
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49 in organizations to enhance failure learning.
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54 **Motivation to learn from failure**

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3 Scholars assume that safety and risk avoidance are central to any organization, such as
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5 airlines, mining companies, hospitals, or banks, and they often ignore that most organizations
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7 to some degree accept failure. Safer practices compete with productivity-enhancing
8
9 investments and since viable operations are necessary for the future of organizations,
10
11 productivity is usually prioritized over the potential risk of a future failure, impacting the
12
13 motivation to invest in failure reduction (Haunschild et al., 2015). This is illustrated by
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15 airlines that experience more accidents after filing for Chapter 11 protection (ABCnews,
16
17 2005) and by a famous quote in the freight rail industry: “Uphill slow, downhill fast, freight
18
19 comes first and safety last” (Ahear & Schick, 2014). Low-prime-lending practices are risky
20
21 behaviors that lead to short-term gains but jeopardize organizations and the banking industry.
22
23 In other words, failure reduction attempts will almost always compete with other activities,
24
25 which is a situation that we must acknowledge when theorizing about and investigating
26
27 failure learning. In addition, some failures are seen as being unavoidable by managers, and
28
29 they are relegated to productivity equations’ error terms and more or less accepted as a
30
31 necessary evil rather than something to improve upon (cf. Jovanovic & Nyarko, 1995). Trade-
32
33 offs therefore help to explain the low motivation to reduce failure risks (Haunschild et al.,
34
35 2015). In many settings, regulators move in to change the balance, for instance, imposing
36
37 fines if safety targets are not met. However, it ultimately comes down to decisions that are
38
39 made by individuals and organizations on the costs that they are ready to allocate to learning
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41 and further improving their learning rate.
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47 This leads us to ask if slow-learning settings face stronger trade-offs between
48
49 productivity-enhancing activities and failure reduction.
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52 ***Motivation and the case of non-learning: is motivation THE key factor in failure learning?***
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54 A handful of empirical studies describe settings without failure learning even when similar
55
56 events provide learning opportunities (Baumol & Starbuck, 2005; Tucker & Edmondson
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3 2003). Their findings led some scholars to question if failure learning is generally to be
4 expected at all (Baumold & Starbuck, 2005). Analyzing these studies, we find that they
5 describe situations with low motivation to learn (Baumold & Starbuck, 2005; Eggers & Song,
6 2015), limited opportunity to learn in combination with low motivation to solve underlying
7 problems (Tucker & Edmondson, 2003) and potentially an inability to learn due to low
8 motivation (Eggers & Song, 2015). A conclusion is that failure learning is difficult since is
9 only likely to happen when all three mechanisms are sufficiently activated, and that
10 motivation is a necessary condition for deliberate learning.
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21 In an in-depth case study of a large European telecom firm that suffered 14 strategic
22 failures with no learning, Baumol & Starbuck (2005) describe lack of systematic reporting
23 about failed projects, lack of interest in better understanding what went wrong and managers
24 making external attributions to explain away bad outcomes caused by internal factors. The
25 authors find opportunity but low-to-no motivation to learn, which in the end resulted in no
26 learning. Low motivation involved managers expecting that admitting failure would have
27 negative career ramifications and possibly also harm the organization (many projects were
28 imposed by external stake-holders and the firm was publicly listed). Applying Zhao &
29 Olivera's (2011) cost-benefit reasoning, the cost to the individual managers was high, the
30 benefit to the organization not clear and, hence, low motivation to report was to be expected.
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43 We find a similar argument around individuals using external attributions rather than
44 changing their own behaviour among Chinese serial entrepreneurs (Eggers & Song, 2015).
45 Entrepreneurs with failed start-ups were less likely to alter the way they structured their
46 companies than were entrepreneurs with successful start-ups. Rather, they pursued the same
47 firm strategies and structures when launching a new venture which, in turn, increased the risk
48 for failure. They preferred a new industrial setting which made the authors conclude that this
49 inability to learn is in line with self-serving attribution theory: Using external attributions to
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3 avoid altering ones' method of working is an individual-level defense mechanism
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5 demonstrating both lack of motivation and inability to learn. In contrast, entrepreneurs with
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7 successful ventures who stayed in the same industry kept enjoying more success.
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9 Tucker and Edmondson (2003) report high incidences of errors without organizational-level
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11 learning in a study of nine hospitals known for nursing excellence. Front line nurses that
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13 constantly saw patients were confronted with many problems, such as errors and mistakes
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15 made by others, when executing their tasks. Surprisingly, the nurses' error learning was low
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17 despite their skill and motivation. The reason for low error learning is that the nurses solved
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19 the problems themselves on an *ad hoc* basis since they rarely had time to deal with the
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21 underlying causes. As a consequence, the same errors were repeatedly made and failure rates
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23 remained high. The insight from this study is that the nurses were highly motivated to execute
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25 their work, got a confidence boost in effectively managing problems created by others, and
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27 had little time to provide feedback to the organization. This is both a story of lack of
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29 motivation that emphasizes that the motivation in question is about addressing underlying
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31 problems caused by others, and that the support structure did not offer sufficient opportunity
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33 to get to the root cause of the problems, both in terms of managerial support but also the lack
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35 of time-based opportunity to analyze errors and come up with solutions to reduce their
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37 recurrence.
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43 Across these three non-learning cases motivation plays different roles: ego protection,
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45 career protection, protecting the organization and focus on other parts of the job than error, or
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47 problem reduction. In what way besides motivation do these non-learning cases contrast with
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49 learning cases? Are there more competing motivations in non-learning cases?

