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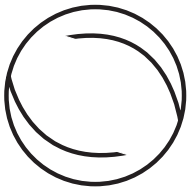

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Abstract

We present an in-depth analysis of post-flight reviews in a fighter aircraft squadron of the Israel Defense Force Air Force. Our findings demonstrate how organizations can learn non-metaphorically and highlight the dynamics of learning in a central organizational learning mechanism in this type of after-action review. They also show that learning in the post-flight reviews is a multi-layered process of retrospective sense-making, detection and correction of error, social comparison, social control, socialization, and bonding, where lessons-learned pertain to different domains and different levels — individual, unit, and Force-wide. The process is facilitated by five values specified by the multi-facet model (Lipshitz, Popper and Friedman 2002), and the assumption that learning through critical examination of one's own experience is the key to improvement.

Key words: organizational learning mechanisms, after-action reviews, learning culture, learning from experience

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The question of how organizations learn has attracted the attention of scholars, managers, and consultants in a variety of disciplines (Crossan and Guatto 1996). This interest spawned a rich multidisciplinary literature (Easterby-Smith 1997) offering a wealth of thoughtful discussions from different perspectives, models, and empirical evidence regarding the acquisition, accumulation, and utilization of knowledge in organizational settings (Berthoin-Antal et al. 2001; Easterby-Smith and Lyles 2003). Nevertheless, some fundamental questions are arguably yet to be resolved in a compelling fashion, for example 'Is "organizational learning" an anthropomorphism?' 'How do individual and organizational learning differ?' and 'How does individual-level learning become organizational-level learning?' (Argyris and Schön 1996; Kim 1993; Lipshitz et al. 2002; Simon 1991; Weick 1991; Yanow 2000).

This paper has two objectives. The first is to examine the above questions through an in-depth analysis of post-flight reviews in a combat squadron of the Israel Defense Force Air Force (IDFAF), an organizational learning mechanism that is critical for the high performance level of these units. The concept of organizational learning mechanisms is taken from Lipshitz et al.'s (2002) multi-facet model of organizational learning. Since the model provided

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the conceptual framework for the present study, we review it briefly, followed by a review of the literature on after-action reviews.

The multi-facet model consists of structural, cultural, psychological, policy and leadership, and contextual facets. Each facet relates to a different aspect of the complex phenomenon of organizational learning. The structural facet consists of organizational learning mechanisms (OLMs). They are institutionalized structural and procedural arrangements in which members of the organization collect, analyze, codify, exchange and disseminate information and knowledge relevant to the organization's and their own welfare and performance. OLMs link individuals to organizational learning (Simon 1991): the knowledge created by individuals working in OLMs is disseminated throughout the organization and transformed into formal procedures or informal routines.

The cultural facet specifies five behavioral norms that increase the probability that learning will be productive: transparency (exposing one's thoughts and actions to others); integrity (giving and receiving feedback without defending oneself and others); issue orientation (focusing on the relevance of information to the issues at hand, regardless of extraneous factors such as hidden agendas and the social standing of its source); inquiry (persisting in an investigation until a satisfactory understanding is achieved); and accountability (assuming responsibility for learning and the implementation of lessons-learned). The first four norms help to produce knowledge that is not based on willfully distorted information and which has passed the critical evaluation of inferences and assumptions. The fifth value increases the probability that whatever has been learned will be implemented in action.

The psychological facet specifies two psychological conditions that are necessary for learning in social contexts (in which it takes place): psychological safety and organizational commitment. The former is important for risk taking and for experimenting with new ideas and behaviors (Edmondson 1999, 2003). The latter motivates sharing information and knowledge with others.

The policy and leadership facet specifies managerial actions that promote learning, such as tolerance for error (to increase psychological safety) and job security (which promotes both psychological safety and organizational commitment).

Finally, the contextual facet specifies factors, such as environmental uncertainty, that influence the likelihood of organizational learning outside the control of management (Dodgson 1993).

The concept of OLM applies to every systematic organizational learning activity that is described in the literature. For example, communities of practice in which persons with similar professional interests meet to exchange information and knowledge (Wenger and Snyder 2000); post-project reviews that are conducted by central assessment units (Gulliver 1987); on-line experimentation in which workers test new work methods of their own design (Leonard-Barton 1992); and peer assists in which workers are coached by their peers (Dixon 2000), are all OLMs that differ on two parameters: the agents of learning (identical to or different from the persons who perform the task), and the time of learning (separate from or in conjunction with action).

One OLM that is discussed fairly extensively in the literature is the after-action (or post-project) review (Cusumano and Selby 1995; Darling and Parry 2001; Di Bella et al. 1996; Garvin 2000; Gulliver 1987). Two research programs on after-action reviews are particularly noteworthy. Baird and his associates (Baird, Henderson, and Watts 1997; Baird, Holland, and Deacon 1999) studied the US Army Center for Lessons Learned (CALL) and identified the basic characteristics of effective after-action reviews: focused on few critical issues; done immediately after the action; inclusive of all those who took part in the action; follow a structured process; and lead back to action as soon as possible. Carroll (1995, 1998; Carroll et al. 2003) observed after-accident reviews in nuclear power and chemical plants. Based on these observations, Carroll et al. (2003) identified four patterns that signify increasing levels of organizational learning quality: learning activities become more structured and institutionalized; prevailing structures and assumptions are challenged rather than taken for granted; solutions call for exploration rather than exploitation (March 1991); and systemic changes are preferred to quick fixes. Progressing from one stage to another requires the promotion of psychological safety, including the open expression of conflicts and emotions, increased participation of and collaboration among organization members, and systematic use of inquiry tools such as root cause analysis.

The literature quoted above offers detailed descriptions of different procedures that are employed in conducting after-action reviews in different settings, and some general insights on the factors that contribute to their effectiveness. Still missing from the literature is a systematic analysis of the dynamics of learning in after-action reviews: what happens in them and how do participants experience the process? The second purpose of the present study, accordingly, is to address this gap by analyzing a special case of after-action reviews, post-flight reviews in a fighter squadron of the IDFAF.

Post-flight reviews in the fighter squadron of the IDFAF are highly regarded in the Israel Defense Force, where they are considered a practice worthy of emulation (Gordon 2003; Marinko 1991). The particular squadron in which the study was conducted was an F-16 all-purpose fighter squadron with diverse operational and training missions. It was selected on the basis of the likely cooperativeness of its commander and because it allowed us to observe a variety of post-flight reviews in operation.

Working days in the squadron begin with a 30-minute briefing for the air crews scheduled to fly. The briefing occasionally includes reviews of lessons-learned from past missions. Next, air crews attend short formation (pilot–navigator teams) briefings that are facilitated by the formation leaders ('number ones'). These are not assigned by position or rank, so that relatively junior pilots may lead and debrief pilots who are their senior in rank and experience. A typical sortie lasts 30–60 minutes, and these are interspersed by 45-minute *formation* post-flight reviews which are also facilitated by the formation leader. Typical training days consist of two or three cycles of formation briefing–sortie–formation post-flight review, and occasionally an additional nighttime cycle. The day concludes with a 60-minute *daily* post-flight review which is facilitated by either the squadron commander, one of

his two deputies, or by a veteran formation leader, and attended by all air crews and representatives of the relevant support staffs. Formation post-flight reviews are conducted in various designated locations in the squadron. These locations are equipped with VCR and TV screens for reviewing flight films recorded by cockpit-mounted VCRs. Morning briefings and daily post-flight reviews are conducted in a central briefing room equipped with maps, VCRs, and overhanging TV screens. Post-flight reviews account for 40–50% of training and operational flying days, a proportion that is reduced in wartime owing to heavier workload and the longer required rest periods.

Formation and daily post-flight reviews focus on different issues. Formation post-flight reviews focus on what happened during the sortie and how each pilot flew his plane in combat. To this end each pilot's video record is reviewed meticulously, with particular attention paid to errors (typically inappropriate actions), causes of error, and potential remedies (e.g. alternative actions). Daily post-flight reviews focus more on *output*: mission accomplishment, the functioning of the formations as units, and errors that are generally relevant due to their pervasiveness or risk, or rule infractions necessitating disciplinary action. The films to be reviewed by the general assembly in the daily post-flight reviews are selected by the pilots themselves according to these criteria.

Method

Participants

Thirteen pilots and navigators representing approximately 30% of the squadron's air-crew personnel volunteered to participate in the study. They were selected in consultation with the squadron commander to represent a cross section of the air-crew population: relatively inexperienced (compulsory service) vs experienced pilots and navigators; regular members of the squadron vs persons who serve in it on a part-time basis (emergency assignments and reserve duties); and low-rank vs high-rank pilots and navigators (including the commander and his two deputies).

Data Collection

Interviews were taped and transcribed by the first author. Following informal interviews with the squadron commander and one of his deputies and observations of formation and daily post-flight reviews, data were collected by semi-structured interviews conducted by the first author. Interviews lasted 1–2 hours and took place in a variety of locations according to the interviewee's preference — the squadron, cafes and interviewees' homes.

All interviewees were asked the same set of basic questions (Table 1). Thanks to the semi-open format of the interview, their answers yielded information on a variety of subjects beyond the narrow domains delimited by the questions.

Table 1. Interview Protocol

How would you describe the post-flight reviews to a person who has never observed one?
What types of post-flight reviews are operated in the Israel Defense Force Air Force and in which ways are they similar or different?
What is the importance and contribution of the different types of post-flight reviews?
How would the Israel Defense Force Air Force be without them?
What is a high-quality post-flight review and what factors determine the quality of post-flight reviews?
Can you remember a particular post-flight review that was meaningful or exceptional for you?
What is required from post-flight review participants?
How are they evaluated?
What tips will you give to a young pilot regarding participation in the post-flight reviews?
How do pilots acquire the skills for participating in post-flight reviews?
To what extent is behavior in post-flight reviews taken into account in a pilot's evaluations by superiors and colleagues?

Data Analysis

Analysis was based on Kvale (1996), Miles and Huberman (1994), Strauss (1987), and Weiss (1994), and consisted of line-by-line coding, model construction, and member validation.

Line-by-line coding: Coding was an iterative process with the coding scheme formed and revised (and interviews coded and re-coded accordingly) on the basis of insights gained in the process of reading, re-reading, coding and re-coding of the interviews. The process was facilitated by the use of a code-and-retrieve software specifically designed to handle Hebrew texts. Data were coded by the first author with the second and third authors reading and making notes on the pre-coded interviews and discussing the formation and revision of the coding scheme, as well as the appropriateness of its application to specific text segments.

