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# Multilevel influences of transactive memory systems on individual innovative behavior and team innovation

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ABSTRACT

Despite the dual benefits of transactive memory systems (TMSs) for individual innovative behavior and team innovation, prior literature has seldom explored these issues simultaneously. This study both explores how TMSs affects individual creative self-efficacy and innovative behavior and examines whether the TMS affects team innovation by collecting survey data from 475 individuals in 86 teams participating in two iterations of the Intelligent Ironman Creativity Contest in Taiwan. Findings suggest a multilevel mediation model in which creative self-efficacy partially mediates the relationship between TMSs and the individual's innovative behavior. At the team level, the TMS positively affects team innovation. This paper concludes with a discussion of theoretical and practical implications.



## 1. Introduction

Creativity and innovation are associated not only with socio-economic development but with the advancement of health and welfare in the population (Edwards-Schachter, García-Granero, Sánchez-Barrioluengo, Quesada-Pineda, & Amara, 2015; West & Altink, 1996). However, while numerous studies have focused on factors that enhance or inhibit the generation of novel and useful ideas offered by individuals (i.e., creativity), the literature has paid less attention to the subsequent stage of idea implementation (i.e., innovative behavior) intended to produce better procedures, practices, or products (Anderson, Potocnik, & Zhou, 2014).

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Recently, scholars have increasingly recognized the importance individual innovative behavior and attempted to identify individual and task characteristics that predict innovative behavior (Anderson et al., 2014; Edwards-Schachter et al., 2015; Hammond, Neff, Farr, Schwall, & Zhao, 2011). Still, little is known about how an individual's innovative behavior can be improved within the team context. Teams represent an almost ubiquitous social context in which individual creativity and innovation is enacted (Richter, Hirst, van Knippenberg, & Baer, 2012), and the importance of collaboration and teamwork is a focus across different settings, such as education (Sawyer, 2006; Tierney, 2014) and management (LePine, Piccolo, Jackson, Mathieu, & Saul, 2008). Given that the literature has attributed the stimulation of divergent perspectives, greater information, and collaborative learning to the team (Anderson et al., 2014; Chen, Farh, Campbell-Bush, Wu, & Wu, 2013), there is a need to explore team level factors that drive individual innovative behavior.

Transactive memory systems (TMSs) (Wegner, 1986) can help explain how team members share knowledge and learn from each other, and related research seeks to understand how individuals both contribute to overall team innovation while benefiting themselves as well. A TMS refers to a shared system describing how team members use mutual reliance and coordinated access to encode, store, retrieve, and communicate differentiated yet complementary knowledge in order to complete collective tasks (Lewis & Herndon, 2011). Therefore, as is generally assumed, the TMS benefits both team members individually through transactive memory processes and the team's collective performance. Despite the multilevel nature of TMSs (Lewis & Herndon, 2011) and the dual benefits to the individual and team, to our knowledge, prior literature has not examined this phenomenon from a multilevel perspective. Thus, this study develops and tests a multilevel model of TMSs (see Fig. 1).

The first aim of this study is to investigate the multilevel role of creative self-efficacy, which mediates the relationship between TMSs and innovative behavior. In executing creativity or innovation tasks, individuals with access to an effective TMS may view their team as providing task-related assistance, such as necessary resources (Bakker, 2005, 2008; Lewis, 2003; Schaufeli, Bakker, & Salanova, 2006) or emotional support (Deci & Ryan, 2008), and thus realize increased creative self-efficacy (e.g., the belief that one has the ability to produce creative outcomes; Tierney & Farmer, 2002) when performing an innovation task. Subsequently, individuals are more likely to demonstrate innovative behavior in their work.

The second aim of this study is to examine the influence of TMSs on team level innovation. The literature has found TMSs to be positively associated with desired team outcomes, such as team performance or team effectiveness (Hammedi, van Riel, & Sasovova, 2013; Lewis & Herndon, 2011; Ren & Argote, 2011), yet relatively little is known about whether TMSs improve team innovation. We argue that TMSs may nurture team innovation because the structural and process components of the TMS help the team coordinate member learning and knowledge retrieval while executing collective tasks (Gino, Argote, Miron-Spektor, & Todorova, 2010; Wegner, 1986; Zhang, Hempel, Han, & Tjosvold, 2007), which are considered important elements of team innovation.

Our study is the first to empirically examine the multilevel model of TMSs, and thus contributes to extant literature in several ways. First, the results of this study shed light on how team dynamics affect individual outcomes by demonstrating that the TMS is an important source of creative self-efficacy and facilitates innovative behavior, both considered important variables in the creativity and innovation literatures. Second, the multilevel perspective advances the TMS literature by responding to Lewis and Herndon's (2011) call for multilevel research. Finally, exactly how TMSs affect team innovation has received little attention. Thus, results of this study also contribute to the external validity of TMSs.

