When shared cognition leads to closed minds: Temporal mental models, team learning, adaptation and performance

When shared cognition leads to closed minds: Temporal mental models, team learning, adaptation and performance

Catarina Marques Santos[1]

Instituto Universitário de Lisboa (ISCTE-IUL), BRU-IUL

Lisboa, Portugal

Ana Margarida Passos[2]

Instituto Universitário de Lisboa (ISCTE-IUL), BRU-IUL

Lisboa, Portugal

Sjir Uitdewilligen[3]

Maastricht University, Department of Work and Social Psychology

Maastricht, Netherlands

[1] Instituto Universitário de Lisboa (ISCTE-IUL), Avenida das Forças Armadas, Edifício ISCTE, BRU-IUL, 1649-026 Lisbon, Portugal. Telephone: +351 21 0464 019. Fax: +351 21 0464 175. Electronic mail: catarina_marques_santos@iscte.pt. Correspondence concerning this article at all stages of refereeing, publication, and post-publication should be addressed to Catarina Marques Santos.

[2] Instituto Universitário de Lisboa (ISCTE-IUL), Avenida das Forças Armadas, Edifício ISCTE, BRU-IUL, 1649-026 Lisbon, Portugal. Telephone: +351217903000. Fax: +351 21 0464 175. Electronic mail: ana.passos@iscte.pt

[3] Maastricht University, Universiteitssingel 5, Maastricht, 6229 ES, Netherlands, Telephone: +31 43 3884324. Fax: +31 43 3884211. Electronic mail: sjir.uitdewilligen@maastrichtuniversity.nl

When shared cognition leads to closed minds: Temporal mental models, team learning, adaptation and performance

Abstract

In this study we examined the moderating effect of temporal mental model accuracy on the relationship between temporal mental model similarity and team learning. Further, we investigated the mediating mechanism of team adaptation in the relationship between team learning and performance. The study was conducted in a management simulation involving 68 teams (319 individuals). We collected data at three time points. The results showed that when accuracy is high, temporal mental model similarity is not significantly related to team learning; whereas, when accuracy is low, the more similar the team members' mental models are, the less they engage in learning behaviors. This suggests that sharing an inaccurate mental model leads to closed minds. In addition, we found team adaptation to mediate the relationship between team learning and performance. These findings emphasize the importance of temporal mental models in predicting team learning, and the importance of team learning for team adaptation and performance.

Key-words: shared mental models; closed-minded; team learning; team adaptation; team performance.

1 Introduction

Increasingly scholars emphasize that in complex and demanding contexts teams need to be able to adapt quickly and appropriately to recurrent changes (Baard, Rench, & Kozlowski, 2014; Burke, Stagl, Salas, Pierce, & Kendal, 2006; Rosen et al., 2011). Teams need to adjust their cognitive and behavioral processes to allow them to evaluate and analyze situations in order to adjust to them in the best way possible (Burke et al., 2006; Randall, Resick, & DeChurch, 2011; Uitdewilligen, Waller, & Pitariu, 2013). Team learning plays a crucial role as an essential, though not sufficient, condition for team adaptation (Burke et al., 2006; Rosen et al., 2011). Team adaptation, as a process, occurs when a team recognizes that a change happens in the team environment, and is able to effectively address the unexpected situation (Baard et al., 2014; Maynard, Kennedy, & Sommer, 2015). When team members engage in team learning processes, they evaluate and reflect on past performance episodes and interpret the consequences of team actions. Therefore, they are likely to improve their task and team processes, which enables the team to adapt to novel situations, which in turn facilitates performance – the objective criterion that indicates team level task accomplishment (Hackman, 1987; Rosen et al., 2011).

Team learning refers to a team process in which team members ask questions, seek feedback, reflect and discuss results, errors, and (un)expected outcomes (Edmondson, 1999). A shared understanding about the temporal aspects of work is crucial to promote the team learning process. As teams operate in organizational contexts that are systematically pressured by time, they are better able to engage in learning behaviors when team members share a temporal mental model – common knowledge about deadlines for task accomplishment, the pacing or speed at which activities occur, the time available for each activity, and the sequencing of tasks (Mohammed, Hamilton, Tesler, Mancuso & McNeese, 2015; Santos, Uitdewilligen, & Passos, 2015; Standifer & Bluedorn, 2006). A temporal mental model helps teams to coordinate their activities according to the time schedule and to anticipate and understand the actions of each other based on a commonly shared blueprint of plans and schedules (Mohammed et al., 2015; Santos et al., 2015).

In this study we focus on the relevance of temporal mental models for team learning. We postulate that when team members share a temporal mental model they make an efficient use of the team's time, thereby creating more time for the team to engage in learning behaviors (Santos et al., 2015). The common temporal understanding ensures that team members are aligned regarding the temporal demands of the team's work, such as when deadlines have to be met and how much time is available for each activity (Cannon-Bowers, Salas, & Converse, 1993). Teams may have a *similar* temporal mental model – a mental model that is similar among team members – and an *accurate* temporal mental model – a mental model that is appropriate for the task according to experts in the respective area (Edwards, Day, Arthur, & Bell, 2006). Thus far, researchers have investigated how task and team mental model similarity and accuracy interact to predict team adaptation and performance (e.g., Burtscher, Kolbe, Wacker, & Manser, 2011; Marks, Zaccaro, & Mathieu, 2000); however, research on the interactive effects of *temporal* mental model similarity and accuracy is missing. Moreover, a relevant discussion that needs clarification is whether teams with a similar but inaccurate temporal mental model are able to learn from each other as much as teams in which team members share a similar and accurate temporal mental model. We posit that when team members have a similar but inaccurate understanding of the temporal aspects of their work, this will keep them from discussing their tasks, reflecting on the results and learning from each other.

To summarize, with this study we contribute to shared mental model literature by analyzing the temporal dimension of mental models, and analyzing the interactive effect of temporal mental model similarity and accuracy on team learning. Further, we contribute to the team learning literature by analyzing the effect of team learning on team adaptation, and on performance, as recent theoretical models have suggested (Burke et al., 2006; Rosen et al., 2011).

2 Theoretical Background

2.1 Team Learning and Temporal Mental Models

In 2005, the United States faced Hurricane Katrina – one of the most deadly hurricanes in the United States' history (Moynihan, 2007). While Katrina raged through the United States, the different teams that worked to save people and to minimize the damages failed to coordinate themselves, to learn from each other, and to adapt their responses to the unexpected situation and under a lot of time pressure. Additionally, there were a number of delays in making the correct decisions, which led to dramatic consequences: aid was not delivered in time, people were not evacuated in time because of the delays in providing buses to do it, and people were left with no basic supplies (Moynihan, 2007). This example demonstrates the negative consequences that may occur when teams fail mostly because team members do not establish and maintain congruence in their temporal perceptions (Mohammed, Tesler, & Hamilton, 2012). As Moynihan (2007) mentioned, "time is an essential ingredient in learning", and, although learning has occurred during the Hurricane, "learning did not occur rapidly enough to dramatically impact the Katrina response" (p. 18).

The example of how teams dealt with Hurricane Katrina shows the importance of congruence in team members' temporal perceptions in extreme conditions, as well as the importance of engaging in team learning behaviors. These two aspects are not only important in extreme situations like the Hurricane Katrina. Most of the team work environments are increasingly complex, dynamic, and adaptive, and teams are constantly pressured by time. Nowadays, people often are member of more than one team, and team members may be geographically dispersed and often need to manage multiple projects simultaneously (Ancona

& Chong, 1999; Waller, Conte, Gibson, & Carpenter, 2001). Therefore, teams often need to discuss, make decisions, and achieve their goals in a short-period of time and under high time pressure (Waller et al., 2001). Team members planning and setting deadlines is crucial to ensure that teams are able to perform their tasks under time pressure and stress, particularly when something unexpected happens. In sum, because managing time well is so crucial for team functioning, it is important that team members develop a shared and accurate cognitive structure about the temporal aspects of their work.

