DESIGNING PERSUASIVE SYSTEMS FOR USER ENGAGEMENT IN COLLABORATIVE INTERACTION

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Abstract

Social influence concepts have great potential to positively affect the behaviors and attitudes of individuals. Drawing on socio-psychological theories, this study explores how social influence design principles alter user engagement in collaborative interaction during public events. Based on a theory-driven research model, a persuasive information system comprising social influence design principles of cooperation, social learning, and social facilitation was implemented and examined with a sample of 101 participants. The results reveal interactions between the design principles and their capacity to explain the persuasiveness of the system, which further substantially predicts the actual engagement of participants in collaborative interaction and their intention to use such systems in the future. Both cooperation and social learning are significantly correlated to perceived persuasiveness, and the cooperation also noticeably moderates the effect of social facilitation on social learning. These findings are potentially instrumental in achieving a richer understanding of how best to further harness social influence for enhanced user engagement through novel socio-technical environments and for the future development of persuasive systems.

Keywords: User engagement, Social influence, Persuasive Systems Design, Collaboration, Twitter.

1 Introduction

With ever-growing digital interconnectedness, emergent socio-technical environments are increasingly designed for active participation and contribution rather than for passive consumption (Mumford, 2000). Users have gradually become co-creators of content and value, and even co-designers of these environments in emerging cultures of participation (Fischer et al., 2005), while the social web provides the necessary infrastructure for engaging diverse audiences, enhancing creativity, and fostering collaboration among users as active contributors (Fischer, 2011; Harper et al., 2008; Oinas-Kukkonen and Oinas-Kukkonen, 2013).

Contemporary technological advances expand the boundaries of traditional social environments, enabling novel contexts for collaboration. One such context arises from the confluence of people empowered with instant mobile connectivity (Gaonkar et al., 2008; Schwabe and Göth, 2005) and public environments enriched with situated displays (Dalsgaard et al., 2011; Eriksson et al., 2007; Memarovic et al., 2012a; Memarovic et al., 2012b; O'Hara, 2003). Common examples of such environments—with large screens and a space in which people can gather—are Wi-Fi enabled conference rooms and lecture auditoriums. These locations are eminently suitable for collaborative activities and, in tandem with appropriate social software (Green and Pearson, 2005; Koch, 2012; Raeth et al., 2009; Schubert and Williams, 2012), they afford great opportunities for enhancing user engagement in cooperative interaction (Ahmad and Pinkwart, 2012; Barthelmess et al., 2006; O'Reilly, 2007; Pinkwart et al., 2003).

Social software supports social interaction and socialization through information systems (Wang et al., 2007) and is typically designed to add value to human social behavior (Coates, 2005). In this context, participation is a central concept, and this is assumed to be voluntary (Koch, 2012). The real challenge in this regard is to design operational software features that promote user engagement in voluntary cooperation. According to Oinas-Kukkonen and Harjumaa (2009), information systems can be expected to facilitate social behavior when augmented with relevant persuasive principles. This implies that people can experience social influence not only from others around them but equally through information systems based on persuasive design principles.

As postulated by Oinas-Kukkonen and Harjumaa (2009), information technology is never neutral, but more targeted effects on the behaviors and attitudes of their users should be sought through implementation of persuasive design principles. By implication, users are more likely to perceive information systems as persuasive when based on these principles, facilitating behavioral and attitudinal change within the novel socio-technical context described earlier. For example, a public projection system in an auditorium could harness social influence design principles such as social facilitation, social learning, and cooperation (Fogg, 2003) to engage people in collaborative interaction. To enable a natural and habitual communication channel for participant interaction, which is inherently social in nature, appropriate social media could be integrated into the displayed system.

These persuasive systems are potentially applicable and helpful in a wide range of contexts (Briggs et al., 2009; Kolfschoten et al., 2012), including business and education. Earlier studies have emphasized the importance of developing refined customer relationships through dialog and interaction (Payne et al. 2008) and incentivizing customers' motivation for voluntary participation (Nambisan and Baron, 2009) in the co-creation of value (Fragidis et al., 2010; Tuunanen et al., 2010). Such systems would enable organizations to facilitate collaborative innovations with customers (Greer and Lei, 2012), designing novel models through cooperation to better anticipate market changes (Prahalad and Ramaswamy, 2004), catalyze their innovation processes (von Hippel, 2009), and respond more effectively to customer needs (Sawhney et al., 2005). In education, these persuasive systems could positively impact student learning and engagement: research indicates that interactive classroom environments positively influence collaborative learning (Blasco-Arcas et al., 2013), which, in turn, increases student motivation (Roblyer and Wiencke, 2003), enhancing learning outcomes (Loftin et al., 2010), and boosting their satisfaction with the course in question (Campion et al., 2012).

