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Quantity and quality: Increasing safety norms through after action reviews

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Abstract

Workplace safety is a concern for both scholars and practitioners alike because accidents and injuries can result in time away from work and lost organizational resources. This study focuses on how one type of post-incident discussion can be effectively used to promote positive safety norms. It adds to the growing body of research on after action review (AAR) meetings, one type of post-incident discussion intervention commonly used in high reliability organizations to increase future workplace safety behaviors. This study also extends the sensemaking and high reliability literatures by examining a three-way interaction between perceived frequency of AAR meetings, ambiguity reduction, and psychological safety. Survey data were obtained from 330 firefighters. Results from the three-way interaction showed that safety norms were highest when perceived AAR frequency, ambiguity reduction, and psychological safety were simultaneously high and safety norms were lowest when perceived AAR frequency, ambiguity reduction, and psychological safety were simultaneously low. By examining both the perceived quantity and quality of AAR meetings, this study provides insight into which AAR facilitation objectives are most likely to increase positive safety norms and ultimately create a shared understanding of how to behave safely in future workplace events in high reliability organizational contexts.

Keywords: After Action Reviews, AAR meeting, Safety Norms, Psychological Safety, Ambiguity Reduction, Sensemaking, Meetings, Workplace Safety

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In 2013 alone, over three million non-fatal workplace injuries were recorded, which resulted in 917,100 days away from work (Bureau of Labor Statistics, 2015) and organizations losing significant resources. In order to reduce the number and impact of accidents and injuries that occur at work, organizational scholars and practitioners alike are increasingly united around a consensus that behavioral interventions can be used to shape desired outcomes (e.g., positive safety norms, error prevention, accident rates). In fact, studies about interventions that focus on post-incident communication have recently been published in a range of disciplinary journals, from organizational psychology (Busby, 1999) to organizational communication (Beck, Littlefield, & Weber, 2012; Scott et al., 2013). Although previous research has begun to make these connections, the importance of normative factors in occupational safety has been largely ignored (Tesluk & Quigley, 2003). That is, even though perceived norms have a strong contextual influence on attitudes and behaviors (Fugas, Melia, & Silva, 2011), research has largely ignored how organizations can promote positive safety norms through specific post-incident interventions. For these reasons, we focus on how post-incident discussions can be effectively used to promote positive safety norms (Pronovost et al., 2006; Zohar & Luria, 2005).

One reason that these behavioral interventions are successful is because they provide employees with a common time and place for purposeful discussion-based learning. However, since researchers have mainly focused on the frequency with which the discussions occur (Allen, et al., 2010; Scott et al., 2013) and the efficacy of different types of AARs (Ellis & Davidi, 2005; Ellis, Mendel, & Nir, 2006) to the exclusion of assessing how these reviews should be facilitated, practitioners are left with limited academic insight as to how such discussions should be facilitated. Until we can understand how to run these post-incident discussions properly and can

provide facilitators with empirically grounded advice regarding what the goals of implementation should be, poorly facilitated reviews could have negative attitudinal and behavioral outcomes. It is important to understand how the underlying values and procedures around these interventions are communicated to employees, intentionally and unintentionally, as well as how the interventions are received by employees, subjectively and intersubjectively, because these attitudes will shape the extent to which safety norms are developed, reinforced and converted into safer behavior in future incidents (Hoffman & Stetzer, 1998).

For example, Collinson's (1999) ethnographic case study of safety on an oceanic oil-drilling platform described how the implementation of an intervention intended to increase positive safety norms by incentivizing injury prevention ironically resulted in deterioration of safety norms. Essentially, the positive safety norms began to breakdown and the organization noticed a shift from a shared understanding of "safety first" to an understanding that "efficient performance" was more about getting things done quickly to get an incentive. Since this case study, there has been little research regarding how employees make sense of the process that occurs during behavioral interventions as well as the norms that these interventions shape, create, and reinforce.

This turns our attention toward the need to study behavioral interventions in a manner that accounts not just for the consistent presence of the interventions (van Aken, 2007), but also for their quality—end user perceptions of their content as they are implemented in everyday practice—because the quality of the post-incident discussion and meeting process will shape each group's understanding of how they should behave in the future. Otherwise, practitioners and scholars lack the insight to understand how to design future interventions successfully. The current study addresses these goals by examining variables related to the quantity and quality of

one intervention, after action review meetings (AARs), and one intended organizational outcome, positive safety norms. We seek to add to the literature on AARs by providing researchers and practitioners with insight into how the combination of perceived AAR frequency, psychological safety, and ambiguity reduction increases positive safety norms.

The purpose of this paper is to connect literature on AARs that has focused on only one or two elements of effective AARs, but have not yet considered the power of considering multiple elements in one study. Our findings suggest that successful AARs that yield positive safety norms contain three elements: 1) they occur frequently, 2) they reduce ambiguity, and 3) they have high psychological safety. When these three factors are combined, participants not only feel comfortable with the group, but they are more likely to walk away with an understanding of what the current incident suggests about how to behave safely in future events. First, we briefly introduce high reliability organizations; a common context in which AARs are implemented and where positive safety norms are vital to maintaining a productive, efficient, and safe working environment. We then review literature concerning the collective sensemaking process that occurs in AAR meetings and discuss a theoretical framework for explaining how the relationship between the perceived quantity and quality of AARs (i.e., ambiguity reduction and psychological safety) leads to the development of one desirable outcome, positive safety norms.

Literature review

High reliability organizations, safety norms, and after action reviews

High reliability organizations (HROs) are organizations that that are able to sustain nearly error-free operations, despite the fact that hazardous conditions and possible failures may lead to dramatic consequences (Roberts, 1990; Weick & Roberts, 1993). HROs (e.g., firefighting crews, nuclear reactors, military organizations, first responders) rely on collaborators to monitor and

respond efficiently to risky, turbulent environments as a primary organizational objective. Because HROs typically feature highly interdependent, complex, and uncertain relationships with their environments (Barton & Sutcliffe, 2009), it is particularly important for HROs to have positive safety norms. Norms, in general, are a shared way of both understanding and behaving within a given group or organizational environment where the norms exist (Erhart & Naumann, 2004). By extension, safety norms in this study refer to the extent to which understandings of what it means to be safe and how to behave safely in the group/organization are shared (Allen, Baran, & Scott, 2010). Norms are learned through both formal and informal communication processes, become part of group and organizational culture, and help individuals quickly detect a dangerous situation as well as guide decisions about how to respond (Erhart & Naumann, 2004).