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52 Is it an illustration of how motivation is a necessary factor for learning to occur and without it
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54 neither opportunity nor ability matter? Also, how common are non-learning outcomes and
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3 when do they matter? In the telecom case, the firm still did well and clearly was not very
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5 concerned with the failed strategic projects. When do organizations ignore failures?
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8 **The nature of the failure event**

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10 We suggest three areas of research to expand how we study failure events to improve
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12 causality in studies: using counterfactuals by applying the process-outcome matrix in Table 2
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14 when selecting events; extending our failure measures to also consider per-event learning; and
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16 standardizing or at least improving the measures of the learning process.
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19 ***Selection of the dependent variable.*** Few learning studies allow for both successes and
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21 failures to be key events in the research design (Denrell, 2003). Most studies choose to focus
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23 on either successful or failed outcomes (sometimes controlling for the other), and the set of
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25 factors that cause such outcomes. However, to extend our understanding of the relationship
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27 between processes and outcomes, the inclusion of both types of events in the research design
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29 would allow for stronger causal linkages. Currently, this is done in studies in which an
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31 intervention is randomly assigned to different organizational units and the outcomes are
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33 monitored, such as the introduction of checklists in health care into one subset of hospitals,
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35 while the comparison group works as before, and the reduction of adverse events is monitored
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37 (cf. Walker, Reshamwalla & Wilson, 2012). In checklist studies an outcome is either a
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39 success or a failure, thus the rate includes both possibilities while the focus remains on the
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41 effect of a single mechanism, the use of a checklist or not. The initiation of such studies are
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43 usually third-party organizations, such as the WHO, in the health care checklist example
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45 (WHO, 2017).
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50 Including both successful and failed outcomes would also allow for a study of the role
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52 that is played by noise in the learning process (the off-diagonal outcomes in Table 2) to cover
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54 the full range of process-outcome combinations, thus allowing us to better understand
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56 disturbances in learning processes.
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3 *Extending failure measures.* The failure learning literature covers a diverse set of events,
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5 from bankruptcies to patient deaths to large-scale accidents that involve hundreds of victims
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7 who have been injured or killed. Some events occur once per hour and some occur once per
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9 week, while others occur once per decade. While the magnitude of events matter for learning,
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11 higher-impact events motivate organizations to respond more forcefully. An important
12
13 question to ask is whether the sensitivity to failure events varies across industries, and, if so,
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15 what determines the level of sensitivity. In settings with many adverse events that are caused
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17 less by errors and more by the nature of operations (very elderly patients dying in health care,
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19 for instance), we expect a greater insensitivity to the adverse events that are caused by errors.
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21 Three dimensions that should matter when considering events are (1) the frequency with
22
23 which failures occur; (2) the frequency with which adverse events that are NOT caused by
24
25 errors occur; (3) the magnitude of the failure, including the failure magnitude when compared
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27 to industry averages (killed, injured, failure costs). Few studies show us how much a single
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29 failure event affects learning (see Dahlin & Baum, 2012 for an exception), which might
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31 provide a clue to how frequency and magnitude matter. A per-event measure would also make
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33 comparisons across setting more applicable. Here, a meta-analysis could reveal the different
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35 effects of failure events.
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40 We expect the industries that experience a combination of high failure volume and
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42 high spurious failure volume to have an elevated error acceptance. Elevated error acceptance
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44 reduces the motivation to learn, which would explain a lower learning rate in such settings.
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49 *Are learning rates overestimated?* A paper critiquing the methods used in econometric