The present study attempts to answer the following research question:

How do social influence design principles of social facilitation, social learning, and cooperation, persuade people to collaborate through publicly displayed systems integrated with social media?

To answer this question, the paper first reviews the relevant literature, before proposing a research model and formulating hypotheses (section 3), and describing the study methodology (section 4), followed by results (section 5), discussion of findings (section 6), and conclusions (section 7).

2 Background

Social influence theory has a long history in psychology, describing several forms of potential influences on human behavior by the actual, imagined, or implied presence of others (Rashotte, 2007). Historically, social influence has often been associated with compliance, identification, internalization, obedience, and persuasion, although at the same time distinct from conformity, power, and authority. Current research on social influence falls mainly into the areas of minority influence in group settings, dynamic social impact theory, social influence in expectation states theory, and persuasion, broadly defined as change in behaviors or attitudes due to information received from others (Crano and Prislin, 2006; Cialdini et al., 1991). Persuasion focuses on the interaction between source and recipient, so providing the theoretical framework for this study.

In line with the socio-technical context of this study, Fogg (2003) suggests that computers are effective persuaders because of their capacity for maintaining high levels of interactivity and for adjusting influencing strategies as situations develop. In addition, they can provide persistent solutions, protect anonymity, manage huge volumes of data, display information in multiple ways, rescale according to demand, and can be accessed ubiquitously. Technologies do not in themselves typically seek to influence users, but they can facilitate and simplify the process of behavior change through services designed on top of them (Lockton, 2012). To date, persuasive technologies have been successfully employed in various contexts such as health (Chatterjee and Price, 2009), electronic commerce (Kaptein and Eckles, 2011), safety education (Chittaro, 2012), environment (Loock et al., 2011), and learning (Mintz and Aagaard, 2012).

Along with an overall comprehension of information systems and software development, designers of persuasive systems are required to maintain a certain level of understanding about human psychology (Oinas-Kukkonen, 2013). Theories from social and cognitive psychology, such as social cognitive theory, cooperation theory, and social facilitation theory, were employed to develop the theoretical framework for this study. Social cognitive theory explains how people acquire and maintain certain behavioral patterns and provides the basis for intervention strategies (Bandura, 1976; 1986). It deals with cognitive, emotional, and behavioral factors in changing behaviors and attitudes, positing that people can acquire new types of behavior by observing others through social interactions, experiences, and external media (Bandura, 2001). Cooperation theory (Deutsch, 1949; Deutsch, 2011; Johnson and Johnson, 1989) describes cooperation as the act of working together to one end (Mead, 1937), and it addresses the commonly occurring tension between what is good for the individual right now and what is good for the group in the long run (Axelrod, 2000). Social facilitation theory posits that the presence of other people creates an atmosphere of evaluation, which directly influences human behavior in social situations (Zajonc, 1965; Guerin and Innes, 2009).

The conceptual framework for this study was built on the social cognitive model (Figure 1), which has previously been applied in a similar setting (Stibe et al., 2013). According to Bandura (2001), this model captures the dynamic interaction of person, behavior, and environment in which the behavior occurs. This triadic reciprocal determinism unfolds multiple pathways for studying behavioral change, including environmental and personal change (Bandura, 1986).

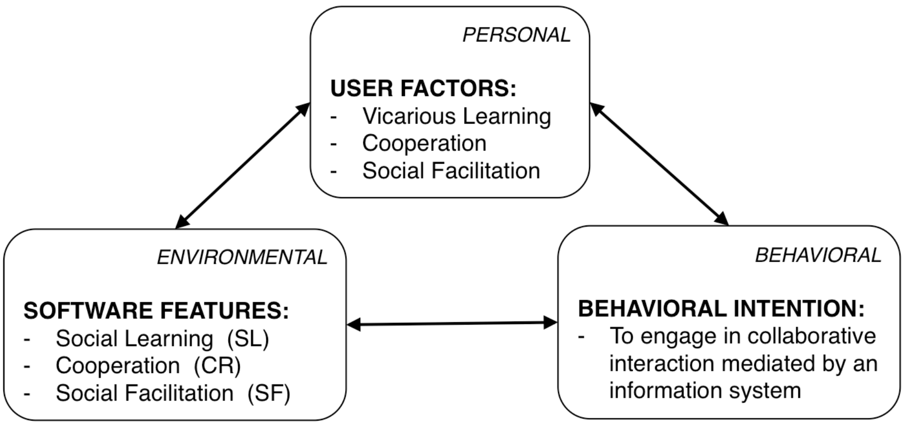

Figure 1. Social cognitive model (Bandura, 2001).