## 2. Theoretical background and hypotheses

### 2.1. TMSs and the issue of analysis level

The TMS is a shared system that describes how team members use mutual reliance and coordinated access to encode, store, retrieve, and communicate differentiated yet complementary knowledge in order to complete collective tasks (Lewis &

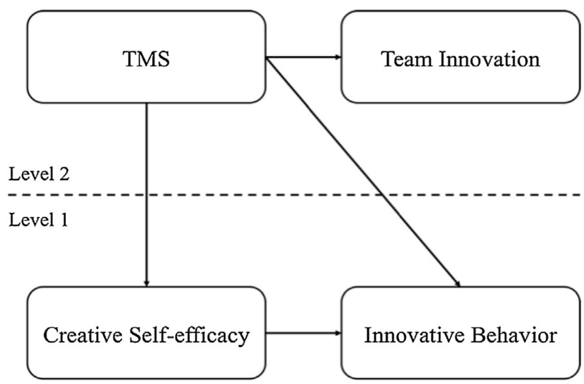


**Fig. 1.** A Multilevel Framework of the TMS.

Herndon, 2011). Lewis (2003) proposed that a TMS manifests along three dimensions: specialization (e.g., each team member has differentiated knowledge), credibility (e.g., team members trust the expertise of other members), and coordination (e.g., teams work together efficiently). A TMS functions as team members develop specialized knowledge and trust and rely on other members' knowledge in a coordinated manner (Lewis, 2003). The effectiveness of a TMS depends on cognitive interdependence among members as they interact with, trust, and learn from each other (Peltokorpi, 2008). Most prior literature has conceptualized the TMS as a team level construct reflecting a shared phenomenon (see Ren & Argote, 2011 for a review) and an individual level construct when the TMS functions as a composite of individual knowledge (Lewis, 2003). However, research focusing on the mechanisms underlying the effects of the TMS shows that it simultaneously functions as a multilevel phenomenon, in which an individual's motivation, attitudes, and behaviors improve within the team context (Lewis & Herndon, 2011). This study demonstrates a multilevel model of TMS.

Argote and Ren (2012) proposed that TMSs facilitate the combinative integration and renovation of an organization's knowledge assets; TMSs were more valuable in environments where problems changed and knowledge became obsolete than when problems were stable (Argote & Ren, 2012). We propose that the TMS can be seen as an important resource that fosters individual and team engagement in innovation related tasks. Thus, in the following section, we propose the influence of TMSs on individual and team outcomes.

### 2.2. Effects of TMSs on individual outcomes

#### 2.2.1. TMSs and creative self-efficacy

Creative self-efficacy refers to the belief that one has the ability to produce creative outcomes (Tierney & Farmer, 2002). Individuals with high creative self-efficacy can mobilize intrinsic motivation and cognitive resources, as well as make increased effort to meet situational demands (Tierney & Farmer, 2002; Tierney & Farmer, 2011). Gist and Mitchell (1992), based on Bandura's (1986) work, propose that self-efficacy is formed through information processing, such that self-based internal cues and external contextual cues determine an individual's self-efficacy. The team may also serve as an important source of necessary information and knowledge helpful for individuals completing innovation tasks (Richter et al., 2012), which in turn fosters individual creative self-efficacy. We propose that the TMS may act as an important informational source for creative self-efficacy.

In a team-based context, the TMS facilitates creative self-efficacy in several ways. First, as mentioned earlier, in order to realize an effectively functioning TMS, team members must learn from each other through observations of knowledge exchange and coordination behaviors (Liao, Jimmieson, O'Brien, & Restubog, 2012; Michinov & Michinov, 2009). Second, individuals within a team receiving diverse specialized knowledge skills from other team members assume that the team values their work, which may explain their willingness to provide task-related assistance, such as necessary resources and emotional support. These in turn motivate individuals to take risks and face failures as required of innovation (Michinov & Michinov, 2009). Such individuals thus feel confident and flexible in coping with uncertain situations. We thus hypothesize the following:

**Hypothesis 1.** TMSs positively affect the creative self-efficacy of individuals.

#### 2.2.2. TMSs and individual innovative behavior

Creativity is defined as the generation of novel and useful ideas, while innovative behavior refers to the subsequent stage of implementing ideas intended to improve procedures, practices, or products (Anderson et al., 2014). Individuals with high innovative behavior actively engage in problem-seeking and -solving processes, such as seeking sponsorship for novel and useful idea and attempting to build a coalition of supporters. They also actualize ideas by producing prototypes, innovation models, or products (Scott & Bruce, 1994).

Amabile's (1997) componential theory of organizational creativity and innovation suggests that components of the social environment (organizational motivation to innovate, resources, and management practices) impact individual creativity and innovation by influencing three components of individual creativity (i.e., task motivation, domain-relevant skills, and creativity-relevant processes). In the team-based context, we propose that TMSs reflect two components of Amabile's (1997) model, which ultimately influence an individual's innovative behavior.

First, the TMS reflects the resource component, aiding work in the domain target for innovation (Amabile, 1997). Collective action and outcomes are aggregates of input from individuals who have been assigned various contributive roles and tasks. In order to accomplish specifically assigned tasks, individuals must utilize resources and gain expertise from other team members. When members are aware of "who knows what" they are likely to reconfigure their existing knowledge or create new capabilities (Argote & Ren, 2012). Second, TMSs also reflect the management practice component, which can foster effective teamwork and constructive interaction among members. Heavey and Simsek (2014) used creative friction and reflective framing to describe how the TMS facilitates the transaction of nonredundant knowledge between members, which can help to accelerate the discovery and conversion of new knowledge and ideas.

Overall, individuals who work within a highly developed TMS context will feel the team provides information regarding the actual results of work-related activities, ultimately stimulating a deep level of active engagement when demonstrating innovative behavior. We thus hypothesize that individuals are motivated to more actively engage in and enjoy tasks when they perceive a more fully developed TMS within the team.

**Hypothesis 2.** TMSs positively affect individual innovative behavior.

*2.2.3. The mediating role of creative self-efficacy*

Self-efficacy is an important mechanism that mediates perceptions about the environment and behavioral reactions (Bandura, 1986), such as creative performance (Gong, Huang, & Farh, 2009; Tierney & Farmer, 2002, 2011).

As discussed above, this study proposes a multilevel mediating model in which TMSs at the team level are related to individual creative self-efficacy. This correlation is also mediated by creative self-efficacy. As mentioned, both TMSs and creative self-efficacy are important antecedents for individual innovative behavior. Individuals are likely to actively engage in a target activity when they either perceive a more fully developed TMS or have confidence in generating creative ideas. Additionally, individuals feel confident in undertaking an innovation task when receiving cognitive and affective support from their team. Hsu, Hou, and Fan (2011) found that individuals demonstrate higher innovative behavior when intrinsically motivated toward an innovation task.

Individuals accessing a fully developed TMS assume their work is valued and are thus more willing to provide task-related assistance. Such individuals subsequently feel confident and flexible when facing uncertain task-related circumstances, ultimately increasing willingness to dedicate additional effort towards completion. Therefore, this study proposes that creative self-efficacy is a mechanism through which the TMS affects an individual's innovative behavior. We thus hypothesize the following:

**Hypothesis 3.** Creative self-efficacy mediates the extent to which TMSs influence innovative behavior.

### *2.3. TMSs and team innovation*

Team innovation refers to the generation and implementation of novel and useful ideas from team members regarding products, services, and processes (West & Farr, 1990). Owing to the complexity, potential problems, and risks associated with team innovation processes, successful achievement of collective team innovation tasks such as solving problems or developing new products demands team members recombine specialized expertise in novel ways (Shin, Kim, Lee, & Bian, 2012).

The operation of a team's TMS may enhance team innovation for three reasons. First, team members posses different specialized knowledge; this is the structural component of TMS (Lewis, 2003), and prior literature has discussed its effects on team innovation (Hulsheger, Anderson, & Salgado, 2009). Members within the team not only retrieve diverse resources (skills, knowledge, and expertise) for actualizing innovation tasks, but also bring divergent perspectives, which stimulate creativity-related cognitive processes (Hulsheger et al., 2009).

The second reason is evident from a team process perspective. Wegner (1986) proposed that the TMS formation and functioning occurs through encoding, storage, and retrieval phases. As members within the team perform different functions, each member has access to external knowledge labeled and located by others. Discussion among members may be confusing due to the complexity of the innovation task and the obscurity of the comprehensive picture of the innovation goal. Such discussions can recombine team members' differentiated but complementary task knowledge. Thus, Wegner (1986) suggests that individuals in differentiated TMSs can produce creative group products.

The third reason is the interaction between the components of structure and process. The function of a team's TMS relies on the shared understanding of who knows what, as well as trust and coordination, which are also part of the foundation of team innovation. For example, trust between team members may reduce uncertainty and the costs of searching for reliable information (Tsai & Ghoshal, 1998) and thus enhance team innovation. Furthermore, when teams coordinate well, team members exchange information and retrieve knowledge from each other effectively. This offers extra time for implementing creative ideas (Caldwell & O'Reilly, 2003). Based on this reasoning, we propose the following hypothesis:

**Hypothesis 4.** The TMS positively affects team innovation.

## 3. Methods

### *3.1. Research context: Intelligent Ironman Creativity Contest*

This study uses samples from the 2011 and 2012 Intelligent Ironman Creativity Contest (IICC) in Taiwan. The contest has become enormously popular among high schools in Taiwan and is known internationally. Contest participants were involved with IICC in teams for at least six months, during which period teams must utilize members' different specializations to solve contest-designated problems.

The IICC promotes skills touted by educational, academic, and policy proponents of the 21st Century Skills framework at the front of recent educational discourse (Tierney, 2014). Central to this framework are 4Cs of Learning and Innovation Skills: critical thinking, communication, collaboration, and creativity (Partnership for 21st Century Skills, 2007), all of which are embodied in the IICC. With team members working closely together, each IICC team must overcome multiple challenges and create a deliverable outcome (project) reflecting both a concern for humanity and evidence of teamwork skills. The contest demands a well-rounded personality that includes creativity, competitiveness, physical stamina, perseverance, as well as technical, presentation, and drama skills. Each team must complete a series of tasks within 24 h (semi-finals) or 72 h (finals), without a break. To ensure fairness, the teams are not allowed to communicate with any party, except for the competition organizers via the Internet. How well a team completes a task determines the resources earned towards development of final projects. Therefore teams must leverage shared knowledge, skills, and individual specializations to obtain sufficient resources for solving complex problems and demonstrating innovative products. This process of exhibiting projects for each task and building resources towards a final project requires coordination of knowledge in pursuit of solutions to task-related problems.

The top prize is awarded based on the final project, with a different theme each year. Criteria for evaluating the final project include creativity, functionality, and aesthetics. Achieving a high score on the final project requires that students demonstrate teamwork implementation skills, physical stamina, and mental agility in applying scientific knowledge. In addition to evaluating the fundamental knowledge of individuals (e.g., natural or social sciences) and creativity, IICC also tests the collaborative capacity of a team in using multidisciplinary specializations from team members for the development of innovative products.

### *3.2. Sampling and procedure*

Data were collected during the 2011 and 2012 semi-finals of the IICC via paper-based questionnaires administered during IICC registration. To increase sample size and enhance the effectiveness of hypothesis testing, we combined the 2011 and 2012 sample into a single sample. We used bootstrapping to compute exact $p$-values of the $t$-tests on the variables (perspective taking, flow experience, creative self-efficacy, TMS, and innovative behavior) using 1000 replications. The results indicated that there was no difference ($p > .05$) between these two data sets, and thus the combination of data sets was appropriate.

The 2011 and 2012 IICC semi-finals competition consisted of 601 participants in 109 teams, of which 126 individuals from 23 teams were eliminated due to missing responses, leaving a final sample of 475 participants in 86 teams (with an average team size of 5.52 members, SD = .65); 29.9% of the individuals were male, while 17.5% were high school freshmen, 34.1% were juniors, 42.7% were seniors, and 5.7% were graduates.

### *3.3. Measures*

We collected data for this study using a multi-source approach, except for data regarding team innovation, which we obtained from archival data provided by a senior IICC organizer. Since the questionnaires used in this study were originally developed in English, two experienced psychologists performed back translation to avoid cultural bias and ensure questionnaire validity. Additionally, scholars have previously used measures of TMSs (Zhang et al., 2007), creative self-efficacy (Li & Wu, 2011), and innovative behavior (Hsu et al., 2011) in Chinese cultural contexts. Therefore, cultural bias is unlikely for the measures used in this study.

#### *3.3.1. Team innovation*

A panel of judges evaluated team innovation based on final theme-related projects, and a senior IICC organizer provided the data for this study. A higher score in the project under the main theme implies higher team innovation. For example, during the 2011 IICC competition, each team was required to perform a stage drama in order to interpret the main theme for that year (Root: Transition through time by traveling between two time frames). The evaluation criteria included the following: (1) creativity of the time traveling method and process with visual and sound effects (20%); (2) interpretation of topic (20%); (3) stage design and change (20%); (4) life values depicted in the performance (i.e. value establishment, value transfer, and value development) (20%); (5) overall performance and teamwork (20%); (6) a 20% penalty deducted from the final score if one frame contained the three stage sets; and (7) an explanatory note could influence final grades by ±5%.

#### *3.3.2. Innovative behavior*

We measured innovative behavior with Scott and Bruce's (1994) five-item scale, which is a self-report measure, and appropriate to this study as individuals have the most accurate information regarding their personal performance on innovation-related tasks in organizational settings (Janssen, 2000). Sample items included "*At work, I always promote and champion ideas to others,* " and " *I always investigate and secure the funds needed to implement new ideas* " (Cronbach's $\alpha = .87$).

#### *3.3.3. TMS*

We used Lewis's (2003) TMS scale in this study. This five-point Likert scale (1 = " *strongly disagree* " to 5 = "*strongly agree*") scale includes 15 items over three dimensions: (1) specialization (e.g. "*each team member has specialized knowledge of some aspect of our project*"), (2) credibility (e.g. "*I believe that other members' knowledge about the project was credible*"), and (3) coordination (e.g. "*the task was achieved smoothly and efficiently*"). A second-order confirmatory factor analysis (CFA) indicated a good fit for a model depicting the specialization, credibility, and coordination ( $\chi^2/df = 3.88$, IFI = .91, CFI = .91, SRMR = .06) (Cronbach's $\alpha = .76$).

**Table 1**
Comparison of alternative factor structures for measurement validation.

| Model | $\chi^2$ (d*f*) | $\chi^2$/d*f* | CFI | IFI | NNFI | SRMR | RMSEA | $\Delta\chi^2$ ($\Delta$d*f*) |
|---|---|---|---|---|---|---|---|---|
| Three-factor model[a] | 335.66 (51) | 6.58 | .92 | .92 | .89 | .07 | .11 | |
| Two-factor model[b] | 456.45 (53) | 8.61 | .88 | .88 | .85 | .07 | .13 | 120.79 (2)*** |
| One-factor model[c] | 732.82 (54) | 13.57 | .80 | .80 | .76 | .10 | .16 | 397.16 (3)*** |

*Note:* Level 1 $N = 475$ individuals. ***$p < .001$.
[a] Three-factor model: creative self-efficacy, TMS, and innovative behavior as distinct factors.
[b] Two-factor model: creative self-efficacy and innovative behavior as factor 1; TMS as factor 2.
[c] One-factor model: all items as one factor.

#### 3.3.4. Creative self-efficacy

We used Tierney and Farmer's (2002) three-item creative self-efficacy scale. Sample items for this seven-point Likert scale (1 = "*strongly disagree*" to 7 = "*strongly agree*") included " *I am confident in my ability to solve problems creatively*" and "*I believe that I am good at generating novel ideas*" (Cronbach's $\alpha = .89$).

#### 3.3.5. Control variables

Drawing on a review of prior literature, we controlled for several variables. At the individual level, we control for gender (0 = female, 1 = male), perspective taking based on Grant and Berry's (2011) scale (four items, Cronbach's $\alpha = .92$), and flow experience based on Tiggemann and Slater's (2001) scale (four items, Cronbach's $\alpha = .79$). We selected these personal characteristics given their potential relationships with creative self-efficacy (Gong et al., 2009) and innovative behavior (Csikszentmihalyi, 2013; Grant & Berry, 2011). At the team level, prior empirical evidence has indicated that team size (Hulsheger et al., 2009) and team heterogeneity (Shin & Zhou, 2007; Somech, 2006; Van der Vegt & Janssen, 2003) influence team innovation, and thus we also controlled for both team size and team heterogeneity (the variance of grade of team numbers).

### 3.4. Measurement model and common method variance

We conducted a CFA to examine discriminant validity and common method variance (James, Mulaik, & Brett, 1982) for three main variables (TMS, creative self-efficacy, and innovative behavior). As shown in Table 1, the hypothesized three-factor model has the best fit ($\chi^2/df = 6.58$, CFI = .92, IFI = .92, NNFI = .89, SRMR = .07, RMSEA = .11) relative to the alternative two-factor ($\chi^2/df = 8.61$, CFI = .88, IFI = .88, NNFI = .85, SRMR = .07, RMSEA = .13) or one-factor model ($\chi^2/df = 13.57$, CFI = .80, IFI = .80, NNFI = .76, SRMR = .10, RMSEA = .16), demonstrating that the TMS, creative self-efficacy, and innovative behavior are three distinct constructs.

Furthermore, since we gathered the dependent and independent data from a single respondent, we explored and ruled out common method variance (CMV) as a serious concern using Harman's single-factor test to assess its potential influence. The results (see Table 1) suggest a worse fit for a single-factor (all items load on one common factor) as compared with the three-factor model; common factor bias does not pose an important threat (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

### 3.5. Data aggregation

Operationalizing TMSs in this study as a team level construct, it was necessary to examine the justification of aggregating individual responses into team-level constructs. We first examined the inter-rater agreement of TMSs by calculating $r_{wg}$ values (James, Demaree, & Wolf, 1984). The mean $r_{wg}$ across teams was .96 for TMS, suggesting an acceptable level of inter-rater agreement. In addition, we calculated intraclass correlation coefficients according to Bliese's (2000) suggestion. We obtained an ICC(1) value of .17, and the ANOVA test showed a significant between-team variance compared to within-team variance for TMS ($F = 2.17$, $p < .001$). The ICC(2) value for TMS was .54. Together, these indices provided sufficient justification for aggregation of TMS values to the team level.

## 4. Results

Descriptive statistics, scale reliabilities (Cronbach's α), and correlations among variables of interest at the individual and team levels are presented in Table 2. Most of the zero -order correlations were in the expected directions. For example, at the individual level, the relationships between creative self-efficacy and TMS ($r = .40$, $p < .01$), self-efficacy and innovative behavior ($r = .76$, $p < .01$), and TMS and innovative behavior ($r = .33$, $p < .01$) are positively significant. At the team level, TMS positively affected team innovation ($r = .35$, $p < .01$).

Hypotheses were tested using Hierarchical linear modeling. In Hypothesis 1 and Hypothesis 2, we proposed that TMS (team-level) would positively predict creative self-efficacy (individual-level) and innovative behavior (individual-level). As shown in Table 3, after controlling for the effect of control variables, we found that TMS was positively related to creative self-efficacy ($\gamma_{03} = .80$, $p < .001$, Model 2) and innovative behavior ($\gamma_{03} = .50$, $p < .01$, Model 1). Therefore, Hypothesis 1 and Hypothesis 2 are supported.

**Table 2**
Descriptive statistics, reliability and correlations.

| Variable | Mean | S.D. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|
| Individual level | | | | | | | | | |
| 1. Gender | .70 | .46 | – | | | | | | |
| 2. Grade | 2.37 | 1.06 | .13** | – | | | | | |
| 3. Prospective talking | 5.40 | 1.06 | −.13** | −.02** | (.92) | | | | |
| 4. Flow experience | 5.52 | .97 | −.20** | −.07 | .42** | (.79) | | | |
| 5. Creative self-efficiency | 5.27 | 1.02 | .03 | .08 | .42** | .37** | (.89) | | |
| 6. TMS | 4.07 | .43 | −.16** | −.01 | .33** | .40** | .40** | (.76) | |
| 7. Innovative behavior | 5.29 | 1.02 | −.00 | .07 | .49** | .37** | .76** | .33** | (.87) |
| Team level | | | | | | | | | |
| 1. Team size | 5.52 | .65 | – | | | | | | |
| 2. Team heterogeneity | .10 | .21 | .10 | – | | | | | |
| 3. TMS (mean) | 4.06 | .25 | .09 | .05 | – | | | | |
| 4. Team innovation | 80.40 | 4.20 | .14 | .16 | .35** | – | | | |

*Note*. Level 1 $N = 475$ individuals; Level 2 $N = 86$ teams. Individual-level descriptive statistics and correlations are shown in the upper part of the table. Team-level descriptive statistics and correlations are shown in the lower part of the table. Coefficient alpha reliability estimates are shown in the diagonal.
** $p < .01$.

**Table 3**
Hierarchical linear modeling testing effects of TMSs on creative self-efficacy and innovative behavior[a].

| Variables | Model 1 (X → Y) DV = innovative behavior | | | Model 2 (X → M) DV = creative self-efficacy | | | Model 3 (X, M → Y) DV = innovative behavior | | |
|---|---|---|---|---|---|---|---|---|---|
| | γ | S.E. | t | γ | S.E. | t | γ | S.E. | t |
| Intercept ($\gamma_{00}$) | 2.30** | .84 | 2.73 | 1.30 | .80 | 1.62 | 2.63** | .85 | 3.08 |
| Level-1 effects | | | | | | | | | |
| Gender ($\gamma_{10}$) | .17 | .10 | 1.58 | .25** | .09 | 2.81 | .01 | .07 | .08 |
| Perspective taking($\gamma_{20}$) | .36** | .06 | 6.33 | .29** | .05 | 5.22 | .18** | .04 | 4.13 |
| Flow experience($\gamma_{30}$) | .27** | .06 | 4.54 | .30** | .06 | 5.05 | .08 | .04 | 1.85 |
| Creative self-efficacy($\gamma_{40}$) | | | | | | | .63** | .05 | 12.95 |
| Level-2 effects | | | | | | | | | |
| Team size($\gamma_{01}$) | .14 | .10 | 1.49 | .09 | .07 | 1.21 | .14 | .10 | 1.38 |
| Team heterogeneity($\gamma_{02}$) | .30 | .16 | 1.83 | .23 | .19 | 1.21 | .29 | .17 | 1.72 |
| TMS (mean $\gamma_{03}$) | .50** | .17 | 2.87 | .80** | .16 | 4.91 | .46* | .18 | 2.57 |
| $\tau$00 | .11** | .05* | .17** | | | | | | |
| Pseudo $R^{2\,b}$ | .22 | .19 | .47 | | | | | | |

*Note*: [a]Level 1: $N = 475$ individuals; level 2: $N = 86$ teams. Entities presented are estimations of HLM regression coefficients. We followed Liaw, Chi, and Chuang's (2010) analytical approach at level 1, perspective taking, flow experience, and creative self-efficacy were group-mean centered; at level 2, team size, team heterogeneity, and TMS were not centered. X refers to the predictor. M refers to the mediator. Y refers to the outcome variable.
[b]Pseudo $R^2$ was calculated based on Snijders and Bosker's (1999) formula.
* $p < .05$.
** $p < .01$.

Next, we tested Hypothesis 3, which proposed that creative self-efficacy (individual-level) would mediate the relationship between TMS (team-level) and innovative behavior (individual-level), by following Mathieu and Taylor's (2007) approach. As indicated, TMS was positively related to creative self-efficacy and innovative behavior. This satisfied the first two conditions for mediation. In addition, as shown in Model 3 of Table 3, the relationship between creative self-efficacy and innovative behavior was significant ($\gamma_{40} = .63$, $p < .001$) when TMS was incorporated into the model, satisfying Mathieu and Taylor's third condition. Finally, after including creative self-efficacy in the model, we found that the coefficient of TMS relative to innovative behavior was reduced to .46 ($p < .05$; see Model 3), which satisfied the condition of cross-level partial mediation. Sobel's (1982) test further confirmed that there was an indirect effect of TMS on innovative behavior via creative self-efficacy ($z = 4.51$, $p < .001$). Therefore, Hypothesis 3 was supported.

For Hypothesis 4, we proposed that TMS (team-level) would positively predict team innovation (team-level). As shown in Model 2 of Table 4, we found that TMS was positively related to team innovation ($\beta = .33$, $p < .01$). Therefore, Hypothesis 4 was supported.

## 5. Discussion

There has been growing interest in exploring the team–individual (T–I) interface, whereby team phenomena influence the innovative behavior of individual team members (Anderson et al., 2014; Hammond et al., 2011). This study contributes to this literature by demonstrating the dual benefits of TMSs for individual innovative behavior and team innovation. Specifically, the TMS at the team level is an important antecedent of an individual's creative self-efficacy and innovative behavior and

**Table 4**
Regression results for team innovation.

| Variable | DV = team innovation | |
|---|---|---|
| | Model 1 | Model 2 |
| Team size | .12 | .09 |
| Team heterogeneity | .15 | .14 |
| TMS (mean) | | .33** |
| $R^2$ | .04 | .15 |
| $\Delta R^2$ | – | .11 |

*Note*: Level 2 $N = 86$ teams. All regression coefficients are standardized.
** $p < .01$.

team innovation. Moreover, creative self-efficacy mediates the relationship between the TMS and an individual's innovative behavior.

### 5.1. Theoretical implications

#### 5.1.1. Creativity and innovation literature

Numerous studies on individual innovation have focused on individual factors such as personality, traits, and job characteristics (Hammond et al., 2011), yet little empirical work has examined the contribution of team phenomena to individual innovation (Hammond et al., 2011; West & Farr, 1990). Our results have two important implications. First, they enrich the literature by pointing to TMSs as an important situational influence on individual's creative self-efficacy and innovative behavior. The results are consistent with arguments that teams with a more fully developed TMS realize greater opportunity for collaborative learning and exchange of task-related support (Argote & Ren, 2012; Heavey & Simsek, 2014; Richter et al., 2012). Individual members thus feel confident and flexible in coping with uncertain situations. Our results also indicate that the TMS also serves as an important social environmental factor that impacts individual innovative behavior through creative friction processes and interdependence with other team members.

Second, our multilevel mediation model reveals the mediating mechanism of creative self-efficacy between the TMS and individual innovative behavior. These results are generally consistent with Amabile (1996), specifically that both personal (e.g. creative self-efficacy) and contextual (e.g. TMS) factors may facilitate individual creativity and innovative behavior. Our study provides a better understanding of how TMSs affect individual innovative behavior while responding to Anderson et al.'s (2014) call to study the team–individual (T–I) interface through a multilevel approach.

#### 5.1.2. Transactive memory system literature

Most TMS literature has focused only on the effects of TMSs at either team or individual levels. Ren and Argote (2011) reviewed 76 papers published from 1985 to 2010 and found that 59 were team or group level studies, 10 were dyadic level studies, three were individual level studies, and four were either case studies or organizational level studies. However, the TMS also functions as a multilevel phenomenon, with research on underlying TMS mechanisms showing relationships to improvements in individual motivation, attitudes, and behaviors (Lewis & Herndon, 2011). This study responds to recent calls for multilevel studies of TMSs (Lewis & Herndon, 2011) by demonstrating a multilevel mediation model of TMSs.

Results of this study also add strong external validity to the TMS literature. Previous literature examining how TMSs affect team innovation generally used self-reported measures or supervisor ratings. For example, Zhang et al. (2007) explored how TMSs and team performance are related, measuring team performance based on team manager or leader perceptions. Since theoretical research should be applicable across analysis level, sample, setting, and variables (McGrath & Brinberg, 1983), the results of this study contribute to the literature by demonstrating how TMSs affect creative outcomes across settings, research levels, and measures.

### 5.2. Practical implications

This study has several important implications for educators, organizational managers, or team leaders hoping to encourage team or individual innovative behavior. First, our results highlight the importance of TMSs for innovative behavior both at the group and individual levels. We suggest educators, organizational managers, or team leaders enhance the TMS by establishing favorable environments that encourage constructive interaction and friction among team members. Such an environment would allow individuals to freely express ideas and abilities and share knowledge without fear of criticism. The more easily members may do so, the greater opportunity there is to know who knows what, the sooner needed skills are identified, the sooner they can access the TMS.

Second, team managers should bear in mind that teams do not always perform well in all challenges because the TMS may change over time. To perform well in subsequent sets of challenges, team members need to be open to discussing why a task failed. While some individuals may admit that their mistakes led to a task failure, other team members can provide emotional support. Through this process, individuals gradually learned how to interact, trust, and learn different specializations from each other.

Third, our results also show that creative self-efficacy mediates the relationship between the TMS and individual innovative behavior. Since collaborative learning and teamwork are emphasized in school and work settings, it is important to recognize that beyond situational factors (e.g. TMS), self-confidence in executing innovation tasks also facilitates individual innovation. To realize higher innovative behavior, educators, organizational managers, or team leaders could consider creative self-efficacy as part of the team formation criteria. The TMS may also help compensate for low creative self-efficacy among individuals. Moreover, individuals' creative self-efficacy can also be improved through training (Mathisen, & Bronnick, 2009).

Finally, in the IICC setting of our study, individual learning and cooperative behaviors occur outside the classroom, providing a more realistic learning environment. Although formal and informal team-based learning are important instructional methods, most practical issues are discussed in formal learning situations (e.g. in the classroom) (Slavin, 1995). For instance, team-based learning has been adopted in courses on innovation and entrepreneurship. Therefore, the study of TMS in an informal team-based learning situation (e.g. IICC) has important implications for nurturing workplace talent.

### *5.3. Limitations and suggestions for future research*

Despite its contributions, this study is limited in generalizability. While TMS research has primarily focused on workplace teams, this study employs samples from a team-based innovation contest. These temporary teams are formed exclusively for achieving a specific task, and thus friendship bonds between members emerge without formal organizational norms. Our results may not be fully generalizable to teams pursuing long-term goals within formal working structures. It would be of interest to explore the dual benefits of TMSs for individual and team outcomes to teams within various domains.

We also invite further explorations of how and when TMSs enhance individual and team innovative outcomes. First, TMS is essentially about diversity in resources and ideas. Teams or members in more fully developed TMS contexts should feel comfortable sharing ideas with each other while being aware of unique abilities that can be brought to bear on a problem. However, conflict is unavoidable during interpersonal interactions (Anderson et al., 2014). It would be worthwhile to explore how and when TMSs can function as an intrateam system for expressing and hearing ideas in a way that views these contributions as positive assets rather than sources of personal conflict.

## 6. Conclusion

Scholars conducting team research are increasingly interested in how to enhance an individual's psychological strengths through the team experience, which has implications for individual learning and achievement. This close examination of 475 individuals from 86 teams revealed that individual creative self-efficacy and innovative behavior may be enhanced within a more fully developed TMS context. The TMS also positively affects team innovation among students during actual tasks. Results of this study provide valuable insights into how to further enhance positive outcomes for both individuals and teams in the team setting.

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