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51 studies of failure learning, argues that statistical estimations used in failure learning studies
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53 are prone to yielding falsely positive results (Bennett & Snyder, 2017). The authors point out
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55 that the classical learning model where current performance (cost per unit) is a logarithmic
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3 function of accumulated experience (number of units produced) has some econometric issues
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5 when translated to failure learning and risk overstating the case for failure learning. Similarly,
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7 they point out the risk for false positive coefficient results increase when including successful
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9 as well as unsuccessful learning opportunities in the same equation. They recommend using
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11 moving time windows of past failures, and separating the success and failure opportunities
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13 into different estimations. Most studies already use moving windows and also discount events
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15 further back in time (albeit they do this for theoretical and data rather than estimation reasons)
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17 (cf. Baum & Dahlin, 20017; Kim & Miner, 2007).
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21 Even if Bennett and Snyder overstate the risk of falsely positive results, their paper
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23 raises a more fundamental question about econometric failure learning models. Usually a
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25 learning curve is assumed (often without this functional form being established as the one
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27 best-fitting the data) which means that a key assumption is that success and failure learning
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29 follow the same learning pattern. Similarly, when including both successful and failed prior
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31 events these are seen as additive which is an untested assumption. For instance, in traditional
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33 success learning, failed outcomes can be seen as reducing the learning rate but it is usually
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35 relegated to the error term. To model the interaction between success and failure, we need to
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37 develop new models accounting for both failure and learning as potential complements rather
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39 than substitutes. This way we could for instance see spill-overs from number of successful
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41 repetitions in learning-by-doing (such as driving a car) – when skills increase, errors and
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43 mistakes decrease as a function of more successful events. Rather than substitutes, there is
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45 complementarity with success learning leading to fewer failures and also enhancing failure
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47 learning. Conversely, we can observe that failure has a complex effect on normal operations,
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49 slowing down success learning since overall output might be reduced after a serious accident.
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51 The recommendation from Bennett and Snyder (2017) is to, for econometric reasons, not
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53 include both successful and failed events in the same estimations, we would argue that they
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3 should also be estimated separately for theoretical reasons – we simply don't know how they
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5 relate.
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10 ***Measuring failure and its responses.*** The empirical studies on failure learning face two
11 measurement issues. First, individuals and organizations often fail to identify or report all
12 failure events. This makes examining failures' effects on learning processes more of a
13 challenge. Common approaches to collecting failure and error data include using public
14 archival data (e.g., Baum & Dahlin, 2007; Desai, 2015; Lawton et al., 2012), experimental
15 designs (Dillon & Tinsley, 2008; Ellis et al., 2006), or employee recall (Ginsburg, et al.,
16 2010). Archival data and employee recall increase under-reporting biases, and the question is
17 how to account for this when interpreting studies. Audits are, for instance undertaken in a
18 number of industries, with the Federal Railroad Administration performing spot-checks on
19 regulation compliance (FRA, 2017). Legal cases where non-reporting leads to penalties
20 usually state the expected underreporting. Union representatives also have addressed
21 underreporting.
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36 Second, our review revealed that there is a lack of common measures with regard to
37 failure learning behaviors, such as the schemas that are used when responding to failures.
38 Without common measures, it is difficult to compare the results from studies with different
39 research settings. With few exceptions (cf. Ginsburg, et al, 2010; Shepherd et al., 2011) most
40 studies measure broad learning behaviors, such as whether employees can challenge work
41 processes or if they have improved work procedures, rather than learning behaviors that are
42 specifically related to failures, such as the identification of an adverse event, cause analysis
43 and corrective action. Most importantly, to better understand errors and failure learning
44 requires a research design with an explicit link between failure events and the different
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3 elements of learning behavior, such as Israeli flight crews' post-event analyses (Ellis *et al.*,
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5 2006).
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8 9 10 **CONCLUSION**