The reciprocal causation connecting personal determinants (user factors) and behavioral determinants (behavioral intention) reflects the interaction between what people think, believe, and feel and how they behave (Bandura, 1986). According to Bandura (2001), people are equipped with the capacity for vicarious learning, increasing behavioral knowledge and skills by observing others and so exerting a direct influence on their own behavioral intentions and consequent behaviors. Further, Deutsch (1949) has suggested that individuals cooperate when they are motivated to achieve the same or complementary goals, and that they experience increased motivation to engage when surrounded by other active participants (Zajonc, 1965; Guerin and Innes, 2009). The present study incorporates the constructs of vicarious learning, cooperation, and social facilitation to explore the effects of these user factors on behavioral intention to engage in collaborative interaction mediated by an information system.

That segment of reciprocal causation between environmental determinants (software features) and personal determinants (user factors) encompasses the interplay of human beliefs, emotions, and cognitive competencies, and how they are developed and modified by social influences in the surrounding environment (Bandura, 1986). In addition, social cognitive theory informs an exploration of social persuasion as embodied in ambient environments. In the present study, the Persuasive Systems Design model (Oinas-Kukkonen and Harjumaa, 2009) was applied to identify those persuasive design principles (i.e., persuasive software features) that support social influence on behavioral intention to engage in feedback sharing.

3 Research Model and Hypotheses

Oinas-Kukkonen and Harjumaa (2009) have extended Fogg's (2003) work on persuasive technologies to propose the Persuasive Systems Design model, which describes key issues, a process model, and design principles for developing and evaluating persuasive information systems. The model has previously been examined in a number of contexts (Kelders et al., 2012; Langrial et al., 2012) and it suggests that not all the design principles should be applied in every case, but that their selection should be based on a thorough understanding of a given problem domain and the underlying theories (Oinas-Kukkonen, 2013). In general, the model lists the technological possibilities for designing persuasive systems, while social psychology provides the influencing strategies that might motivate people to engage.

The Persuasive Systems Design model suggests that the selection of relevant persuasive design principles requires careful analysis of the context of persuasion—that is, the intent, the event, and the strategy (Oinas-Kukkonen and Harjumaa, 2009). Intent comprises two components: persuader, and type of change. In the present study, persuaders are entities (e.g., organizations or educational institutions) that seek to alter user behavior (change type) toward increased engagement in collaborative interaction. The persuasion event contains three parts: use context, user context, and technology context. First, entities endow a physical space with a persuasive system (use context) designed for the aforementioned intent. Second, users observe and interact with the system through their existing social media account by posting messages (user context). Third, the system collects all relevant user-generated content from social media, aggregates it, and then displays it on a public screen (technology context). For the persuasion strategy, it is important to understand the message and the route. In the present study, the underlying message is that the collaborative efforts of users and entities can lead to co-creation of value for both. This study employs indirect routes of persuasion through the social influence design principles of cooperation, social learning, and social facilitation, discussed in more detail below.

Social science theories related to persuasion provide multiple sources for each of the aforementioned social influence design principles (Table 2). The interpersonal factor of cooperation supplies important intrinsic motives that would not be present in the absence of others (Malone and Lepper, 1987). Cooperation is defined as activity directed toward the same social end by at least two individuals (May and Doob, 1937). At a social level, people cooperate when they are striving to achieve same goals or work together (Mead, 1937). On independent tasks, combining the scores of different people can encourage cooperation (Malone and Lepper, 1987). Cooperation influences various behaviors, including learning (Malone and Lepper, 1987) and use of blogs and podcasts for generating a sense of community (Firpo et al., 2009).

Construct	Description	References
Cooperation	People cooperate when they are striving to achieve same goals or work together. For example, users could see the results of their cooperative efforts through the system.	Axelrod (2000), Deutsch (1949), May and Doob (1937), Mead (1937), Malone and Lepper (1987)
Social Learning	People learn from others by observing their behaviors. For example, users could observe others through the system and learn from them.	Bandura (1977), Bandura (1986), Bandura (2001)
Social Facilitation	People are influenced when surrounded or watched by others. For example, users could perceive others using the system along with them.	Flynn and Amanatullah (2012), Guerin and Innes (2009), Yerkes and Dodson (1908), Zajonc (1965)
Perceived Persuasiveness	Persuasiveness is operationalized as people's favorable impressions of the collaborative system —in other words, to what extent participants felt persuaded by the system.	Crano and Prislin (2006), Drozd et al. (2012), Lehto et al. (2012), Lehto (2013), Petty and Cacioppo (1986), Wood (2000)
Behavioral Intention	This refers to people's beliefs about their possible engagement with such collaborative systems in the future—that is, their perceptions about future behavior.	Ajzen (1991), Venkatesh and Bala (2008), Venkatesh et al. (2003), Venkatesh et al. (2012)
Engagement	Participants' reported interactions with the collaborative system during the session—either one had sent at least one tweet to the system or had no interaction with it but only observed.	This is a binary variable indicating whether a participant engaged in collaboration through the system or not.

