Comparative Analysis of the Use of Mobile Microblogging and Nonmobile Online Message Board for Group Collaboration

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ABSTRACT: Microblogging (e.g., Twitter) used in tandem with a mobile device as one integrated unit is rapidly emerging as the preferred choice for group communication among mobile users. To better understand this phenomenon and leverage its potential, more empirical studies are required. In this study, we empirically examine the saliencies of mobile conversations and user experiences of mobile microblogging via Twitter on a mobile device (TMD), in a comparative analysis including nonmobile online message boards (OMB) by using a participant pool of 423 business students. Mobile-mediated communication is presented as a subdomain of computer-mediated communication and used in describing TMD conversationality. The experiment revealed significant differences in the process-related messages, communication satisfaction, and perceived outcome of TMD small group communication compared to those of OMB. These results imply that Twitter mobile can be an effective group communication tool in an ad hoc dispersed small group setting.

KEY WORDS AND PHRASES: Communication affordances, microblogging, mobile communication, mobile-mediated communication, Twitter.

Background and Motivation

Technological influences are integral to many processes in our society. Sometimes, their influences can be so profound that they can even replace certain long-standing conventional practices. For example, social media and the use of mobile devices are ostensibly transforming personal and business communication and data-sharing practices in many ways [3, 21, 33, 59]. These technologies enable people to communicate more dynamically and to make more connections than ever before.

The Telecommunications Industry Association reports [61] that mobile services spending in the United States increased by a walloping 1,700 percent from 2005 to 2013 and is expected to be at 2,700 percent by 2016. Moreover, global shipments of smartphones and tablet personal computers (PCs) (e.g., the iPad) surpassed sales of desktop and notebook PCs back in 2011, and in 2013 the difference in sales doubled [42]. Thus, industry reports and research statistics indicate that significantly more data access than voice communication is occurring than ever before, and more mobile devices than nonmobile devices are being used to accomplish our purposes.

These new technologies have created a more liberal and active ecosystem in which users may voice and share personal thoughts and opinions. The Pew Research Center [32] reports that 73 percent of wired American

International Journal of Electronic Commerce / Summer 2015, Vol. 19, No. 4, pp. 112–135.

ISSN 1086–4415 (print) / ISSN 1557–9301 (online)
DOI: 10.1080/10864415.2015.1029360

young adults now use social networking websites. Recent business reports reveal that out of 241 million monthly active Twitter users, 184 million are mobile users (76 percent), 75 percent of advertising revenue is from the mobile users and 71 percent of users access Twitter and other social media from a mobile device [6, 50]. "Going mobile" is not only the major trend among users but also the prime target among business organizations.

Among the various social media available to users, microblogging stands out as a leading trend. Each year, more and more people become microbloggers [32]. Many business organizations are strategically integrating microblogging functions into their enterprises [19, 53]. Although microblogging and mobile devices are complementary rather than codependent technologies, more and more people are identifying the two as one, and more and more users are taking advantage of the synergistic effects of these two technologies when they are used in tandem. This fact is supported by the recent business reports mentioned earlier.

Communication via microblogging on a mobile device may differ in many ways from other forms of communication. The most noticeable difference is mobility. Constant changes of location and surroundings can influence a person's cognitive process and can affect a person's mobile conversation. Another difference is the technology. The easiness of thumb-driving touch technology of today's smartphones and mobile devices invites frequent access and affords more connections. These differences may be amplified in various contexts, such as in a group collaboration with a group task due date. Users can actively discuss and collaborate on a given task for its due date. One may expect some conflicts, disagreements, or compromises from the group.

This study aims to investigate those group dynamics and capture the group communication saliencies using Twitter on a mobile device for communication. In addition, it evaluates user behavior, experience, and perception. The study also provides a theoretical framework, mobile-mediate communication (MMC) and communication affordances that may provide plausible explanations and interpretations for mobile microblogging communication. To our knowledge, this is the first study of its kind—we find no studies that have focused on mobile device and microblogging as an integrated single unit. Copious studies have investigated microblogging, mobile technology, and computer-mediated communication separately, but very few studies have examined communication via microblogging on a mobile device. The increase in communication using these two technologies in tandem is expected to continue. Therefore, this progressive study and its results are timely and helpful for future research.

Research Framework

Defining the Boundaries of the Technologies

For the purpose of this study, it is imperative to clearly define the exact *boundaries* of the technologies and why they are framed as they are. Two

different social communication technologies—microblogging via Twitter and communicating via online message board (OMB)—and two different platforms—mobile and nonmobile—are presented here. Each provides its own unique services and benefits to users. Each technology can also be coupled with either of the platforms (e.g., microblogging on a mobile or nonmobile device and OMB on a mobile or nonmobile device).

Both microblogging and online message board applications have notable attractions. For example, OMB applications may facilitate microblogging through notification protocols such as Really Simple Syndication. Similarly, a microblogging application may exhibit some OMB features, such as the listing of all exchanged tweets on the Twitter board.

These days, more and more people prefer to do their microblogging on a mobile device rather than on a nonmobile PC [4, 6, 27, 57]. The convenience and efficiency of microblogging on a portable mobile device in thumb-drive navigation mode has certainly made it popular. The Twitter company reports an increase in the number of people using Twitter on mobile platforms and more engagement of users in communication and information sharing than nonmobile platform users [54]. We investigate these recent developments and trends in this study. However, we examine microblogging on a mobile device as one singly integrated unit; we do not examine them separately. In addition, we consider only the primary functions of microblogging and OMB applications, not other features that include new or enhanced extra third-party features.

OMB on a nonmobile device (e.g., a desktop computer) has been discussed in many computer-mediated communication (CMC) studies in recent years. Several studies on microblogging and mobile platforms also exist [8, 13, 33]. The findings and contributions of these studies are significant. However, no comparison between microblogging on a mobile device (mobile platform) and OMB on a desktop PC (nonmobile platform) has been conducted. In addition, no research has compared microblogging on a mobile platform versus a mobile device.

This study has both theoretical and practical merits. Most CMC studies are based on nonmobile desktop computers, but for a long time, the nonmobility of CMC was not conspicuous; it was mostly assumed to be a normal part of the CMC environment. In many cases, CMC was equated with OMB on a nonmobile PC. In keeping with the terminology of previous studies, microblogging on a mobile device may be perceived as "mobile-mediated communication" (MMC). Hence, in this study, we compare CMC with MMC. MMC—in this study, Twitter on a mobile device—is a different communication process and experience for users than CMC, largely due to its mobility and immediacy. Differences in behaviors of users of these types of technology are a focus of this study.

Research on Small Group Decision Making

Internal and external factors pertinent to small group decision making, or small group study, have been examined extensively in previous research.

Some internal factors include team size, dispersion, member familiarity, member attributes, member interaction, duration, anonymous identity, gender, number of meetings, social influence, relevant background, and conflicts [18, 28, 60].

Several studies point to the fact that the choice of technology makes a significant difference in group performance or output. For example, Alavi [1] studied group decision support system (GDSS) collaborative learning and found an association with higher levels of perceived skill development, self-reported learning, and positive evaluation of classroom experience in comparison with non-GDSS collaborative learning.

In an investigation of more than 200 major empirical studies on group collaboration, Fjermestad and Hiltz [18] found more positive evaluations when CMC systems were used for group decision-making tasks and group support systems (GSS) were used with tasks related to idea generation. Strauss and McGrath [60] compared CMC and face-to-face interaction in the group context using cognitively different tasks, and found significant interactions and productivity differences between groups using these two communication media. Similarly, Hollingshead, McGrath, and O'Connor [28] compared performance in groups using CMC and working face to face using cognitively different tasks (creative, intellective, decision-making, and negotiation tasks). They reported that use of CMC significantly affected team performance. In that study, significantly superior group performance was observed in groups completing certain cognitive tasks through face-to-face interaction. Other similar studies [15, 16, 28, 40] also point to the fact that technology plays a significant role in the success of group performance or output.

In summary, studies of CMC in small groups have covered a number of influencing factors extensively. The chosen technology or technology platform significantly affected overall progress and output of group collaboration in completing a task. In certain situations, a technology such as GDSS is a key enabler for output maximization.

Research on Mobile Microblogging

Since the debut of social media, several studies have examined social media and their influence. In this study, we narrow our survey to research performed on microblogging and mobile applications. In its incipient period, research in this area centered on the definition of microblogging and its most immediately obvious attributes [20, 41]. With the recent exponential growth in use of social media, researchers have begun writing on more diverse topics, including structures [9, 45], social behaviors [58], enterprises [19], education [12, 34], use of social media in emergencies [26, 46], and marketing [30, 31]. The diverse findings of this research manifest the potency and versatility of microblogging.

The most outstanding feature of microblogging, according to previous studies, is its mobility [17, 52, 56]. Although other features and attributes of microblogging software applications have been studied, research on

mobility has facilitated our understanding of this social medium in new ways. For example, studies on the spatial and temporal aspects of microblogging lend a multidimensional aspect to the discussion. Field and O'Brien [17] presented a framework labeled "cartoblography," which is mapping of the spatial context of microblogging. The added spatiotemporal indices of cartoblography bring rich information about how users engage in initiatory conversations.

Perreault and Ruths [49] studied 2,000,000 tweets from 154,311 distinct Twitter users using both mobile devices and desktop PCs. Mobile platform users were reported to have more personal content in their more numerous tweets, to initiate and maintain more conversations, to share tweets that were more often directed at an individual (an important feature of starting or maintaining conversations), and to be more active in their microblogging communities. In explaining these tendencies of mobile platform users, the authors pointed to two factors: a low barrier to accessing the microblogging application via mobile platforms, and changing contexts due to mobility. The study concluded that the mobile platform profoundly influences the behaviors of microblogging users. An important implication of this study is that the ease of access affects not only frequency but also the content of communication.

Honeycutt and Herring [29] studied 36,987 public access tweets from the Twitter.com website collected at four one-hour intervals—6 a.m., 10 a.m., 2 p.m., and 6 p.m. They focused on conversational interaction for the purposes of collaboration. They reported that the tweets exhibited a high degree of conversationality that reflected the friendly environment required for group collaboration. The authors stated that "microblogging has the potential to add lightweight, mobile access to a repertoire of older CMC tools that are bound to a computer" [29, p. 9].

Several business reports describe the recent surge in Twitter mobile use and the transforming nature of the mobile ecosystem. Twitter provides the following information on current trends in Twitter mobile user behaviors [54]: Twitter mobile users are 47 percent less likely to use Twitter on a desktop computer than the average Twitter user, 79 percent more likely to be on Twitter several times a day than the average Twitter user, twice as likely to use Twitter when they wake up, 181 percent more likely to use it when commuting, 119 percent more likely to use it at work or school, three times more likely to use it while shopping, and twice as likely to use it when going to sleep. In addition, 57 percent of Twitter mobile users communicate with people near them via Twitter, and 46 percent of Twitter mobile users are more likely to compose original tweets than the average Twitter user. A report dated October 2013 stated that 75 percent of active Twitter users access the site from mobile devices [38]. Most studies of microblogging emphasize the mobility attribute, which adds a substantial dimension to the discussion on this social media phenomenon. However, no mobile microblogging studies have focused on the dynamics and interactions of mobility and conversationality in group decision-making processes.

The Concept of "Communication Affordances"

The technology affordances and constraint theory (TACT) refers to "action potential, that is, … what an individual or organization with a particular purpose can do with a technology" [39]. Studies based on this theory point to the possibilities and potential of an optimal ecosystem constituted by actors, environments, objectives, and technology [35, 55]. Conceptualized by the ecological psychologist James Gibson, an action potential is defined as "the affordance of anything [that] is a specific combination of the properties of its substance and its surface taken with reference to an animal" [22, p. 67].

Gibson explains this by saying "the affordance may be more easily perceived by an animal than the property in isolation, for the invariant combination of properties is 'meaningful,' whereas any single property is not" [22, p. 68]. He describes the actor, who realizes the meaningful combination. Similarly, Majchrzak and Markus [39] define the concept of technology affordance in the context of an action potential, that is, "to what an individual or organization with a particular purpose can do with a technology or information system." When the available technologies exhibit the potential for a similar affordance, the question then turns to the level of affordance. The actor quickly analyzes the available technologies, selecting two that fit best and are perceived to have a high affordance level, in order to achieve his or her goal.

According to TACT, the communication affordances concept may be developed by specifically focusing on the communication technology. There are three major categories of communication technology: FtF (face-to-face), CMC, and mobile communication. For mobile communication, we herein coin the term "mobile-mediated communication," or MMC. For each category, the communication platform, message-conveying process, and effort or cost are all expected to be different. Castells, Fernández-Ardèvol, and Qiu [7] categorized the characteristics of mobile communication user behavior. To build on this work, we add the unique features of mobile microblogging to the six categories of communication affordances. Each category can also be used to measure the performance of a target technology. The measured constructs are: synchronicity (SYN), deindividuation and copresence (DCP), accessibility readiness (ARD), information filtering (IFT), cognizance of change in the external environment (CEV), and number of sessions (NMS). These six constructs are elaborated below.

Synchronicity (SYN): Synchronicity is the degree to which two-way communication between two or more parties is seamless and trouble-free. FtF is a good example of high-level synchronicity, whereas nonmobile CMC is lower and TMD can be either high or low, depending on the context.

Deindividuation and copresence (DCP): This refers to the phenomenon wherein users may be active or inactive in one or more live meetings without much hindrance. For example, they may simply watch the screen, "eyeing" the incoming messages without responding, while replying back to others in a different setting. A user may even be engaged in two or more online

Table 1. Communication Affordance Measures.

	SYN	DCP	ARD	IFT	CEV	NMS
MMC	High/Low	High	High	High	High	High
CMC	Low	Medium	Medium	High	Low	Medium
FtF	High	Low	Low	Low	High	Low

Notes: ARD–accessibility readiness; CEV–cognizance of change in the external environment; CMC–computer-mediated communication; DCP–deindividuation and copresence; FtF–face-to-face; IFT–information filtering; MMC–mobile-mediated communication; NMS–number of sessions; SYN–synchronicity.

meetings simultaneously without other participants in the meetings knowing or noticing his or her absence. FtF scores low for DCP, whereas MMC is high and nonmobile CMC is in the middle.

Accessibility readiness (ARD): This phrase refers to ease of access to or sending of a message. TMD scores high for ARD with its pocket-size portability, mobility, and instant accessibility. FtF scores low because people must actually meet each other in order to start an exchange.

Information filtering (IFT): This measurement refers to the ability to filter out any undesired or unnecessary information in a given session. Users of CMC and MMC software applications can easily set a filtering function, but those communicating FtF cannot. CMC and MMC are therefore high, and FtF is low.

Cognizance of change in the external environment (CEV): This construct refers to awareness of the surrounding environment and changes in it over a given time period. MMC and FtF yield a high level of CEV, but nonmobile CMC scores low.

Number of live sessions (NMS): This item reflects how many live sessions can be supported in a particular medium. MMC is high because multiple live sessions may be held simultaneously, whereas FtF is low. CMC falls between the two.

The term "communication affordances" refers to the combined levels of these six measures. Table 1 illustrates the levels of communication affordances for MMC, nonmobile CMC, and FtF.

The overall level of communication affordance is a measure of the output of these six constructs. Thus, for every form of MMC or CMC, measurement levels can vary. For TMD, the measurements are as follows: SYN = high/low, DCP = high, ARD = high, IFT = high, CEV = high, and NMS = high. Generally, high levels indicate high communication affordance, and low levels indicate low communication affordance.

Hypotheses Development

The concept of communication affordances explains how a particular communication technology allows a user to achieve a communication goal and perceive the possibilities of using the technology. In a study of CMC,

Fjermestad and Hiltz [18] reported that in a decision-making group setting, a communication tool or platform can be significant for group collaboration. In this study, we show that TMD is equipped with all the communication affordances. Microbloggers using TMD may therefore have many advantages over conventional CMC technology such as the nonmobile OMB.

In their studies, Honeycutt and Herring [29] and Perreault and Ruths [49] reported that mobile microbloggers initiate more conversations in a more conversation-friendly atmosphere than during communication via a desktop PC, largely due to mobile accessibility. Because mobile microbloggers carry their mobile devices throughout the day and therefore have easy access to them [54], their thoughts and cognitive input can be easily conveyed in group decision-making contexts [62]. The high-level values for ARD and CEV support this assertion. Mobile microbloggers are reportedly more likely to send more original or initiatory tweets or messages [54]. An initiatory tweet is one that initiates a new, meaningful discussion thread that differs in value from the preceding conversation. It triggers a series of ensuing tweets that ultimately add value to the overall discussion.

Users of mobile devices enjoy a spontaneity that is not always possible with desktop PCs, synchronicity value being high and low. They can exchange process-related tweets in clarifying their next move and solving their given problem, which expedites the group decision-making process. Many tasks are easier to accomplish in synchronous mode. Mobile microbloggers may also have more lively, free discussions, agreeing and disagreeing on a wide variety of topics. In addition, we expect that mobile microbloggers would use the communication affordances of TMD in more lively communications of various kinds than would nonmobile OMB users. Thus, we hypothesize that:

> ***Hypothesis 1:*** *Mobile microblogging TMD users will engage in significantly more lively communication than nonmobile OMB users.*
>
> ***Hypothesis 1a:*** *Mobile microblogging TMD users will send significantly more initiatory messages than nonmobile OMB users.*
>
> ***Hypothesis 1b:*** *Mobile microblogging TMD users will send significantly more process-related messages than nonmobile OMB users.*
>
> ***Hypothesis 1c:*** *Mobile microblogging TMD users will experience a significantly livelier discussion than nonmobile OMB users.*

Based on the arguments related to H1, we also postulate about communication affordances and the suitability of microblogging for convergence communication processes.

In this study, we also posit that mobile microblogging influences the user's experience. Ocker and Yaverbaum [44] reported that use of a synchronous medium results in a significantly higher satisfaction level than use of an asynchronous medium. Previous CMC studies have shown that interactivity in group communication affects communication

quality, which, in turn, affects communication satisfaction [36]. Li, Berens, and De Maertelaere [33] speculated that users of Twitter in a collective setting would be more engaged when assigned to a specific purpose or task. Given that mobile devices accommodate a significant amount of interactivity among users compared to OMB on a PC, mobile microblogging users are expected to experience greater communication satisfaction.

The subjective or perceived user experience is another important dimension. Chen [8] and Coursaris, Yun, and Sung [13] reported that gratification is a significant factor and a driving and sustainable force for users of Twitter. Users feel gratified when they receive timely tweets and replies from others. Many users continue to use Twitter and recommend it to others based on these feelings. Pentina et al. [48] point to the positive effect of perceived quality of user and social media interactions on associated products or outcomes. Technological self-empowerment and exercising of unique communication affordance attributes induce more user engagement [33] and improve the quality of the outcome [48]. Studies have shown that solving problems in small groups also positively influences user engagement [47]. Given these circumstances, we hypothesize that:

> ***Hypothesis 2:*** *Mobile microblogging TMD users will have a more favorable group communication experience than nonmobile OMB users.*
>
> ***Hypothesis 2a:*** *Mobile microblogging TMD users will exhibit a significantly higher level of friendliness than nonmobile OMB users.*
>
> ***Hypothesis 2b:*** *Mobile microblogging TMD users will experience a significantly higher level of communication satisfaction than nonmobile OMB users.*
>
> ***Hypothesis 2c:*** *Mobile microblogging TMD users will experience a significantly higher-quality perceived outcome than nonmobile OMB users.*

Research Methodology

Setting Up the Experiment

The major logistical steps involved securing the participant pool, setting up the group, designing tasks, validating the instrument, administering the experiments, and analyzing the data. These steps are elaborated below.

Securing the participant pool: Because this study was undertaken to elucidate how business professionals conduct their group communication and decision-making processes using microblogging on a mobile device, we felt that MBA students provided an ideal participant pool. A typical MBA student is a full-time working business professional attending an MBA program. Undergraduate students were also recruited. Participants were recruited through on-campus advertisements and in-class announcements.

This experiment was conducted at two universities. To control for variations between them, "university" was set as a control variable. In all, we secured a total of 423 participants (Table 2), among whom 128 were MBA students and 295 were undergraduate students. MBA and undergraduate participants were not mixed in the groups. This program-level difference was also set as a control variable. The participants were compensated with a course credit in return for their voluntary participation in the experiment.

Setting up the groups: A preliminary participant background check was performed to obtain background information about participants' experience with the technologies examined in this study. This assessment indicated that all participants were well-informed about microblogging, mobile devices, OMBs, and PCs. Due to their equal status and ability in terms of technology, the participant pool was divided into two tracks randomly: the groups of users of Twitter on a mobile communication device (TMD) and the users of Google Groups, an OMB application, on a fixed-location PC (OMB). Google Groups (http://groups.google.com) offers a full set of user-friendly OMB features, making it an ideal choice for our study. In the grouping process, in addition to the education level, university, and program-level variables, a special effort was made to control for any compounding factors such as gender, university major, or age.

Designing tasks and validating the instrument: Two pilot experiments were conducted in order to fine-tune the experimental procedures and verify the precision of the instrument. Choosing an appropriate task is important because it is the focus of group communication and discussion. Altogether, six tasks—University Ethics Committee [60], McDonald's (Harvard case study #9-303-098), Noble Industries [11], Zappos, Radio Frequency Identification, and Starbucks problems [51], pp. 201, 251, 263]—were adopted in the pilot experiments to evaluate their appropriateness for the main experiment.

Among the six tasks included in the pilots, two tasks—Noble Industries and Starbucks—were selected for the main experiment. The selection was based mainly on two factors: diversity of tasks and the number of messages exchanged. The two tasks were significantly different in terms of required actions and equivocality of the problem, which, according to the Media Synchronicity Theory (MST) [14], are the two major factors determining level of conveyance/convergence of tasks. On the other hand, these two tasks generated almost equal numbers of messages on average, which makes their comparison more valid than that of other tasks. Employing two polarized tasks—conveyance and convergence—ensures the balance and internal validity of the study. These contrasting tasks aid in preventing task-biased results while conforming to the study's objective.

Administering the Main Experiment

In the main experiment, thirty-three groups were assigned to the Noble Industries task and thirty-two groups to the Starbucks task. The main experiment was carried out according to the following steps:

Table 2. Subjects, Groups, and Messages Coded.

	Pilot I						Pilot II			Main Experiment						
	University A			University B			University A			University A			University B			
	OMB	TMD	Total	OMB	TMD	Total	OMB	TMD	Total	OMB	TMD	Total	OMB	TMD	Total	Total
No. of participating subjects	24	15	39	38	46	84	22	22	44	102	67	169	27	60	87	423
No. of participating groups	6	4	10	10	12	22	6	6	12	25	17	42	7	16	23	109
# of Completed subjects	24	8	32	29	36	65	15	14	29	57	34	91	20	42	62	279
No. of completed groups	6	2	8	10	12	22	4	4	8	16	9	25	7	11	18	81

Notes: OMB–online message board; TMD–Twitter on a mobile communication device.

1. According to their assigned communication technology track, the participants were asked to set up new accounts either for Twitter for the TMD group or Google Groups for the OMB group.
2. The participants were asked to validate the in-group members' accounts by exchanging a few "Hello" messages.
3. Both the TMD and OMB groups were private and inaccessible to outsiders for security reasons.
4. A ten-day period was allowed for discussion of the task and submission of a final solution. During this period, the experiment facilitator reminded participants only to use their assigned technologies.
5. Upon completing their tasks, participants completed an online post-experiment questionnaire.
6. All tweets, replies, direct messages, and posted messages from Twitter and Google Groups were collected for analysis.

The participants were firmly advised about the significance of using the assigned communication mode. They were asked to notify any tweets that were inadvertently sent by using an incorrect communication mode or device.

During the experiment, a few participants dropped out. If a group had fewer than three members, then the results for that group were excluded from the final analysis. In the end, twenty-two groups—ten TMD and twelve OMB—had completed the Noble Industries task and twenty-one groups—ten TMD and eleven OMB—had completed the Starbucks task.

Results

For analysis of the data obtained in the main experiment, any outliers or values over three sigmas were eliminated. More specifically, one TMD group with an abnormally small number of words per message (8.2) and one OMB group with an excessively high total number of words (2,828) were eliminated. The researchers reexamined these groups' messages to identify the causes of this anomalies. The TMD group spent most of the time in personal conversation rather than working on the given task, which resulted in significantly shorter messages. The OMB group had several messages obviously copied from external sources such as consulting reports and research papers, which resulted in a message volume greater than those of the other teams. Consequently, these two data points were eliminated. In the end, data for forty-one groups were available for the final data analysis.

Analysis of the Messages

From the TMD group, we identified and collected all tweets, retweets, direct messages, and replies. From the OMB group, we downloaded and collected all posted messages and replies. Hereafter, the term "message" is used to

refer to tweets, retweets, direct messages, and replies on Twitter and posted messages and replies on the OMB.

For the descriptive data analysis, we coded and counted the number of messages and words. For Twitter, in some cases, several tweets were used to transmit long messages because of the 140-character limit. If we had counted these divided messages separately and compared them with the messages from the OMB groups, the number of messages from the TMD groups would have been inflated. For compatibility with the OMB group, therefore, these divided messages were merged into one message if the coders agreed that these tweets represented a single message divided due to the 140-character limit. The coders were four information systems (IS) graduate students trained in multiple practice sessions (more details about coding methods are provided in the following section). Messages from the OMB groups were crawled by group and analyzed using the same method as that used for the messages from the TMD groups.

Number of messages: The word and message counts were analyzed per technology (Table 3). The TMD group produced more messages and used fewer words than the OMB group.

Message coding: The messages were coded to identify various types, including "initiatory," "friendly," "agreeing," and "disagreeing" messages. An initiatory message was defined as a new task-related message initiated by a group member to start a new conversation (e.g., "Harry should be next and then Tom and Phil"). If a message contained an emoticon or a specifically friendly expression such as "how nice!" or "good job!" it was coded as a friendly message. A message with specific words expressing agreement or disagreement was coded as an agreeing or a disagreeing message. If a message dealt with logistics such as the schedule of task completion or the division of work, it was coded as a "process-related" message.

Because of Twitter's 140-character limitation, the TMD users sent a significantly higher number of messages than users of the OMB. Therefore, we considered use of the ratio measure to be a reasonable and unbiased method for comparison. For example, if a group had 3 initiatory messages out of a total of 30 messages, 0.1 (= 3/30) was entered as the measure for initiatory messages for the group.

Coders included a panel of four graduate students majoring in Information Systems. The coders were trained in five rounds of practice-coding sessions. In each coding session, they independently coded messages by type (e.g., initiatory, agreeing/disagreeing process-related, etc.) from a sample message set (including both TMD and OMB messages) and the

Table 3. Word and Message Counts (per Group).

Groups		Word count	Message count	Words per message count
Technologies	TMD	679.5	29.8	29.4
	OMB	1,122.7	14.5	105.2

Notes: OMB–online message board; TMD–Twitter on a mobile communication device.

results were compared afterward. Any differences were reconciled through discussions. At the end of the five practice sessions, the intercoder reliability was 0.97.

Another effect of Twitter's 140-character limitation is that people sometimes divide a long sentence into multiple tweets when using Twitter. If these multiple tweets were counted separately, the data analysis results would be biased and obvious. As a part of the message counting procedure, the coders also made decisions as to what tweets should be merged during the five practice-coding sessions. Any disagreements were resolved through discussion. The coders were instructed to examine the messages of tweets and their time stamps carefully to determine whether they formed one long sentence.

General linear model analysis: A general linear model (GLM) analysis was carried out on the data sets. The independent variable was technology type —TMD and OMB. We controlled for the group size—set as a covariant because some groups had three or five members instead of four—and different university—set as a covariant because the participants were from two different universities. Task type (Noble Industries or Starbucks) was also controlled.

Table 4 provides a summary of the analysis results. TMD users sent significantly fewer initiatory messages than OMB users. Although TMD users sent significantly more initiatory messages in terms of absolute numbers, a significantly smaller percentage of initiatory messages was sent overall ($F = 7.0$, $p < 0.05$). Thus, H1a (*Mobile microblogging TMD users will send significantly more initiatory messages than nonmobile OMB users*) was not supported. TMD users sent a significantly higher percentage of process-related messages ($F = 6.1$, $p < 0.05$), which supports H1b (*Mobile microblogging TMD*

Table 4. Message Analysis Results (Comparison of Technologies).

Dependent variables	*F*-values	Notes
Message count	13.5**	❖ The TMD users sent significantly more messages (29.8) than the OMB users (14.5)
Words per message	27.7**	❖ The TMD users included significantly fewer words per message (29.4) than the OMB users (105.2)
Ratio of initiatory messages	7.0*	❖ The TMD users sent significantly fewer initiatory messages (0.41) than the OMB users (0.53)
Ratio of process-related messages	6.1*	❖ The TMD users sent significantly more process-related messages (0.33) than the OMB users (0.26)
Ratio of agreeing messages	4.7*	❖ The TMD users sent significantly fewer agreeing messages (0.09) than the OMB users (0.20)
Ratio of disagreeing messages	0.5	❖ Not significant
Ratio of friendly messages	5.6*	❖ The TMD users sent significantly fewer friendly messages (0.22) than the OMB users (0.44)

Notes: *Significant at $\alpha = 0.05$; **significant at $\alpha = 0.01$.
OMB–online message board; TMD–Twitter on a mobile communication device.

users will send significantly more process-related messages than nonmobile OMB users). Table 4 shows that TMD users sent significantly fewer agreeing messages, and that the number of disagreeing messages is not significantly different between groups. Therefore, H1c (*Mobile microblogging TMD users will experience a significantly livelier discussion than nonmobile OMB users*) was not supported. The percentage of friendly messages was significantly lower for TMD users than for OMB users. Therefore, H2a (*Mobile microblogging TMD users will exhibit a significantly higher level of friendliness than nonmobile OMB users*) was not supported.

Analysis of the Post-Experiment Questionnaire

The post-experiment questionnaire was designed to measure the levels of communication satisfaction and perceived quality of outcome. From the groups that worked on the Starbucks task, forty-three questionnaire responses were obtained, and from the groups that worked on the Noble Industries task, forty-two questionnaire responses were obtained. After a few invalid responses had been eliminated, eighty-five responses were used in the final analysis.

Comparison of the t-test results: To ensure the instrument's validity and reliability, a factor analysis was conducted using the principal component method. Items with factor loading values less than 0.5 were removed. One item ("The group's movement towards reaching a conclusion on the discussion question, under the circumstances, was significant") from the communication satisfaction construct was removed due to its low factor loading value. The finalized constructs and items, their corresponding Cronbach's alpha values, and *t*-test results are reported in Table 5. The factor scores of the two constructs were used as dependent variables in the subsequent analyses. Significant differences were observed for communication satisfaction and perceived quality of outcome between the users in the OMB and TMD groups. TMD users expressed significantly higher communication satisfaction and perceived quality of outcome than OMB users.

Comparison of the GLM results: In the comparison of results obtained using the GLM, the main independent variable was the communication technology: TMD and OMB. Gender, task type, and different universities were controlled. As shown in Table 6, both communication satisfaction and perceived quality of outcome showed significant differences.

The communication technology had a significant effect (F-value = 5.4, p-value < 0.05) on the participants' communication satisfaction. This result supports H2b (*Mobile microblogging TMD users will experience a significantly higher level of communication satisfaction than nonmobile OMB users*). The communication technology also had significant effects on perceived quality of outcome. The TMD group reported a significantly higher perceived quality of outcome (F-value = 5.1, $p < 0.05$) than the OMB group. This supports H2c (*Mobile microblogging TMD users will experience a significantly higher perceived quality of outcome than nonmobile OMB users*).

Table 5. Factor Analysis Results.

Constructs	Items (Factor loadings)	Cronbach's α	*t*-test (Technology)
Communication satisfaction [10, 24, 43]	• Were group members well committed to the goals and objectives of the group? (0.856) • Did members have a strong sense of belonging to the group? (0.843) • Did group members recognize and respect individual differences and contributions? (0.871) • Were group members open and frank in expressing their ideas and feelings? (0.810) • Were you satisfied with the quality of your group's solution? (0.837)	0.895	TMD = 0.23 OMB = − 0.15 (p = 0.05)
Perceived quality of outcome [5, 23, 25, 43]	• The issues explored in the discussion were substantial (0.750) • The content of the discussion was carefully developed (0.874) • The manner in which the participants examined issues was constructive (0.933) • The group's movement towards reaching a conclusion on the discussion question, under the circumstances, was significant (0.857)	0.875	TMD = 0.20 OMB = − 0.13 (p = 0.08)

Note: OMB–online message board; TMD–Twitter on a mobile communication device.

Table 6. Post-Questionnaire Analysis Results (Comparison of Technologies).

Dependent variables	*F*-Values	Notes
Communication satisfaction	5.1*	❖ The TMD users experienced a significantly higher level of satisfaction than the OMB users
Perceived quality of outcome	5.4*	❖ The TMD users perceived significantly higher-quality outcomes than the OMB users

Notes: *Significant at α = 0.05.
OMB–online message board; TMD–Twitter on a mobile communication device.

Discussion

H1b (*Mobile microblogging TMD users will send significantly more process-related messages than nonmobile OMB users*) was supported. Process-related tweets are considered to be important for progression of group discussions, but they do not add value directly to the discussion. The communication affordance attributes can be interpreted economically via required time and effort. For example, accessibility readiness (ARD) refers to the level of ease in accessing or sending a message. This measure reflects the time and effort required to

perform the task. Higher values for ARD mean that the time and effort required are minimal. In this study, process-related tweets are associated with higher levels of communication affordances than OMB messages at minimal cost, whereas OMB messages are associated with lower levels of communication affordances than tweets at higher cost. This may explain why the result is significant.

H1a (*Mobile microblogging TMD users will send significantly more initiatory messages than nonmobile OMB users*) and H1c (*Mobile microblogging TMD users will experience a significantly livelier discussion than nonmobile OMB users*) were not supported. Both hypotheses were directly related to the group discussion. The concept of "communication affordances" suggests that the users will send more messages with TMD because it provides higher affordances than nonmobile OMB. It was hypothesized that the affordances of TMD would induce a more initiatory-message-sending environment and more dense discussions on the given task. The results showed that the number of total messages increased, as expected, but not the initiatory messages or the intensity of discussions. We speculate that this is because the initiatory and discussion-related messages require more cognitive effort from the users. In other words, it is cognitively less burden for the users to leverage the affordances of TMD to send the process-related messages rather than the messages requiring more cognitive effort such as the initiatory messages. Minimizing cognitive burden is a natural human behavior and, therefore, it seems that the higher levels of affordances of TMD tend to promote a certain type of communication—cognitively less burden—rather than to promote all types of communications.

H2a (*Mobile microblogging TMD users will exhibit a significantly higher level of friendliness than nonmobile OMB users*) was not supported. Despite the conversation-friendly atmosphere of TMD and dexterous ability of TMD users, the results of this study indicated that these features do not extend to the context of our experiment. By contrast, H2b (*Mobile microblogging TMD users will experience a significantly higher level of communication satisfaction than nonmobile OMB users*) was supported. This result confirms similar findings in prior CMC studies, in which more group interactivity and use of a synchronous medium induced higher levels of satisfaction [37, 44]. People are gratified when their tweets are noticed and elicit a response [8, 13] from another member; the more responses a user receives, the higher his or her satisfaction level was. In addition, the speed of these responses adds to this fact; quicker responses yield higher communication satisfaction. The high levels of communication affordances may have contributed to communication satisfaction in this study. This result is also similar to H1b in terms of process. Communication satisfaction may also be related to satisfaction due to completion of process-related tasks. The feeling of accomplishment certainly adds to the feeling of satisfaction.

H2c (*Mobile microblogging TMD users will experience a significantly higher-quality perceived outcome than nonmobile OMB users*) was supported. The communication satisfaction hypotheses, H2b, is closely related to H2c, perceived quality of outcome, in this qualitatively subjective measure. The

Table 7. Hypotheses Test Results.

Hypotheses			Results
H1	Mobile microblogging TMD users will engage in significantly more lively communication than nonmobile OMB users.		
	H1a	Mobile microblogging TMD users will send significantly more initiatory messages than nonmobile OMB users.	Not supported
	H1b	Mobile microblogging TMD users will send significantly more process-related messages than nonmobile OMB users.	Supported
	H1c	Mobile microblogging TMD users will experience a significantly livelier discussion than nonmobile OMB users.	Not supported
H2	Mobile microblogging TMD users will have a more favorable group communication experience than nonmobile OMB users.		
	H2a	Mobile microblogging TMD users will exhibit a significantly higher level of friendliness than nonmobile OMB users.	Not supported
	H2b	Mobile microblogging TMD users will experience a significantly higher level of communication satisfaction than non-mobile OMB users.	Supported
	H2c	Mobile microblogging TMD users will experience a significantly higher-quality perceived outcome than nonmobile OMB users.	Supported

Notes: OMB–online message board; TMD–Twitter on a mobile communication device.

rationale is that the communication process is a precedent to the outcome; if the communication process was satisfactory, then it is likely that the outcome will be favorable. A swift and able communication process helps the user to be satisfied and to form a favorable outcome expectation. For the summary, the hypotheses results are provided in Table 7.

Implications and Contributions

In this study, the term mobile-mediated communication (MMC) was introduced and presented. CMC has frequently been studied in the IS literature, which continues to provide significant positive contributions for the advancement of our knowledge. MMC is a related subdomain to CMC. Both terms can address the emerging issues and complexities in communications research specifically and more effectively as the population of users of mobile devices and mobile applications continues to grow.

The communication affordances were also introduced in this study: synchronicity—SYN, deindividuation and copresence—DCP, accessibility readiness—ARD, information filtering—IFT, cognizance in the changing external environment—CEV, and the number of sessions—NMS. These constructive analytical terms distinctively outline and address each attribute of MMC, creating a framework for future research. We also identified a need for a scrupulous microblogging coding scheme. There is a well-established CMC coding manual [2], but there is no equivalent one for microblogging. Given the inherent differences between mobile microblogging and CMC, separate

coding manuals would be prudent. Greater understanding of the inner nature and mechanism of conversationality of this new communication medium would be possible using such a system.

In this study, we provide the first empirical examination of Twitter on a mobile device as one integrated unit. Twitter is currently the most preferred communication technology for many users. There is tremendous value in doing specific research on Twitter and mobile devices separately, as several studies demonstrate, but the effects of the two used in tandem cannot be ignored. Further studies on this combination would reveal more insights.

On a practical note, the results of this study imply that combination technologies such as TMD can be an effective group communication tool. The immediacy and spontaneity of TMD allow clarification of any process-related issues and expedite group processes. The results of this study and the motivational and circumstantial information provide insights into how to make group collaboration and communication more effective using these technologies.

Limitations

Among the limitations, we mention the "other research path" that was not included in this study's scope. It refers to a comparative analysis between Twitter mobile versus Twitter nonmobile. This analysis would reveal how much of the effect is from Twitter and how much from the platform. Such a study certainly carries as high a research value as the current study and would well complement the results presented here.

Another limitation of this study is that university students were used as subjects in the experiment. As mentioned earlier, user motivation is a critical component in MMC. Because the subjects knew they were participating in an experiment and that its results would have no direct negative effect on their interests, the purpose of the study may have been undermined. This student-as-subject concern is well-known in the IS research community; thus, the results of this study require further examination to determine their validity. Another limitation concerns the low volume of tweet/message transactions. Higher volume ensures that the analysis is reliable and provides adequate insight into the meaning of the data.

Conclusion

Given the rapidly growing mobile and social media markets and the increasing number of Twitter mobile users, Twitter mobile communication continues to be a preferred choice for small group communication and collaboration. Addressing the research void in Twitter mobile use under small group context, this timely study conducted a comparative analysis of the use of Twitter mobile and nonmobile online message board for group collaboration. The results revealed that (1) mobile

microblogging TMD users sent significantly more process-related messages than nonmobile OMB users, (2) mobile microblogging TMD users experienced a significantly higher level of communication satisfaction than nonmobile OMB users, and (3) mobile microblogging TMD users experienced a significantly higher-quality perceived outcome than nonmobile OMB users. Moreover, mobile-mediated communication (MMC) and its six constructs provides a theoretical basis for subsequent Twitter mobile studies.

FUNDING

This study was funded by a National Research Foundation of Korea Grant from the Korean Government (NRF-2013S1A3A2055050).

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