11
12 Reviewing the literature on error and failure learning, we clustered learning mechanisms into
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14 three categories of opportunity to learn (the factors of information and time), motivation to
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16 learn (willingness to act) and ability to learn (competence to act). Failure and error learning
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18 have been studied across academic areas and address multiple levels of analysis, from
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20 individual, group and organizational perspectives. While motivation and ability factors
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22 dominate studies at the individual and group levels of analysis, opportunity factors dominate
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24 studies at the organizational level. Studies in health management are also concerned with
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26 procedure-level studies, with a wealth of data showing time trends for procedures on the
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28 national level, where learning diverges greatly across treatment types from negative, over no
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30 improvement, to some positive learning (Downey *et al.*, 2012).
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34 In summary, the findings suggest that more information about errors and failures in
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36 the form of one's own and others' prior failures or near failures facilitate learning. They go on
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38 to report that leaders and organizations with a punitive attitude toward errors and failures
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40 obtain less information because individuals in such organizations consider the cost of
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42 reporting to be too high. Additionally, they state that the ability to process and learn from
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44 errors and failures is partly based on attribution and inherent attitudes; however, this ability
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46 can be boosted through active post-event reviews. We argue that the cross-industry
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48 differences in learning rates depend on a number of factors. Among those factors, a noisy
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50 learning environment in which organizations experience spurious successes and spurious
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52 failures exerts a strong influence on failure learning. Noisy information about cause-effect
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54 makes failure information more difficult to interpret, which lowers learning opportunities and
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3 ability. Spurious successes and failures also create ambiguity, which lowers the motivation to
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5 learn because the awareness of weak error-failure connections risks leading to normalized
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7 deviance, and it can also lower individuals' motivations to report errors and failures.
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10 An organization that seeks to enhance error and failure learning should analyze the
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12 causes of its most common errors and failures. To maximize the opportunity to learn, the
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14 organization should not only study its own but also the events of similar organizations.
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16 Further, including near-misses would add information and suggestions for ways to avoid an
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18 adverse outcome after a process error has occurred. When attributing causes, management
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20 must ensure that operators are not unduly blamed and if the cause is found to be operator
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22 error, look for systematic such errors to find if there are structural or organizational factors
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24 leading to operator error.
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28 We propose a number of unexplored research areas in error and failure learning, some
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30 of which are related to a lack of linkages across academic disciplines. In short: management
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32 scholars tend to ignore the role that is played by regulators in failure reduction; policy
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34 scholars tend to ignore organizational differences and the role that is played by management
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36 in failure reduction; safety scholars have devised methods for the transfer of learning and for
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38 the development of ability; however, they have not yet fully established the efficacy of these
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40 tools. To that end, scholars across academic disciplines have "failed" to learn from each
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42 other's failure research. Through our review, we have found fruitful opportunities for future
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44 research to learn from the extant failure studies to enhance our understanding of failure
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46 learning in organizations.
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Table 1. Factors investigated in failure learning studies classified by level of analysis and mechanisms.

	Opportunity	Motivation	Ability
Individual level	Perceived autonomy (Stern et al., 2008) Situational learning (Stern et al., 2008) Experience (KC, Staats, & Gino 2013)	Motivation to learn (Zhao, 2011) and safety motivation (Buljac-Samardzic, et al. 2012; Neal & Griffin, 2006; Probst, 2015) Attribution (Ilgen and Davis, 2000; Nisbett and Ross, 1980; Ellis, Mendel & Nir, 2006; KC, Staats, & Gino 2013; Naquin & Tynan, 2003) Emotion (Edmondson, 1996; Paget, 1988; Keith & Frese, 2005; Neal & Griffin, 2006; Shepherd et al., 2011; Zhao, 2011) Psychological safety (Carmeli & Gittell, 2009) Perception of outcomes (Dillon & Tinsley, 2008) Coping orientation (Shepherd et al. 2011)	Training (Gully, et al., 2002; Keith & Frese, 2005) After-event reviews (Ellis & Davidi, 2005; Ellis, Mendel, & Nir, 2006) Coping orientation (Shepherd, et al., 2011) Relationships with others (Carmeli & Gittell, 2009)
Group level	Member rotation (Argote & Todorova, 2007) Group diversity and intergroup-linkages (Chuang et al. 2007; Tucker & Edmondson, 2003) Team stability (Edmondson, 1996) Routines to gather information (Lawton, et al. 2012; Edmondson, et al 2001; Tucker & Spear, 2006) Autonomy (Kerr, 2009) and load (Malone et al. 2007)	Group norms and team orientation (Katz-Navon, et al., 2009; Vogus & Sutcliffe, 2007; Zohar, 2002; Tjosvold et al. 2004) Psychological safety (Edmondson, et al. 2001) Tacit belief about failure (Cannon & Edmondson, 2001; Edmondson, et al., 2001) Leadership style (Cannon & Edmondson, 2001; Katz-Navon et al., 2009; Carmeli et al., 2012) Safety climate (Zohar & Luria, 2005) Status dynamics (Edmondson, et al. 2001) Routines (Gersick & Hackman, 1990) Debriefing and reviewing abilities (Ron, et al. 2006) Resistance to change (Hodgkinson & Wright, 2002) Workload (Lawton et al., 2012) and autonomy (Kerr, 2009)	Failure climate (Buljac-Samardzic et al., 2012) Leadership style (Buljac-Samardzic et al., 2012; Zhao, 2011; Cannon & Edmondson, 2001) Training (Morey, et al. 2002) Membership stability (Buljac-Samardzic et al., 2012) Understanding of team process (Baker et al., 2006) Workload (Lawton et al., 2012) and work process (Edmondson, 1996) Coordination and communication (Baker et al. 2006) to develop cooperative goals (Tjosvold et al. 2004)

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Organizational level (includes inter-organizational factors)	Own and others' failure experience and processes to collect information on those failures (Tucker & Spear, 2006; Baum & Dahlin, 2007; Chuang & Baum, 2003; Haunschild & Rhee, 2004; Haunschild & Sullivan, 2002; Kim & Miner, 2007; Madsen & Desai, 2010; Madsen, Dillon & Tinsley, 2016) Own success experience (Madsen & Desai, 2010; Pisano et al., 2001) Recency of event (Haunschild, Polidoro & Chandler, 2015) Magnitude of event (Desai, 2011; Madsen, 2009) Complexity of problems (Stan & Vermuelen, 2013) Organizational size (Desai, 2009; Slonim, 2007) Near failures / near misses (Kim & Miner, 2007; Kessels-Habraken, et al. 2010) Geographic proximity (Kim & Miner, 2007)	Performance aspirations (Baum & Dahlin, 2007) Media attention (Desai, 2011 and Desai 2014; opposite results) Reputation (Haunschild & Rhee, 2004; Rhee, 2009) Safety climate (Hofman & Stetzer, 1998) Other's similar errors (Mitsuhashi, 2011)	Organizational form (Hanschild & Sullivan, 2002) Failure climate (Khatri et al., 2009) Error management culture (Dyck et al., 2005) Leadership style (Desai, 2015) Culture, work load (Kralewski, et al. 2005; Malone et al. 2007) Post-experience reviews (Ron, Lipshitz & Popper, 2006) and external pressures (Haunschild & Rhee, 2004). Patient-centered hospitals, climate (Rahert & May, 2007; Lawton et al., 2012) Standardized procedures/protocols (Thornlow & Merlin, 2009) Organizational size (Ginsburg, et al., 2010)
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Table 2. 2x2 table of four process and outcome combinations.

		Outcome of event	
		Success	Failure
Process/behavior/routine	Correct	1. Traditional learning	2. Spurious failure
	Faulty	3. Spurious success	4. Traditional failure learning

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Authors	JOURNAL	YEAR	LEVEL OF ANALYSIS	O/M/A ¹	DATA/SETTING	METHOD	N	RESULT
Edmondson	Journal of Applied Behavioral Science	1996	Group	O, A	Patient care groups	Survey	8 units	L=O, A
Hofman & Stetzer	Academy of Management Journal	1998	Group	M	Utility company	Field experiment	Safety communication and attributions in 159 groups	L: A→M
Edmondson, Bohmer & Pisano	Administrative Science Quarterly	2001	Group	M	Team in hospitals	Qualitative	16 hospitals	L=M
Cannon & Edmondson	Journal of Organizational Behavior	2001	Group	M, A	Organization teams	Field study	51 groups	L=M+A
Haunschild & Sullivan	Administrative Science Quarterly	2002	Organization	O, A	airlines	Archival data	310 airlines	L=O*A, Specialist airlines learn more from heterogeneous accidents
Tucker & Edmondson	California Management Review	2002	Group	O, M	Hospitals	Qualitative	9 hospitals	No learning
Zohar	Journal of Organizational Behavior	2002	Group	M	Work groups	Survey	49 groups	L=M
Gully, Payne, Kiechel Koles & Whiteman	Journal of Applied Psychology	2002	Individual	A	Undergraduate students	Experiment	188	L=A
Morey, et al.	Health Services Review	2002	Group	A	Emergency departments in hospitals	Field experiment	9 emergency departments	L=A
Hodgkinson & Wright	Organization Studies	2002	Team	M	Top management teams	Qualitative	1 team	L=M

¹ Please note that this is our interpretation of how to classify a study’s mechanisms.

Madsen & Desai	Academy of Management Journal	2010	Organization	O	Orbital launch	Archival data	26 launch vehicle organizations	L=O
Ginsburg, Chuang, Berta, Norton, Ng, Tregunno & Richardson	Health Services Research	2010	Organization	A	Patient safety	Survey	69 hospitals	L=A
Desai	Academy of Management Journal	2011	Press release Organization	O, M	Railroad accidents	Archival data	234 press releases, 391 firm-years	L=M, O
Mitsubishi	Industrial and Corporate Change	2011	Organization	M and O	Japanese nuclear plants	Archival data	56 reactors	L=M, O has no effect
Banja	Business Horizons	2011	Event	A, M	Health care	Case histories and theory	Description of systematic rule breaking	L=M, A
Carmeli, Tishler & Edmondson	Strategic Organization	2011	Group	M	Top management teams	Survey	77 TMTs	L=M*A
Zhao	Journal of Organizational Behavior	2011	Individual	M	Undergraduate students	Survey with experiment	127	L=M
Shepherd, Patzelt & Wolfe	Academy of Management Journal	2011	Individual	M, A	Research institutes	Survey	585	L=M+A+M*A
Downey, Hernandez-Boussard, Banka & Morton	Health Services Research	2012	Procedure	Trends, no mechanism	Medical failure trends using US national data	Archival data	7.6 million adverse events for 69 million hospitalizations	14 procedures: 6 with decrease 1 with no change and 7 with increases in adverse events
Muehlfeld, Sahib & Van Witteloostuijn	Strategic Management Journal	2012	Transaction	O	Newspaper merger and acquisitions	Archival data	4973 m&a attempts 1981-2008 by 1964 firms	L=O, U-shaped relationship
Buljac-Samardzic, Van Woerkom & Paauwe	Health Care Management Review	2012	Group	A	Hospitals	Survey	152 teams	L=A

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Lawton, Carruthers, Gardner, Wright & Mceachan	Health Services Research	2012	Group	O, A	Hospitals	Qualitative	3 wards	L=O*A
Stan & Vermeulen	Management Science	2013	Organization	O	Fertility clinics	Archival data	116 UK fertility clinics 1991-2006	O--> A --> L
Zheng, Miner & George	Industrial and Corporate Change	2013	Patent (IVs on individual and group levels)	M, O	University technology transfer office	Archival and interviews	778 patents of which 170 were licensed	L=M*O
Kc, Staat & Gino	Management Science	2013	Individual	O, M	Hospitals	Archival data	71 cardiac surgeons	L=O+M+M*O
Desai	Journal of Management	2014	Organization	M	Air traffic controllers, near misses	Archival data	US class I railroad firms	L=M
Haunschild, Polodori & Chandler	Organization Science	2015	Organization	O	Pharmaceutical firms, drug recalls	Archival data	146 firms	L=O, M Motivation varies over Time.
Eggers & Song	Academy of Management Journal	2015	Individual	M, A	Serial entrepreneurs in China	Survey	253 entrepreneurs	L=M, A tested, no learning
Probst	Journal of Applied Psychology	2015	Individual	M	33 organizations	Survey	1238	L=M
Desai	Academy of Management Journal	2015	Organization	O	Heart bypass surgeries	Archival data	116 hospitals	L=O
Madsen, Dillon & Tinsley	Risk Analysis	2016	Organization	O	Airlines	Archival data	64 commercial airlines	L=O