Table 2. Theoretical backgrounds informing constructs.

Within a social context, people learn from others by observing their behaviors (Bandura, 1977; 1986). This implies that the transmission of information from one individual to another happens through imitation, teaching, and spoken or written language. According to Bandura (1977), social learning is ubiquitous and potent because it enables people to avoid the costs of individual learning. Accordingly, new behaviors may be acquired through learning, for example, content generation (Burke et al., 2009), knowledge sharing (Chiu et al., 2006), or use of information systems (Yi and Hwang, 2003).

Finally, the mere or imagined presence of people in social situations creates an atmosphere of evaluation, which enhances speed and accuracy in performing well-practiced tasks, but reduces performance levels on less familiar tasks (Yerkes and Dodson, 1908). Social facilitation effects occur in the presence of others who are either passive or are actively engaged in the same activity (Zajonc, 1965; Guerin and Innes, 2009), influencing human behaviors such as, for example, the usage and acceptance of a mobile lifestyle coaching application (Gasser et al., 2006).

Based on the three social influence design principles described above and their theoretical backgrounds (Table 2), the research model for this study is developed further below (Figure 3). The social facilitation design principle helps in promoting social learning by discerning others actively engaged in collaboration (Gasser et al., 2006; Zajonc, 1965), so increasing everyone's ability to learn from each other. It is therefore hypothesized that *social facilitation has a positive effect on social learning (H1)*. In novel social contexts, social learning advances cooperation as it provides means for observing how others collaborate (Barthelmess et al., 2006; Burke et al., 2009) and learning from them (Bandura, 1977), thus increasing peoples' capabilities to collaborate. It is therefore hypothesized that *social learning has a positive effect on cooperation (H2)*.

The major aim of this study is to uncover how the three social influence design principles modify people's attitudes—that is, persuade them to engage in collaboration within the specified context—and behaviors—that is, actual engagement or behavioral intention to do it in the future. Attitude is defined as people's positive or negative feelings about performing the target behavior (Ajzen, 1991). Crano and Prislin (2006) suggest that attitude is the central issue to be considered when reflecting on persuasion, as it represents an evaluative integration of cognitions and affects. According to the theory of planned behavior (Ajzen, 1991), attitude towards behavior is influenced by perceived behavioral control, originating from human self-efficacy (Bandura, 1986). This implies that people's attitudes toward engaging in collaboration, which for present purposes can be operationalized as perceived persuasiveness (Drozd et al., 2012; Lehto et al., 2012; Lehto, 2013), is determined by beliefs about capability to collaborate with others (Bowles and Gintis, 2002) and learning how to do it (Bandura, 1977; 1986). If such beliefs are facilitated through environmental factors, then people experience positive feelings about the target behavior. It is therefore hypothesized that *social learning (H3a) and cooperation (H3b) positively affect perceived persuasiveness*.

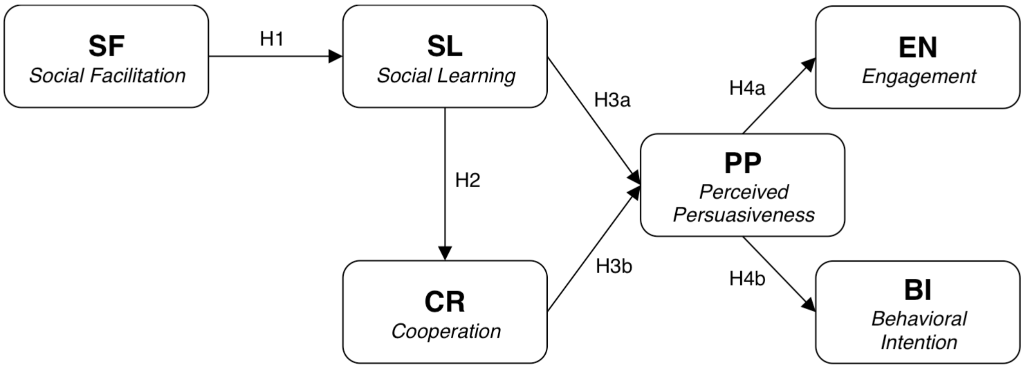

Figure 3. Research model for this study.