One way that organizational leaders can attempt to foster these positive safety norms is by implementing strategic organizational communication processes that will facilitate and continuously improve awareness of emergent problem situations and the factors that should contribute to decision making about contingent responses (Maitlis & Sonenshein, 2010; Weick & Roberts, 1993). How organizations build up this resiliency may vary, but one intervention that has been used to increase safety norms is the after action review (AAR). We define AARs as a specific type of work meeting in which people discuss, interpret, and attempt to make constructive sense of a recent event during which they collaborated (Scott et al., 2013). Sometimes labeled post-incident critiques, post mortems, hot washes, or debriefs, AARs have been a common feature of military and HROs for decades because they help groups maintain reliability and resiliency by learning from past events, promoting changes in perceptions, and hopefully enabling individuals and teams to recall lessons learned and apply them to future relevant incidents (Busby, 1999).

Therefore, the purpose of AARs is to enhance the reliability of group processes through post-incident discussion, which facilitates collective sensemaking about a prior incident (Rasmussen, 2011) and ensures that the group remains safe during future events with analogous characteristics. AARs are assumed to enhance reliability by continuously producing discussions that reflect, reinforce, and enhance desired safety attitudes as well as shared frameworks for interpreting incidents as they unfold (Weick, Sutcliffe, & Obstfeld, 2008). If an effective AAR is not held after this complex event, it increases the likelihood that individuals will walk away with a mistaken or highly partial understanding of why the incident unfolded the way it did, specifically how individual and collective action contributed to its outcome, and how to improve for future incidents.

Retrospective discussion as collective sensemaking

Although improved performance is an important outcome, research also needs to focus on the process by which AARs can promote positive safety norms in order to reduce nonfatal and fatal accidents. Because AARs function through post-incident discussion, we use collective sensemaking as a theoretical framework to help explain how perceptions of various elements of AARs combine and relate to an overall increase in positive safety norms. Collective sensemaking theory (Weick, 1993; 1999) emphasizes how collaborators use post-incident discussion to interpret and respond to equivocal shifts in organizational environments intersubjectively. It helps us understand how meeting participants collaboratively learn by managing shared ambiguity about what happened, why it happened, and how this understanding should be applied in future incidents. Shared meanings are important because they can be retained and later applied quickly during seemingly analogous situations, even if the conditions are variable and unknown (Weick, Sutcliffe, & Obstfeld, 2005).

Unlike more psychological approaches to sensemaking that focus on individual cognition as the unit of analysis, collective sensemaking theory explains how meanings are *inter*subjectively created and sustained over time, retrospectively, and are used to inform future incidents interactants perceive as analogous (Bean & Hamilton, 2006; Weick, 1995). As Maitlis (2005) succinctly puts it, in sensemaking "organization members interpret their environment in and through interactions with others, constructing accounts that allow them to comprehend the world and act collectively" (p. 21). From this perspective, sense is not made through individual cognition alone but also through post-incident communication (e.g., during AARs).

Of course, achieving that objective is a challenging interactive task, and to date, that has been a point largely taken for granted in the HRO and AAR literature. In an HRO context, post-incident discussion that reduces such ambiguity constructively is likely to not only improve sensemaking in future incidents but also to enhance the positive safety norms that would underlie these efforts. In fact, AARs are often as much about figuring out what happened in a focal incident as they are about developing a consensus about what should be learned from it (Scott et al., in press). In this paper, we assume that collective sensemaking is the underlying process that occurs during AARs that will ultimately shape perceptions of positive safety norms. Therefore, we argue that AARs are essential to the formation of positive safety norms because without them, collaborators lack a purposeful basis for learning about the relationship between incident outcomes and the safe practices their organization seeks to normalize. For example, collaborators who struggle with reliability because they fail to stop and redirect ongoing action (Barton & Sutcliffe, 2009) cannot learn to more accurately and efficiently identify potential hazards in future incidents if they do not first reach some level of consensus about how action was unfolding to begin with in a specific prior event.

But how can organizations and group leaders have a better understanding that the sensemaking process is a positive one? Thinking back to the Collinson's (1999) example of when sensemaking can go awry by changing the shared understanding of how individuals think they should behave in future events, we examine three variables that can be used as content-oriented indicators of effective collective sensemaking that strengthen positive safety norms. Since collective sensemaking cannot be captured quantitatively, we argue that the combination of perceptions from individuals regarding AAR frequency, ambiguity reduction, and psychological safety all play a shared role in the normalization of perceptions of safe workplace behavior.

Increasing quantity: Perceived after action review frequency and positive safety norms

Even though recent studies have associated the frequency of AARs with desired outcomes (see Lacerenza, Gregory, Marshall, & Salas, in press, for a review) and Tannenbaum and Cerasoli's (2013) meta-analysis provides evidence that AARs increase team performance by 20-25%, it is unclear how individual perceptions of the frequency of AARs relate to these desirable outcomes (e.g., positive safety norms). Research has shown that positive safety norms are somewhat fluid and perishable (Zohar, 2000) and if they are not reoccurring, positive safety norms may be less reinforced and diminish over time (Allen et al., 2010). Rather than reinforcing safety norms in the abstract through training and the enforcement of standard operating procedures alone, AARs should create a context where the group can focus on collective sensemaking and afford organizations an ability to shape safety norms in the context of specific incidents the collaborators have actually encountered in the field. The development of new norms is more easily facilitated when group communication focuses on the relevance of those norms to specific work incidents and desired operational outcomes (Barker, 1993).

We were interested in understanding how the individual perceives the frequency, rather than the actual number of meetings held because frequency can be subjective and may be evaluated relative to other groups. These perceptions may be more important than the actual number of meetings because if the individual thinks they meet with a group frequently to discuss safety, they are also engaging in the collective sensemaking process more often. As they perceive these meetings to be more frequent, the shared understanding that safety is important and that their leader and crewmembers are committed to safety, is likely to be reinforced (Mullen, 2004). Perceptions of more frequent AAR discussions also means that the individual is experiencing more frequent opportunities to compare their performance to normative safety standards and to evaluate it with regard to those shared standards, a process that not only highlights safety norms, but reinforces them.

Hypothesis 1: As the perceived frequency of AARs increases, the perception of positive safety norms also increases.

Increasing quality: Ambiguity reduction during after action reviews

Although previous research suggests that AARs are usually a positive addition to any HRO group's regimen, we cannot assume that all AARs are created equal. We aim to understand how the perceived quantity, but also the quality of the AAR's content, including if one of the main goals of the AAR, ambiguity reduction, occurs through the collective sensemaking process. During a hazardous event, incidents occur that may shift action into a form that interrupts flow, may be initially unintelligible, and may have more than one plausible explanation (Weick et al., 2005). These shifts increase ambiguity (i.e., the range of plausible interpretations of the incident). Generally speaking, ambiguity is not desired because individuals aim to make

interactions with the work environment and one another increasingly predictable (Berger & Calabrese, 1975; Miller & Jablin, 1991).

Because ambiguity involves a plurality of interpretations produced by multiple frames of reference about the same information, ambiguity can be reduced through group discussion that arrives at a more shared interpretation of the event (Keleman, 2000). Collective sensemaking theory indicates that ambiguity is reduced when groups use post-incident discussion to collaboratively enact the most relevant elements of the incident environment and interactively propose, discuss, and develop a consensus about what happened and what it should mean for future operations. We believe that when discussions are focused upon these matters in a manner that reduces incident ambiguity, a more plausible understanding of the incident is produced that does more to highlight and reinforce positive safety norms than discussions that fail to reduce ambiguity and thus maintain or even expand a multiplicity of conflicting explanations.

Indeed, because AARs require participants to work through competing notions of what happened, why, and what it means moving forward if ambiguity about the incident is to be reduced, the meetings provide an ideal setting in which the importance and relevance of positive safety norms can be regularly highlighted. This is also likely to increase perceptions that positive safety norms are shared within the group. Indeed, during AARs, individuals have the chance to cross-validate information about their experiences through comparison with others involved in the same incident, to reduce potential errors and mental biases, and to achieve a more constructive account of the incident (Ellis, Ganzach, Castle, & Sekely, 2010) as they relate to different stories and perspectives about a shared event. When ambiguity is reduced, increasingly plausible interpretations of an incident (e.g., discussing key incident events, root cause issues,

and near misses) are created, which highlights the shared understanding of values and practices that constitute positive safety norms.

Hypothesis 2: As ambiguity reduction increases, the perception of positive safety norms also increases.

Increasing quality: The importance of psychological safety during after action reviews

The literature reviewed above suggests that a high quality AAR needs to reduce ambiguity so that participants can arrive at a shared understanding of how to behave safely in future events (Keleman, 2000), but how can we ensure that individuals are not only contributing, but contributing honestly to the meeting? Specifically, we were interested in another potential meeting quality indicator: psychological safety. In order to promote an environment where collaborators do not withhold information and perspective, employers should consider each member's perception of psychological safety, defined as a "shared belief that a team is safe for taking interpersonal risks" (Edmondson, 1999). All AARs should have a positive discussion atmosphere that encourages participants to share diverse viewpoints and opinions because when individuals feel like they can share the truth about their own experience, there are more viewpoints to consider.

During the collective sensemaking process, feeling safe to share all experiences (e.g., a mistake, another interpretation) should help individuals consider and discuss multiple viewpoints, reduce ambiguity surrounding individual experiences, and ultimately increase the perception that positive safety norms are shared. As Naslund & Pemer (2012) demonstrated, some stories in retrospective discussions are typically more dominant or more easily believed than others in a given context. It makes sense to assume, then, that AAR participants may be tempted to withhold descriptions of their experiences of an incident when they perceive their

stories are less welcome than others and may be reluctant to speak up about their own experiences.

In order for effective collective sensemaking to occur so that each employee develops authentic interpretations of an event during the course of an AAR, they need to perceive that other employees are open to their personal interpretations, that their interpretations will not be automatically rejected, and that they will not be punished formally or informally for what they say (Baer & Frese, 2003). Although differences of opinion may certainly arise during these discussions (see Rasmussen, 2013 for an example), if employees are more open to sharing their interpretation of events and to hearing divergent incident descriptions from others because they perceive the discussion environment is psychologically safe (Edmondson, 2004), this should enhance the collective sensemaking process and promote more robust and open discussions that contribute to an improved shared understanding of the previous event and the safety norms it represents and reinforces. Thus, we propose that psychological safety would enhance the quality of the AARs, thereby improving safety norms.

Hypothesis 3: As psychological safety increases, the perception of positive safety norms also increases.

Increasing quality and quantity: Perceptions of AARs and positive safety norms

Finally, all the forgoing literature review, theory, and hypothesizing suggest the possibility that the quality, including ambiguity reduction and psychological safety, and quantity of AARs interact to explain the development of positive safety norms. That is, we propose that without these three aspects, groups will have less positive safety norms. Although previous research has examined the importance of frequency of AARs, there has not been research to date that considers the importance of both the quantity and quality of AARs. For example, in

Collinson's (1999) ethnography, the offshore oil-drilling company had frequent meetings and discussions about the importance of safety. However, because the organization decided to tie safety to individual monetary incentives, psychological safety was low. In fact, one employee reported that, "I've never seen an accident yet where they haven't blamed the individual. Management scapegoats people." (Collinson, 1999, p. 586). This made individuals actually less likely to speak up about failures and near misses, which hurt the collective sensemaking process and the amount of ambiguity that could be reduced.

Building off of Collinson's (1999) findings, this paper aims to understand the relationships between perceived quality and quantity. Specifically, it is believed that AARs need to reduce the ambiguity experienced from the call (Scott et al., 2013), participants need to feel psychologically safe, and crewmembers need to perceive that AARs occur frequently (Allen et al., 2010). This way, the more often that individuals perceive that they interact during AARs, the more that they will feel comfortable sharing multiple plausible interpretations, and the more likely it is that ambiguity will be reduced and a greater shared understanding of positive safety norms will be produced. We expect that positive safety norms will suffer if one of these three aspects is low (or absent) because the collective sensemaking process will not be as effective as when all three aspects are present. Thus, the following three-way interaction is proposed:

> *Hypothesis 4*: The strongest safety norms will arise from the three-way interaction between high perceived AAR frequency, high ambiguity reduction, and high psychological safety. The weakest safety norms will arise from the three-way interaction between low perceived AAR frequency, low ambiguity reduction, and low psychological safety.

Methods

Sample and procedure

All participants were active career (non-volunteer) firefighters within a large municipal fire department in the southeastern United States. One common way that fire departments try to minimize accidents and injuries is through AARs (Allen et al., 2010). Therefore, the fire service is an ideal context for this study because firefighters are constantly faced with occupational hazards that, if not handled correctly, could result in accidents and injuries (e.g. 81 fatalities in the U.S. among firefighters in 2012; FEMA, 2012). With the permission of the departmental officials, we distributed an electronic survey to 1,002 firefighters at stations around a large metropolitan area. In total, 330 firefighters completed the survey for a response rate of 32.9%. Most respondents were male (96.4%), middle-aged (M = 40.11 years, SD = 9.56), and had experience working as a firefighter (M = 14.65 years, SD = 9.33). As survey research becomes ubiquitous and survey saturation becomes commonplace, survey response rates has declined over time (Rogelberg & Stanton, 2007) and has continued to decline in recent years. Our response rate is within one standard deviation of a recent review on average response rates across organizational studies journals (M = 52.7%, SD = 20.4%) and within one standard deviation of average response rates in *Human Relations* (M = 44.1%; SD = 22.4%) (Baruch & Holtom, 2008).

Measures

Perceived AAR frequency. We used a seven-item measure developed for this study. The items built upon items used in Allen et al., (2010). The authors had subject matter experts rate how relevant the items were to the context. To better understand the structure of our measure, an exploratory factor analysis (EFA) was conducted to ensure that all items were, in fact, measuring perceived AAR frequency. Using principal axis factoring, we rotated obliquely and obtained a one-factor solution. The researchers used the Kaiser rule and examined a scree plot and found a

clear one-factor solution. All factor loadings were acceptable and ranged from .53 to .89. Using a five-point Likert-type scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), participants were asked to "indicate how much you agree with the following statements about you feel, in general, about the frequency of your AARs." Sample items included "My crew holds AARs frequently" and "My crew holds AARs only once in a while (RS)".

Ambiguity reduction. We used a five-item measure developed by Szulanski, Cappetta, and Jensen (2004). The directions for rating items were adapted to reflect the study's focus on AARs. Participants were asked to rate how much they agreed with specific outcomes after their AAR meetings using a five-point Likert-type scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Sample items included "After AARs, I usually know why a certain action resulted in a certain outcome (RS)" and "When a problem surfaces during an incident, the AARs help me understand the precise reasons for the problem (RS)".

Psychological safety. Psychological safety was assessed using a seven-item measure developed by Baer and Freese (2003). We dropped one item that had to do with feeling free to take risks that was not appropriate for the sample or context. Participants were asked to rate how much they agree with each of the statements that described how they feel during their AARs, using a five-point Likert-type scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Sample items included "No one in our crew would deliberately act in a way that undermines others' efforts" and "During AARs, it is difficult to ask others questions and for help".

Safety Norms. We assessed safety norms by adapting a twelve-item scale developed by Zohar & Luria (2005), which asked participants to think about their AARs, in general, and rate the extent to which they agree that they would engage in each behavior. We used a five-point Likert-type scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Sample items included

"I emphasize safety procedures when we are working under pressure" and "I frequently talk about safety related issues throughout the workweek".

Control variables

We chose to assess age, sex, and tenure with the organization as potential demographic control variables in our study. According to status characteristics theory, age is a symbol of status and older firefighters may be judged as superior compared to younger firefighters (Nembhard & Edmondson, 2006). High status individuals (i.e., older firefighters) are more likely to be asked for their opinion and offer their opinions freely without being worried about being rejected for sharing contradictory thoughts, which may influence ratings of psychological safety. It was important to control for sex because firefighting is a job that asserts masculinity and these masculine characteristics are further enhanced by men's numerical dominance in these organizations (Ely & Meyerson, 2010). Since masculine jobs usually involve risk-taking, male firefighters may be less concerned with safety and feel less psychologically safe to speak up about incidents when they felt unsafe. Finally, we controlled for tenure because the longer a firefighter is part of a crew, the more likely it is that they may not be concerned with safety because they begin to view themselves as "experts" (Scott & Trethewey, 2008).

Results

Descriptive statistics and correlations

Table 1 lists the means, standard deviations, zero-order correlations, and reliabilities among the study variables. Both sex and tenure were significantly related to one focal study variable. Sex was negatively related to psychological safety (r = -.12, p < .01) and tenure was negatively related to safety norms (r = -.12, p < .01). Consistent with current conventions for the treatment of control variables and for the sake of parsimony (Becker, 2005), because age was not

significantly correlated with any of the focal study variables it was not included in subsequent analyses. Correlations among the focal study variables were consistent with the direction of all hypotheses: Perceived AAR frequency (r = .41, p < .05), ambiguity reduction (r = .33, p < .05), and psychological safety (r = .42, p < .05) were all significantly positively related to safety norms. According to Cohen (1992) and Tabachnick and Fidell (2007), these are moderate effect sizes that can be used for subsequent analyses.

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INSERT TABLE 1 ABOUT HERE
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Discriminant validity of constructs

We examined the distinctiveness of the variables and that the indicators loaded onto their intended latent variables by performing a series of nested confirmatory factor analytic (CFA) models. We used Mplus version 6 (Muthén & Muthén, 2011) to compare the fit of four nested models (see Table 2). The highest loading item from each measure (or for each factor when combined) was set to one. Each more differentiated model showed a significantly better chi-squared statistic and the model treating each hypothesized construct as a separate construct (four-factor model) showed the best fit ($\chi^2(399) = 242.09$ (p < .05); CFI = .86; TLI = .87; RMSEA = .07). Additionally, all indicators in the four-factor model loaded reliably on their predicted factors (lowest loading = .32). Although the RMSEA values below .05 are considered good fit, values up to .08 represent reasonable errors of approximation (Byrne, 2001).

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INSERT TABLE 2 ABOUT HERE
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Test of hypothesized relationships

We used hierarchical multiple regression analysis to assess the incremental-explanatory power of variables in each step (Aiken & West, 1991) and to test for the moderating roles of

ambiguity and psychological safety in the relationship between perceived AAR frequency and safety norms (see Table 3). Following recommendations by Cohen, Cohen, West, and Aiken (2003), the independent variables were centered. In step 1, the control variables (i.e. sex and tenure) were entered. In step 2, perceived AAR frequency, ambiguity, and psychological safety were entered. In step 3, the two-way interaction terms created by centering and multiplying perceived AAR frequency with ambiguity, AAR frequency with psychological safety, and ambiguity with psychological safety were entered. In Step 4, the three-way interaction term between perceived AAR frequency, ambiguity, and psychological safety was entered. We examined the sign and significance of the slope of the relationship between perceived AAR frequency and the focal-moderating variables. If the interaction was significant, we plotted the slopes at one standard deviation above the and below the mean.

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INSERT TABLE 3 ABOUT HERE
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Main effects

As can be seen in Table 3, the control variables, and main effects of perceived AAR frequency, ambiguity, and psychological safety explained 27% of the overall variance in safety norms (R^2 = .28, p < .01). Perceived AAR frequency was positively significantly related to safety norms (b = .21, p < .01), thus supporting Hypothesis 1. Ambiguity reduction was not significantly positively related to safety norms (b = .15, p = .06), thus not supporting Hypothesis 2. Finally, psychological safety was positively and significantly related to safety norms (b = .22, p < .01), thus supporting Hypothesis 3.

Three-way interaction

The three-way interaction term, entered in step 4, significantly predicted positive safety norms and explained an additional 3% of the variance in safety norms, increasing the amount of

variance explained in safety norms to 30% ($\Delta R^2 = .03$, $p < .01$) (see Table 3). The interaction term was significantly related to safety norms ($b = .33$, $p < .01$). This suggests that the relationship between perceived AAR frequency and safety norms depends, in part, on the level of ambiguity and psychological safety during AARs.

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INSERT FIGURE 1 & FIGURE 2 ABOUT HERE
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The nature of the interaction was probed following recommendations from Aiken and West (1991) and Dawson and Richter (2006). To aid our interpretation, we plotted lines representing the relationships between perceived AAR frequency and safety norms, when ambiguity reduction is high, at different levels of psychological safety (i.e., at one standard deviation above and below the mean) (cf. Cohen et al., 2003) in Figure 1. We also plotted lines representing the relationships between perceived AAR frequency and safety norms, when ambiguity reduction is low, at different levels of psychological safety (i.e., at one standard deviation above and below the mean) (cf. Cohen et al., 2003) in Figure 2.

When examining the figures, it is evident that safety norms are highest when perceived AAR frequency is high. This finding supports Hypothesis 1 and provides evidence that AARs are an excellent strategic communication tool that can be used to promote safety norms. The form of the interaction also supports Hypothesis 4, indicating that the positive relationship between perceived AAR frequency and safety norms was highest when ambiguity was reduced and individuals had high psychological safety during AARs (see Figure 1). Simple effects tests (Aiken & West, 1991) were conducted to further test the nature and significance of the three-way interaction (Hypothesis 4). The effects test revealed significant differences in the slope for the line when psychological safety was high and ambiguity reduction was high, $t(318) = 2.43$, $p < .05$. When psychological safety was low and ambiguity reduction was high, there was a

significant difference in the slope of the line, $t(318) = 5.37$, $p < .01$, indicating the importance of the perception of holding frequent AARs.

Positive safety norms were lowest when there was low perceived AAR frequency, low ambiguity reduction, and low psychological safety (see Figure 2). When there was low ambiguity reduction and psychological safety was low, the slope of the line representing the relationship between perceived AAR frequency and safety norms was positive (see Figure 2). The simple effects test revealed that this positive slope was also significantly different from zero, $t(318) = 2.04$, $p < .05$. The simple effects test revealed non-significant relationships between perceived AAR frequency and safety norms when psychological safety was high and ambiguity reduction was low, $t(318) = 1.23$, $p = .22$, indicating that psychological safety is less beneficial in relative absence of ambiguity reduction.

Discussion

This study allows us to better understand the interactive effects of perceived AAR frequency, psychological safety, and ambiguity reduction during AAR meetings on perceptions of positive safety norms. First, we found that the more frequently crewmembers perceive that AARs are held, the more positive were group safety norms (Hypothesis 1). This confirms the importance of perceptions that discussion of safety-related work incidents is a normal course of activity for the group and contributes to the development of norms for engaging in safe behavior through the collective sensemaking process. Additionally, crewmembers who perceived to hold AARs more frequently may report more positive safety norms because the greater number of purposeful collective retrospective discussions presents them with more opportunities to discuss shared incidents in a manner that forces participants to observe, demonstrate and reinforce positive safety norms in relation to specific incidents. Indeed, the finding of a positive

relationship between AAR frequency and safety-related attitudes underscores the claim that safety norms are emergent and perishable. If they are not repeatedly reinforced over time in relation to specific work incidents, they weaken and dissipate. This is an important finding because this is not just a count of how many AARs the individual attended. Instead, it is a perception of AAR frequency, which helps us understand if the individual is tuning into the collective sensemaking process and contributing to positive safety norms.

Next, contrary to our expectations, the results showed that ambiguity reduction in AARs was not related to perceptions of positive safety norms (Hypothesis 2). Although one purpose of AARs is to promote learning by facilitating discussion that helps participants minimize the range of interpretation that could explain what happened during an incident, simply reducing the ambiguity from the call in this manner does not translate directly to more positive safety norms. For example, if AARs are facilitated in a manner that emphasizes mostly one-way communication from a supervisor to the group informing them of what happened and what should be learned from it, as opposed to a more balanced, interactive discussion, incident ambiguity may be reduced but not in a manner that is associated with improvement in positive safety norms. This suggests that in addition to reducing ambiguity, other important facilitation steps or interactive processes within the AAR meeting are necessary to actually observe increases in positive safety norms.

Next, the findings revealed that psychological safety in AAR meetings was positively related to perceptions of safety norms (Hypothesis 3). That is, when firefighters felt safe to share their genuine thoughts and ideas in AAR meetings about a specific incident, they were also more likely to indicate they have more positive safety norms in their crew. This suggests that the perceived relational climate of the meeting may play a role in the development of the desirable

safety related attitudes by shaping the extent to which participants interpret the AAR environment as a safe one in which open discussion of one's mistakes and viewpoints is valued, rewarded and supported. Conversely, the results also suggest that when AAR participants believe they cannot realistically expect to express their views or confess errors in action or judgment without fear of recrimination, AARs do not contribute as strongly to the development of pro-safety attitudes. Crewmembers may not ask questions or discuss in detail a hazard that others were potentially unaware of if they are not used to AARs and do not feel psychologically safe.

Finally, upon finding these differential direct effects, we proposed and tested a three-way interaction suggesting perceived frequency of AARs, ambiguity reduction, and psychological safety interact to produce the positive safety norms desired by organizations. This is the first study that considers these variables in combination and the proposed three-way interaction was indeed supported (Hypothesis 4). AARs are most likely to shape positive safety norms when they are perceived to be held frequently and their content is facilitated in such a way as to: 1) positively encourage frank expression of observations and opinions about the incident and self-disclosure about one's mistakes in a manner that minimizes fears of recrimination and 2) minimize ambiguity regarding what happened during the incident and how various actions likely contributed to particular incident outcomes.

Frequent AARs, when facilitated in this manner, are more likely to accomplish the positive sensemaking objectives for which they were designed (i.e., ambiguity reduction, positive safety norms) and enhance the perception that safety is genuinely valued in the group. This study advances our understanding of how to create positive safety norms through the collective sensemaking process offered by focused, purposeful AAR meetings. By examining these three variables in combination, we can better provide practical recommendations for how

to run AARs that promote a shared understanding of how to behave safely in future events. This study builds off of previous research that has examined these variables individually, but has not considered the power of all three variables in combination. Our results show that while the perception of frequent AARs is important, the perception of safety norms also depends on ambiguity reduction and psychological safety.

Implications for research and theory

The current research has several implications for research and theory relative to both implementing AAR meetings and collective sensemaking in high reliability organizations. First, in terms of AARs, this study builds upon recent research and shows that meetings can and ought to be used as a tool for key strategic organizational purposes as opposed to an oppressive component of workplace life (Allen & Rogelberg, 2013). Essentially, much of the research on workplace meetings laments the amount of time spent in meetings and discusses how this impacts employees' well-being (Rogelberg et al., 2006; Rogelberg, Shanock, & Scott, 2012). In contrast, this study argues that managers in organizations, or in this case captain of firefighter crews, can facilitate AARs in a manner that bolsters psychological safety and ambiguity reduction. The AAR can be used as one type of meeting that enhances continuous improvement efforts and promotes positive change in their employees' attitudes. In other words, frequent and high quality AARs are helpful not just because they ritualistically remind the group about positive safety norms but rather because they do so through psychologically safe discussions that reinforce the relevance of these norms to particular incidents.

Second, in terms of collective sensemaking research, this study suggests that AARs are a location where strategic, deliberate discussion occurs and where sensemaking theory can be used to explain the relationship between retrospective discussion processes and safety related

perceptions. To date, the vast majority of sensemaking research studies the phenomenon in settings where it occurs spontaneously and naturalistically rather than strategically. Future research should examine even more closely the discussion processes through which AAR participants use this safety intervention to intersubjectively enact relevant portions of the incident environment, select plausible interpretations of the incident, and retain these lessons for future incidents, all in a manner that enhances group safety norms. Future sensemaking research on AARs should seek to explain what particular communication behaviors and facilitation strategies can be used during the collective sensemaking process that promote feelings of psychological safety when discussing incident vulnerabilities that can be reinforced and maintained, regardless of whether the story is one that typically dominates (Naslund & Pemer, 2012). It would be even more practically useful to understand what facilitator and participant behaviors are most likely to shape psychological safety positively or negatively in the context of AARs in HROs.

The current findings also suggest an additional avenue for future collective sensemaking research on AARs and other forms of post-incident discussion. Although the present study detected a strong relationship among psychological safety, ambiguity reduction, and positive safety norms, the findings should not be interpreted as suggesting that high quality AAR discussions must completely eliminate all uncertainty about the incident or that good AAR facilitation always promotes a high degree of consensus. Members of HROs monitor complex environments and problem situations through distributed labor, so each AAR participant observes different incident elements. Although well-facilitated AARs should reduce ambiguity about what happened, why, and what should be learned from it, efforts to completely root out ambiguity through forced consensus have the potential to reduce psychological safety by inhibiting discussion of contradictory views, diminishing satisfaction with, and motivation to

participate in future AARs. Future research should examine this delicate balance between the need to develop consensus and reduce incident ambiguity in a manner that reinforces safety norms against the objective of maintaining a discussion environment that feels psychologically safe.

Third, relative to high reliability theory, the current results have some key implications concerning preoccupation with failures (Weick et al., 2005). Findings suggest that when collaborators in these settings are preoccupied with frequently making constructive sense of recent calls through open discussion of the group's vulnerabilities as well as individual and collective mistakes and near misses, they also develop norms that encourage safe behaviors. Despite working in dangerous environments, high reliability organizations may thrive because groups within the organization are extremely focused on not allowing small errors to combine and produce disaster, but not all open discussions of error are created equal. Some are likely more psychologically safe and ambiguity reducing than others. Our findings suggest that when groups maintain a less competitive, more open discussion environment that promotes unguarded communication about operational vulnerabilities, more ambiguity reduction is likely to occur and increase positively safety norms. Such a climate enables open discussion of personal, even conflicting views and enables learning from mistakes to become a group habit rather than an offense to avoid, which is likely to enhance shared safety-oriented norms more broadly (Scott et al., 2013).

This is significant because many so-called best practices for AARs arguably emphasize the role of the facilitator in shaping the groups sense of what happened and what it means through mostly one-way communication to the exclusion of practices that emphasize open, multidirectional discussions in which suspected vulnerabilities are enacted, discussed, debated,

and reinforced relative to the group's safety norms. Indeed, the preoccupation with failure, when robust and reinforced in a manner that feels psychologically safe, actually promotes success through reducing ambiguity around the event in general and promoting safe behavior in subsequent dangerous events. While we suggest that a shared understanding of safety norms comes from the collective sensemaking process and organizations remaining reliable, future research should consider how the development of positive safety norms may be created from both a structural and systems theory perspective (e.g., Bigley & Roberts, 2001; Leveson, Dulac, Marais, & Carroll, 2009). By comparing and contrasting these theoretical viewpoints, research may create a more nuanced theoretical understanding of the development of safety norms.

Implications for practice

Given the applied nature of the research presented here, implications for practice are readily apparent. It should also be noted that these implications, though framed in a firefighter context, can be applied to many different high reliability organizations and may even be useful in organizations that do not manage such dangerous environments but seek to learn from their regular operations. First, captains (or in other occupations, managers) should call after-action reviews frequently with their group members (Allen et al., 2010). This study suggests that there is some direct benefit from simply facilitating AARs regularly and having individuals perceive that they are part of a frequent collective sensemaking process. This implication is significant because in many practitioner circles, AARs are only held after major incidents in which significant errors or losses occur. The current findings point to the importance of holding regular AARs after a range of incident types—major or minor, successful or unsuccessful.

More importantly, it is the perception that they are held frequently and that they held in a safe environment where ambiguity can be reduced. Thus, sheer volume of AARs may not

translate to safety norm improvement, but the belief that enough AARs are happening and that they are high quality meetings, makes this an organization and occupation specific recommendation. For example, in the fire service, perhaps AARs should occur after every call, but in the police service, this may be perceived as overly burdensome. Such questions would need to be considered by managers as they encourage the use of AARs with their organizations.

Second, captains should endeavor to make the AAR meeting environment a safe environment for crew members to confess mistakes, share contrasting points of view, and be willing to accept that one's interpretation may not account for all the information in spite of one's supervisory status. That is, the meeting environment should be a welcoming environment where participants in the meeting feel free to voice their ideas without concern for individualized repercussions (Allen & Rogelberg, 2013; Scott et al., 2013) and without extreme concern for whether their story is most likely to dominate (Naslund & Pemer, 2012). In other words, quantity and quality both matter, so training and assessment practices should focus not only on frequency but quality of facilitation as well.

Limitations and future directions

While this study makes valuable contributions to AAR research, it is not without limitations. Future research that involves replication of the results is needed so that the findings will be more generalizable to different organizations, industries, and jobs. We would also like to point out that although a general bias exists in AAR research toward the assumption that firms making use of this intervention are HRO's, there is little or no evidence available to suggest that using AARs cannot benefit any type organization seeking to learn from their daily operations (e.g., teams leading training, post-business meetings, and presentations).

This study is also susceptible to potential methodological issues related to common method bias because the predictor and criterion variables were assessed simultaneously on a common survey instrument (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Similarly, because our research design was cross-sectional, we were not able to make any causal claims and the hypothesized relationships may, in fact, be bi-directional. Additionally, our results may need to be interpreted with some caution because our response rate was slightly below the average response rate across organizational studies journals (Baruch & Holtom, 2008). Future research should consider conducting a cross-lagged panel design to better understand the nature of causality among these variables and encourage higher response rates to better evaluate the reliability and validity of our findings.

Conclusions

In confirmation of previous research, the perception of holding AAR meetings frequently appears to be important. Additionally, the interaction between the frequency and the quality of the content of the AAR meetings contribute to positive safety norms, which can potentially, over time reinforce safe behaviors. This study reinforces the importance of holding frequent AAR meetings and sheds light on the importance of good AAR facilitation and promoting an environment that allows individuals to freely contribute to the meeting, which may subsequently lead to safer decisions during future dangerous events. Although future research is required before results can be generalized, organizations should consider implementing AARs to promote sensemaking, learning, and safe behaviors in future ambiguous and dangerous events. If facilitated correctly, frequent AARs should promote psychological safety and reduce ambiguity leading to positive safety norms and safer organizations overall.

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Table 1

Means, standard deviations, and zero-order correlations

Variables	*M*	*SD*	1	2	3	4	5	6	7
1. Age	40.11	9.56	(N/A)						
2. Sex	1.04	.19	.12	(N/A)					
3. Tenure	14.66	9.32	.85*	.02	(N/A)				
4. AAR frequency	3.43	.78	-.02	-.03	-.01	(.87)			
5. Ambiguity Reduction	3.76	.48	-.09	-.06	-.09	.43*	(.73)		
6. Psychological Safety	3.95	.59	-.05	-.12**	-.07	.39*	.33*	(.71)	
7. Safety norms	3.71	.67	-.05	-.11	-.12**	.41*	.33*	.42*	(.95)

Note. N = 330. Sex was coded as 1 = male and 2 = female. Age and tenure were assessed as a continuous variable and rounded to the nearest whole number. Alpha reliabilities are reported on the diagonal. **$p < .05$; *$p < .01$.

Table 2

Confirmatory Factor Analyses Model Fit Indices

Model	CFI	TLI	χ^2	*df*	Difference	RMSEA
One-factor	.63	.60	2,680.42*	405		.12*
Two-factor	.79	.77	1,698.82*	404	981.60	.09*
Three-factor	.83	.82	1,409.71*	402	289.11	.08*
Four-factor	.87	.86	1,167.62*	399	242.09	.07*

Note. N = 330. The one-factor model includes AAR frequency, ambiguity, psychological safety, and safety norms. The two-factor model treats AAR frequency, ambiguity, and psychological safety as one factor and safety norms as a second factor. The three-factor model treats AAR frequency (factor 1) and safety norms (factor 2) as separate factors and ambiguity and psychological safety as one factor (factor 3). The four-factor model treats each variable a separate factor. CFI = comparative fit index; TLI = Tucker-Lewis index; Difference = difference in chi-square from the next model; RMSEA = root-mean-square error of approximation. *$p < .01$.

Table 3
Results of hierarchical multiple regression on safety norms

Model		***B***	**S.E.**	R^2	ΔR^2
Step 1				.02**	.02
	(Intercept)	4.21	.21		
	Sex	-.37	.20		
	Tenure	-.01	.01		
Step 2				.27*	.25
	(Intercept)	4.00*	.19		
	Sex	-.20	.17		
	Tenure	-.01	.00		
	AAR Frequency (centered)	.22*	.05		
	Ambiguity reduction (centered)	.16**	.08		
	Psychological safety (centered)	.32*	.06		
Step 3				.29	.02
	(Intercept)	3.98*	.03		
	Sex	-.16	.17		
	Tenure	-.01	.00		
	AAR Frequency (centered)	.22*	.05		
	Ambiguity reduction (centered)	.21*	.08		
	Psychological safety (centered)	.28*	.06		
	AAR Frequency x Ambiguity reduction (centered)	.11	.06		
	AAR Frequency x Psychological safety (centered)	-.13	.08		
	Ambiguity reduction x Psychological safety (centered)	-.05	.10		
Step 4				.32*	.03
	(Intercept)	3.99*	.18		
	Sex	-.20	.17		
	Tenure	-.01	.00		
	AAR Frequency (centered)	.21*	.05		
	Ambiguity reduction (centered)	.15	.08		
	Psychological safety (centered)	.22*	.06		
	AAR Frequency x Ambiguity reduction (centered)	-.06	.08		
	AAR Frequency x Psychological safety (centered)	-.09	.08		
	Ambiguity reduction x Psychological safety (centered)	.16	.11		
	AAR Frequency x Ambiguity reduction x Psychological Safety (centered)	.33*	.09		

Note. N=330. b = unstandardized beta weight. **$p < .05$, *$p < .01$.

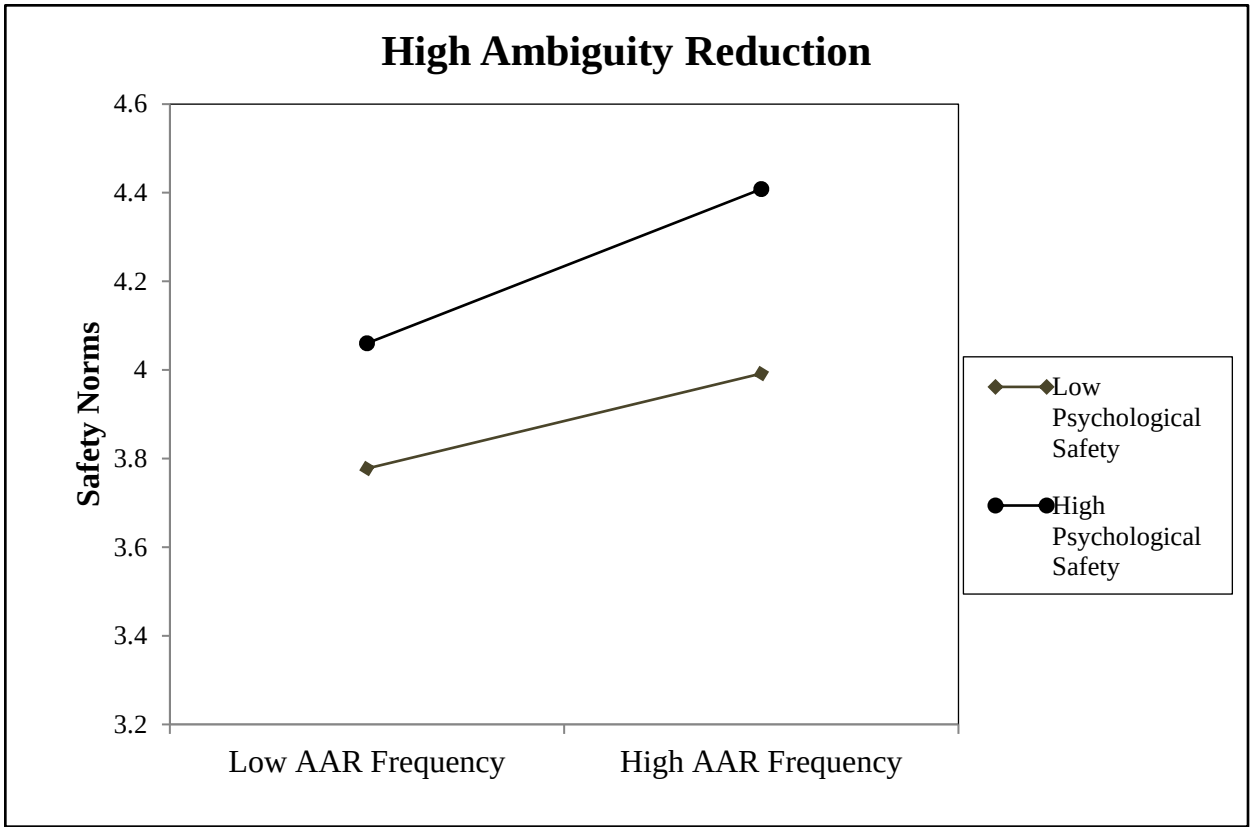

Figure 1. Graphed moderating effect of AAR Frequency, high ambiguity reduction, and psychological safety on safety norms. All predictor variables (AAR frequency, psychological safety, ambiguity reduction, and the interaction terms) were centered prior to analyses.

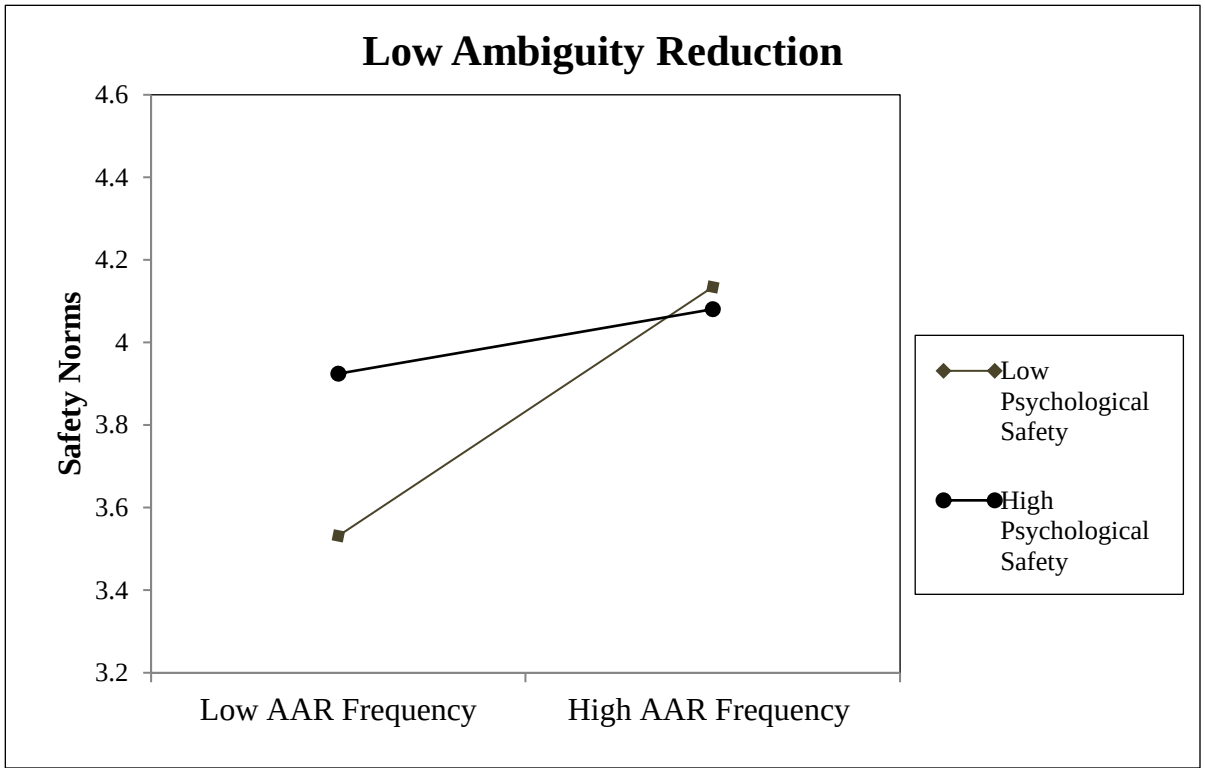

Figure 2. Graphed moderating effect of AAR Frequency, low ambiguity reduction, and psychological safety on safety norms. All predictor variables (AAR frequency, psychological safety, ambiguity reduction, and the interaction terms) were centered prior to analyses.