

虛擬領導者：他 或 它？

Virtual Leader of a Virtual Team: He or It?

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摘要：虛擬團隊往往依靠電子化的溝通和資訊技術來完成其工作。隨著資訊技術的進步，讓虛擬領導者的出現成為一種可能性，也是虛擬團隊研究中有興趣的一項議題。在透過對電子化領導的干預的實驗室研究中，本研究從領導替代的觀點，以電腦系統替代領導行為，並觀察其對領導效能的影響。在 106 組的實驗性研究顯示，虛擬領導者的存在是具有意義的，尤其是對於替代真人領導者某些規則化的工作上。此外，我們認為在虛擬團隊中，領導者仍須以較為積極的領導作為，才能帶領團隊成員創造出更好的績效。

關鍵詞：群體決策支援系統；領導；虛擬團隊

Abstract: Virtual teams tend to rely on electronic communication and information technology to accomplish their tasks. The progress of information technology has made the development of a virtual leader possible. Thus, the emergence of virtual leaders has become an interesting issue for researchers when focusing on virtual teams. In this study, a 106-team experiment adopted the theory of substitutes for leadership by replacing human leaders with computer systems to examine the effectiveness of virtual leadership. The results indicated that a virtual leader could

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be important, particularly as regards certain routine tasks. In addition, we believed that if the leaders of virtual teams would behave more proactively, their team members could perform better.

Keywords: Group decision support system; Leadership; Virtual team

1. Introduction

Virtual teams are emerging as an important work structure (Kahai *et al.*, 2007). Virtual teams create a setting that maintains flexibility and responds to the shifting environments in today's organizations. The temporary arrangement of virtual teams offers a series of strategic advantages for organizations, for instance, the ability to acquire unavailable expertise and to cut down the costs of production. However, leading a virtual team is obviously unlike traditional face-to-face leadership. Because the team members can be located in different time zones; virtual teams tend to rely on computer-mediated communication (CMC), for instance electronic meetings, video conferences or electronic mail, to accomplish their tasks. Thus, technology plays a vital role in facilitating communication among the virtual team members.

In spite of the efficacy of these innovative technologies, virtual teams can present a host of problems that are not typically found in face-to-face group settings in terms of communication, culture, logistics, and technology (Kayworth and Leidner, 2002). The complicated context that arises from the dispersal of members presents a new leadership challenge. Unfortunately, the research on leadership in virtual teams has not kept pace with the growth of virtual teams, and the topic of leadership has been virtually ignored in the literature on technology-mediated work (Kahai *et al.*, 2007).

Following the context of leadership theory, contingency theorists argue that no best behavioral style produces the most effective leadership. Leaders must consider different situations and contexts and adopt different behaviors (Glückler and Schrott, 2007). However, the situations of virtual teams are more complex than those of the traditional face-to-face teams; it is necessary to create a new position to manage situations including the technological support of employees,

leader-member interactions and its influence on team performance. According to the viewpoint of substitutes for leadership proposed by Kerr and Jermier in 1978, particular individual, task, and organizational variables could substitute for or neutralize the influence of leadership behaviors. This viewpoint can provide suggestions for the leaders who command the virtual teams.

Previous research on leadership in virtual teams indicated that the presence of leaders was associated with higher decision quality (e.g., Hiltz *et al.*, 1991; Kim *et al.*, 2002), greater levels of participation (e.g., George *et al.*, 1990; Kim *et al.*, 2002), and the most satisfied members (e.g., George *et al.*, 1990; Kim *et al.*, 2002). Some ideas concerning how leadership might affect interaction and performance in virtual teams were provided by a series of laboratory studies (e.g., Kahai *et al.*, 1997, 2003 and 2004; Sosik *et al.*, 1997; Sosik *et al.*, 1998) in computer-mediated teams (Hambley *et al.*, 2007a). Therefore, effective leadership is very important for team cooperation in an information environment.

Although Kahai *et al.* (2007) reviewed the leadership literature on virtual teams and reported that the past laboratory studies of leadership in electronic teams presented an important foundation for building new knowledge of leadership in virtual teams, these results should be viewed with caution because the student groups that these studies employed were set at the same time and place, which limited their generalizability. In addition, researchers' ability to systematically manipulate the leader's behaviors would support commanding behaviors in the leaders. Moreover, the previous research also provided evidence that some features of technology indicated that it would be possible to substitute technology for human leaders in some cases.

In summary, the researchers first attempted to adopt the concept of e-leadership proposed by Avolio and Dodge in 2000 and reviewed the literature published between 1997 and 2007 that included leader behaviors (for example, behavior, role, participation, and intermediate), their processes (for example, anonymous, faith and convenience), and their outputs (for example, perception and creativity). The researchers further adopted the substitutes for leadership model (Kerr and Jermier, 1978) to manipulate the leader behaviors, for example task feedback, routine tasks, and the leader's support. Finally, the researchers

conducted a 4-week experiment using the concept of motivational language theory proposed by Mayfield *et al.* (1995; 1998) to design written messages for the designated leaders to communicate with subordinates as the manipulation of leadership in virtual teams. Furthermore, some human leaders were replaced by virtual leaders to allow for a comparison of the differences in their effectiveness. The virtual leaders were programmed to command their subordinates electronically via electronic mail, which were modularized in the information system according to individual performance. In addition, the researchers investigated how the leaders of the virtual teams treated their members to allow for recognition of effective leadership behaviors. The researchers believe that these results could contribute to a design for command of the virtual leaders in the future.