Finally, Ajzen (1991) suggests that people's attitude toward behaviors is one of the primary determinants of their behavioral intentions, which are immediate and important predictors of actual human behavior. This means that if people develop a positive attitude toward such cooperative behavior through persuasive experiences, they are likely to collaborate both now and in the future. It is therefore hypothesized that *perceived persuasiveness affects actual engagement (H4a) and behavioral intention to engage in the future (H4b)*.

4 Research Methodology

For the present study, a persuasive system (hereinafter, "the system") was set up to engage people in a collaborative interaction, as in previous research (Stibe et al., 2013; Stibe and Oinas-Kukkonen, 2014). The system was designed with all three social influence principles (hereinafter, "features") at its core, adjusted for large displays, and integrated with Twitter, the popular micro-blogging platform (Murthy, 2013), and a particular type of social software (Stocker et al., 2012). To run the system, users needed to post their messages in Twitter, from where the software would collect them through Twitter API (Application Programming Interface) and present all relevant content on a public display.

By comparison with other social media, Twitter is convenient for rapid real-time collaboration because it restricts the number of characters for each message to 140, encouraging users to contribute in a more efficient way (Boyd et al., 2010). This characteristic makes Twitter one of the most suitable social media tools for integration in the kind of socio-technical system described earlier. Moreover, Twitter is found to be effective for user engagement (Junco et al., 2011), for persuasion (Young, 2010), and for influencing actions outside the virtual world (Stibe et al., 2011).

4.1 Persuasive System

In line with the socio-technical context described earlier, the system was designed for large-scale projection in an auditorium (Figure 4, right). In such settings, particular topics or tasks can be displayed on the other screen (Figure 4, left) or discussed by the speaker. Users can generate their ideas, opinions, and comments about given topics as tweets, and then instantly post them to the system using Twitter on their everyday computing devices. As people start to use the system, it automatically shows all updates on the screen display so that everyone can follow both their own actions and what others are tweeting. As mentioned earlier, such environments can be helpful in facilitating collaborative learning, as well as innovation processes and co-creation with other users.

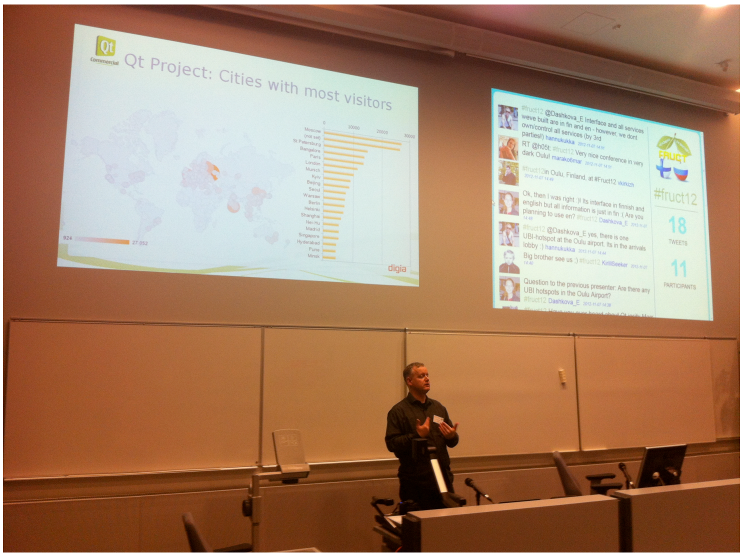

Figure 4. *Socio-technical context for this study.*

User-generated content is displayed in the form of a news feed on the left side of the interface (Figure 5). This feature supports social learning, as it allows people to observe how others generate tweets and to learn continuously from them (Bandura, 1977). The right side of the interface contains a logo, a hash-tag (#) to be used in tweets so that the system can capture them from Twitter, and two counters. The upper counter displays the number of tweets provided by all users, and the bottom counter displays the total number of users. This count of active participants allows each user to discern how many others are using the system at the same time, thus emphasizing social facilitation (Zajonc, 1965), while the number of current tweets promotes an experience of cooperation (Malone and Lepper, 1987). Both features should have a persuasive effect on people's attitudes and consequent engagement behaviors.

Figure 5. *Example interface of the publicly displayed system.*

4.2 Data Collection

To empirically assess the effects of the designed social influence features, the system was tested in five sessions designed to engage users in collaborative interaction. All the sessions were run in similar settings, with topics and tasks adjusted to the specific interests of each audience: for example, in one of the sessions, participants addressed issues related to airline travel, where the task was to generate suggestions that would motivate travelers to arrive earlier to an airport. On each occasion, the main role of the facilitator was to present the session topic and task. Each session took place in an auditorium where the system was projected on a large screen (Figure 4). At the beginning of each session, the system was briefly explained, along with a reminder that participation was voluntary. Complimentary access to Twitter was provided for those who did not have their own accounts.

People in the audience could choose whether to participate or not, and when and how to interact with the system (i.e., send tweets). Participants were told that the main purpose for having the system displayed in front of them was as an alternative means of exchanging content related to the presented topic and task. Verbal communication was permitted in just the same way as is typical during lectures and presentations. In such a setting, participants naturally tend to pose questions while trying not to interrupt the presenter too often, and so the system became a convenient tool for participants to share, discuss, and develop ideas for the given task.

Each session lasted about an hour. At the end, an identical questionnaire was distributed to participants in both online and paper form, with questions measuring respondents' perceptions about the system (Appendix A), Twitter experience, and demographics (Table 1). Again, filling out the questionnaire was voluntary, so people could choose whether to respond to it or not.

4.3 Respondent Characteristics

In five sessions, 101 valid responses were collected from 135 participants (ranging from 15 to 38 people per session). From the valid responses, 57 (56.4%) came from users of the system who had posted at least one tweet, while 44 (43.6%) came from respondents who had only observed the system being used by others. In terms of gender distribution, 34% of respondents were female and 67% were male. More detailed descriptive statistics for the sample are provided in Table 1.

Total number of respondents: 101		*#*	*%*
Gender	Female	34	33.7
	Male	67	66.3
Age	Range 19–48 years Mean 26.03 years (S.D. 5.63)		
Education	Bachelors level or lower	53	52.5
	Masters level or higher	48	47.5
Length of Twitter use	Less than 1 month or never	44	43.6
	1 to 12 months	29	28.7
	More than 12 months	28	27.7
Frequency of tweeting	Never	41	40.6
	Monthly or less	31	30.7
	Weekly or more	29	28.7
Content generation on Twitter	Never	31	30.7
	Reader only	46	45.5
	More than a reader	24	23.8
Engagement	Only observed	44	43.6
	Posted at least 1 tweet	57	56.4

Table 6. Descriptive statistics for the sample.

5 Data Analysis and Results

The research model was analyzed using partial least squares structural equation modeling (PLS-SEM) with WarpPLS 4.0 software (www.scriptwarp.com/warppls/). WarpPLS is a component-based path modeling software application, which is appropriate for use when the purpose of the model is to predict, rather than to test, established theory (Hair et al., 2011). According to Gefen et al. (2011), PLS-SEM is well suited for exploratory research. Moreover, PLS-SEM is reasonably robust to deviations from a multivariate distribution.

The statistical objective of PLS-SEM is similar to that of linear regression—that is, to demonstrate explained variance in the latent variable as indicated by R-squared values, to indicate the strength of the relationship between latent variables in terms of β values, and to test the significance of the relationship between latent variables by estimating t-values and reporting their corresponding p-values (Gefen et al., 2011; Hair et al., 2011).

Overall, testing the PLS-SEM model is carried out in two steps: assessment of the reliability and validity of the measurement model and assessment of the structural model. The measurement model includes the relationships between the constructs (Table 7) and the indicators used to measure them (Appendix A). The convergent and discriminant validity of the measurement instrument is examined in order to verify that the constructs' measures are valid and reliable before attempting to draw conclusions regarding relationships among constructs (i.e., structural model).

5.1 Measurement Model

The indicators of the measurement instrument employed in this study (Appendix A) were derived from a number of sources to operationalize the constructs (Table 2). The items for measuring social facilitation, social learning, cooperation, and perceived persuasiveness are self-developed, because there were no suitable existing instruments to measure these concepts. According to Boudreau et al. (2001), the use of previously validated instruments is efficient, but the fast pace of technological change often deters researchers from investing time in novel instrument development. The scales for measuring behavioral intention are modified from Venkatesh et al. (2003; 2012). Besides, similar and identical items for measuring the aforementioned constructs have already been tested in earlier studies (Stibe et al., 2013; Stibe and Oinas-Kukkonen, 2014). Before the study, the survey items were checked with four researchers from the same field to establish that the items demonstrate good face and expert validity.

	CRA	*COR*	*AVE*	*SF*	*SL*	*CR*	*PP*	*BI*
SF	.73	.85	.65	**.81**				
SL	.77	.87	.69	.35	**.83**			
CR	.75	.86	.66	.30	.75	**.81**		
PP	.71	.84	.63	.29	.60	.57	**.80**	
BI	.94	.96	.90	.23	.57	.57	.66	**.95**
COR = Composite Reliability; CRA = Cronbach's Alpha; Bolded diagonal = square root of Average Variance Extracted (AVE)								

Table 7. Latent variable properties.

The latent variables in the present model display good internal consistency, as shown by composite reliability (COR) scores that ranged from .84 to .96 (Table 7), while item loadings ranged from .72 to .96 (Appendix A). Further, all latent variables share more variance with their own indicators than with other latent variables, and square root of the average variance extracted (Table 7) values of all the latent variables were well above the suggested minimum of .50 (Fornell and Larcker, 1981), demonstrating adequate internal consistency.

5.2 Structural Model

For nomological validity, the research model was tested by applying a bootstrapping procedure. The path coefficients and explained variances for the model were obtained. All five constructs were modeled as reflective and included in the model with three indicators (Appendix A).

In the structural model (Figure 8), social facilitation explains one-third (33%) of the variance in social learning, which further explains 59% of the variance in cooperation. Next, social learning in combination with cooperation explains 46% of the variance in perceived persuasiveness, which alone explains 34% of the variance in actual engagement and 45% of the variance in users' behavioral intention to engage in collaboration through such systems in the future. In addition, it was found that cooperation has a strong and significant moderating effect on the relationship between social facilitation and social learning (dotted line). Further, INFL (respondents' perceptions of Twitter as an influential tool to influence action outside the virtual world) was found to be a control variable with an impact on social facilitation, while FREQ (respondents' reported frequency of tweeting) was found to be a control variable with an impact on social learning. Both control variables are marked with the dashed lines in Figure 8.

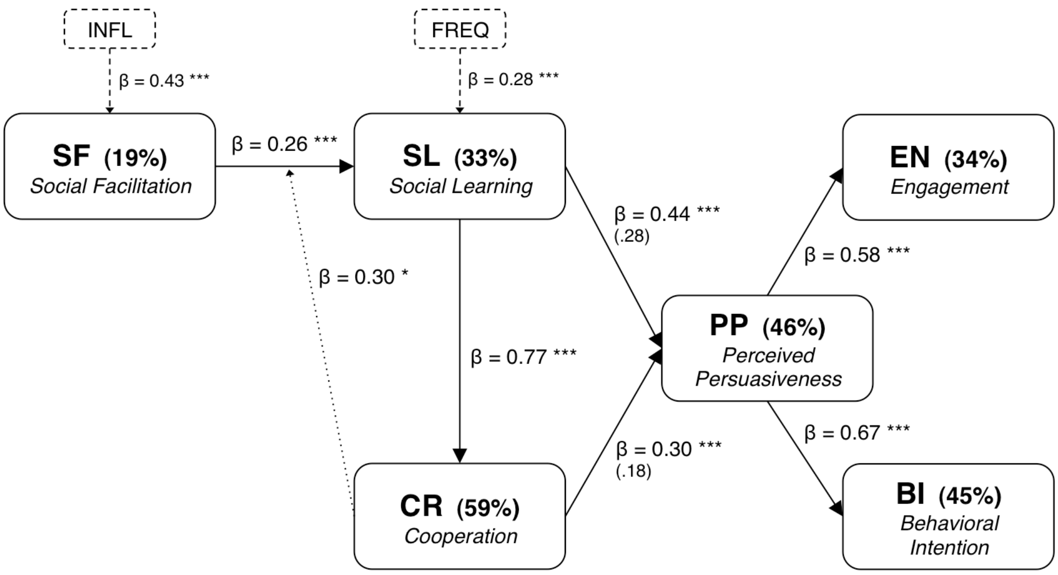

*Figure 8. Results of PLS-SEM analysis: *** $p < .001$; * $p < .05$; (R-squared contributions).*

The β values next to the arrows explain the strengths of the particular relationships, but the asterisks (*) mark their statistical significance. Effect sizes (f^2) determine whether the effects indicated by path coefficients are small (.02), medium (.15), or large (.35) (Cohen, 1988). Total effects and effect sizes for total effects are presented in Table 9.

Additionally, the results of PLS-SEM analysis provide fit and quality indices that support the structural model (Kock, 2013). Besides reporting the values of average path coefficient (APC = .448, $p < .001$), average adjusted R-squared (AARS = .382, $p < .001$), and average block variance inflation factor (AVIF = 1.405), the model demonstrates a large explanatory power GoF = .558 (Tenenhaus et al., 2005). Moreover, both Simpson's paradox ratio (SPR = 1.000) and the nonlinear bivariate causality direction ratio (NLBCDR = 1.000) provide evidence that the model is free from instances of Simpson's paradox (Pearl, 2009), and the direction of causality is supported.

	SF	*SL*	*CR*	*PP*	*FREQ*	*INFL*	*CR*SF*
SF						.433*** (.19)	
SL	.256*** (.09)				.281*** (.11)	.111** (.03)	.304* (.13)
CR	.197*** (.06)	.768*** (.59)			.216** (.07)	.085** (.03)	.234* (.00)
PP	.171** (.05)	.667*** (.43)	.296*** (.18)		.187*** (.06)	.074** (.02)	.203* (.01)
BI	.115** (.03)	.447*** (.26)	.198*** (.11)	.670*** (.45)	.126** (.04)	.050** (.01)	.136* (.00)
EN	.099** (.01)	.388*** (.11)	.172** (.04)	.581*** (.34)	.109** (.02)	.043** (.00)	.118* (.00)
*** $p < .001$; ** $p < .01$; * $p < .05$; (f^2) = Cohen's f-squared							

Table 9. Total effects and effect sizes.

5.3 Common Method Variance

Because all variables were measured using the same instrument, common method variance poses a potential threat to the validity of the results. To diminish common method variance *ex ante*, the survey items were randomized prior to the study. Measures were also taken *ex post* to test and possibly control common method variance. Harman's single-factor test (Podsakoff et al., 2003) was conducted. More than one factor emerged to explain the variance, and no single factor explained the majority of covariance among the measures. On this basis, common method variance was unlikely to be a serious concern in the present study.

6 Discussion

These findings confirm the importance of social influence features in designing persuasive systems for user engagement in collaborative interaction, using physically situated displays and social media. The findings provide empirical evidence for the pertinence of the research model and theory-driven hypotheses. All effects in the model are significant, and most are strong and sizeable.

It is noteworthy to find such strong confirmation of the persuasive capacity of social learning (Bandura, 1977; 1986). As outlined earlier in the theory section, this concept is one of the main building blocks of social influence among humans in groups: people learn from others and so develop their capabilities (Burke et al., 2009; Chiu et al., 2006). This study demonstrates the effects of social learning as persistent throughout the model up to actual engagement and behavioral intention, thus reaffirming its theoretical foundations. Social facilitation (Zajonc, 1965) also plays an important role in fostering the learning process: in other words, if people are able to discern others as being actively engaged, they are more likely to learn from them.

Social learning also strongly affects cooperation (Malone and Lepper, 1987; May and Doob, 1937; Mead, 1937; Schoenau-Fog, 2012), and together they largely account for perceived persuasiveness. By observing others, people acquire knowledge about ways of collaborating in a certain social context (Burke et al., 2009; Firpo et al., 2009), giving rise to people's favorable impression of a given system —that is, how much they felt persuaded to engage in collaborative activity. As expected, users' perceptions of the persuasiveness of the system strongly affect their actual engagement and behavioral intentions to use such systems in the future (Ajzen, 1991; Venkatesh, 2003; Venkatesh, 2012). This implies that social influence design principles affect not only users' behaviors while using the system, but also their attitudes concerning intended future behaviors, which is a longer term effect.

Additionally, cooperation demonstrates a strong and significant moderating effect on the relationship between social facilitation and social learning. In other words, the more users experience collaboration the more they learn from a growing number of other active participants. This implies that cooperation may exert a considerable effect on social learning as well, meaning that the more people collaborate the more they learn from each other. All three social influence design principles are seen to have a strong and significant role in explaining and predicting user engagement in collaboration mediated by the designed persuasive system.

The findings also reveal two control variables. First, INFL has a controlling effect on social facilitation, which means that those respondents who perceived Twitter to be an influential tool for stimulating action outside the virtual world were more receptive to recognizing others participating with them. In other words, people who are more sensitive to social facilitation effects (Zajonc, 1965) may be also more inclined to develop beliefs about Twitter as an influential tool, and vice versa. Second, FREQ has a controlling effect on social learning, which means that more frequent tweeters had richer learning experiences while using the system. This implies that frequent Twitter users are better equipped with social learning capabilities (Bandura 1977; 1986) in this setting than those users who tweet less often.

7 Conclusions

The study reviewed here is highly relevant in advancing the design of future collaboration systems (Briggs et al., 2009; Kolfschoten et al., 2012; Loock et al., 2011). It provides both researchers and practitioners with richer insights into how social influence principles can be designed as persuasive software features in information systems aimed at facilitating behavior change. Drawing on socio-psychological theories (Axelrod, 2000; Bandura, 1986; Zajonc, 1965) and interconnecting them through the Persuasive Systems Design model (Oinas-Kukkonen and Harjumaa, 2009), this study explores the effects of social influence design principles on altering user engagement in collaborative activity, through publicly displayed systems integrated with social media such as Twitter.

The main contributions of the present study include construction of the research model and testing of the measurement instrument, as they supplement existing knowledge of social influence effects on user behaviors mediated by information systems. