PROJECT FAILURE, ERROR ORIENTATION AND LEARNING FROM FAILURE

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ABSTRACT

Why are some entrepreneurs more able to learn from failures, while others are not? To address this controversial but crucial research question, combining experiential learning theory and an error management perspective, this study builds a conceptual model to explore the relationship between failure experience and learning from failure, as well as the moderating role of error orientation. Using a survey sample of 237 high-technology ventures in China, the results show that: (1) The volume of failure experience affects learning from failure negatively; (2) The volatility of failure experience affects learning from failure positively; (3) Error competence plays a positive moderating role in the relationship between the volume of failure experience and learning from failure; and, (4) Error strain plays a negative moderating role in the relationship between the volatility of failure experience and learning from failure. The results reveal that the level of entrepreneurs' learning behaviours with different failure experience not only depends on the nature of failure experience but also their individual error orientation, which functions like a catalyst that promotes failure experience into learning behaviour or not.

Keywords

Failure experience; error orientation; learning from failure; NPD project; entrepreneurs

"Failure is a great teacher and, if you are open to it, every mistake has a lesson to offer."
—Oprah Winfrey

INTRODUCTION

New product development (NPD) projects are crucial to high-tech ventures, which cultivate cutting-edge technology to develop novel products and enter nascent markets (Scarmozzino, Corvello, & Grimaldi, 2017). Successful NPD projects can propel high-tech ventures to rapid growth, enabling them to take a strong foothold in the market and outperform competition (Chang & Taylor, 2016). However, failure is inherent to the entrepreneurial process and more frequent than success (Byrne & Shepherd, 2015), due to the highly uncertain nature of NPD projects (Hu, McNamara, & Piaskowska, 2017). Failure is not necessarily a completely negative outcome as it can serve as a fundamental learning experience for entrepreneurs (Cope, 2011; Shepherd, Patzelt, & Wolfe, 2011; Ucbasaran, Shepherd, Lockett, & Lyon, 2013; Yamakawa & Cardon, 2015). However, some entrepreneurs are more able to learn from failure than others. Thus, how entrepreneurs learn from NPD failures and ensure that lessons are learned towards subsequent projects is a key differentiating factor.

Understanding both the nature of failure and individual entrepreneurs involved in the failure experience helps shed light on how learning from failure takes place. First, Politis (2005, p.411) rightly argue that "not all failures are equally adept at facilitating learning." The nature of failure is complex, but often over-simplified in prior literature, partly explaining the inconclusive evidence relating to the relationship between failure and learning (Boso, Adeleye, Donbesuur, & Gyensare, 2018). For example, the existing studies have found a non-significant relationship (Liu, Geng, Xia, & Bridge, 2017), a positive relationship (e.g. Boso et al., 2018), a negative relationship (e.g. He, 2013) and even an inverted U-shaped relationship (e.g. He, Sirén, Singh, Solomon, & von Krogh, 2018). Therefore, our first research question is: how does the nature of failure experience influence entrepreneurs' learning behaviour? In this study, we

focus on two main aspects of the nature of failure experience, namely, the volume (i.e. the number of failures experienced by an entrepreneur) and the volatility (i.e. the intensity and relevance that an entrepreneur associate with failure) (Morris, Kuratko, Schindehutte, & Spivack, 2012), and examine their relationships with learning from failure.

Second, prior research suggests that not all entrepreneurs are equally versed in learning from failure (Baumard & Starbuck, 2005; Cannon & Edmondson, 2005; Funken, Gielnik, & Foo, 2018;Van Gelderen, Van de Sluis, & Jansen, 2005), as their positive and negative attitudes and reactions to failure might facilitate or impede learning (Shepherd & Cardon, 2009; Shepherd et al., 2011; Ucbasaran et al., 2013). Because individual learning is the result of personal and situational drivers (Van Gelderen et al., 2005), understand how learning takes place must take into account individual factors, for example, individuals' attitudes and responses to the errors and failures (Van Dyck, Van Hooft, De Gilder, & Liesveld, 2010). Therefore, our second question is: what difference does entrepreneurs' individual factors make on the relationship between failure and learning? Based on error management perspective (Frese & Keith, 2015), we identify two contrasting individual error orientations, namely error competence (i.e. enhanced confidence in one's ability to handle and recover from errors quickly) and error strain (i.e. induced emotional strain resulting from fear of making or reacting to errors), and examine how they influence the relationships between the nature of failure and learning from failure.

In summary, our study examines the relationships of the volume and volatility of NPD project failure and learning from failure, and how error competence and error strain influence these relationships, drawing on a new survey dataset of 237 Chinese high-technology ventures. Our study intends to make three contributions. First, our study contributes to the experiential learning theory by exploring the heterogeneous nature of failure experience and how its heterogeneity affects entrepreneurs' learning behaviour differently. This responds to the call

for a better understanding of entrepreneurs' experiential learning: "If entrepreneurship is fundamentally experiential, we know surprisingly little about the nature of the experience" (Morris et al., 2012, p11). Our study not only empirically tests the heterogeneous nature of experience in the context of NPD project failure but also distinguishes entrepreneurs' error orientations towards failure experience, which together enhance our understanding of the learning from failure. Second, our study broadens the theoretical boundary of the error management perspective into the field of entrepreneurship research. Error management is an important construct in psychology (Frese & Keith, 2015). It could help explain the underlying influencing mechanism concerning entrepreneurs' attitudinal and behavioural tendencies, but has not yet been incorporated in the entrepreneurship literature (Gielnik et al., 2017). Our study is one of the few to adopt the error management perspective to explore how the nature of failure and entrepreneurs' attitudes and responses to failure together help understand learning from failure. Furthermore, this study focuses on an important but often overlooked entrepreneurial context, namely NPD project failure, for exploring the underlying mechanism of learning from failure. Our study opens up potentially new avenues for research on failure and in particular, how project feedback informs learning (Jenkins & McKelvie, 2016).

THEORETICAL BACKGROUND

The overarching theory of this study lies in experiential learning, which defines learning as "the process whereby knowledge is created through the transformation of experience" (Kolb 1984, p41)". The "experience" has been mainly applied in entrepreneurship area as the experientially acquired knowledge and skills that result in entrepreneurial know-how and practical wisdom (Corbett, 2007); the outcome of involvement in previous entrepreneurial activities (Baron & Ensley, 2006); and the direct observation of or participation in activities associated with an entrepreneurial context (Cope &Watts, 2000). Unlike with these theoretical

perspectives, experiential learning theory (ELT) holds valuable potential for entrepreneurship scholars as it provides a useful way to "moves us past a static "snapshot" perspective and approaches entrepreneurship as a dynamic, socially situated process driven by unfolding events." (Morris et al., 2012, p13).