2. Literature Review and Hypothesis

2.1 Virtual Teams and Substitutes for Leadership

A virtual team is composed of individuals from different locations that work together on a specific assignment. Caused by the dispersion of geographical distance or time zones, members are seldom able to communicate face-to-face but rather communicate electronically to accomplish their tasks (Grenier and Metes, 1995; Igbaria, 1999; Lipnack and Stamps, 1997). In other words, traditional teams can communicate face-to-face when decision making (Ocker, 2005) while a virtual team works across time, space and organizational boundaries with links strengthened by webs of communication technologies (Lipnack and Stamps, 1997), such as electronic meetings, video conferences or electronic mail. Thus, the type of organization, management, leadership, communication and team patterns are accompanied by the development of technology (Lipnack and Stamp, 1997). Because the interaction of the members in a virtual team is constrained by the electronic communication tools, these constraints can affect the leader's effectiveness on certain levels. Therefore, the leaders must adjust their leadership behaviors flexibly according to different circumstances to maintain or increase

team performance. Similar to the viewpoint of Kayworth and Leidner (2002), the leaders in virtual teams must be aware of the environment, the climate, and communication to ensure that their teams achieve the goal. However, a few issues concerned virtual team researchers, for instance, “how should leaders to adjust their leadership behaviors?” and “what type of leadership style is appropriate for a virtual team?” This research is similar to the suggestion given by Kayworth and Leidner (2002): “the trend toward physically dispersed work groups has necessitated a fresh inquiry into the role and nature of team leadership in virtual settings” .

Robbins and Judge (2008) defined leadership as “the ability to influence a group toward the achievement of goals.” In other words, the roles that a leader plays can effectively influence the behavior of the followers. Although a variety of frameworks exist that explain leadership effectiveness, most theories can be classified into one of three traditions: trait, behavioral, or contingency theories (Kayworth and Leidner, 2002). The first approach is trait theory. Trait theorists tend to find related features between leaders in terms of their personality, social and physical traits, or intelligence to distinguish the leaders from the members. However, the early stage of this line of research was not successful, and the researchers turned their focus to the leader’s behaviors, which is call “behavior theory.” Behavior theorists argued that researchers should focus on the leader’s behaviors because the leaders adopted certain behaviors to facilitate the effectiveness of their leadership. The difference between trait theory and behavior theory is embedded in the essential concept. Trait theorists argue that the traits of leaders are inherent, while behavior theorists suggest that the leader’s behaviors can be taught. Despite some research on trait theory (for example, the big five personality traits) and behavior theory (for example, development-oriented) that was successfully used to predict the appearance of leadership, researchers still failed to explain the influence of external environment and any consistent relevance between behavior and performance. Therefore, the contingency theorists argued that a given manager’s leadership effectiveness would be dependent on his particular style as applied to specific circumstances (Robbins and Judge, 2008). The approach of these theorists to leadership assumes that there

is no best leadership style and that effective leadership relied on the proper match between the leadership style and the situation (Fiedler, 1967). Among the contingency theorists, Kerr and Jermier (1978) further developed the substitute for leadership theory. This theory focuses on four individual characteristics of subordinates (ability/experience/knowledge, need for independence, professional orientation, indifference to organizational rewards), three task characteristics (routine and methodological invariant tasks; task provided feedback; intrinsically satisfying tasks), and six organizational characteristics (formalization, inflexibility, highly specified functions, cohesive work group, organizational rewards not within leader control, spatial distance between leader and subordinate). These thirteen variables might negate the hierarchical superior's ability to exert either a positive or a negative influence over the subordinate's attitudes and effectiveness. In addition, some factors including work design, reward systems, informal peer leadership, and self-management could replace a leader's influence on the subordinates (Mary and Susan, 2004). Thus, substitute for leadership theory is recognized as one of the major approaches of leadership research that is particularly applicable to the virtual environment.

2.2 Leadership Effectiveness in Virtual Teams

The Adaptive Structuration Theory (AST), developed by DeSanctis and Poole (1994), was based on Anthony Giddens' structuration theory and was the first research on leadership in the virtual team. The theory indicates that the groups and organizations using information technology for their work can dynamically create perceptions about the role and the utility of the technology and can consider how to apply the technology to their activities. Avolio and Dodge (2000) then proposed a framework based on AST, an E-leadership of concept, which is defined as a social influence process mediated by Advanced Information Technology (AIT) to produce a change in attitudes, feelings, thinking, behavior, and/or performance with individuals, groups, and/or organizations. In the past decade, Avolio and his peers conducted a series of leadership studies on virtual teams based on this concept.

Some findings focused on the leadership behaviors in the virtual environment have been proposed in recent years. Kahai *et al.* (2007) distinguished the research on leadership in virtual teams into four categories: laboratory studies without manipulating leadership behavior, laboratory studies with manipulating leadership behavior, field studies, and current research. The studies that did not manipulate leadership behavior provided the preliminary evidence that the presence of a leader was positively associated with higher decision quality (e.g., Hiltz *et al.*, 1991; Kim *et al.*, 2002), greater levels of participation (e.g., George *et al.*, 1990; Kim *et al.*, 2002), and greater satisfaction (e.g., George *et al.*, 1990; Kim *et al.*, 2002) with the decision process. These studies also demonstrated that the use of the technologies did not stop the leader from exercising influence to a greater degree than others (e.g., Harmon *et al.*, 1995; Lim *et al.*, 1994). However, in the studies that manipulated leadership behavior, the researchers further suggested that the participative-directive (e.g., Kahai *et al.*, 1997; Kahai *et al.*, 2004) and transformational-transactional (e.g., Sosik *et al.*, 1997; Sosik *et al.*, 1998; Sosik *et al.*, 1998; Hoyt and Blascovich, 2003; Kahai *et al.*, 2003; Kahai and Avolio, 2006) behavior of leaders and that the various contextual factors, including anonymity (e.g., Sosik *et al.*, 1997; Sosik *et al.*, 1998; Sosik *et al.*, 1998; Kahai *et al.*, 2003), trust (e.g., Hoyt and Blascovich, 2003) and facilitation (e.g., Tan *et al.*, 1999) can influence group processes and outcomes in electronic teams. There have been relatively fewer published papers using field study. Authors such as Kayworth and Leidner (2002) indicated that highly effective virtual team leaders acted as mentors and clarified the roles of the team members; Yoo and Alavi (2004) argued that emergent leaders sent more oriented electronic messages towards members than others in the team. Current researchers suggested some views that indicate that leadership is critical and that leaders and members need to learn how to use different media effectively in virtual teams (e.g., Hambley, *et al.*, 2007b); that the less difficult and less important tasks faced by a leader should be automated in virtual teams (Tarmizi, de Vreed and Zigurs); and that more than one leader can emerge from a virtual team (Wickham and Walther). Kahai *et al.* (2007) further criticized those studies. These criticisms included a concern that a lack of systematic manipulation of the leader's behaviors would assist in directing

leadership behaviors, and those studies using student groups set in the same time and place would have limited generality. These results of these field studies should be viewed with caution because of their limited statistical validity and because they use student teams rather than organizational teams. Overall, these findings have suggested that leadership behaviors, for instance transformational-transactional and participative-directive, can be manipulated and can influence group process and outcomes in a virtual environment. However, we are at the beginning of understanding leadership in virtual teams, as Kahai *et al.* (2007) had said.

Robbins and Judge (2008) proposed that one of the common characteristics of effective teams is trust. In virtual teams, team members are geographically dispersed and cannot communicate face-to-face and are limited to interacting primarily through the use of electronic mail or chat facilities, both of which are text-based communication technologies, to reinforce trust (Jarvenpaa *et al.*, 1998). Because of the popularization of computers and the internet, electronic mail has become an indispensable computer-mediated communication tool in work environments today, and leaders can deliver and exchange information with their subordinates at any time. However, the simple and virtualized tool, electronic mail, can cause misunderstandings in communication and can further create larger conflicts (Griffith *et al.*, 2003). Cramton (2001) also provided the viewpoint that computer-mediated communication can much more easily cause misunderstandings. In other words, the limitation of this electronic communication pattern, e.g., e-mail, can more easily create misunderstanding among members than the traditional face-to-face mode. These limitations further affect the quality of communication and the trust between members and leaders. In particular, during the earlier development stage of a virtual team, if the norms of trust and communication have been built up among the members, it is good for them to seek for clues and successfully control conflicts in a non-oral environment (Likoebe and Ritu, 2004). Therefore, the question “what is the best strategy for leaders to communicate with the members of virtual teams?” is worth studying.

2.3 Hypothesis

Cohen and Gibson (2003) mentioned that a highly virtual team might have members who are spread throughout the world in different time zones. Bell and Kozlowski (2002) also mentioned that the most important character of virtual teams is that they cross the boundaries of time and space. The past studies indicate that if employees in the same organization are physically separated over 30 meters, it can strongly decrease face-to-face interpersonal interaction and non-official contact (Kiesler and Cummings, 2002). Within this type of situation, the content of communication and information exchange must rely on advanced information technology to cross boundaries, for instance time, space, organizations, countries, and cultures (Kirkman and Malthieu, 2005). In particular, teams will be more virtualized when more boundaries (e.g., organizations, countries, cultures, and time zones) are crossed. Therefore, the virtual environment created through various communication technologies has created a new style of leadership and new teamwork situations (Avolio *et al.*, 2001). According to the substitutes for leadership theory proposed by Kerr and Jermier (1978), these changes can prevent or replace the leader's effect on subordinate job satisfaction or organizational commitment. Thus, persons, groups, organizations, attitudes, perceptions, thinking, behavior and performance in teams can bring about change (Avolio *et al.*, 2001). The contingency theorists argued that leaders must be aware of the change to these contextual factors and adapt leadership behavior to the environment to facilitate or maintain the team performance.

Tarmizi, de Vreede, and Zigurs argued that automation should be considered for the easy and simple tasks of leaders (Kahai *et al.*, 2007). Therefore, the researchers of virtual teams considered the idea that in certain situations because of the progress in information technology, technology can be a substitute for human leaders. In other words, under virtual settings, programmed leader behavior is apparently possible. Thus, the researchers proposed the idea of the virtual leader, a programmed system that can perform some leadership behaviors. However, the idea must be premised so that the virtual leader should be perceived as the leader by subordinates to create the same level or an even higher level of

team effectiveness than that provided by human leaders. The existence of virtual leaders can then be valuable and necessary; thus, we propose the following hypotheses:

H1 : The effect of a virtual leader on its followers' creative performance will be equal to or better than that of a human leader.

H2 : The effect of a virtual leader on its followers' perceptions will be equal to or better than that of a human leader.

Trust is the foundation of leadership (Robbins and Judge, 2008). Past studies identified that the frequency of communication and feedback among members in virtual teams can increase the individual's trust (Jarvenpaa *et al.*, 1998). In other words, when a leader adopts active and regular communication with the members in a traditional team organization, the members demonstrate better performance. However, in a virtual environment, can providing the same leadership style using electronic communication tools to perform tasks create better performance? This issue is worthy of our attention, and the study results will be helpful for the behavior design when programming virtual leaders.

Virtual teams are teams with geographically dispersed members who primarily communicate through the use of information and communication technologies together to accomplish important tasks (Townsend *et al.*, 1998). The researchers argue that although virtual teams are different from the traditional face-to-face teams, with the members possibly not knowing each other, the leaders still need to adopt active leadership behavior, e.g., to increase the frequency of communication among the members and to gradually increase and maintain the individual's trust. In particular, electronic mail is adopted in the study as the primary computer-mediated tool. The nature of electronic mail includes low complexity and unsynchronized exchanges, and only the facilitating member's cooperation through frequent interaction can make the goal achievable; thus, we propose a third hypothesis. The frequency of the virtual leader's behaviors was systemically and regularly controlled, and then the study eliminated the virtual leaders to detect the frequency of the human leader

behaviors. Human leaders were divided into two groups, proactive leaders and passive leaders, to further analyze whether the frequency of communications is good (or not) for leadership effectiveness.

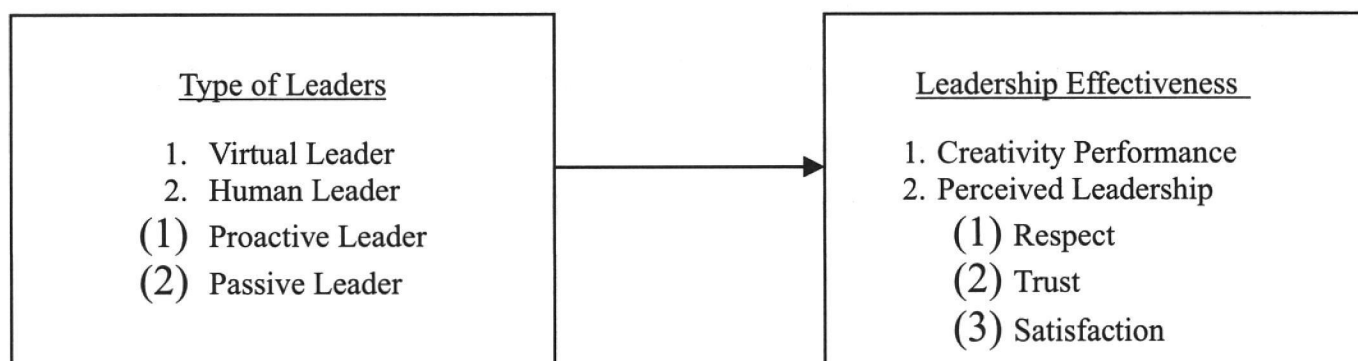
H3 : The difference in the impacts on the followers' creative performance between a proactive leader and a passive leader will be significant.

3. Methodology

3.1 Research Structure

The purpose of this study was to explore the impacts from different types of leaders on the team members' creative performance and perceptions of leadership in a task-oriented virtual team based on the perspective of the substitute for leadership theory. The types of leaders, virtual and human leaders, were the independent variables, while human leaders were further divided into proactive leaders and passive leaders in the study. Leadership effectiveness is the dependent variable, including creative performance and the perception of leadership by the individual member. Creative performance was assessed by the level of participation and the report score, and perceived leadership consisted of the respect, trust, and satisfaction felt toward the leaders. The structure of the research is shown in Figure 1.