We analyze the effect of temporal mental model on team learning, arguing that a mental model works as a common basis that provides a fertile breeding ground for teams to engage in team learning behaviors (Santos et al., 2015; Tindale, Stawiski, & Jacobs, 2008), which is related to the resource allocation perspective on team functioning (Barnes et al., 2008; Kanfer & Ackerman, 1989). Team learning "is a resource-intensive process that detracts from core task performance and that consumes time and cognitive resources" (Santos et al., 2015, p. 719). Therefore, teams in which members have a similar and accurate temporal mental model are more likely to naturally engage in team learning behaviors without requiring any substantial extra effort in the process. When team members have a common understanding about the temporal aspects of the work, they are able to communicate ideas and coordinate themselves. Thus, team members are able to engage in team learning behaviors using few temporal and cognitive resources (Bunderson & Sutcliffe, 2003).

A temporal mental model helps teams to coordinate their actions and perform the tasks on time, and is particularly important when team members are highly interdependent, and need to collaborate and share information continuously (Mohammed et al., 2015). Further, a temporal mental model allows team members to anticipate and understand how the actions of the other team members fit within the plans and schedules, and to know in advance what other team members need to finish a task on time (Gevers, Rutte, & van Eerde, 2006;

Standifer & Bluedorn, 2006). A similar temporal mental model helps team members to synchronize their actions with the actions of other members; while an accurate temporal mental model helps to fit the team' actions with the external temporal demands (Gevers et al., 2006; Mohammed et al., 2012, 2015).

A number of studies have integrated the notion of time in team cognition and team processes research (e.g., Gevers et al., 2006; Standifer et al., 2015). Moreover, several authors argued that shared mental models should cover not only task and team contents but also the temporal aspects of work (Guiette & Vandenbempt, 2013; Mohammed et al., 2012; Standifer & Bluedorn, 2006). However, to date there are only two studies (Mohammed et al., 2015; Santos et al., 2015) measuring temporal mental models. Mohammed and colleagues' study (2015) operationalized the notion of temporal mental model assessing its discriminant validity relative to team and task mental model constructs in predicting team performance. The results showed that temporal mental model positively predicted team performance beyond task and team mental models. The results also showed that temporal mental model positively influenced team performance early on and later on in the teams' lifecycle. Santos and colleagues' study (2015) investigated whether team learning processes lead to performance improvement, and whether this relationship is moderated by the similarity of shared mental models. The authors looked at the effects of task, team, and temporal mental models. Their results showed that when task and temporal mental model similarity were high, team learning processes were positively related to team performance improvement. Thus, temporal and task mental models function as a boundary condition for the translation of team learning processes into team performance improvement (Santos et al., 2015).

2.1.1 The Effect of Temporal Mental Model Similarity and Accuracy on Team Learning

Team members that have a similar temporal mental model have a common vision regarding important temporal aspects of work (Mohammed et al., 2015; Santos et al., 2015).

When team members have a similar understanding of the timing of their processes, they use the team's time in an effective way, which creates more time for the team to engage in learning behaviors. With a temporal mental model, team members are able to time and synchronize their actions and activities, and to be aware about the time they have for learning behaviors in order to not interfere with other aspects of task execution (Bunderson & Sutcliffe, 2003; March, 1991). Further, teams that have a similar temporal mental model are likely to coordinate their activities, increase the efficiency of their communication, and decrease communication and coordination breakdowns, during the team learning process, leading them to engage in team learning behaviors (Cataldo & Herbsleb, 2013). The reduction in communication and coordination breakdowns lead to the team to engage in team learning behaviors because team members are able to efficiently communicate errors, discuss them, analyze the information and find solutions for the problems. Further, as team members are coordinated, the suggestions, feedback and ideas are voiced at appropriate times being more likely to be acquired and accepted by other team members (Kulik & Kulik, 1988).

Team members need to have similar knowledge about the deadlines, the pacing at which activities occur, and the time available for each activity in order to engage in team learning behaviors (Gevers et al., 2006; Standifer & Bluedorn, 2006). By sharing this temporal understanding, team members are able to more efficiently learn from each other, seek feedback, and reflect on results. Furthermore, when they have similar mental models, the ideas team members discuss, the feedback they receive and provide, and the changes they plan will be aligned with the team plans and deadlines (Gevers et al., 2006). Without a similar temporal mental model, team members may answer questions in a way that is not related to the tasks they need to accomplish, may seek or give inappropriate feedback, or even work and discuss ideas and plans that take into account different deadlines and schedules (Tindale et al., 2008).

Hypothesis 1 – Temporal mental model similarity is positively related to team learning.

When team members have an accurate temporal mental model, the mental model is an appropriate representation of the temporal aspects of the teams' work (Marks et al., 2000). This means that they have a correct understanding about the right priorities, the appropriate strategies to accomplish the tasks on time, and the correct amount of time they have for each activity. Teams that have an accurate temporal mental model are likely to effectively discuss the tasks, provide feedback, and exchange ideas. They are able to optimize the timing and synchronization of team learning. Those teams are likely to engage in team learning behaviors without interfering with task accomplishment because they are correct about the most appropriate time to work on the tasks, when the deadlines need to be met, the exact time they have to discuss, and when they need to stop learn from each other and return to their tasks in order to accomplish the team goals on time (Edmondson, 1999; Santos et al., 2015). If team members have an inaccurate temporal mental model, team members may focus on the wrong priorities and underestimate (or overestimate) the time they have to accomplish the tasks and meet deadlines. Therefore, team members may not engage in team learning behaviors when, in fact, they had time to do it, or may engage in team learning behaviors but discuss issues very quickly, or may engage in inappropriate learning behaviors to the team's task and goal.

Hypothesis 2 – Temporal mental model accuracy is positively related to team learning.

Temporal mental model similarity and accuracy also have an interaction effect on team learning. Although we expect that overall temporal mental model similarity is positively related to team learning behaviors, if the team members have an inaccurate temporal mental model, team members will engage less in team learning behaviors. It is not necessarily detrimental for team learning if members initially have dissimilar inaccurate temporal mental models. If members disagree on temporal aspects of their task, this can serve as an impetus for discussions and clarifications, resulting in reflection and team learning behaviors (Van den Boosche, Gijselaers, Segers, Woltjer, & Kirschner, 2011). However, if team members agree on an inaccurate mental model this may lead to closed-mindedness where team members refrain from engaging in learning behaviors because they incorrectly perceive that they already have an accurate mental model. Similarity of mental models may foster rigidity as team members may resist letting go of previously established beliefs when these are reinforced by others (Gersick & Hackman, 1990).

Closed-mindedness occurs when team members engage in collective rationalization ignoring or resisting to new information and ideas in particular when those ideas are inconsistent with the team's beliefs or challenge the existing ideas (Dijksterhuis, van Knippenberg, Kruglanski, & Schape, 1996; Thompson, 2004). Closed-mindedness is a symptom of groupthink (Janis, 1972) – a phenomenon that "involves a deterioration of mental efficiency, reality testing, and moral judgements as a result of group pressures toward conformity of opinion" (Thompson, 2004, p. 130). Teams that have a similar and inaccurate temporal mental model may fail to retest, question, or discuss the ideas and assumptions they have about the way they work. Team members' mental models may reach a level of overlap that hinders the team to engage in team learning behaviors because "an exact replication [of mental models] would reduce the availability of alternative solutions or strategies because of team members' varying perspectives and understandings" (Salas, Sims, & Burke, 2005, p. 566). In sum, when teams have inaccurate temporal mental models, they will engage in less learning behaviors when mental models are similar than when they are dissimilar.

Hypothesis 3 – The influence of temporal mental model similarity on team learning depends on temporal mental model accuracy; the less accurate the mental model is, the *weaker the relationship between mental model similarity and team learning will be.*

2.3 Team Learning, Adaptation, and Performance

A number of studies have demonstrated that team learning has a positive effect on team performance because by asking questions, discussing errors, and seeking feedback, team members can test their assumptions about the way they work, discuss divergent opinions, and thereby achieve high levels of performance (Edmondson, 1999; Savelsbergh, van der Heijden, & Poel, 2009; van Woerkom & Croon, 2009). Teams also need to be able to adapt quickly to recurrent changes in order to perform well (Burke et al., 2006; Uitdewilligen et al., 2013). Often changes occurring in team contexts are unexpected. Team learning behaviors help teams to adjust their interaction processes, and to evaluate and analyze the changing situations (Rosen et al., 2011; Uitdewilligen et al., 2013). Through the team learning process, team members evaluate past performance episodes, interpret the consequences of team actions, explore different perspectives, and proactively develop new strategies (Burke et al., 2006; Kozlowski & Bell, 2008). Those learning behaviors facilitate teams in changing and improving their working methods, which is an important requirement for team adaptation (Kozlowski & Bell, 2008; Rosen et al., 2011). Thus, when teams engage in team learning behaviors they acquire, combine, and share knowledge that allows them to work in a coordinated way, and to behave adaptively (Rosen et al., 2001). As adaptation is crucial for performance, especially in dynamic contexts, teams that behave adaptively achieve high levels of performance because they adapt the way they work, use new ideas to deal with problems, and think about alternative solutions in short periods of time (Marques-Quinteiro, Curral, Passos, & Lewis, 2013; Maynard et al., 2015). So, teams that effectively engage in team learning behaviors are able to exchange information and ideas about the way they perform in previous task episodes, and integrate new with previous information to overcome the obstacles. They are able to adapt the methods they use according to the unexpected situations they face. Then, they achieve high levels of performance.

Hypothesis 4 – Team adaptation mediates the relationship between team learning and team performance.

The research model is represented in Figure 1.

- INSERT FIGURE 1 HERE -

3 Method

3.1 Participants

A total of 68 teams (319 individuals) participated in this study. All teams were enrolled in a national management and strategy simulation for a 5-week period. The teams were composed of workers (45.1%), or university students (36.4%), or a mix of workers and students (18.5%). The teams consisted of three to five persons with an average team size of 4.76 persons (S.D. = 0.51). The average age of the members was 31 years (S.D. = 8.88) and 66.5 percent of the members were male.

Worker teams' participants had a degree in engineering (38.2%), finance, economics or accounting (26.4%), management (20.1%), or other (15.3%). Participants from mixed teams had a degree in management (27.5%), finance, economics, and accounting (26.1%), engineering (26.1%), or other (14.3%); 5.8% of participants did not provide information about their degree. University students were completing their bachelor or master degree in management (57.0%), engineering (20.7%), finance, economics or accounting (12.4%), or other (9.9%).

3.2 Simulation

Data were collected from the participants of the Global Management Challenge® (GMC®) developed by a company specialized in developing business simulations (http://www.worldgmc.com). The GMC® consists of a management and strategy simulation in which each team runs a company, with the objective of getting the highest company share price on the simulated stock exchange. Most of the teams are sponsored by their employer organization or by large organizations that sponsor GMC® within their scientific and cultural patronage policy. In fact, many top companies encourage their employees to take part in it. Companies that sponsor teams formed by their own employees use the simulation as a training experience to promote the development of employees' skills about management, decision making in changing and complex environments, and teamwork. Students use the simulation as a way to acquire skills and competencies of business operations related to running a company (e.g., marketing, human resources, and production). As GMC® participants needed to apply for take part of the simulation, and they were free to assemble their own team, some team members may know each other beforehand from their university (for student teams), or from their jobs (worker teams).

An incentive is offered in the simulation. The winning team of the national final of the GMC® wins an Intercontinental trip for each team member and represents the country in the international final of the simulation against the winning teams of the other countries. Similar simulations have been used by others researchers (e.g., Costa, Passos, & Bakker, 2014; Marques-Quinteiro, Passos, & Curral, 2014; Mathieu & Rapp, 2009; Santos & Passos, 2013).

Teams were organized into groups (each group with a maximum of 8 teams). Each group comprised a competitive market, in which the teams had to compete with one another in a common business environment (the "group") to achieve the highest share price. Teams managed the company by making decisions, once a week over five weeks, about marketing, production, human resources, purchasing, and finances. A simulator analyzed and compared the decisions made by the various competing teams, and calculated the share price of each enterprise and the ranking of all teams after each team made their decision. Then each team received feedback about their decisions through a management report the simulator produced showing the detailed results in financial and operational terms. The competition simulates a year and a quarter of each company's activity, and each week corresponds to one quarter of year.

Team adaptation is important in this context because teams need to adapt their strategy in accordance with their performance and other teams' performance because they compete with one another to achieve the highest share price. Further, over the simulation unexpected events can occur in companies that teams manage, such as, strikes and absenteeism, or even world events, such as, wars and physical disasters. Thus, teams need to develop the ability to adapt after these unexpected events occur.

3.3 Procedure

Team members answered three different on-line questionnaires during the simulation. The link to the questionnaires was sent to the team members by e-mail at different weeks of the simulation, two days after the beginning of each weekly task. A reminder was sent to the participants one day before the deadline to submit the weekly decision. The questionnaires were available until the moment in which teams had to submit their weekly decision. Participants answered to the questionnaires in week 3, week 4 and week 5 before receiving the management report. Temporal mental model was measured in the third week of the simulation. Team learning was measured in the fourth week of the simulation. Team adaptation and performance were measured at the end of the simulation after the fifth week. Performance and composition variables were provided by the company responsible for the simulation. This longitudinal procedure reinforces causality inferences (Mathieu & Taylor, 2006) and reduces the common-method variance (Brannick, Chan, Conway, Lance, & Spector, 2010; Spector, 2006).

2.4 Measures

2.4.1 Temporal Mental Model

To operationalize the temporal mental model, we created four items for the specific context. By means of a detailed task analysis of the simulation and with the help of a group of company managers who develop the simulation, we derived four sentences for understanding the temporal aspects of the simulation (Mathieu & Rapp, 2009; Uitdewilligen et al., 2013). Then those four sentences were paired among each other resulting in six pairs of sentences. A list of pairs of sentences is provided in the Appendix. We asked each team member to rate the relatedness of the pairs of statements on a 7-point scale (1 = *the sentences are not related* to 7 = *the sentences are extremely related*).

Shared mental models may be measured through different techniques: content (i.e., the focus of mental models), elicitation of content (i.e., the content or components of the mental model), structure representation or structural networks (i.e., the way as the content of mental models is cognitively organized), and representation of emergence (i.e., the representation of the team-mental model as a collection of individuals' mental models) (Mohammed, Klimoski, & Rentsch, 2000). The procedure we used to operationalize the temporal mental model – structural representation using pairwise ratings – is used most generally and considered most valid in mental models research (Resick et al., 2010). Consistent with Lim and Klein (2006), we asked participants to evaluate the relatedness between pairs of brief sentences. This pairwise rating procedure is a way to analyze the network of relationships among key temporal aspects of the simulation associated with the achievement of the team goal (Resick et al., 2010).

2.4.1.1Temporal Mental Model Similarity

To calculate temporal mental model similarity, we used UCINET (Borgatti, Everett, & Freeman, 2002), following the procedure developed by Mathieu, Heffner, Goodwin, Salas, and Cannon-Bowers (2000). This network-analysis program provides a similarity measure based on Pearson's correlations. As each team member evaluated six pairs of sentences, the first step was to make a matrix for each team containing the individuals' matrices (i.e., the individuals' evaluation of the pairs of sentences). Next, we used UCINET to calculate the similarity among the six pairs of sentences of all team members, for each team-level matrix. This similarity index ranged from −1 (complete disagreement) to 1 (complete agreement/sharedness). The six similarity values were also displayed in a matrix. The mental model similarity index of each team was then calculated based on the average of the six similarity values.

2.4.1.2 Temporal Mental Model Accuracy

To obtain an assessment of mental model accuracy, we asked 12 expert-members (members who had won previous editions of the simulation) to answer to the same mental models items. To analyze the reliability of our mental model accuracy measure we computed the intraclass correlation coefficient (ICC) (Rankin & Stokes, 1998). The estimated reliability score across raters is 0.85 with a 95% confidence interval of $CI_{\text{lower bound}}$: 0.70, $CI_{\text{upper bound}}$: 0.94 (Rankin & Stokes, 1998), supporting the reliability of the measure. We calculated individual mental model accuracy for each item by calculating the absolute difference between each team member's response and the average response value obtained by the experts (Webber, Chen, Payne, Marsch, & Zaccaro, 2000). To calculate the levels of mental model accuracy for each team, we averaged the individual team member mental model accuracy scores. The mental model accuracy index ranges from 0 (completely accurate mental models) to 6 (completely inaccurate mental models). Values were recoded in a way that the lowest values corresponded to more inaccurate mental models and the highest values corresponded to more accurate mental models.

2.4.2 Team Learning

Team learning was measured using the 15 items of Savelsbergh and colleagues (2009) that cover the following dimensions: co-construction of meaning, exploring different perspectives, error analysis, and error communication. On a 7-point scale (1 = *totally disagree*; 7 *totally agree*), the participants rated the extent to which they agree with each sentence (e.g., “Team members collectively draw conclusions from the ideas that are discussed in the team”). A confirmatory factor analysis (CFA) was implemented by Mplus (Muthén & Muthén, 2012) which presented a goodness-of-fit index as all indices fell within acceptable ranges (Hu & Bentler, 1999; Schreiber, Stage, King, Nora, & Barlow, 2006): $\chi^2_{(91)} = 1574.34$, $p = .00$; RMSEA = .00; CFI = .94; TLI = .93; SRMR = .03. The internal consistency of the scale was very good ($\alpha = .98$).

2.4.3 Team Adaptation

Ten items adapted from the study by Pulakos and colleagues (2002) were used to measure team adaptation (Marques-Quinteiro et al., 2013). On a 7-point scale (1 = *totally disagree* to 7 = *totally agree*), the participants rated the extent to which they agreed with each sentence (e.g., “My team was effective in quickly developing plans of action for dealing with unpredictable situations”). The internal consistency of the scale was very good (α=.98).

As team learning and team adaptation were highly correlated, we conducted a CFA in Mplus to distinguish the two constructs (Muthén & Muthén, 2012). In the first model all variables were modeled as indicators of a single factor: $\chi^2_{(252)} = 1249.55$, $p = .00$; AIC = 1727.19; BIC = 1890.10; RMSEA = .00; CFI = .66; TLI = .63; SRMR = .11. In the second model team learning was modeled as a single factor, and team adaptation was modeled as other single factor: $\chi^2_{(251)} = 539.80$, $p = .00$; AIC = 1019.44; BIC = 1184.62; RMSEA = .00; CFI = .90; TLI = .89; SRMR = .04. Although the fit of the second model was not perfect, because of the CFI and TLI values that were not above .95 (Schreiber et al., 2006), it presented a better goodness of fit than the first model suggesting that team learning and team adaptation are distinct constructs (Hu & Bentler, 1999).

2.4.4 Team Performance

Team performance was operationalized as the share price at the end of the simulation. The share price comprehensively captured the quality of the team decisions, as it was a function of the appropriateness of the teams' decisions given the specific context in which these decisions were made. Share price was given in Euros, was automatically calculated by the simulation, and was the measure on which teams were evaluated. Share price was a complex outcome measure that combines the decisions on the distinct topics on which team members need to make decisions (e.g., production, finance, and marketing), and thereby captured the combined effort of the team as a whole.

2.4.5 Control Variables

We included team size, task experience, team familiarity, team composition (workers, university students, and both), and the group in which teams compete as control variables in our analyses (Humphrey, Morgeson, & Mannor, 2009; van Knippenberg & Schippers, 2007). We controlled for team size because this can impact the teams' learning processes, and the ability to construct accurate and similar mental models. Team size was measured as the number of team members. We controlled for task experience because it may impact on team learning and team performance. Task experience was measured as the number of participations in previous editions of the competition. We controlled for team familiarity because this can impact the ability to construct similar and accurate mental models. Team familiarity was measured as the percentage of team members that already knew each other before the start of the simulation. We operationalized team composition by transforming the categorical variable into two dummy variables, using the workers as a baseline, since they represented more teams in the competition. We controlled for the group because in this simulation the teams were nested within groups. The different characteristics of each group (the common business environment) may have an impact on performance.

3 Results

3.1 Aggregation

As the level of analysis in this study was the team, all individual survey responses were aggregated to the team level for further analysis (Costa et al., 2013). To justify aggregation, we computed $r_{wg(j)}$ (James, Demaree, & Wolf, 1993), designed for multiple-item scales, and intraclass correlation coefficients (ICCs) (Bliese, 2000). All the mean values of $r_{wg(j)}$ were in accordance with the required criteria ($r_{wg(j)}$ >.70), as well as the values of ICCs: Team learning ($r_{wg(j)}$ = 0.83; ICC(1) = 0.19; ICC(2) = 0.52; $F_{(66,246)}$ = 2.09, p = .00); team adaptation ($r_{wg(j)}$ = 0.83; ICC(1) = 0.15; ICC(2) = 0.46; $F_{(67,241)}$ = 1.85, p = .00).

3.2 Hypotheses Testing

Table 1 provides the means, standard deviations, and the correlations for all study variables at the team level. A significant positive correlation was found between team learning and adaptation (r =.67, p < .01), as well as between team adaptation and performance (r = .31, p < .05) A non-significant correlation was found between team learning and team performance (r = -.14, p = .27). We continued with the analysis because an input variable (team learning) could indirectly affect an outcome (team performance), even when there is no association between input and outcome variables, through an intervening variable (team adaptation) (Hayes, Preacher, & Myers, 2011).

- INSERT TABLE 1 HERE -

To analyze the direct effect of mental model similarity (hypothesis 1) and accuracy (hypothesis 2) on team learning, as well as, the moderating effect of mental model accuracy on the relationship between mental model similarity and team learning (hypothesis 3) we performed a step-wise hierarchical multiple regression. Mental model similarity and accuracy were centered, following the procedures suggested by Aiken and West (1991). The block of control variables was entered in the first step and it was not significantly related to team learning (R^2 = -.05, $F_{(6,66)}$ = 0.53, p = .78). The addition of the main effects for mental model similarity and accuracy at step two did not explain incremental variance in team learning (ΔR^2 = .05, $F_{(8,66)}$ = 0.79, *p* = .62). There was no main effect of mental model similarity (*B* = -0.24, *t* = -1.13, *p* = .27) nor of accuracy (*B* = -0.33, *t* = -1.43, *p* = .16) on team learning. Thus, hypotheses 1 and 2 were not supported. The addition of the interaction between mental model similarity and accuracy at step three explained a significant amount of incremental variance in team learning (ΔR^2 = .14, $F_{(9,66)}$ = 2.00, *p* = .05). The interaction effect of mental model similarity and accuracy on team learning was negative and significant (*B* = 2.15, *t* = 3.27, *p* = .00).

- INSERT TABLE 2 HERE -

As the interaction effect was significant, we estimated and graphed the conditional indirect effects to represent high and low levels of mental model accuracy (one standard deviation above the mean and one standard deviation below the mean, respectively; Aiken & West, 1991; Dawson, 2013). Figure 2 shows the interaction effect of mental model similarity and accuracy on team learning. The effect of temporal mental model similarity on team learning was positive and non-significant in a high temporal mental model accuracy condition (*B* = 0.45; *t* = 1.55; *p* = .13). By contrast, the effect of temporal mental model similarity on team learning was negative and significant in a low temporal mental model accuracy condition (*B* = -1.15; *t* = -3.37; *p* = .00). These results showed that with low levels of temporal mental model accuracy the influence of temporal mental model similarity on team learning was negative. Hypothesis 3 was supported.

- INSERT FIGURE 2 HERE -

To analyze the mediation effect of team adaptation between team learning and performance we used the statistical software Mplus (Muthén & Muthén, 2012). We conducted a path analysis with 5000 bootstraps and 95% confidence interval (CI) (Preacher & Hayes, 2008). This mediation model was a saturated model, which means that the number of free/estimated parameters equals the number of known values/data points, indicating that the model has zero degrees of freedom (Byrne, 2012). For that reason, the overall model fit information was not available. The unstandardized parameter estimate showed that team adaptation positively mediated the relationship of team learning with performance (.06 [CI $_{\text{lower bound}}$ = .03, CI $_{\text{upper bound}}$ = .12], $p < .05$). Hypothesis 4 was supported. Figure 3 shows the research model with the direct, mediation, and moderation effects.