While ELT on entrepreneurial failure and its influences on entrepreneurial behaviours have helped advance the entrepreneurship discipline (Amankwah-Amoah, Boso, & Antwi-Agyei, 2018), an important issue that has been under-recognized and understudied is how entrepreneurs' failure experience interact with their attitudinal and behavioural orientation on failure to influence their subsequent behaviours. A useful foundation for exploring the role of individuals' attitudes and responses to the failure and error and is error management perspective (Frese & Keith, 2015), which incorporates error orientation as distinguishing boundary conditions that help explain the transformation of experience into knowledge. Overall, the experiential learning theory and error management perspective, therefore, provide useful theoretical lenses to clarify the complex and inconclusive relationships between failure experience and learning from failure.

Project Failure

NPD projects are associated with high risks and hence project failure (Urbig, Bürger, Patzelt, & Schweizer, 2013). NPD project failure, especially within the research and development (R&D) environment, has attracted appreciable attention in recent years (e.g. García-Quevedo, Segarra-Blasco, & Teruel, 2018; Hu et al., 2017; Shepherd, Patzelt, Williams, & Warnecke, 2014; Shepherd et al., 2011), but its concept remains nebulous (Jugdev & Moller, 2006). Scholars (e.g. Ucbasaran et al., 2013) have cautioned that failure must be clearly defined as different definitions may result in different research outcomes. Subsequently, Jenkins and McKelvie (2016) propose a multi-faceted conceptualization of entrepreneurial failure using a

matrix of the firm and individual levels and subjective and objective criteria. Our study further develops this matrix by incorporating project level to form a new matrix as shown in Figure 1. In particular, we define project failure as "the termination of a project due to the realization of unacceptably low performance as operationally defined by the project's key resource providers" (Shepherd & Cardon, 2009 p. 924), which has been widely referred and used (e.g. Liu et al., 2017; Shepherd, Covin, & Kuratko, 2009; Shepherd et al., 2011; Shepherd et al., 2014).

Insert Figure 1 about here

Within this broad definition of project failure, we recognize that no two failures are identical (Haunschild & Rhee, 2004), and neither are they of equal value in promoting learning (Madsen & Desai, 2010). According to Morris et al. (2012), any entrepreneurial experience differs in its volume (i.e. the number of salient events making up the stream), velocity (i.e. the rate at which those events are processed), and volatility (i.e. the intensity associated with those events). Existing research mainly focuses on the volume of failure experience (e.g. Cardon, Stevens, & Potter, 2011; Ucbasaran, Westhead, & Wright, 2009; Yamakawa et al., 2015) and the velocity of failure experience (e.g. He et al., 2018). However, very few studies discuss the volatility of failure experience and differentiate between these dimensions of analysis (Cardon et al., 2011). Failures, as salient events not only informs the volume and velocity of failure but also provides key information regarding the personal saliency of these events (i.e. the volatility of failure) which involves the interaction of emotions and cognition (He, 2013). For example, it is likely that for two entrepreneurs who have experienced the same volume or velocity of failure, the volatility of their failure experience differs drastically. In align with the previous definition of failure classified in subjective and objective criteria, we chose to focus on the volatility of failure experience from the subjective aspect and the volume of failure experience

from the objective aspect. In this study, the volume of failure experience is operationalized as the ratio of the number of failure experience to the whole managing experience within the latest three years, which presents the combination of the volume and velocity of failure experience.

Learning from failure is not only about knowing how to avoid the respective failure but rather the implementation of the lessons learned by adapting and modifying existing theories and adjusting own actions (Lyytinen & Robey, 1999). What's more, according to Shepherd (2003), an even deeper level of learning involves revising "assumptions about the consequences of previous assessments, decisions, actions, and inactions" (p. 320). This is akin to the term 'regenerative failures' developed by Cope (2011) - entrepreneurs that experience failure go on to apply the lessons they learned by actively re-engaging with the entrepreneurial process, thereby completing the learning cycle. Accordingly, this study focuses on behaviour-based learning from failure, which involves collecting information, identifying the root cause of failure, reflecting on and discussing relevant experience, and applying what they have learned from previous failures to the subsequent behaviours(e.g. Carmeli, 2007; He et al., 2018;Yu, Chen & Nguyen, 2014).

Error Orientation

Learning from failure is a key success factor for entrepreneurs. However, experiencing failures does not automatically lead to learning behaviour (Cannon & Edmondson, 2005; Funken et al., 2018), as entrepreneurs differ in their usually attitudinal and behavioural response towards errors and failures (Van Dyck et al., 2010). A concept that explains how people respond to errors (failures) is error management, which views error as a common part of human life and an important source of learning (Frese & Keith, 2015). As errors will constantly occur (Frese & Keith, 2015), especially in uncertain situations like starting a new business or develop a new project, what individuals do after an error has occurred matters(Van Dyck, Frese, Baer, &

Sonnentag, 2005). Error management originates in psychology, but its implications for entrepreneurship have not been studied (Gielnik et al., 2017). This study brings in error management study why some entrepreneurs are able to learn from failures, while others are not.

The error management concept has been operationalized as error orientation (e.g. Funken et al., 2018; Gielnik et al., 2017). Error orientation describes how individuals generally handle errors and their consequences, containing eight original component factors: error competence, error strain, error anticipation, error communication, learning from errors, error risk-taking, covering up errors, and thinking about errors (Rybowiak, Garst, Frese, & Batinic, 1999). The unidimensionality of the component factors has been subject to validation. Some scholars arrive at a two-factor of error mastery orientation and error aversion orientation (e.g. Funken et al., 2018; Van Dyck et al., 2010), but the components of each factor vary: Funken et al.'s (2018) error mastery orientation includes five subscales and error aversion orientation four subscales, while the error risk-taking loads on both factors, which is against the premise of construct unidimensionality. Consequently, Hetzner, Gartmeier, Heid, &Gruber(2011) conclude that the error orientation construct does not represent a self-contained theoretical construct, and that researchers should select the component factors best suited to 'the heuristic goals' of a study. In particular, error competence and error strain have stood the test of time in various research settings (e.g. Hetzner et al., 2011; Schell & Conte, 2008; Zhao, Emby, & Sieweke, 2018). This study focuses on error competence and error strain due to their contrasting influence on the relationship between project failure and learning from failure.

Error competence refers to one's confidence in his or her knowledge and capability to immediately recover from an error and reduce its negative consequences (Rybowiak et al., 1999). An individual with a high error competence has a strong sense of self-efficacy and self-esteem (Bandura, 1986) even in an error situation (Schell, & Conte, 2008), and is able to take actions after failure to mitigate negative outcomes (Rybowiak et al., 1999). Error strain is

marked by a generalized fear of committing errors and negative emotional reactions towards failure (Rybowiak et al., 1999), such as anger, shame, guilt, and fear (Keith & Frese, 2005; Zhao & Olivera, 2006). A high level of error strain interferes with cognitive processing of failure (Hetzner et al., 2011), and consequently negatively affect an individual's attitudes and behaviour towards failure. Based on behavioural responses to errors (Schell & Conte, 2008), error competence and error strain are expected to be negatively correlated, but conceptually distinguish from each other. Error competence is underpinned by individual knowledge and capability to dissect failure experience and develop strategies to cope with failure. Rybowiak et al., (1999) found error competence positively affects self-efficacy and action-orientation after failure. Thus, we expect that error competence has a positive moderating impact on the relationship between project failure and subsequent learning behaviours. However, error strain reflects an individual's negative emotional response to failure. This such error-related negative emotions not only correlate negatively with self-efficacy and initiative (Rybowiak et al., 1999) but also are assumed to inhibit cognition and productive learning (Hetzner et al., 2011). Thus, on the contrary, we hypothesise that error strain exerts a negative impact on the relationship between project failure and subsequent learning behaviours.

HYPOTHESES

We propose a theoretical framework of the relationships between the nature of failure experience, error orientation and learning from failure (see Figure 2). Below, we articulate the research hypotheses pertinent to the understanding of how the nature (volume and volatility) of failure experience and entrepreneurs' error orientation (error competence and error strain) influence their learning from failure.

Insert Figure 2 about here

Project Failure and Learning from Failure

Learning is tied to the nature of the events being experienced (Morris et al., 2012). Failure experience can be a double-edged sword: it can hinder learning and restrict the motivation to try again (Shepherd, 2003), or stimulate learning and adaptation (McGrath, 1999). According to Morris et al., (2012), the nature of failure needs to be considered to understand its various effects on learning, for example, the number (i.e. volume) of failure experiences and the intensity (i.e. volatility) relating to failure experience.

"Learning is greater with the first or second encounter with a particular type of event" (Morris et al., 2012, p23), for example, the NPD project failure. However, with an increased volume of failures can evoke negative emotional responses that are potentially detrimental to entrepreneurs' learning behaviour (He et al., 2018). On the one hand, the increased volume of project failure will heighten negative emotions that can divert entrepreneurs' cognition resources away from them and interfere their cognitive function (Foo, Uy, & Murnieks, 2015). According to Catino and Patriotta (2013), the learning behaviour is cognitively demanding. Thus the high volume of failure will interfere with individuals' cognitive ability to learn from failure (Shepherd, 2003). On the other hand, experiencing too much project failures will make entrepreneurs feel self-stigmatization (He et al., 2018), which will suppress their willingness and initiative to discuss prior project failures and obtain suggestions with other team members in the same NPD projects (Cope, 2011).

Thus, increased volume of failure experience is more likely to be negatively associated with learning from failure due to the creation of motivational and cognitive deficits that restrict entrepreneurs' cognitively learning behaviour, and self-stigmatization than hinders their learning behaviour from others. Overall, we argue for a negative relationship between the volume of failure experience and learning from failure:

Hypothesis 1: The volume of failure experience negatively affects learning from failure.

The volatility of failure experience "refers to the relative intensity due to the peaks and valleys in the series of events given salience by the entrepreneur" (Morris et al., 2012, p19), and the more important a project is to an entrepreneur, the more intense its failure is likely to be. In this study, we argue that the volatility of failure experience positively affects learning from failure as it facilitates two necessary conditions of learning: "the motivation to alert knowledge and ability to extract meaningful knowledge from experience" (Madsen & Desai, 2010, p. 454).

On the one hand, when the project failure means much to the entrepreneurs, it will motivate individuals to reflect upon the attributes of an event and their actions and emotions during the incident. The high level of volatility of failure experience attracts increased attention (Cope, 2003; Sitkin, 1992), and the increased attention will disrupt automatic processes (Frese & Keith, 2015) and enforces a more effortful deeper-level processing (Keith, 2011), which is instrumental in generating higher-level learning from these experiences (Cope, 2003). On the other hand, the increased volatility reflects the intensity of failure experience perceived by entrepreneurs who can actively search for information and seek feedback about the failure experience. This information or feedback then helps entrepreneurs experiment with new ways of doing things and increase the variance in their decision-making algorithms, which together signify a shift into the exploration mode of solution search (Minniti & Bygrave, 2001).

There is evidence, for instance, Shepherd et al. (2011) find that the relative importance that individuals assign to a given failed project positively influences their overall learning from project failure. Overall, we argue for a positive relationship between the volatility of failure experience and learning from failure:

Hypothesis 2: The volatility of failure experience positively affects learning from failure.

The Moderation of Error Orientation

The complexities and opposing effects in learning from failure not only depend on the nature of failure experience, but the individuals' attitudinal and behavioural orientation on failures, such as error orientation (He et al., 2018). In addition, the prior studies argued that entrepreneurial failure leads to immediate as well as long-term emotional reactions (Gielnik et al., 2017), which have different functions in the learning process (Shepherd et al., 2011). In this study, we consider error orientation as a moderator of the contradictory relationships between failure experience and learning from failure. Specifically, the error competence overarches a positive moderator and error strain, on the contrary, works as a negative one.

Error competence, defined as the perception of one's ability to handle and recover from error in the short-term (Rybowiak et al., 1999), which presents a positive behavioural orientation towards project failure in this study, will positively affect the relationship between failure and learning through cognitive and emotional aspects. Firstly, error competence depends on one's sense of efficacy in error and failure situations (Schell, & Conte, 2008). Entrepreneurs with a high level of error competence usually have a strong sense of self-efficacy (Bandura, 1986) and will increase cognitive processing of the failure situation because failures are seen as learning opportunities (Politis & Gabrielsson, 2009). The increased volume and volatility of failure signal that the expected goal has not (yet) been achieved and "something need to be done" (Frese & Keith, 2015, p673). Thus, holding a high error competence, entrepreneurs will have strong confidence in confronting error and failures, quickly detecting and handing the increased volume and volatility of projects failure, which promotes their learning behaviours after experiencing NPD project failures.

Secondly, entrepreneurs with an error competence will immediately recover from errors and failures and are able to take actions after failure to mitigate negative outcomes (Rybowiak et al., 1999). Holding a high error competence, the entrepreneurs will buffer the negative

emotions that usually accompany project failures, which will help them to accept failures and in turn helps to control negative emotions in response to increased volume and volatility of failure and to stay focused on the task (Heimbeck, Frese, Sonnentag, & Keith, 2003). Thus, error competence will help to transform the project failure failures into learning behaviour. Similarly, perceived normalization of failure in a venture reduces negative emotions from project failure (Shepherd et al., 2011), which provides a suitable situation for stimulating learn from failure. Thus, we argue the followings:

Hypothesis 3a: The relationship between the volume of failure experience and learning from failure is moderated by error competence such that the negative relationship will be attenuated when error competence is high.