Figure 1
The Structure of the Research



3.2 Subjects and Study Procedure

3.2.1 Participants

In this study, 399 students from four universities in Taiwan were invited and assigned randomly into 106 groups. Each group was composed of 3 to 7 participants. MBA students led 34 groups, and EMBA students led 31 groups. The remaining 41 groups were led by assigned virtual leaders. In total, 178 participants (44.6%) were commanded by virtual leaders, and 221 participants (55.4%) were commanded by human leaders, but no group members knew whether they were led by human or virtual leaders. To facilitate their participation in the experiment, each individual's report score accounted for 10% of their semester final score in a specific subject. In addition, all of the participants had been clearly reminded to only use group decision support system (GDSS) to communicate regarding all concerns to avoid any interference in the research findings.

3.2.2 Experiment Design

The experimental activity lasted for 4 weeks. Week 1 (W1) was used for preparation, and all of the participants were trained for 2 to 3 hours to gain familiarity with operating GDSS. The leaders had sent notification via electronic mail to explain the activity procedures and to circulate the team list before the first meeting held using GDSS. Then, 4 sessions of GDSS meetings were held during week 2 (W2) and week 3 (W3). Every team member was assigned a task in a single session with an agenda and questions for discussion. The 4 tasks were brainstorming (Task1), voting (Task2), brainstorming (Task3) and submitting a final report (Task4). All of the questions were low-structured and constant. All of the participants were asked to login to GDSS during the 4 sessions in accordance with the agenda. Finally, they were required to respond to the perception scale in week 4 (W4). Table 1 presents the experimental procedure in this study.

Table 1
Experimental Procedure

\leftarrow W1 \rightarrow	\leftarrow	W2	\rightarrow	\leftarrow	W3	\rightarrow	\leftarrow W4 \rightarrow
	D1~D4	D5~D6	D7	D8~D11	D12~D14	D15	
★■	\triangle 1	\triangle 2 ○	○	\triangle 3	\triangle 4 ○	○	◆

Note : Task performed: \triangle ; E-mailing by leaders: ○ ; Training:★; Explaining: ■ ; Surveying:◆

3.2.3 Manipulation of Leadership

In this study, the researchers were responsible for performing and controlling the experimental process as well as for manipulating the leadership behavior of the virtual leaders. The class instructors of the participants assisted in conducting the experiment and supervising the participation of each group. The researchers provided a 3-hour training to introduce the principle of motivating language to the MBA and EMBA students who acted as the human leaders before the activity. All of the human leaders were required to provide feedback via electronic mail when their members shared any idea on GDSS during the activity. All of the human leaders were also required to turn in a copy of each electronic mail after the activity for statistical calculation. To manipulate the behavior of the virtual leaders, the researchers used the theory of motivating language to write three categories of mail scripts based on the members' low, medium, or high levels of participation. These electronic mails adopted direct-giving and empathetic language but left the member's name and the frequency of the member's idea sharing blank. In total, 12 mail scripts, representing the leader's behaviors, were used as input to the added GDSS system, and the mail scripts were automatically sent to the members at the end of each session according to their level of participation as shown on the TeamSpirit system for individuals. None of the members were informed of anything regarding the mail scripts to assure that all members perceived that the leadership behaviors derived from those mails.

3.3 Instruments

In the research, the type of leader was the dependent variable, and the leader behaviors and motivating language were assessed and manipulated so that they could be examined. The leadership effectiveness was defined as the independent variable.

3.3.1 Independent Variables and Manipulation Checks

Leadership Behavior. The number of electronic mail messages received for the individual members were calculated as the leadership behavior. Data were separately collected from the human leaders, including copies and the numbers of the electronic mail, and from the virtual leaders, including records on the added system of GDSS, after the end of the tasks. The added system developed by the researchers to simulate the virtual leaders could automatically send an electronic mail to a specific member according to timing, level of participation, and personal information. Moreover, the human leaders were classified as either proactive leaders, with higher levels of leadership behavior, or passive leaders, with lower levels of leadership behavior, for further analysis. In the calculation of all of the electronic mails sent by the leaders, the maximum number of mail messages received by an individual was 8 and the minimum number of mail messages received by an individual was 1, and 207 members (51.9%) received 5 mails. Table 2 compares the different leadership behaviors. According to the results of the t tests, which are used to examine the differences in the two-paired forms of leadership behaviors, the mean differences for the leadership behaviors between the virtual leader ($M = 5.00$, $SD = .00$) and the human leader ($M = 3.03$, $SD = 1.96$) are highly significant ($t = 14.85$, $p < 0.01$); the mean differences for the leadership behaviors of the human leaders between the proactive leader ($M = 4.71$, $SD = 1.34$) and the passive leader ($M = 1.36$, $SD = .62$) are also highly significant ($t = 23.79$, $p < 0.01$).

Table 2
A Comparison of Different Leadership Behaviors

Led by	Number	Mean	S.D.	df	t
Virtual leader	173	5.00	.00	220	14.85**
Human leader	221	3.03	1.96		
Proactive leader	110	4.71	1.34	152	23.79**
Passive leader	111	1.36	.62		

Note : * : $p < .05$; ** : $p < .01$

Motivating Language. Motivating language theory was introduced by Sullivan (1988); it is based on the strategic language used by leaders, and it proposes three types of motivating languages according to language behaviors or communications. The researchers reviewed the literature regarding motivating language from the most recent 10 years and found that strategic communication became an important tool for encouragement and positively affected performance and employee satisfaction (e.g., Mayfield *et al.* 1995; Sullivan 1988). Based on the Sullivan's theory, Mayfield *et al.* (1995) developed the Motivating Language Scale (MLS) to distribute the motivating languages used by leaders into three dimensions: direction-giving, empathetic, and meaning-making. Direction-giving language represents a leader trying to reduce uncertainty and facilitate employee performance through explicit definitions of tasks, goals, and rewards. The direction-giving measurement contains 10 items using a 5-point Likert scale, and the Cronbach's α value is .927 (N = 317). Empathetic language occurs when a leader expresses his caring, e.g., empathy and affection, to subordinates. The empathetic measurement contains 6 items using a 5-point Likert scale, and the Cronbach's α value is .921 (N = 320). Meaning-making language occurs when a leader explains the organization's features to a worker, including its culture, norms, and values. In the research, although all participants were assigned to the same tasks and received the same letter regarding the meaning and value of this task performance, the team culture, norms, and values might not be formed within just four weeks. Therefore, to reduce interference and further explanation of

variables, the researchers excluded meaning-making language and only adopted direction-giving and empathetic language to manipulate the motivating language of the leaders. Both direction-giving language and empathetic language were combined in a mail script before the experiment as the basis for the leadership behaviors of the virtual leaders. After the experiment, all participants were required to respond to the 16-item scale for direction-giving and empathetic language to provide the data for manipulating the motivating language of the leaders. Although the mail scripts of the virtual leaders were written based on MLT, the human leaders had to write their electronic mails personally, based on their understanding of MLT and according to the shared records of their members on GDSS. Thus, from the perspective of the substitute for leadership theory, the research suggested that there should not be a significant difference between the virtual leader and the human leader based on the perception of motivating language. The comparison of perceived motivating language between the virtual leader and the human leader is shown in Table 3. The results indicate that no significant differences were detected for either direction-giving language ($t = -.65$, $p > 0.05$) or empathetic language ($t = 1.36$, $p > 0.05$) between the virtual and the human leader.

Table 3
A Comparison of Perceived Motivating Language

ML	Leader	Number	Mean	SD	df	t
Direction-giving (N = 317)	Virtual	157	3.29	0.72	315	-.65
	Human	160	3.34	0.63		
Empathetic (N = 320)	Virtual	161	3.26	0.83	318	1.36
	Human	159	3.14	0.74		

Note : *: $p < .05$; **: $p < .01$

3.3.2 Dependent Variables

Creative Performance. Creative performance was assessed through two different measures. The first measure was the total number of ideas proposed during the two brainstorming sessions aggregated, and the second measure was the score of final report. The members submitted 266 reports (66.7% of members). Then, the final reports were scored on a 1 to 10 point scale by 2 study researchers. SPSS was used to conduct a T-test examination to verify the compatibility of the two activity outcomes, and the results indicated that no significant differences could be detected. Therefore, the researchers adopted the average score of the two activities to represent the creative performance.

Perceptions of Leadership. The perceptions were composed of respect, trust and satisfaction in the leaders. Respect represents the level of esteem that the members felt for their leaders. The research adopted 3 items using a 5-point Likert scale developed by Conger et al. (2000) to measure the level of respect for the leaders. The 3 items are "I hold him/her in high respect," "I have great esteem for him/her," and "I admire him/her as a leader" with a .528 (N = 321) Cronbach's α value. Trust was defined as the level of trust that the members felt for their leaders. The research had 3 items using a 5-point Likert scale that were assessed by Conger et al. in 2000 to measure trust in leaders. The 3 items are "I have complete faith in him/her" (Bass, 1985), "Sometimes I cannot trust him/her" (reverse scored; Butler, 1991), and "I can count on him/her to be trustworthy" (Butler, 1991) with a .774 (N = 321) Cronbach's α value. Satisfaction means the level of satisfaction that the members feel with their leaders. The research had 3 items using a 5-point Likert scale that were assessed by Conger et al. in 2000 to measure satisfaction with leaders. The 3 items are "I feel good when I am around him/her" (Bass, 1985), "I am satisfied that his/her style of leadership is the right one for getting our group's job done" (Bass, 1985), and "I am pleased (or satisfied) with his/her leadership" (Bass, 1985) with a .915 (N = 322) Cronbach's α value. The participants were sent 399 questionnaires, and 329 completed questionnaires were returned (82.5%).

3.3.3 Platform

The research adopted two platforms including a front system and a back system to simulate the virtual environment. The front system, TeamSpirit, was developed by Chen and Wang based on the concept of Creative Problem Solving (CPS) to measure objective data related to creative performance. TeamSpirit is a web-based group decision support system (GDSS) that coordinates those who are using it at different times and in different places with the feature of usage in different time and place, and can provide an online forum for sharing ideas and creative thinking without time and space constraints. Chen, Liou, Wang, Fan, and Chi (2007) have proven the benefits of TeamSpirit, including generating more ideas in groups, planning projects, and the ability to use the platform over the long-term through several experiments. During the experiment, TeamSpirit provided a platform for the operation of all of the virtual teams via the internet, and data could be gathered to assess the creative performance of individuals. The back platform linked with TeamSpirit is a customized additional system to play the role of the virtual leaders. The back platform followed the rules and agenda programmed into the system to calculate the frequency of individual idea sharing on GDSS. The system could also select the appropriate mail script and fill in the names and the frequency of idea sharing; the mail was then sent to individual members. The sending results were always recorded in the daily log. The added system was as reliable as the commercial system with the verification of examination and stimulation.

4. Results

To further observe the connection between the different types of leaders (leadership behaviors) and leadership effectiveness (creative performance and perceptions of leadership), the researchers conducted a T-test to validate the hypotheses proposed in the research.

4.1 Effects on Creativity Performance

Table 4 shows the influence of the leader behavior on creative performance; the results indicate that the mean differences for the effects on frequency of idea sharing ($t = 7.40, p < 0.01$) and the score of the final report ($t = 10.58, p < 0.01$) between the virtual leader and the human leader were highly significant. The mean score of the virtual leaders is even higher than that of the human leaders. To compare the two types of human leaders, the results indicated that the mean differences for the effects on the frequency of idea sharing ($t = 5.81, p < 0.01$) and the score of the final report ($t = 7.05, p < 0.01$) between a proactive leader and a passive leader were highly significant. In conclusion, hypothesis 1 and hypothesis 3 were supported.

Table 4
The Differential Comparison of Leader Behavior to Creativity Performance

	Leader	Number	Mean	SD	<i>df</i>	<i>t</i>
Frequency of idea sharing	Virtual	178	4.97	4.60	263	7.40**
	Human	221	2.11	2.57		
	Proactive	283	4.00	4.08	282	5.81**
	Passive	111	1.87	2.89		
Score of final report	Virtual	178	5.52	3.03	397	10.58**
	Human	221	2.52	2.63		
	Proactive	283	4.48	3.12	392	7.05**
	Passive	111	2.13	2.62		

Note : *: $p < .05$; **: $p < .01$

4.2 Effects on Perceptions to Leadership

Table 5 shows a comparison of the different leadership behaviors and perceptions of leadership. For the perception of respect, although no statistical significance was detected ($t = -1.03, p > 0.05$), the members perceived a higher level of respect for the human leaders ($M = 3.44, SD = .61$). For the perception of

trust, no statistical significance was detected ($t = -.13, p > 0.05$); however, the members also perceived a higher level of trust in the human leaders ($M = 3.26, SD = .76$). For the perception of satisfaction, no statistical significance was detected ($t = .36, p > 0.05$); however, the members perceived a higher level of trust in the virtual leaders ($M = 3.23, SD = .83$). In conclusion, hypothesis 2 was supported.

Table 5
The Comparison of Different Leadership Behaviors on The Perceptions of Leadership

	Leader	Number	Mean	S.D.	df	t
Respect	Virtual	161	3.37	.63	319	-1.03
	Human	160	3.44	.61		
Trust	Virtual	162	3.26	.76	319	-.13
	Human	159	3.27	.73		
Satisfaction	Virtual	162	3.23	.83	320	.36
	Human	160	3.20	.77		

Note: *: $p < .05$; **: $p < .01$

4.3 Summary of Validation

The validation for all of the hypotheses is summarized in Table 6. In hypothesis 1, the result indicates that no statistical significance was found for the followers' creative performance between the virtual leader and the human leader; thus hypothesis 1 was supported. In hypothesis 2, no statistical significance was found in the followers' perception between the virtual leader and the human leader; thus hypothesis 2 was supported. In hypothesis 3, a significant effect was found on the followers' creative performance between the proactive leader and the passive leader; thus hypothesis 3 was supported.

Table 6
Summary of Validation for all Hypotheses

H1	<i>The effect of a virtual leader on its followers' creative performance will be equal to or better than that of a human leader.</i>	Supported
H2	<i>The effect of a virtual leader on its followers' perceptions will be equal to or better than that of a human leader.</i>	Supported
H3	<i>The difference in the impacts on the followers' creative performance between a proactive leader and a passive leader will be significant.</i>	Supported

5. Conclusions

The goal of this research was primarily to assess the influences of different leaders on leader effectiveness in a virtual environment. Altogether, 106 teams, all consisting of college students, were organized to conduct the experiment. The members of the same team had to interact through a series of low-structure discussions that were conducted electronically via the GDSS to perform an assigned creative task. After completion of the task, the researchers observed the individual creative performance through the GDSS records and surveyed the perceived leadership of all of the members including the presence of motivating language, respect, trust, and satisfaction. According to the statistical analysis, the researchers propose a discussion of the results, their contributions, the study's limitations, and suggestions for further research.

5.1 Discussion

In the study, the researchers obtained values for the frequency (the quantity of electronic mails) and intensity (the quality of motivating language) of the leadership behaviors to examine the independent variables. The quantity of mails providing feedback from the leaders revealed the frequency of the leadership behaviors. The results indicated that the frequency of communication from the virtual leaders was greater than the frequency from the human leaders. This

advantage might stem from the programmed rules of the virtual leaders. However, the features, e.g., diversity, flexibility and thinking, of the human leaders were the greatest weakness for virtual leaders when the virtual leaders responded to the members for encouraging ideas. The quality of the motivating language offered by the leaders revealed the intensity of leadership behaviors. The results under a situation where the types of leaders were not announced indicated no difference between the intensity of the virtual leaders and the intensity of the human leaders. In other words, when the members were geographically dispersed in a virtual environment and unable to communicate face-to-face, their sense of perception regarding their leader's behaviors might be blind. Furthermore, the influence of the virtual leaders on the creative performance of the individuals including quantity (the total number of ideas shared) and quality (the score of the final report) was significantly higher than the influence of the human leaders. These results might be caused by the manipulation of the virtual leaders, who performed proactive leadership behaviors. The same results were obtained from the human leaders when comparing the proactive and the passive leadership behaviors. The results implied that even in a virtual environment, more proactive interaction from leaders can facilitate the creative performance of individual group members.

According to the results regarding creative performance and the perception of leadership behaviors, the research provided evidence that the substitution of human leaders with virtual leaders is possible in the virtual environment. The results also imply that virtual leaders will emerge sooner or later. The research suggested that the existence of virtual leaders can be meaningful, particularly for certain routine tasks. The effects of the virtual leaders were equal to or even better than the effects of the human leaders. However, the researchers do not imply that the virtual leaders could completely substitute for the human leaders in a virtual environment. Human leaders have some features, for instance wisdom and flexibility, that allow for quick response and the ability to address complicated interactions with members. In spite of the rapid development of technology, artificial intelligence (AI) is still in an immature stage. The researchers argue that the role of human leaders could not be completely replaced, only some specific routine tasks. In addition, a leader should proactively interact with their members

via computer mediated communication (CMC) technologies to create better performance for the individual members of a virtual team. The future program design of virtual leaders should seek for a better team performance.

5.2 Contributions and Implications

Previous laboratory studies on leadership (Kahai *et al.*, 1997; Kahai *et al.*, 2003; Kahai *et al.*, 2004; Sosik *et al.*, 1997; Sosik *et al.*, 1998) were manipulated in the same time and at the same place within an experimental period of 90 to 180 minutes on GDSS. In this study, the researchers operated the experiment within 2 weeks and assigned the tasks in a virtual environment. Therefore, the members of the virtual teams worked at different times and in different places to accomplish the tasks together on the web-based GDSS. In addition, previous experiments only organized human leaders to command the virtual teams. To bring this experiment much closer to the reality, this research used virtual leaders to select the appropriate mail scripts according to individual performance via an added system and to send these messages automatically to members. Furthermore, the researchers found that the proactive leadership behaviors were much better than the passive leadership behaviors at enhancing individual performance in a virtual environment. These findings help us to understand virtual leadership in these electronic contexts.

Because of the progress of information technology, this study offers the suggestion that computer systems can substitute for a part of the leaders' tasks. If business could sufficiently employ computer systems to provide adequate assistance, for instance, a reminder of a routine task, an immediate brief response, or the computation of complicated data, it would reduce costs and even improve team performance. Therefore, when a short-termed virtual team is built, a real leader does not need to manage everything but can share some burdens with the computer system. The computer system can help to supervise the team, to trace progress, and even to provide feedback according to individual behaviors. The real leader will then not need to spend too much time monitoring the team. In addition, the existence of virtual leaders can reduce the risk of poor leader-member fit and the time required for adaptation. In the meantime, virtual

leaders can increase the emotional stability for individual members in the virtual team.

5.3 Limitations and Suggestions

There are several limitations of this study. Firstly, the features of the samples might limit the generalizability of the findings. The inter-collegial student teams in Taiwan were not inter-cultural teams. The student participants never interacted and had no experience in performing tasks on GDSS before the experiment. In practice, different features or different cultures can cause organizational teams to generate different results. Certainly, the level of experience in performing tasks on GDSS can also affect the results. Another limitation was that the researchers adopted the scores of the final reports to verify leadership effectiveness. Although the researchers had addressed issues of participation by having participation account for 10% of the semester final score, only 66.7% of the students completed and submitted the final reports. The third limitation is that although the added system could manipulate the leader's behaviors by automatically sending mail scripts electronically that addressed the individual quantitative performance, the system was not able to behave as a human leader to distinguish the qualitative performance and to communicate with the members. It is necessary to further discuss the function of the system, although it is difficult to systematize human wisdom and experience, i.e., artificial intelligence, in a short time. It is worth noting that the researchers were not able to exclude the misjudgment of a piece of electronic mail as spam, which might induce a certain level of interference in the measurement of leader behaviors. As a further suggestion, the validation of E-mail accounts could be included in the experimental procedure to secure the completeness of the data on leader behaviors.

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