The process of coding consisted of three sub-phases. First, interviews were coded with top-down codes derived from the interview questions and the multi-facet model. A second, bottom-up set of codes was generated by identifying themes that appeared in the text in a similar fashion to Strauss's (1987) open coding. The resulting 150+ set of codes was reduced to a smaller set of key codes which were refined, elaborated, and tested for convergent and divergent validity by examining the homogeneity of identically coded text segments, and the distinctiveness of differently coded text segments, respectively. The final set of codes is presented in Tables 2 and 3. Coding was accompanied by writing of memos (Miles and Huberman 1994) regarding prominent aspects of the post-flight reviews process. These were integrated into draft reports (Kvale 1996) and discussed among the three authors.

Model construction: Graphical cause-map models linking concepts which emerged from the coding process were constructed to aid the interpretation of the findings.

Member validation: Member validation was used as a method to test the basic validity of our interpretations and conclusions (Erlandson et al. 1993).

Twenty-four instructors in the IDFAF flight school who did not participate in the study served as content experts. They responded to a questionnaire consisting of items corresponding to the principal conclusions of the study. Because of the length of the questionnaire (81 items) 11 instructors responded to the first half of the questionnaire and 13 instructors responded to its second half.

Results

Answers to the open-ended question, 'How would you describe the post-flight reviews to a person who has not seen one?', provided detailed information on the process of learning in the post-flight reviews. In addition to factual descriptions of the post-flight reviews process, answers stressed their indispensability for the performance of individual pilots, for the squadron, and for the IDFAF in general. Line-by-line coding of this material revealed that post-flight reviews fulfilled three basic functions: learning, social control, and psychological. Table 2 presents these functions in conjunction with text segments that illustrate their meanings and exemplify their coding. Following these segments together with reading the following discussion should help comprehend the nature of the various functions.

Functions	Definition	Illustrative example
Learning		
Constructing valid sortie representation	Enable participants to understand what happened in the air	Quite often we simply do not remember what actually happened during the mission. Without the VCR we would miss about 40% of what happened.
		Before the post-flight review our picture of what happened in the sortie is subjective. In the formation post-flight review we try to construct a more objective picture by comparing what each of us saw from his own perspective. By contributing our parts of the puzzle we can construct a more complete and accurate picture.
Improving individual performance	Enable participants to improve their individual performance	If you don't debrief after flying you may as well not fly at all [said with reference to improving performance].
		I can fly without debriefing for a while. In the long run, though, my performance will suffer.
		I personally believe that without post-flight reviews I would not care as much as I do about my performance, which will therefore regress. Post-flight reviews keep you on your toes.
		I attribute the high performance of flight units to the fact that everybody knows that his actions will be scrutinized by others. Every pilot will tell you that as soon as he makes a bad mistake the humiliation of this being seen by everybody at the daily post-flight review jumps right up in front of his eyes. So people learn to 'fly the post-flight review,' i.e., to act in a manner that will look good in the post-flight review.

Table 2: Post-flight Review Functions

Continued

Functions	Definition	Illustrative example
Improving formation performance	Enable participants to improve their collective performance	The post-flight reviews deal with a variety of issues including flying in formation and air-combat tactics and doctrine.
Improving training effectiveness	Help command to improve training	Daily post-flight reviews provide numerous points for improving the design of training.
Developing doctrine	Help command to improve doctrine	I transfer relevant comments that I hear in daily post-flight reviews directly to a squadron SOP. It's really a copy, one level down, of how the Air Force works [comment made by the squadron's deputy commander].
Learning from others	Enable participants to learn from others	Because we cannot observe all our errors, we sometimes find it difficult to admit that we made them. This is particularly true in the case of ambitious and competitive people, i.e., most pilots. One of the things that we learn from experience is that errors are bound to occur, so that making one is no big deal. Having others present in the post-flight review therefore helps to catch errors which we might otherwise either miss altogether, or notice but misinterpret. Furthermore, observing the errors of others helps us avoid them ourselves.
Learning from failure	Enable participants to learn from their failures	When [a cadet in flight school] begins to 'tell stories' during debriefing, the instructor cuts him short: 'Stop the stories and come to the "match-point" — why did you fail?'
		Ultimately, good pilots are distinguished from bad ones by their ability to stand up and say 'That's my error' — and then avoid it the next time around.
Social control		
Disciplining and culpability fixing	Enable commanders to hold subordinates accountable for sub-par performance	The business of the daily post-flight review is to hold people accountable for their errors.
		The squadron is a small, closely knit social system. Exposing a severe error unbecoming of your experience or status is not as bad in the formation post-flight review, with few people around, as in the daily post-flight review, with the commander saying in the presence of 50 people 'This is a very serious matter', pointing out some aspects that had not even occurred to you.
		Occasionally you make such a stupid mistake that you pray the VCR was not working, or that the post-flight review will be skipped that day.
Monitoring performance	Enable commanders to monitor pilots' performance	During the flight each pilot is locked inside his cockpit and formation post-flight reviews take place in small closed groups. The daily post-flight review is when everybody can observe how everyone else performed. I learn whom to assign to which mission, and we all learn with whom we would like to fly in formation [the squadron commander].

Continued

Functions	Definition	Illustrative example
Communicating intent	Enable commanders to communicate goals and policy	The daily post-flight review is a communication channel that can be used to influence the squadron [the squadron commander].
		If post-flight reviews focus only on results they encourage competitiveness so people will do everything to succeed, regardless of procedures and doctrine. This is less likely if post-flight reviews focus on process.
Socialization	Socialize participants to the squadron and post-flight review culture	I learned to surf as kid, and like everybody else I did not think twice when I fell, expecting to improve through mere experience. When I learned to ski, as an experienced pilot I debriefed myself each time I fell: why did I fall and how could I have avoided it? Operating this way became second nature.
Psychological		
Social comparison	Enable participants to evaluate their performance relative to others	Proving the existence of a dark human need, some pilots are happy to observe others fail. I assume they feel that their own performance looks better this way.
		Every time someone speaks at the post-flight review his status is enhanced — provided that his contribution makes sense.
Recognizing and rewarding	Enable commanders to recognize and reward	The daily post-flight review is definitely an arena for rewarding whoever deserves reward and punishing whoever deserves to be punished.
		Every person is naturally happy to hear a good word, all the more so when it is broadcasted to the whole tribe in the daily post-flight review.
Generating involvement	Involve participants in the squadron	The post-flight reviews are an open, democratic social system.
Bonding	Strengthen between participants and between them and the squadron	A post-flight review is a ceremony. It's like a tribe gathering around the camp fire to share the day's events, except that it's done in a structured fashion. It's an opportunity to show off successful experiences and learn from less successful experiences, a catalyst for sharing publicly and candidly, positive and negative feelings and opinions.
Building resilience	Strengthen participants' ability to withstand operational and cultural stresses	Pilots and navigators are required to withstand stressful situations, be it the post-flight review, air combat, or falling into enemy hands. Strengthening one's ability to withstand stresses is an ancillary outcome of participation in post-flight reviews.

Learning Functions

Post-flight reviews are first and foremost vehicles for learning from experience to improve individual, group and organizational performance (i.e. air crews, formation and the squadron and Israel Defense Force Air Force, respectively). The four output learning functions corresponding to these goals are (1) improving individual performance; (2) improving formation performance; (3) improving the effectiveness of the squadron's training methods and (4) developing the squadron's and the IDFAF doctrine (including standard operating procedures). As the output functions are self-explanatory from Table 2, we expand here only on the three process learning functions which facilitate their realization: constructing valid representations, learning from others, and learning from failure.

Constructing valid representations: Reconstructing a valid sortie representation is difficult because pilots have a partial and often distorted picture of what actually happened in the air. Three solutions help to solve this problem in the formation and daily post-flight reviews. The first solution is obtaining objective input from VCRs mounted in each plane's cockpit. The second is *learning from others* (i.e. using the comments and suggestions of other pilots to construct the meaning and pragmatic implications of the VCR input, and learning vicariously from the debriefing of others). The third solution is embedding post-flight reviews in a learning culture as described below.

Learning from failure: Virtually all our interviewees describe the essence of the post-flight reviews by a triple mantra-like slogan: 'What happened? What went wrong? How can we do better next time?' This characterization of the post-flight reviews is consistent with Argyris and Schön's (1996) conceptualization of organizational learning as the detection and correction of error. It is also consistent with numerous findings that learning from experience is driven primarily by failure (Lipshitz and Barak 1995; March 1994; Wong and Weiner 1981, Zakay et al. 1998).

Social Control Functions

Social control functions pertain to social and organizational aspects of participation in post-flight reviews. They include disciplining and culpability fixing, socialization, performance monitoring, and communicating the commander's intent.

Disciplining and culpability fixing: In both formation and daily post-flight reviews pilots are expected to (and according to our observations actually do) point out their errors and to provide a reasonable explanation and alternative course of action for them. When errors involve a breach of safety regulations, pilots can expect to be reprimanded (or worse) by the squadron commander in the daily post-flight reviews. The hardship of being held culpable publicly is twofold. Emotionally, there is the humiliation caused by the public indignity. Cognitively, one has to come up with a plausible explanation that satisfies the other participants in the post-flight reviews:

'Owning up to an error and coming up with a satisfactory explanation for 40 other people is a considerable intellectual effort. Just saying "I made an error" or following that with a lame excuse that is not a real explanation will not do.'

Public viewing of video records compounds these difficulties.

Disciplining and culpability fixing, thus, involves the conflict inherent between monitoring and strict disciplining of a sub-par performance on the one hand, and tolerating error and providing a safe environment for learning on the other. Holding people accountable may entail a punitive stance that is inconsistent with a non-evaluative and safe atmosphere that promotes learning (Edmondson 1999; Schein 1993). Managing the tension between an inquisitive, non-evaluative environment that is conducive to learning and the judgmental environment entailed in determining culpability calls for subtle balancing, as recognized by the squadron commander:

'If I charge a fine for every error people will stop disclosing their errors — it's as simple as that. And if I avoid disciplining altogether they will get the message that "anything goes". That's why the post-flight review is an intricate business that must be handled with judgment and care.'

Managing the tension is helped by pilots' recognition that 'flying is hazardous and, without a disciplining framework, there are bound to be crashes', and by the fact that 'the core values of the debriefing culture are truthful reporting, public accountability, the ability to admit error, and getting — making the most of — an opportunity to try again'.

Because becoming culpable is unpleasant it encourages high-level performance. Pilots learn to 'fly the post-flight review', namely, to fly in a manner that will pass the scrutiny of others. Daily post-flight reviews have a similar effect on the conduct of the formation post-flight reviews. No one wants to gloss over bad performance in the supportive surrounding of the latter, only to be caught in the more formal surrounding of the former.

Socialization: Post-flight reviews are arenas for socializing pilots to the values that contribute to its effectiveness. This process begins in flight school and continues throughout active service until it becomes second nature, influencing pilots' behavior in all spheres of life.

Monitoring individual performance: The daily post-flight review allows the squadron's command to monitor the performance of individual pilots and navigators (including their behavior in the post-flight review itself), and to note repeated performance problems, breaches of safety regulations and other impediments to the squadron's functioning.

Communicating commander's intent: Daily post-flight reviews engage the squadron's command with groups of pilots and navigators including those who are only part-time in the squadron. This provides an opportunity for exercising leadership and communicating the 'commander's intents' either explicitly as, for example, by informing the forum on objectives and policies, or implicitly, through the commander's personal behavior.

Psychological Functions

Psychological functions concern the impact of the demanding and stressful post-flight review situation on participants. There were fewer and less explicit references to these functions in the interviews than either to the learning or the social functions. Their derivation therefore involved more interpretive coding (Miles and Huberman 1994), by attaching psychological significance to interviewees' utterances. Five psychological functions were identified altogether: resilience building, bonding, recognition and reward, social comparison, and involving.

Resilience building is learning to endure the stress that competitive persons experience when their errors are exposed and critiqued in public by colleagues (who may be junior in experience and rank) and superiors. This is a difficult experience even though the difficulty is probably lessened by the fact that every participant is exposed and critiqued this way.

Bonding is strengthening the emotional ties to the squadron through the ritualistic aspects of the post-flight reviews.

Recognition and reward are flip sides of the social function of performance monitoring.

Social comparison is a ubiquitous attribute of social situations in which people engage in comparable tasks (Festinger 1954).

Involving is becoming engaged in the operation of the Israel Defense Force Air Force formal system by contributing lessons-learned that can change its routines and procedures.

A Model of the Post-flight Review Process

We chose the term 'functions' because the 16 entries in Table 2 constitute different answers to the question 'What is the purpose of the post-flight reviews?' However, the functions also reveal the complex dynamics underlying the post-flight reviews: that is, the interacting learning, social, cognitive and emotional processes that are at play 'under the surface'. Figure 1 summarizes our attempt to represent these dynamics as an influence-diagram model. The model assumes that while post-flight reviews are primarily designed for learning, this objective in the context of the post-flight reviews is fourfold: improving individual performance, formation performance, and training methods, and developing the squadron's and IDFAF doctrine. Furthermore, the post-flight reviews fulfill social and psychological needs that exceed its learning functions while being intertwined with them.

Beginning with the learning functions, the model assumes that participants are motivated to learn by the detection of failure ('learning from failure' in the figure), and that the validity of lessons-learned regarding the four areas above is contingent on the validity of the sortie's mental model from which they are derived ('constructing a valid representation'). To construct a valid model participants are helped by objective factual input from the VCRs, and subjective interpretive input from their fellow navigators and pilots ('learning from others'). The four broad social functions support learning as follows.

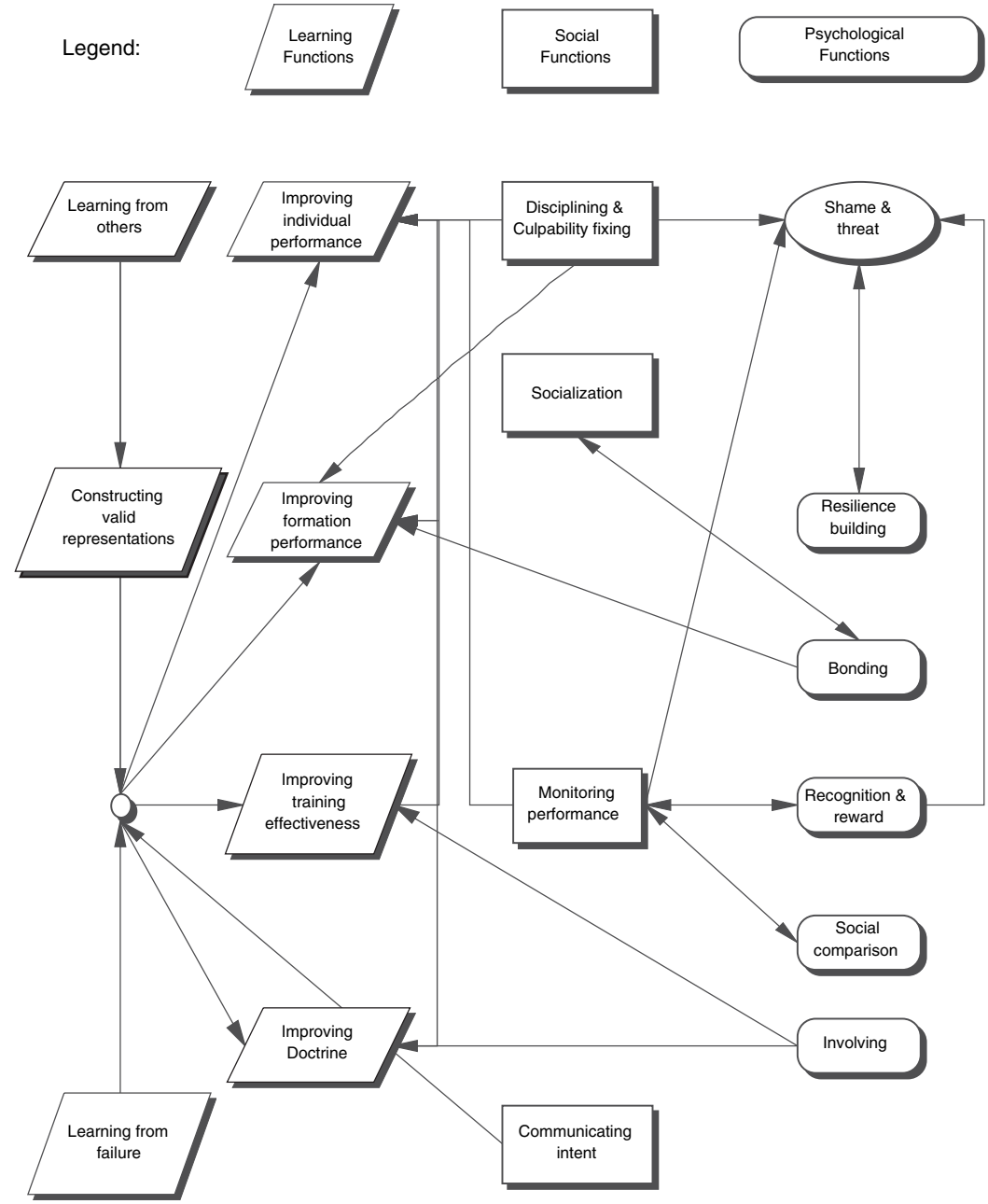

Figure 1. Post-flight Review Functions

Monitoring and disciplining motivate learning, communicating intent sets goals for learning, and socialization (i.e. internalizing values) facilitates learning as described below in the discussion of culture. The psychological functions support learning in two ways. Firstly, 'resilience building' and 'recognition and reward' help participants struggle with the threat and loss of face generated by the public exposure of failure, 'social comparison' and 'culpability

fixing', which retard learning (Schein 1993). Secondly, 'bonding' supports 'socialization' and 'involving' motivates pilots to contribute to the squadron, as well as to themselves, by drawing lessons-learned regarding 'doctrine' and 'training methods'.

Informal discussions of post-flight reviews in the IDFAF refer to their unique culture (Marinko 1991). Our data allowed us to explore the shared values comprising this culture in detail. Values are not directly observable. Consequently, we inferred them from statements regarding goals or behaviors that are appropriate, important, and worthy of sacrifice (Table 3). The values identified this way — inquiry, integrity, transparency, issue orientation, and accountability — are mapped onto the cultural facet of the multi-facet model (Lipshitz et al. 2002). According to these authors, this set of values supports high-quality organizational learning as follows:

> 'Assuming that organizational learning [requires understanding and] involves tackling non-trivial, ill-defined problems in complex and dynamic situations ... understanding requires inquiry, that is, dogged, persistent investigation in spite of difficulties ... In social contexts understanding requires the collaboration of others and transparency, without which input from others necessarily will be limited or flawed. Transparency is risky owing to the potential exposure of one's failures and mistakes. The ensuing anxiety induces defensive routines, which can block inquiry or subvert its validity ... Integrity and issue orientation help people proceed with inquiry despite the threat that it involves. Integrity means that a person prefers the loss of face and other costs incurred by public exposure to the loss of an opportunity to learn and improve. Issue orientation prevents the triggering of defensive behavior by messages that are perceived as disrespectful or offensive.' (Lipshitz et al. 2002: 86)

Schein (1985) suggests that, in addition to shared values, organizational cultures include underlying assumptions that are shared by the organization's members. Consistent with this suggestion, our data indicated the existence of shared assumptions about learning from experience (Table 2). These were (1) personal experiences, if accurately rendered, provide an opportunity to learn and improve; (2) errors are both inevitable and opportunities for learning; (3) learning from experience is best accomplished by those who have participated in the experience; and (4) learning should be done in group settings because individuals have limited knowledge and can benefit from sharing their knowledge with others. Finally, (5) individual and group learning should be shared by other members and by the organization (Constant et al. 2001).

Our data revealed several psychological factors operating in the post-flight review process. The first is organizational commitment which is essential for encouraging people to share knowledge with others (Constant et al. 2001; Lipshitz et al. 2002). This factor was implied by the interviewees' high regard for the IDFAF and their pride in serving as pilots in one of its elite squadrons. The other was psychological safety (Schein 1993) which was implied by the fact that the more intimate and relaxed formation post-flight reviews were regarded as more beneficial to learning than the daily post-flight reviews. Note, however, that the safe environment envisioned by Schein is incompatible with the unrelenting criticism that post-flight reviews participants occasionally endure. Arguably, pilots could endure this criticism because they

Table 3. Post-flight Review Values

Value	Reported behavioral manifestations	Illustrative text
Inquiry	Persistent search for causes of and remedies for sub-optimal performance	We always check what we have done and ask how we can improve. Always ask questions and never take anything for granted.
Integrity	Accounting for one's errors in a frank and convincing fashion	The biggest benefit from the post-flight review is that it forces you to recognize your errors for yourself in order to be able to account for them in public. I have yet to meet a pilot who lied in the post-flight review.
Transparency	Honest reporting of one's actions and reasoning; non-defensive acceptance of feedback from others	Because of the VCR, the post-flight review is an act of mental striptease. People who admit that 'That was an error, I need to improve here' are highly regarded.
Issue orientation	Ignoring rank and personal relationships but not differential experience in the process of learning	I know that my opinion counts, and if I think that it's relevant I will say it even to the commander of the Israel Defense Force Air Force or the world's number one ace. The opinions of someone with more flying hours under his belt count more though.
Accountability	Conscientious participation in the post-flight review process; implementing the post-flight review's lessons-learned	Because post-flight reviews are essential we show them respect: we arrive on time, ready to review the videos and make comments, and all data sheets are properly filled out beforehand. When the post-flight review ends, lessons-learned are left hanging for the picking. Some pilots do so, either because the lessons meet their needs, or because the learning culture is ingrained in them. Others leave without using the opportunity to learn that came their way.

felt safe in the post-flight review process. We prefer to attribute their ability to learn under such pressure to acquired resilience, to a self-critical attitude (see below), to the long process of socialization and high rate of attrition that characterize pilots' training, and to the influence of the values of inquiry, integrity, and issue orientation.

Psychological safety and organizational commitment are included in Lipshitz et al.'s (2002) model. Several additional psychological factors not included in the model were identifiable in our data:

Self-critical attitude and non-defensiveness: Detecting and correcting error in the presence of others is psychologically non-trivial as it involves loss of face and possible loss of confidence. Pilots must develop endurance to critical scrutiny by others:

'The most important thing that I do in self-debrief is prove to myself that I made the error and that it was my responsibility. If I succeed in that I will improve. If, on the other hand, I come to the conclusion that it was someone else's responsibility I may end up being correct — and foolish. Taking on responsibility is essential for doing better next time around.'

Resilience and need for improvement: Self-criticism and non-defensiveness are supported by recognizing the desirability of learning and the importance of valid feedback, however painful:

'Occasionally the post-flight review simply kills you — "Why did you make this error?"; "Here you were shot down"; "Here you screwed up the formation"; "Here you flew below some limit"; "There you broke some safety rule"; and "Here I was shot down because of you". Sometimes nothing goes your way, just as on other occasions everything does go your way. That is why post-flight reviews often require you to be strong.'

Emotional control: Remaining focused on the issues requires, according to some interviewees, ignoring personal considerations and control of emotions:

'Yesterday I flew as number one with a close friend who is two years my elder. In the post-flight review he expressed his anger at some things that I did [during the sortie] in no uncertain terms and I responded in kind. To an outsider it must have seemed that there was really bad blood between us. In fact we agreed to disagree — and that was that. Having unloaded whatever bothered us, we went on to other issues without holding any grudge whatsoever.'

Other interviewees prefer not to see any expression of emotions in the post-flight review:

'In cases where there are expressions of emotions I'll have to say that the process was not well managed. The Air Force is too mature for that.' (squadron commander)

Following Argyris and Schön (1996), our position is that ignoring emotional issues may be dysfunctional to the productiveness of the post-flight reviews if they will block the discussion of errors and policy issues out of desire to avoid unpleasantness or 'irrational' behavior. The transcripts do not have evidence of such dysfunctional effects — which does not mean that they do not exist.

Member Validation

The results from the questionnaire administered to an independent sample of combat pilots showed generally strong agreement with our findings (except for items suggesting that post-flight reviews meet some basic psychological needs). Thus, we conclude that the findings and interpretations are valid for the fighter squadrons of the IDFAF in general.

Discussion

This study investigated the dynamics of learning in a central OLM, after-action/ post-project reviews. The results can be summarized as follows: Learning in the post-flight reviews is a multi-layered process of retrospective

sense-making, the detection and correction of error, social comparison, social control, socialization, and bonding. Learning proceeds by observing one's own and others' performance and receiving feedback on the former. Lessons-learned pertain to different domains and different levels — individual and formation performance, training methods, and the squadron's and Force-wide standard operating procedures and doctrine. The process is facilitated by five values specified by the multi-facet model (Lipshitz et al. 2002), and the assumption that learning through critical examination of one's own experience is the key to improvement.

The post-flight reviews we observed were consistent with Carroll et al.'s (2003) characterization of effective problem investigations in nuclear power plants: frank and intense and totally focused on the VCR displays, the errors which they revealed, and ways of correcting them. Their atmosphere was purely rational, with occasional bursts of humor, hinting at the emotional strain imposed by confronting one's errors as they are mercilessly displayed in front of one's colleagues. Significant learning is emotionally taxing because of concerns about being perceived as incompetent (Edmondson 1996, 1999, 2003; Pfeffer and Sutton 1999; Schein 1993; von Krogh 1998). This concern is countered in the post-flight reviews by (1) the shared beliefs that 'everybody makes errors', and detection and correction of error are the key for learning, and (2) the value of issue orientation (which is basically an expression of acceptance and respect). Additional factors that help pilots to learn productively in an environment that requires them to expose their errors are unique to the IDFAF: the Force's privilege to hand-pick a small group of candidates from the entire population of recruits to the Israel Defense Force. These individuals, who are competitive, high achievers, and eager to serve as navigators and pilots, undergo a long period of socialization into the post-flight review culture. Those who end up serving in the fighter squadrons survive a severe process of attrition. These findings complement Edmondson's (1999: 355) observation that 'interpersonally threatening behavior can occur if the team has a sufficiently safe environment'.

The first purpose of the study was to clarify the questions regarding an organization's ability to learn and the relationship between individual and organizational learning by examining an example where this process ostensibly occurs. The conceptualization of organizational learning that emerges from the study is that organizations learn non-metaphorically when individuals, collaborating in team settings (i.e. organizational learning mechanisms), process information relevant to the organization's performance in a way that leads to systemic changes (e.g. in the squadron or the IDFAF routines). Although the discussion in post-flight reviews focuses on the *individual* performance of each participant, learning is organizational for several reasons. First, air crews perform the core task of the Air Force. Second, lessons-learned pertain to the individual, formation, squadron, and, occasionally organization-wide levels. Third, the post-flight reviews and their culture are institutionalized in the IDFAF. This conceptualization is subsumed by Barnett's (2004: 9) inclusive definition of organizational learning as 'an experience-based process through which knowledge about action–outcome relationships develops, is

encoded in routines, is embedded in organizational memory, and changes collective behavior'. Note that we do not claim that the Israel defense Force is a 'learning organization'. While the latter concept implies that the total organization somehow learns, the basic proposition of the multi-facet model is that learning is located in specific organizational systems, organizational learning mechanisms, and may occur unevenly in different organizational units (Edmondson 2002). The concept of a learning organization serves well as a rhetorical device but is too imprecise for the purposes of research and intervention. The findings are consistent with the cultural facet of Lipshitz et al.'s (2002) model, which they elaborate by the important addition of the basic assumption regarding the values of learning for improved performance. In addition they support and elaborate its psychological facet, and show that the model can be used as a general framework for building organizational- or domain-specific local models.

It is interesting to compare the above conceptualization of organizational learning to the conceptualization offered by Hutchins (1995). He observed how a plotter and a recorder — the navigation team — changed their work routine in order to bring their ship safely into port following the failure of the ship's propulsion and electrical power. These changes were implemented:

> '[b]efore its discovery by the system as a whole ... the final configuration appears not to have been represented or understood by any of the participants. To the extent that the acquisition of a useful adaptation to a changing environment counts as learning, we must say that this is a case of organizational learning.' (Hutchins 1995: 349)

Hutchins bases his conceptualization of organizational learning on the process of learning: the episode that he reports constitutes organizational learning because the agent of learning is a collective, not an individual. We base our conceptualization of organizational learning on the output of learning: although the agents of learning are individuals, their output includes changes at the organizational level. The difference is highlighted by the episode's conclusion. The new routine was not recorded and thus was lost to the navy when both members of the navigation team left the service. In contrast, had an analogous episode of spontaneous invention occurred in the IDFAF, it would have been debriefed, first at the squadron level, and then by a special unit at headquarters, under a procedure called 'near accident'. The unit would have distributed a video recording of the episode and the lessons-learned to all relevant squadrons to be reviewed by pilots and navigators, and appropriate changes, if necessary, introduced in doctrine and standard operating procedures. Thus, we conclude that the output-based conceptualization coupled with the concept of organizational learning mechanisms is more appropriate for describing organizational learning conceptualization which pertains to team rather than organizational learning (e.g. Hutchins 1995).

Case studies do not lend themselves to generalizations (though case-to-case transfer is possible given sufficiently similar contexts). The present study is particularly constrained owing to the uniqueness of the population, the rehearsal-like task structure, and the narrow technical focus of learning. Case studies can, however, be evocative, and some of our findings can be formulated as general propositions worthy of study in organizations in different industries and contexts:

1 Learning in organizations takes place via dedicated organizational learning mechanisms (e.g. after-action reviews) supported by mechanisms that disseminate their lessons-learned throughout the organization (e.g. the unit that disseminates lessons-learned of near accidents).
2 Frank and critical information exchange is facilitated by the five values specified by the cultural facet of the multi-facet model (Lipshitz et al. 2002).
3 Organizational learning is a multi-layered process that combines cognitive, social, and emotional processes, and that fulfills various functions in addition to the improvement of individual, unit, and organizational performance. For learning to be effective, these functions should be consistent with (i.e. support) one another.

Post-flight reviews are a single instance of organizational learning. Additional in-depth studies of other organizational learning mechanisms in different contexts will test the generalizability of our findings and advance our understanding of how organizations learn non-metaphorically and of the contextual factors, culture policies and leadership styles that promote or impede its productiveness.

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