Hypothesis 3b: The relationship between the volatility of failure experience and learning from failure is moderated by error competence such that the positive relationship will be intensified when error competence is high.

Error stain is defined as negative emotional reactions towards failure due to fear of committing an error (Rybowiak et al., 1999), which are assumed as a negative moderator of the relationships between failure experience and learning from failure. Specifically, entrepreneurs with a high level of error strain will create stress and reluctance to change (Hetzner et al., 2011) when confronted with an increased volume of project failures. If people are preoccupied with their negative emotions, necessary actions to correct the failure may be delayed, with potentially harmful effects (Frese & Keith, 2014). Holding a high error strain will intensify the negative emotions experienced after a project failure has occurred because entrepreneurs are afraid of committing failure which is seen as a threat. Consequently, this increased volume of project failures will cause entrepreneurs with a high error strain to avoid action-oriented behaviour and interfere with the accomplishment of cognitive processes, such as reflection (Keith & Frese, 2005) - most important constituent of learning behaviour.

Furthermore, according to Zhao et al., (2018), error strain inhibits constructive coping activities because error strain distracts limited cognitive resources from task-related thinking and behaviour to task-irrelevant emotion coping activities (Frese & Keith 2015). Holding a high level of error strain, these entrepreneurs might divert their attention away from the stressful failure situation to reduce negative emotions when confronted with increased volume and volatility of project failures. They might distract themselves from the negative emotion by engaging in other activities or by quickly dealing with the failure without reflecting on the causes (Shepherd & Cardon, 2009). For example, they would devote time to dealing with negative emotions or with finding someone to blame, necessary actions to learn from failure may be neglected (Van Dyck et al., 2005). Taken together, we assume that:

Hypothesis 4a: The relationship between the volume of failure experience and learning from failure is moderated by error strain such that the negative relationship will be intensified when error strain is high.

Hypothesis 4b: The relationship between the volatility of failure experience and learning from failure is moderated by error strain such that the positive relationship will be attenuated when error strain is high.

METHODS

Our study is based on a survey data of high-technology ventures in Shanghai, China. High-technology ventures pursuing NPD projects for firm growth provide a relevant context for us to study project failure experience and learning from failure since NPD is characterized by a high level of innovativeness (Scarmozzino et al., 2017) and inherent risk of uncertainty (Shepherd & Patzelt, 2017). NPD project failure is a common phenomenon in high-technology ventures (Urbig et al., 2013; Yu et al., 2014). The high-technology sector in China has received considerable attention in business and academia. In particular, Shanghai has a high

concentration of high-technology sectors in China. More importantly, to the best of our knowledge, by now, it's the only provincial administrative region that issues basic information on innovative or NPD projects within technology-based firms yearly. Hence, we selected high-technology ventures in Shanghai as our sample frame.

Data and Sample

We obtained a list of 1812 high-tech ventures, spreading across almost all of the 16 administrative districts of the Shanghai City, provided by the *Technology-Based SMEs List of Approved Technology-Innovation Projects in Shanghai 2017* issued by *Shanghai Science and Technology Committee* (STCSM) on 6th June 2017. The survey was conducted between June and September 2018, via an initial online survey, and followed three waves of reminders (using email, telephone, and on-site visit). Finally, we received 262 responses; after deducting unusable questionnaires, a final sample of 237 was entered in our analysis – an effective response rate of 13.08%. This response rate corresponded to that of similar studies in China, e.g. 14.5% in Wang, Wang, Yang, Yang, Yuan, & Song, 2018).

Our respondents were NPD project leaders, as nominated by the executives of the ventures. We obtained details of the executives from the company's registration records on China's *National Enterprise Credit Information Publicity System (NECIPS)* which is run by the Chinese *State Administration for Industry and Commerce (SAIC)*. Table 1 summarizes the profile of our respondents. NPD project leaders were expected to have comprehensive knowledge of projects, including project goals, operations, and failure- whether the project falls short of its goals (Jenkins & McKelvie, 2016). This approach is consistent with extant empirical studies, which claim that failure is ultimately based on the assessment of the project leader in charge (cf. Liu et al., 2017; Shepherd et al., 2011; Shepherd et al., 2014).

To assess non-response bias, we compared the firm ages of the 237 respondent firms with those of 1550 non-respondent firms provided in the NECIPS. The average age of the respondent firms and non-respondent firms are 6.304years (standard deviation 4.331) and 6.375years (standard deviation 3.333) respectively. The t-statistics were insignificant, confirming that non-response bias was not a serious concern and that there was good external validity in this study.

Insert Table 1 about here

The survey questionnaire was initially in English and then translated into Chinese, following a rigorous and iterative back-translation process (Brislin, 1970), until the Chinese and English versions reached consensus. The questionnaire was also pre-tested with two British academics with expert knowledge in the relevant field and cross-cultural questionnaire surveys. Following this, a pilot study was conducted with 10 NPD project leaders from different Chinese high-tech ventures. Feedback from the pre-test and the pilot study was fully incorporated in the final questionnaire.

The nature of entrepreneurial failure means that the phenomenon is rarely examined in real-time but mainly through retrospective analysis, arguably increasing the risks of recall bias. This study followed guidelines recommended by DeRue and Wellman (2009) for minimizing recall bias: (a) the experience examined in this study occurred within the last 3 years; (b) these events were meaningful enough to be remembered and distinguished by participants; and (c) all participants were directly involved in the experiences they reported. Moreover, the three-year time frame also allowed us to research the outcomes (e.g. learning from failure) several years after the project failures had occurred (Boso et al., 2018; García-Quevedo et al., 2018).

Our on-site follow-up visits and face-to-face interactions also proved that NPD leaders had no problem remembering the details surrounding the highly impactful event of NPD project failure.

Measurements

Existing scales and items were used wherever possible to maximize construct validity (see Table 2). The three main constructs were measured using seven-point Likert scales.

The nature of failure. The volume of failure was measured as referring to Ucbasaran et al., (2009) and Shepherd et al., (2011). Each respondent was asked to "indicate the total number of projects they had managed in while at their current position" as well as what the "the overall number of failed projects they had experienced." The volume of failure was operationalized as the ratio of the number of failed projects to the number of projects managed. The volatility of failure was measured using items adapted from He (2013), who firstly developed this measurement with good validity.

Error orientation. Consistent with Schell and Conte (2008), nine relevant items of the error orientation questionnaire (EOQ; Rybowiak et al., 1999) were administrated. These items were measured for attitudinal and behavioural action-oriented tendencies. Four of them refer to error competence (e.g., "When I have made an error, I know immediately how to correct it"). Five related to error strain (e.g., "I find it stressful when I err").

Learning from failure. The construct was assessed using a seven-item scale created by Edmondson (1999) to assess team learning but later adapted by Liu, Hu, Li, Wang, and Lin (2014) and He et al. (2018) to assess individual learning from failure. Questions included "I frequently seek new information that leads me to make important changes" and "I always make sure that I stop to reflect on my work process."

Control variables. Prior research (e.g. Sherpherd et al., 2011) suggested that age, gender, education and position could all potentially impact individuals' response to failure. In line with

them, this study also controlled three other variables that could significantly affect learning from failure: the time spent on the project before failure, time elapsed since project failure, and the size of the failed NPD project (i.e. using the number of team members as a proxy).

Insert Table 2 about here

Common Method Variance

Following Podsakoff, MacKenzie, Lee and Podsakoff (2003), we integrated both procedural methods and statistical techniques to reduce the risk of common method bias. We assured the respondents that their answers were confidential and that there were no right or wrong answers to the questions in the survey, to reduce the respondents' evaluation apprehension. Harman's one-factor test (Podsakoff & Organ, 1986) was performed, resulting in multiple factors with the first factor only accounting for 16.803%. Therefore, common method bias was not a serious concern in this study.

Reliability and Validity

The measurement scales were validated following Hair, Black, Babin, Anderson and Tatham (2006). Unidimensionality of the measurement items was first assessed using exploratory factor analysis and then confirmed through confirmatory factor analysis (CFA). The CFA results showed that all the items loaded onto their respective factors, showing no significant cross-loadings and overall satisfactory model fit indices (see Table 2).

Reliability was assessed using both coefficient alpha and composite reliability. All coefficient alpha reliabilities exceeded the accepted 0.7 thresholds (Cronbach, 1951).

Composite reliability using Fornell and Larcker's (1981) procedures was over 0.7 - the recommended threshold (Hair et al., 2006).

Average variances extracted (AVE) using the Fornell and Larcker's (1981) procedures were used to assess convergent validity. AVEs of all the main constructs were greater than the minimum threshold of 0.5 (Fornell & Larcker, 1981). Additionally, all items load significantly onto their corresponding latent construct, with the lowest t-value at 11.203 (Table 2), providing evidence of convergent validity. Discriminant validity was assessed by comparing the squared correlation between pairs of constructs and the AVEs of the constructs. All the correlations were lower than the square root of AVEs (see Table 3), indicating sufficient discriminant validity (Fornell & Larcker, 1981).

Insert Table 3 about here

Following He et al.'s (2018) approach, we used hierarchical linear regression analysis to test the six hypotheses, first entering the control variables to the analysis, followed by adding the independent and moderating variables. We mean-centred all the study variables, control variables and interaction terms before conducting the hierarchical linear regression, as recommended by Aiken &West (1991).

Table 4 presents the results of regression analysis. Model 1 as the base model included only the control variables which explained a significant amount of the variance in learning from failure ($R^2 = 0.101$; $p < 0.01$). In particular, the position ($\beta = 0.278$, $p < 0.01$) had a positive effect on learning from failure. The number of project team members ($\beta = 0.011$, $p < 0.1$) also had a positive effect on learning from failure. Consistent with Shepherd et al. (2001), the time spent on project before failure had no significant effect on learning from failure ($\beta = 0.001$,

p >0.1), and the time elapsed since project failure also had no significant effect on learning from failure (β = -0.007, p >0.1).

Model 2 included the two independent variables: the volume of failure had a negative effect on learning from failure (β = -0.155, p < 0.05) and the volatility of failure had a positive effect on learning from failure (β = 0.279, p < 0.001). Thus, Hypotheses 1 and 2 were supported.

Model 3 tested the moderating effects of error competence. The results show that the coefficient of the interaction term between error competence and the volume of failure was statistically significant and positive (β = 0.113, p<0.05) (see Figure 2), and indicates that the relationship between the volume of failure experience and learning from failure was positively moderated by error competence, such that the negative relationship was attenuated when error competence was high. Thus, Hypothesis 3a is supported. However, the coefficient of the interaction term between error competence and volatility of failure was not statistically significant (β = 0.028, p > 0.1). Thus, Hypothesis 3b was not supported.

Insert Figure 2 about here

Model 4 (see Table 4) tested the four moderating effects together. Hypothesis 3a remained supported while Hypothesis 3b not supported. The results showed that the coefficient of the interaction term between error strain and volume of failure was not statistically significant (β = -0.018, p > 0.1). Thus, Hypothesis 4a was not supported. The coefficient of the interaction term between error strain and volatility of failure was statistically significant (β = -0.132, p <0.05) (see Figure 3), indicating that the relationship between the volatility of failure experience and learning from failure was moderated by error strain, such that the positive relationship was attenuated when error strain was high. Thus, Hypothesis 4b was supported.

What's more, in the full Model 4, the volatility of failure was positively associated with learning from failure ($\beta = 0.279$, $p < 0.001$), further supporting Hypothesis 2 again. However, the volume of failure had a negative effect on learning from failure but not significant ($\beta = -0.025$, $p > 0.1$), suggesting that Hypothesis 1 was not supported when all the interaction effects were taken into account.

To assess multicollinearity (O'Brien, 2007), the variance inflation factor (VIF) was calculated for every variable but below the threshold of 5 (the largest VIF was 1.340 for the interaction term between the volatility of failure experience and error strain), proving that multi-collinearity was not a serious concern. As a post-hoc analysis to assess the potential curvilinear relationship between failure and learning, we further conducted robustness checks by operationalizing the quadratic term of the nature of failure experience (i.e. the volume and volatility). Because our models include quadratic terms, we further applied the residual centring procedure (Zhang & Rajagopalan, 2010) to handle multicollinearity between the quadratic term and its constituent parts. This procedure had two stages: first, each quadratic term was regressed on its components, and second, we saved the residuals and used the residuals instead of the original quadratic terms in the data analyses. Based on the above approach, the results show that both the volume of failure experience squared ($\beta = 0.054$, $p = 0.617$, VIF=2.838) and the volatility of failure experience squared ($\beta = -0.080$, $p = 0.203$, VIF=1.017) have no significant relationships with learning from failure respectively.

Insert Figure 3 about here

DISCUSSION

Existing entrepreneurship literature recognizes that failure can serve as a fundamental learning experience for entrepreneurs, but also points out that not all failures are equally adept at enabling learning (Politis, 2005), and not all entrepreneurs are equally versed in learning from failure (Baumard & Starbuck, 2005; Cannon & Edmondson, 2005; Funken et al., 2018; Van Gelderen et al., 2005). This is the starting point of our study. We set out to examine two sets of factors that influence learning from failure: the nature of failure regarding the volume and the volatility of failure experience, and entrepreneurs' attitudinal and behavioural orientation towards errors, namely error competence and error strain. Our results suggest that the volume of failure experience affects learning from failure negatively (i.e. Hypothesis 1), but the volatility of failure experience affects learning from failure positively (i.e. Hypothesis 2). These results reinforce the message that an oversimplified approach to failure experience cannot reveal the intricacies of learning from failure, coinciding with the argument that "not all failures are equally adept at facilitating learning" (Politis, 2005 p. 411).

Further, the effects of failure experience on learning are moderated differently by error competence and error strain. The negative effect of the volume of failure experience on learning from failure is stronger when error competence is low (i.e. Hypothesis 3a and Figure 2). On the other hand, the positive effect of the volatility of failure experience on learning from failure is stronger when error strain is low (i.e. Hypothesis 4b and Figure 3). These findings support existing research that explores the role of emotional regulation on learning from failure (e.g. He et al., 2018). More importantly, these findings also add value to the previous study (e.g. Funken et al., 2018) by highlighting the need to examine both emotional response (error strain) and attitudinal and behavioural tendencies based on entrepreneurs' knowledge and capability (error competence). Surprising results are also found regarding the non-significant moderating effect of error competence on the positive relationship between the volatility of failure

experience and learning from failure (i.e. Hypothesis 3b) and error strain on the negative relationship between the volume of failure experience and learning from failure (i.e. Hypothesis 4a). One possible explanation is that these independent and moderating variables act as complementary interactions. Although error competence has a positive effect on the positive relationship between the volatility of failure experience and learning from failure, its developmental value may level off when the volatility exceeds the threshold. For example, if entrepreneurs have a high enough level of volatility of failure experience, they will view project failure as an anomaly and learn from prior NPD failures no matter what the level of error competence is. It is also similar with the negative moderating role of error strain in the negative.

Theoretical Contribution

Building on experiential learning theory, the failure experience represents a cumulative series of failure events and its nature varies in the volume (number) and volatility (degree or intensity) of NPD projects processed by the entrepreneur. Besides, the experiential perspective provides a useful framework for capturing the temporal stream of entrepreneurs' attitudinal and behavioural orientation on failure experience. We argue for an integrated approach to understanding how entrepreneurs can turn failure into a fundamental learning process. In particular, learning from failure takes place when the nature of failure experience is examined in conjunction with entrepreneurs' error orientation. Heterogeneous failure experience and entrepreneurs' actions based on their emotional response and knowledge and capability together have different effects on failure-based learning behaviour. Most studies to date, if not all, do not discriminate among failures when it comes to learning from them, despite the recognition that failures can differ on multiple dimensions (Jenkins & McKelvie, 2016).

First of all, our findings contribute to the experiential learning theory in the entrepreneurship literature. The experiential learning theory emphasizes the importance of

feedback and reflection in the learning process (Kolb, 1984). However, it does not provide any mechanisms to dissect an experience, especially one such as failures that bring about strong negative emotions. This shortcoming hinders the entrepreneurship literature when it comes to understanding how entrepreneurs learn from failure; while the entrepreneurship literature offers rich insights into the content (e.g. Cope, 2005, 2011) and outcomes (e.g. Politis & Gabrielsson, 2009; Shepherd et al., 2011; Yamakawa & Cardon, 2015) of learning from failure, the common measures concerning specific learning behaviours employed by entrepreneurs remain largely unexplored (Dahlin, et al., 2018). Our study is a timely response to the call: "To illuminate how, if at all, entrepreneurs learn from failure, scholars need to directly examine a set of concrete, observable learning behaviours" (He et al., 2018, p2), by directly examining entrepreneurs' concrete learning behavior after experiencing NPD project failures. Therefore, this study went beyond the simple application of experiential learning theory in the entrepreneurial context. It not only provides a valuable addition to the entrepreneurship literature that focuses primarily on the results of learning (e.g. Politis & Gabrielsson, 2009; Shepherd, et al., 2011), but also extends the entrepreneurial learning literature by providing important insights into how entrepreneurs draw lessons from critical learning events (Cope & Watts, 2000), namely, frequent NPD project failure in the high-tech ventures in this study.

Our study also contributes to the entrepreneurship literature in general by applying error management perspective. An emerging body of research starts to stress individual differences which are helpful to explain why some entrepreneurs are more able to learn from failures, while others are not, for example, attribution of failure (Yamakawa & Cardon, 2015), coping strategies (Byrne & Shepherd, 2015), regulatory focus (Metcalfe, 2017), emotion regulation (He et al., 2018), personal control (Wang et al., 2018), and error mastery orientation (Funken et al., 2018). Based on the error management perspective, we argued and found that entrepreneurs' learning behaviours not only depend on the nature of failure experience but also

their specific error orientation, namely, error competence and error strain, which functions like a switch that turns failure into something good or something bad (Funken et al., 2018). Similarly, Funken and colleagues (2018) found a positive moderating role of error mastery orientation (including five subscales of EOQ; Rybowiak et al., 1999) in the relationship between problems and entrepreneurial learning. However, they ignored the various moderating effects of the specific subscales. Our study simultaneously took into account the subscales of error competence and error strain and found their opposite moderating effects on the relationship between failure and learning, which provides a promising starting point for future research to explain the question "under which conditions failure leads to learning in entrepreneurship" (Gielnik et al., 2017, p64).

Limitations and Future Direction

This study has several potential limitations that might offer opportunities for future research. First, our sample includes entrepreneurs working on NPD projects in high-technology ventures where project failure is inherently high. Future research can broaden the perspective and investigate the nature of failure and learning from failure in different environments where project failure may have different characteristics, and employees may have a different experience of failure. Second, the NPD projects in this study vary in sizes. Future research can examine whether the project scale has an impact on the magnitude of cognitive and emotional reactions and learning as larger projects and more invested time in a project might lead to stronger reactions. Thirdly, this is a single country study, and therefore, conclusions can be limited to Chinese entrepreneurs in high-tech ventures. Extant research has pointed out that a range of factors can impede or enhance learning after failures, such as regional culture (Cardon et al., 2011), institutional environment (García-Ramos, Gonzalez-Alvarez, & Nieto, 2017) or social supports (Ucbasaran et al., 2013). For instance, Cave, Eccles and Rundle (2001) find

failure has a more negative connotation in Europe than do entrepreneurs in the United States. Even with the United States, in some regions failure, is perceived as mistakes by entrepreneurs and results in stigmatization, whereas in other regions failure is more tolerated (Cardon et al., 2011). Thus, identifying and examining the influences of cultural variables such as tolerance (e.g. Weinzimmer, & Esken, 2017), fear (e.g. Ng & Jenkins, 2018) or stigmatization (e.g. Singh, Corner, & Pavlovich, 2015) of failure are promising future directions. A cross-cultural study on the learning patterns and mediating and moderating factors from individuals and the society will provide an even richer understanding of this phenomenon.

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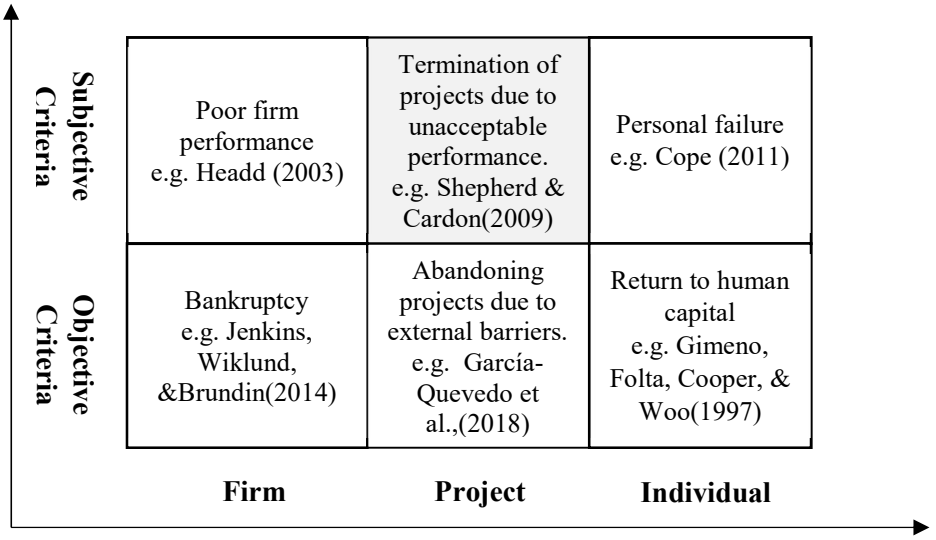
Figure 1. Definition of project failure



Adapted from Jenkins and McKelvie (2016).

Figure 2 Theoretical Framework

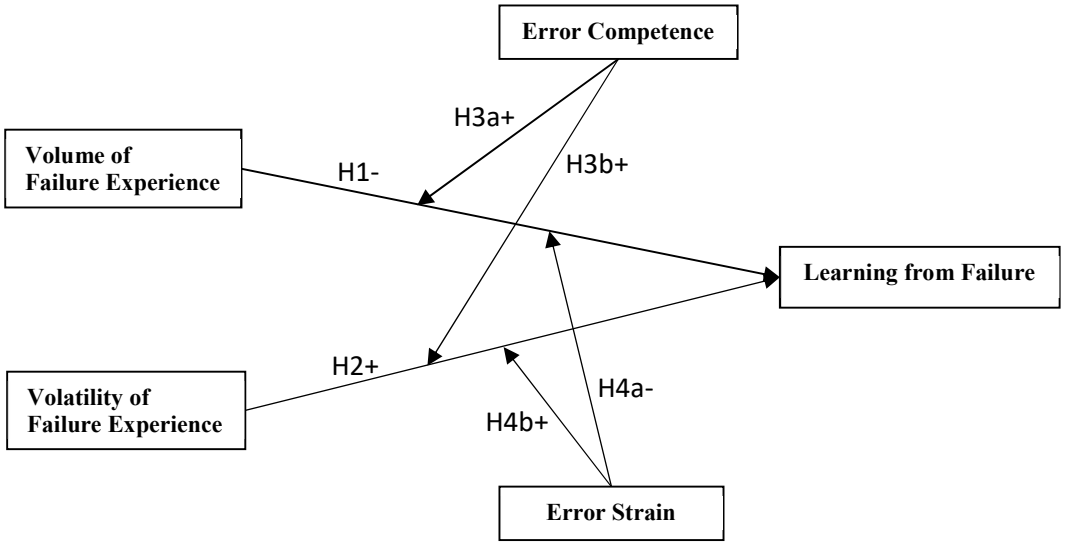


Table 1 Sample Profile

Characteristics		Frequency	Percentage
Gender	Male	128	54.0
	Female	109	46.0
Age	29 or less	35	14.8
	30 to 40	87	36.7
	41 to 50	97	40.9
	51 and above	18	7.6
Position	CEO	19	8.0
	Top manager	61	25.7
	Department manager	63	26.6
	Project manager	94	39.7
Education	Below bachelor	3	1.3
	Bachelor	166	70.0
	Master	65	27.4
	PhD	3	1.3
Venture size[1]	50 or less	47	19.8
	51 to 100	108	45.6
	100 to 150	32	13.5
	151 to 200	18	7.6
	201 to 250	16	6.7
	251 to 516	16	6.8
Venture age	1 to 5	126	53.2
	6 to 10	75	31.6
	11 to 15	26	11.0
	15 to 20	7	2.9
	21 to 25	3	1.3
Ownership type	Joint share	20	8.4
	Privately owned	196	82.7
	Foreign invested	17	7.2
	Stated owned	4	1.7
Industry type	Electronic information	103	43.5
	New energy and materials	41	17.3
	New biotechnology	32	13.5
	Integrated optical	35	14.8
	Others	26	11.0

1. The ventures that the NPD project leaders represented were categorized as small and medium-sized enterprises – with fewer than 2000 employees as defined by the China's "Standards for Medium and Small Enterprises" (2003) (Tang & Tang, 2012).

Table 2 Measurements

Items	Standardized loading	t-value
Volatility of failure (α=**.932; CR=.933; AVE= .777**)		
1. These project failures have defined me as a person.	1.000 [a]	
2. These project failures are of great personal importance to me.	.786	18.815
3. These project failures do not influence the way I view myself.	.980	23.471
4. I have been deeply concerned about these project failures.	.916	19.427
Error competence **(α=.881; CR=.881; AVE=.648)**		
1. When I do something wrong at work, I correct it immediately.	1.000 [a]	
2. When I have made an error, I know immediately how to correct it.	.931	13.671
3. If it is at all possible to correct an error, then I usually know how to go about it.	.918	13.817
4. I do not let go of the goal, although I may make an error.	.866	13.654
Error strain **(α=.961; CR=.961; AVE=.831)**		
1. If I make an error at work, I "Lose my cool" and become angry.	1.000 [a]	
2. I find it stressful when I err.	.971	23.424
3. I am often afraid of making errors.	.963	24.223
4. I feel embarrassed when I make an error.	.993	25.741
5. While working, I am concerned that I could do something wrong.	.929	22.712
Learning from failure (α=**.901; CR=.902; AVE=.569**)		
1. I often speak up to test assumptions about issues under discussion.	1.000 [a]	
2. I regularly take the time to figure out ways to improve my work processes.	.885	11.731
3. I tend to handle differences of opinion privately or off-line, rather than addressing them directly as a group.	.842	11.203
4. I go out and get all the information I possibly can from others-such as customers, or other parts of the organization.	.815	11.378
5. I frequently seek new information that leads me to make important changes.	.929	13.518
6. I always make sure that I stop to reflect on my work process.	.884	13.144
7. I invite people from outside the team to present information or have discussions with me.	.854	11.724
Model fit: χ^2 (164) = 200.479, d.f. =164; DELTA2 = 0.990; CFI =0.990; TLI=0.988; RMSEA=.031; p=0.028.		

[a] Fixed factor loading. α = Cronbach's alpha, CR = Composite Reliability, AVE = Average Variance Extracted

Table 3. Descriptive Statistics

Variables	Mean	S.D.	1	2	3	4	5	6	7	8
1. Time on working [a]	6.536	5.497								
2. Time after leaving [a]	5.882	4.105	-0.012							
3. Number of members	12.219	10.887	0.075	-0.099						
4. Volume of failure	0.345	0.178	0.061	-0.189**	0.127					
5. Volatility of failure	4.963	1.041	-0.046	0.005	0.096	-0.018	*0.881*			
6. Error competence	5.499	0.801	0.003	0.016	0.165*	-0.161*	0.201**	*0.805*		
7. Error strain	4.166	1.143	-0.136*	-0.021	-0.140*	0.066	0.102	-0.209*	*0.912*	
8. Learning from failure	5.499	0.665	0.020	-0.052	0.128*	-0.171**	0.298***	0.586***	-0.066	*0.754*

N = 237

S.D. = Standard deviation

[a] In months

Italic figures on the diagonal are the square root of the average variance extracted for the constructs

*** p< 0.001

** p< 0.01

* p< 0.05

Table 4. Results of Regression Analysis

	Dependent Variable: Learning from Failure			
	Model 1	Model 2	Model 3	Model 4
Control Variables				
Gender	-0.013	0.019	-0.020	-0.006
	(0.127)	(0.121)	(0.103)	(0.104)
Education	0.202	0.184	0.134	0.150
	(0.126)	(0.119)	(0.101)	(0.103)
Age [a]	0.173	0.121	0.141	0.118
	(0.110)	(0.105)	(0.089)	(0.089)
Position	0.278***	0.249***	0.174**	0.180**
	(0.064)	(0.062)	(0.053)	(0.062)
Time on working [b]	0.001	0.005	0.002	0.001
	(0.011)	(0.011)	(0.009)	(0.009)
Time after leaving [b]	-0.007	-0.015	-0.015	-0.013
	(0.015)	(0.015)	(0.013)	(0.013)
Number of members	0.011†	0.010†	0.002	0.002
	(0.006)	(0.006)	(0.005)	(0.005)
Independent Variables				
Volume of failure		-0.155**	-0.037	-0.025
		(0.062)	(0.056)	(0.057)
Volatility of failure		0.279***	0.178**	0.144**
		(0.060)	(0.052)	(0.055)
Interaction Effects				
Error competence			0.517***	0.535***
			(0.054)	(0.055)
Error competence ×			0.113*	0.114*
Volume of failure			(0.055)	(0.057)
Error competence ×			0.028	-0.014
Volatility of failure			(0.053)	(0.056)
Error strain				0.039
				(0.054)
Error strain ×				-0.018
Volume of failure				(0.053)
Error strain ×				-0.132*
Volatility of failure				(0.058)
R-squared	0.101	0.201	0.437	0.450
Adjusted R- squared	0.074	0.170	0.407	0.413
Highest VIF	1.047	1.097	1.267	1.340
F change	3.681**	14.255***	31.251***	1.815

N = 237
Unstandardized regression coefficients are reported
Robust standard errors are provided in parentheses
[a] In years
[b] In months
†p < 0.1
*p < 0.05
**p < 0.01
***p < 0.001

Figure 2 Interaction Term of Volume of Failure and Error Competence on Learning from Failure

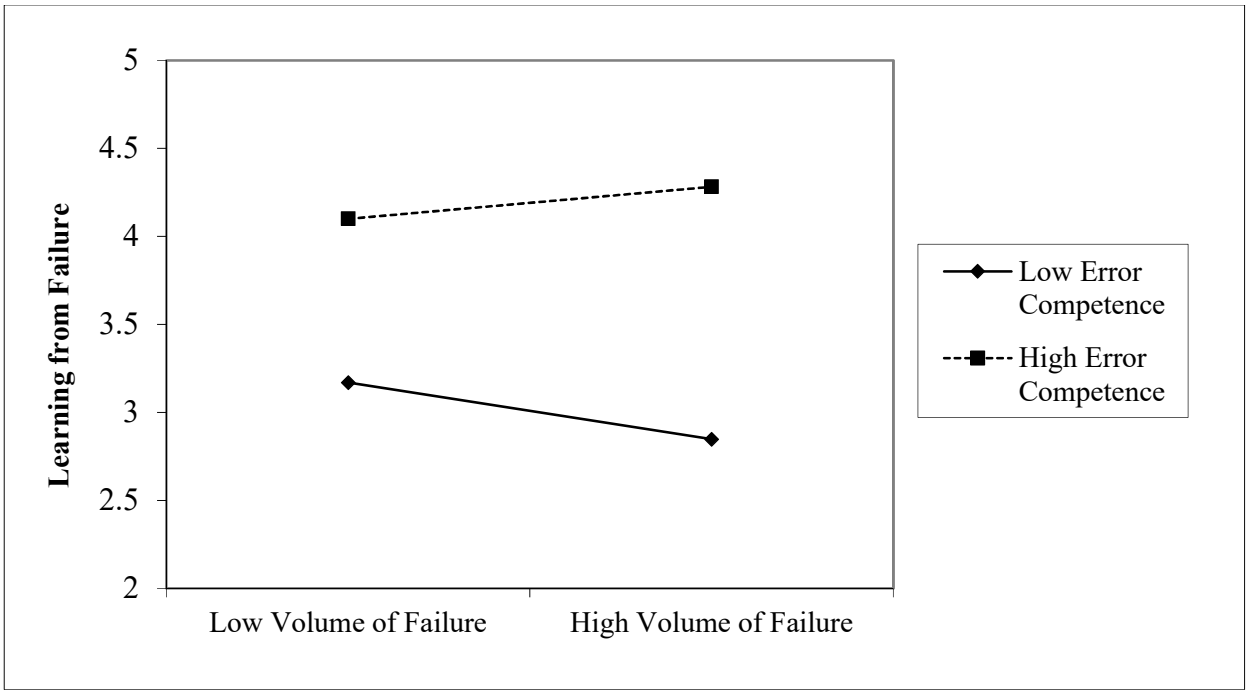


Figure 3 Interaction Term of Volatility of Failure and Error Strain on Learning from Failure