- INSERT FIGURE 3 HERE -

4. Discussion

Organizational teams are systematically and increasingly pressured by time. Teams need to deal with time pressures and engage in team learning behaviors. We found that when temporal mental model similarity is high and accuracy is low teams engage in less learning behaviors. We also found that team learning is an important booster for team adaptation and performance. Our findings offer important contributions for team research providing insight into how temporal mental models relate to team learning, and into the role team learning plays promoting team adaptation and performance.

Our research advances knowledge about shared mental models and their effects on team learning process. Thus far, researchers have focused on *task* mental models (a shared understanding about work objectives, and task duties) and on *team* mental models (a shared understanding about interpersonal interaction, and team members' skills) (Mathieu et al., 2000), neglecting the shared knowledge about the temporal aspects of work. The absence of the temporal dimension of shared mental models hinders researchers to understand how the knowledge about *when* the tasks should be done may benefit team processes and outcomes (Mohammed et al., 2012). Our research represents a first step on temporal mental models research showing that a similar and inaccurate mental model leads teams to engage less in learning behaviors.

Our findings suggest that there is neither a direct link between temporal mental model similarity and team learning, nor a direct link between temporal mental model accuracy and team learning. Our findings suggest that a similar or an accurate temporal mental model is not enough to promote the engagement of team members in team learning behaviors. Our research may suggest that when team members have a similar or an accurate understanding about the deadlines they need to meet and the time available for each activity, team members trust in the way each other work and accomplish the tasks. Therefore, they do not communicate the things they do, and do not analyze the information together to find solutions for problems or new ways to perform the tasks because they think they are correct. Even when team members make mistakes or have some doubts, team members may not want to share their errors or questions in order to avoid disruptive conflicts (Thompson, 2004).

Nevertheless, our findings suggest that when teams have a high similar and low accurate mental model they are not able to engage in learning behaviors. This means that team members ignore new information or ideas that challenge the ideas they strongly and incorrectly share, and are not willing to discuss the errors they made or the problems that occur over the team lifecycle. Therefore, shared cognition can lead to closed-minds when the knowledge the team members share is incorrect. When team members have a high accurate temporal mental model, they engage in learning behaviors whether they have a low or high similar mental model. As those team members are correct about the most appropriate time to work on the tasks and to discuss the problems, they are able to learn from each other without time pressure and without interfere with the task accomplishment. Therefore, the knowledge about the temporal aspects does not need to be highly shared by all the team members in order to engage in learning behaviors, but the knowledge needs to be correct. Team members do not know whether their mental model is accurate or not. However, when team members have a similar but incorrect temporal mental model they may overestimate the quality of their own cognition. Thus, they ignore ideas and suggestions that challenge the way they think (Thompson, 2004). Team members may think there is no need to learn and improve their strategy because the way they work is correct and sufficient to accomplish the task goals. Team members need to have an accurate temporal mental model in order to engage in team learning behaviors.

Our findings suggest that when the shared knowledge is incorrect, a highly similar mental model may be disruptive for team functioning. One of the main benefits of teamwork is the diversity of points of view, ideas, and skills of the team members (Kozlowski & Ilgen, 2006). With an extremely overlap mental model, the diversity benefits may disappear or not emerge in teams. Although team members share a mental model, they should have different perspectives and perceptions on temporal and/or task issues in order to stimulate the discussion about the relevant aspects of team work. If team members do not discuss about and question important aspects of the work, teams may crystalize and they neither update their working methods, nor adapt to (un)expected changes. The effect of an extreme overlapping of mental models on team processes, and even on performance, is a question that deserves attention in future research.

Finally, our research extends knowledge about the effect of team learning on adaptation and performance. Researchers have argued that by engaging in team learning behaviors, team members evaluate past performance episodes, and develop new strategies to overcome previous errors, promoting the team adaptation process, and in turn performance (Burke et al., 2006; Kozlowski & Bell, 2008; Rosen et al., 2011). However, there is a lack of empirical work that supports the recent models of team adaptation (Burke et al., 2006; Rosen et al., 2011). Our research suggests that, indeed, teams that engage in team learning behaviors are able to adapt to changing situations and achieve high levels of performance because those behaviors in which engage result in knowledge that is embedded inside the team and help them to accomplish the team goals (Burke et al., 2006; Rosen et al., 2011).

4.1 Practical Implications

Our study also offers implications for organizational, business, and managing teams. Our findings show that team members should develop and share correct temporal perspectives about the way they work. In the beginning of the team lifecycle is important that team members discuss and share ideas about the best way to allocate the time available for each team activity, plan the work that each team member needs to perform, establish a plan of week activities and agree about time needed to make the weekly decisions. Importantly, whenever possible team members should discuss and share their ideas with someone expert in the task in order to ensure that the knowledge the team members share is correct. This way teams are likely to share an accurate temporal mental model. Furthermore, team members need to be instructed that over the team lifecycle they should discuss the previous task episodes, to explore different perspectives to accomplish the tasks, and communicate and analyze errors that they made in past episodes. If teams know the importance of engaging in these learning behaviors, they are likely to effectively adapt their strategies and procedures, and in turn achieve high levels of performance.

In addition, to avoid a mental model extremely similar and overlapping teams may institute a team member, or even a person outside the team, that plays the role of “devil’s advocate”. This person would review, retest and question the ideas and assumptions team members have about the way to work, and how and when to work, spotting defects to them. The main goal of the devil’s advocate is to falsify the reality and stimulate the debate among team members in order to promote the discussion of different ways to think about the tasks and perform them (Thompson, 2004). The devil’s advocate may help teams to engage in learning behaviors, and in turn to appropriately adapt the way they work and to accomplish the tasks with success.

4.2 Limitations and Directions for Future Research

This research was conducted with teams enrolled in a management simulation. Although team members worked together for more than five weeks and participated in a dynamic competition, which required them to deal with complex decision-making and to focus on several indicators to reach a specific objective, the teams were artificial. However, other authors have also used artificially created teams in their research (e.g., Edwards et al., 2006; Mathieu et al., 2000). As with real teams in authentic organizations, teams are highly pressured by time to make decisions, which demand high levels of coordination and interaction. In particular, in the management simulation teams need to make decisions every week, analyze a large amount of information related to various areas of expertise, and coordinate their efforts efficiently to make the best decisions and submit them at a pre-scheduled moment. The simulation has very rigid weekly deadlines after which teams are not able anymore to submit their decision.

Since all measures were obtained from team members, we were aware there could be possible problems regarding common-method variance (Siemsen, Roth, & Oliveira, 2010). To deal with this, we collected data in different time moments over the five weeks (Brannick et al., 2010; Spector, 2006). However, some authors argue that method variance is “an urban legend” (Brannick et al., 2010, p. 408), and that the spurious causes of relationships among variables are related to the mixture of methods and constructs and not related to the methods themselves (Brannick et al., 2010; Lance, Dawson, Birkelbach, & Hoffman, 2010). In our study, although team learning is significantly correlated to team adaptation, a CFA showed that these two variables are different constructs. Thus, the common method variance threat is minimized in our study.

Future studies should analyze the three dimensions of shared mental models longitudinally. It is important understand whether teams engage in learning behaviors differently depending on the different dimensions of mental models, and whether the development of one mental model dimension influences the development of other dimension. This question is particularly important because a recent paper suggests that the different dimensions of mental models do not develop at the same time and that the development of one dimension may influence the development of another dimension (Maynard & Gilson, 2014).

A challenge when assessing mental model accuracy is to precisely specify an optimal model to use as referent for assessing the accuracy of participants' mental models. In this study, experts were participants who won previous editions of the simulation. Although we compared the team members' mental model with the experts' mental model, the temporal mental model of the individuals who won a previous edition of the simulation may not be the correct one. They might have won despite having had weak temporal mental models. Future studies may use a wider variety of referent models, including previously successful teams but also subject matter experts, such as the simulation developers or researchers that are familiar with the simulation.

4.3 Conclusion

Although shared mental model research has been prospering over the last decades, researchers have neglected the temporal dimension of mental models. By analyzing the joint effect of temporal mental model similarity and accuracy on team learning, our research suggests that when teams have a similar but inaccurate temporal mental model, they engage less in team learning behaviors. Those teams are likely to be closed-minded, which hinder them to accept new ideas or solutions. Further, our findings suggest that team learning fosters team adaptation, and consequently team performance. Our study provides important insights for researchers and practitioners who aim to provide teams with tools for adapting to unexpected situations, and to achieve high levels of performance.

5 Acknowledgements

This work was supported by the Portuguese Foundation for Science and Technology (FCT) under Grant SFRH/BD/79292/2011.

6 Appendix

Temporal mental model scale

1. Allocate the time available for each activity; Agreement about time needed to make decisions
2. Allocate the time available for each activity; Planning the work that each team member needs to perform
3. Allocate the time available for each activity; Establishment of a plan of week activities
4. Agreement about time needed to make decisions; Planning the work that each team member needs to perform
5. Agreement about time needed to make decisions; Establishment of a plan of week activities
6. Planning the work that each team member needs to perform; Establishment of a plan of week activities

7 References

Aiken, L., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions.* Newbury Park, CA: Sage.

Ancona, D. G., & Chong, C. (1999). Cycles and synchrony: The temporal role of context in team behavior. In E. Mannix, & M. Neale (Eds.), *Research on Managing Groups and Teams, Volume 2: Groups in Context* (pp. 33-48). JAI Press. Greenwich, CT: JAI Press Inc.

Baard, S. K., Rench, T. A., & Kozlowski, S. W. J. (2014). Performance adaptation: A theoretical integration and review. *Journal of Management*, *40*, 48-99.

Barnes, C. M., Hollenbeck, J. R., Wagner, D. T., DeRue, D. S., Nahrgang, J. D., & Schwind, K. M. (2008). Harmful help: The costs of backing-up behavior in teams. *Journal of Applied Psychology*, *93*, 529-539.

Bliese, P. D. (2000). Within-group agreement, non-independence, and reliability: Implications for data aggregation and analysis. In K. J. Klein & S. W. J. Kozlowski (Eds*.), Multilevel Theory, Research, and Methods in Organizations* (pp. 349-381). San Francisco: Jossey-Bass.

Borgatti, S. P., Everett, M. G., & Freeman, L. C. (2002). *Ucinet for Windows: Software for Social Network Analysis.* Harvard, MA: Analytic Technologies.

Brannick, M. T., Chan, D., Conway, J. M., Lance, C. E., & Spector, P. E. (2010). What is method variance and how can we cope with it? A panel discussion. *Organizational Research Methods, 13*, 407-420.

Bunderson, J. S., & Sutcliffe, K. M. (2003). Management team learning orientation and business unit performance. *Journal of Applied Psychology*, *88*, 552–560.

Burke, C. S., Stagl, K. C., Salas, E., Pierce, L., & Kendal, D. (2006). Understanding team adaptation: A Conceptual analysis and model. *Journal of Applied Psychology, 91,* 1189-1207.

Burtscher, M. J., Kolbe, M., Wacker, J., & Manser, T. (2011). Interactions of team mental models and monitoring behaviors predict team performance in simulated anesthesia inductions. *Journal of Experimental Psychology: Applied*, *17*, 257-269.

Byrne, B. M. (2012). *Structural equation modeling with Mplus: Basic concepts, applications, and programming*. New York: Routledge.

Cannon-Bowers, J. A., Salas, E., & Converse, S. (1993). Shared mental models in expert team decision-making. In N. J. Castellan, Jr. (Ed.), *Individual and group decision-making: Current issues* (pp.221-246). Hillsdale, NJ: Lawrence Erlbaum.

Cataldo, M., & Herbsleb, J. D. (2013). Coordination breakdowns and their impact on development productivity and software failures. *IEEE Transactions on Software Engineering*, *39,* 343-360.

Costa, P. L., Graça, A. M., Marques-Quinteiro, P., Santos, C. M., Caetano, A., & Passos, A. M. (2013). Multilevel research in the field of Organizational Behavior: An empirical look at 10 years of theory and research. *SAGE Open*, 1-17.

Costa, P., Passos, A. M., & Bakker, A. (2014). Empirical validation of the team work engagement construct. *Journal of Personnel Psychology*, *13*, 34–45.

Dawson, J. F. (2013). Moderation in management research: What, why, when and how. *Journal of Business and Psychology, 29*, 1-19. doi: 10.1007/s10869-013-9308-7

Dijksterhuis, A., van Knippenberg, A., Kruglanski, A. W., Schape, C. (1996). Motivated social cognition: Need for closure effects on memory and judgment. *Journal of Experimental Social Psychology*, *32*, 254-270.

Edmondson, A. (1999). Psychological safety and learning behavior in work teams. *Administrative Science Quarterly*, *44,* 350-383.

Edwards, B. D., Day, E. A., Arthur, W., & Bell, S. T. (2006). Relationships among team ability composition, team mental models, and team performance. *Journal of Applied Psychology*, *91*, 727-736.

Gersick, C. J. G., & Hackman, J. R (1990). Habitual routines in task-performing groups. *Organizational Behavior and Human Decision Processes*, *47,* 65-97.

Gevers, J. M. P., Rutte, C. G., & van Eerde, W. (2006). Meeting deadlines in work groups: Implicit and explicit mechanisms. *Applied Psychology: An International Review*, *55*, 52-72.

Guiette, A., & Vandenbempt, K. (2013). Exploring team mental model dynamics during strategic change implementation in professional service organizations. A sensemaking perspective. *European Management Journal*, *31*, 728-744.

Hackman, J. R. (1987). The design of work teams. In Lorsch J.W. (Ed.). *Handbook of organizational behavior* (pp.315-342). New York: Prentice Hall.

Hayes, A. F., Preacher, K. J., & Myers, T. A. (2011). *Mediation and the estimation of indirect effects in political communication research.* In E. P. Bucy & R. L. Holbert (Eds.), *The sourcebook for political communication research: Methods, measures, and analytical techniques* (pp. 434-465). New York: Routledge.

Hu, L., & Bentler, P. M. (1999). Cut of criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, *6*, 1-55.

Humphrey, S. E., Morgeson, F. P., & Mannor, M. J. (2009). Developing a theory of the strategic core of teams: A role composition model of team performance. *Journal of Applied Psychology*, *94*, 48-61.

James, L. R., Demaree, R. J., & Wolf, G. (1993). r_{wg}: An assessment of within group interrater agreement. *Journal of Applied Psychology*, *78*, 306-309.

Janis, I. L. (1972). *Victims of groupthink: A psychological study of foreign-policy decisions and fiascoes.* Boston, USA: Houghton-Mifflin.

Kanfer, R., & Ackerman, P. L. (1989). Motivation and cognitive abilities: An integrative/ aptitude-treatment interaction approach to skill acquisition. *Journal of Applied Psychology*, *74*, 657-690.

Kozlowski, S. W. J., & Bell, B. S. (2008). *Team learning, development, and adaptation*. In V. I. Sessa, & M. London (Eds.), *Work group learning: Understanding, improving and* *assessing how groups learn in organizations* (pp.15-44). New York: Taylor & Francis Group.

Kozlowski, S. W. J., & Ilgen, D. R. (2006). Enhancing the effectiveness of work groups and teams. *Psychological Science in the Public Interest, 7,* 77-124.

Kulik, J. A., & Kulik, C. L. C. (1988). Timing of feedback and verbal learning. *Review of Educational Research, 58*, 79-97.

Lance, C. E., Dawson, B., Birkelbach, D. & Hoffman, B. J. (2010). Method effects, measurement error, and substantive conclusions. *Organizational Research Methods*, *13*, 435-455.

Lim, B-C., & Klein, K. J. (2006). Team mental models and team performance: A field study of the effects of team mental model similarity and accuracy. *Journal of Organizational Behavior*, *27*, 403–418.

March, J. G. (1991). Exploration and exploitation in organizational learning. *Organization Science*, *2*, 71–87.

Marques-Quinteiro, P., Curral, L., Passos, A. M., & Lewis, K. (2013). And now what do we do? The role of transactive memory systems and task coordination in action teams. *Group Dynamics: Theory, Research, and Practice, 17*, 194-206.

Marques-Quinteiro, P., Passos, A. M., Curral, L. (2014). Thought self-leadership and effectiveness in self-management teams. *Leadership*. Advance online publication.

Marks, M. A., Zaccaro, S. J., & Mathieu, J. E. (2000). Performance implications of leader briefings and team-interaction training for team adaptation to novel environments. *Journal of Applied Psychology*, *85*, 971-986.

Mathieu, J. E., Heffner, T. S., Goodwin, G. F., Salas, E., & Cannon-Bowers, J. A. (2000). The influence of shared mental models on team process and performance. *Journal of Applied Psychology*, *85*, 273-283.

Mathieu, J. E. & Rapp, T. L. (2009). Laying the foundation for successful team performance trajectories: The roles of team charters and performance strategies, *Journal of Applied Psychology*, *94*, 90-103.

Mathieu, J. E., & Taylor, S. R. (2006). Clarifying conditions and decision points for mediational type inferences in Organizational Behavior. *Journal of Organizational Behavior, 27*, 1031–1056.

Maynard, M. T., & Gilson, L. L. (2014). The role of shared mental model development in understanding virtual team effectiveness. *Group & Organization Management*, *39,* 3-32.

Maynard, T., Kennedy, D. M., & Sommer, S. A. (2015). Team adaptation: A fifteen-year synthesis (1998–2013) and framework for how this literature needs to “adapt” going forward. *European Journal of Work and Organizational Psychology*, *24,* 652-677.

Mohammed, S., Hamilton, K., Tesler, R., Mancuso, V., & McNeese, M. (2015). Time for temporal team mental models: Expanding beyond “what” and “how” to incorporate “when”. *European Journal of Work and Organizational Psychology*, *24*, 693-709.

Mohammed, S., Klimoski, R., & Rentsch, J. R. (2000). The measurement of team mental models: We have no shared schema. *Organizational Research Methods*, *3*, 123-165.

Mohammed, S., Tesler, R., & Hamilton, K. (2012). Time and shared cognition: Towards greater integration of temporal dynamics. In E. Salas, S. M. Fiore, & M. P. Letsky (Eds.), *Theories of team cognition: Cross disciplinary perspectives* (pp. 87 - 116). New York: Routledge, Taylor and Francis Group.

Moynihan, D. P. (2007). *From forest fires to hurricane Katrina: Case studies of incident command systems*. Washington, DC: IBM Center for the Business of Government.

Muthén, L. K. & Muthén, B. O. (2012). *Mplus User’s Guide. Seventh Edition*. Los Angeles, CA: Muthén & Muthén.

Pulakos, E. D., Schmitt, N., Dorsey, D. W., Arad, S., Hedge, J. W., & Borman, W. C. (2002). Predicting adaptive performance: Further tests of a model of adaptability. *Human Performance*, *15*, 299-323.

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*, *40*, 879-891.

Randall, K. R., Resick, C. J., & DeChurch, L. A. (2011). Building team adaptive capacity: The roles of sensegiving and team composition. *Journal of Applied Psychology*, *96*, 525-540.

Rankin G. & Stokes M. (1998). Reliability of assessment tools in rehabilitation: An illustration of appropriate statistical analyses. *Clinical Rehabilitation*, *12*, 187-99.

Resick, C. J., Murase, T., Bedwell, W. L., Sanz, E., Jiménez, M., & DeChurch, L. A. (2010). Mental model metrics and team adaptability: A multi-facet multi-method examination. *Group Dynamics: Theory, Research, and Practice*, *14*, 332-349.

Rosen, M. A., Bedwell, W. L., Wildman, J. L., Fritzche, B. A., Salas, E., & Burke, C. S. (2011). Managing adaptive performance in teams: Guiding principles and behavioral markers for measurement. *Human Resource Management Review*, *21*, 107-122.

Salas, E., Sims, D. E., & Burke, C. S. (2005). Is there a "Big Five" in teamwork*? Small Group Research*, *36*, 555-599.

Santos, C. M., & Passos, A. M. (2013). Team mental models, relationship conflict and effectiveness over time. *Team Performance Management*, *19*, 363-385.

Santos, C. M., Uitdewilligen, S., & Passos, A. M. (2015). A temporal common ground for learning: The moderating effect of shared mental models on the relation between team learning behaviours and performance improvement. *European Journal of Work and Organizational Psychology*, *24*, 710-725.

Savelsbergh, C. M. J. H., van der Heijden, B. I. J. M., & Poel, R. F. (2009). The development and empirical validation of a multidimensional measurement instrument for team learning behaviors. *Small Group Research*, *40*, 578-607.

Schreiber, J. B., Stage, F. K., King, J., Nora, A., & Barlow, E. A. (2006). Reporting structural equation modeling and confirmatory factor analysis results: A review. *The Journal of Educational Research, 99*, 323-337.

Siemsen, E., Roth, A. & Oliveira, P. (2010). Common method bias in regression models with linear, quadratic, and interaction effects. *Organizational Research Methods*, *13,* 456-476.

Spector, P. E. (2006). Method variance in organizational research: Truth or urban legend?. *Organizational Research Methods*, *9*, 221-232.

Standifer, R., & Bluedorn, A. (2006). Alliance management teams and entrainment: Sharing temporal mental models. *Human Relations, 59,* 903-927.

Standifer, R. L., Raes, A. M. L., Peus, C., Passos, A. M., Santos, C. M., & Weisweiler, S. (2015). Time in teams: Cognitions, conflict and team satisfaction. *Journal of Managerial Psychology*, *30*, 692-708.

Tindale, R. S., Stawiski, S., & Jacobs, E. (2008). *Shared cognitions and group learning*. In V. Sessa & M. London (Eds.). *Work group learning: Understanding, improving, and assessing how groups learn in organizations* (pp. 73 – 90). New York: Lawrence Erlbaum Associates.

Thompson, L. L. (2004). *Making the team: A guide for managers* (2nd edition). New Jersey: Prentice Hall.

Uitdewilligen, S., Waller, M. J., & Pitariu, A. H. (2013). Mental model updating and team adaptation. *Small Group Research*, *44*, 127–158.

Van den Boosche, P., Gijselaers, W., Segers, M., Woltjer, G., & Kirschner, P. (2011). Team learning: building shared mental models. *Instructional Science*, *39*, 283-301.

van Knippenberg, D., & Schippers, M. C. (2007). Work group diversity. *Annual Review of Psychology*, *58*, 515-41.

van Woerkom, M., & Croon, M. (2009). The relationships between team learning activities and team performance. *Personnel Review*, *38*, 560-577.

Waller, M. J., Conte, J. M., Gibson, C. B., & Carpenter, M. A. (2001). The effect of individual perceptions of deadlines on team performance. *Academy of Management Review*, *26*, 586-600.

Webber, S. S., Chen, G., Payne, S. C., Marsh, S. M., & Zaccaro, S. J. (2000). Enhancing team mental model measurement with performance appraisal practices. *Organizational Research Methods*, *3*, 307-322.

Research highlights

- We analyzed temporal mental model similarity and accuracy.
- Temporal mental models are important to stimulate team learning behaviors.
- When mental models are similar and inaccurate, teams engage less in team learning.
- Sharing an inaccurate mental model leads to closed minds.
- Team learning is an important booster for team adaptation and performance.

Table 1.

Means, standard deviations, and correlations among all team-level variables

	M	SD	1	2	3	4	5	6	7	8	9	10	11
1. Team size	4.67	0.59											
2. Task experience	0.55	0.97	.09										
3. Familiarity	78.43	26.19	-.23	-.04									
4. Students			-.10	-.07	.31*								
5. Workers			-.06	.10	.16	-.70**							
6. Students & Workers			.20	-.05	-.60**	-.35**	-.42**						
7. Group			.10	.07	.08	.05	-.06	.02					
8. Temporal mental model similarity	0.42	0.40	.10	-.16	-.08	.01	-.15	.19	.08				
9. Temporal mental model accuracy[a]	1.04	0.37	.09	-.09	-.17	.02	-.16	.18	.04	.15			
10. Team learning	5.64	0.68	-.06	-.09	-.09	-.13	.12	.01	-.14	-.11	.16		
11. Team adaptation	5.76	0.63	-.15	-.13	.02	-.19	.22	-.05	-.14	-.11	.14	.67**	
12. Team performance	2.07	0.19	-.06	.00	-.19	-.28*	.12	.19	-.07	-.11	-.05	.14	.31*

Note. N = 68 teams, ** $p < .01$, * $p < .05$. [a] For individual participants the mean was 1.05, and the standard deviation was 0.47. Results for the Kolmogorov-Smirnov test for normality indicated that temporal mental model accuracy distribution deviated significantly from a normal distribution (K-S test: $D = 0.13$, $p < .05$).

Table 2.

Regression results for the interaction effect of temporal mental model similarity and accuracy on team learning

	Team learning				
Variables	B	SE B	F	R^2	ΔR^2
Step 1: Controls			0.53	0.05	
Intercept	5.74***	.18			
Team size	-0.07	.15			
Task experience	-0.07	.09			
Team familiarity	-0.00	.00			
Students	-0.17	.19			
Students & Workers	-0.16	.28			
Group	-0.00	.00			
Step 2: Main effects			0.79	0.10	.05
Intercept	5.73***	0.17			
Team size	-0.06	.15			
Task experience	-0.07	.09			
Team familiarity	-0.00	0.00			
Students	-0.18	.19			
Students & Workers	-0.15	.28			
Group	-0.00	.00			
Temporal MM similarity	-0.24	.22			
Temporal MM accuracy	0.33	.23			
Step 2: Interaction effect			2.00*	0.24	.14
Intercept	5.61***	.17			
Team size	0.01	.14			
Task experience	-0.09	.08			
Team familiarity	-0.01	.00			
Students	-0.22	.17			
Students & Workers	-0.37	.27			
Group	-0.00	.00			
Temporal MM similarity	-0.35	.20			
Temporal MM accuracy	0.53*	.22			
Temporal MM similarity X Temporal MM accuracy	2.15**	.66			

Note. N = 68 teams. MM = mental model. * $p < .05$; ** $p < .01$; *** $p < .001$.

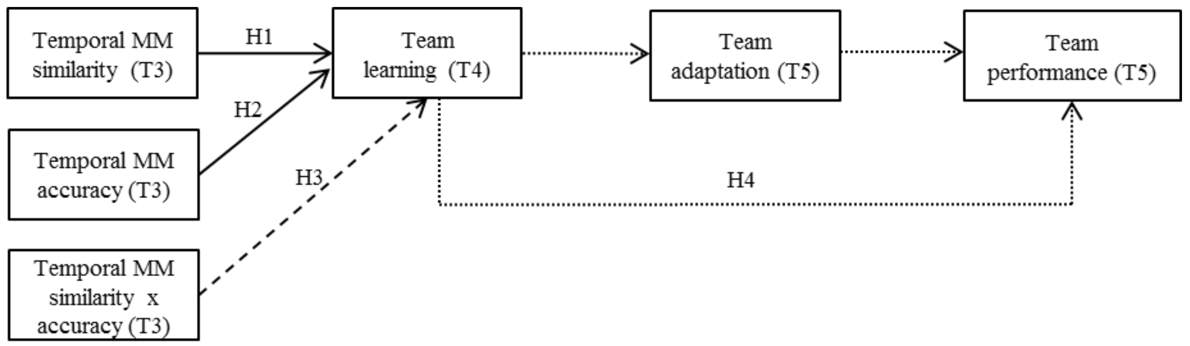

Figure 1. Research model and hypotheses. Solid arrows represent direct effects (H1 and H2). Dashed arrow represents the moderation effect (H3). Dotted arrow represents the mediation effect (H4). T = Time. MM = Mental model.

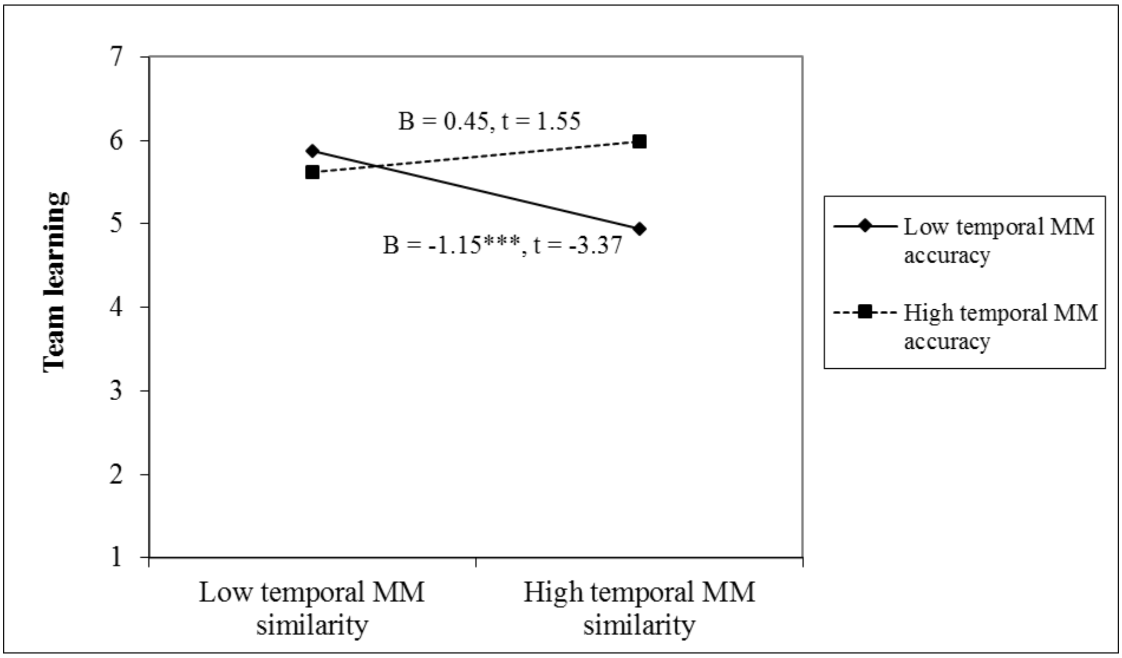

Figure 2. Moderation effect of temporal mental model accuracy between temporal mental model similarity and team learning. MM = Mental model. *** p < .001.

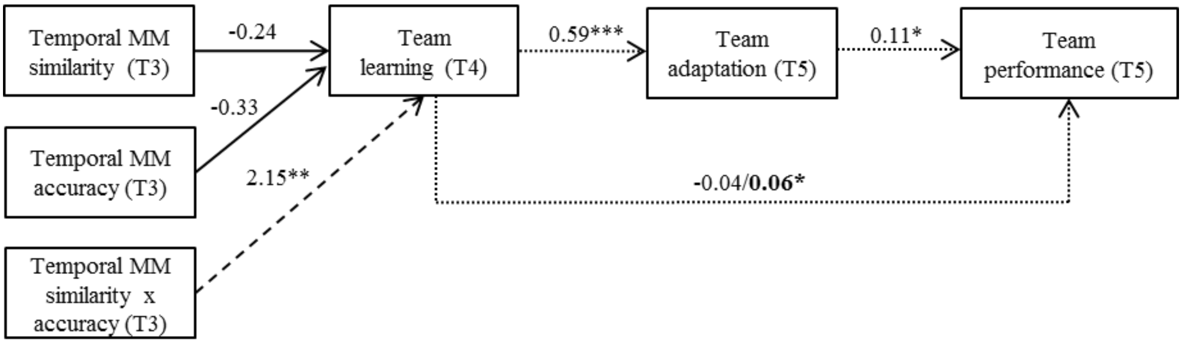

Figure 3. Final model representing the results for the hypotheses (unstandardized parameters). In the mediation model, regular numbers represent unstandardized coefficients obtained when modeling mediation. Bold number represents the indirect effect of team learning on performance including team adaptation. MM = Mental model. *** $p < .001$, ** $p < .01$, * $p < .05$.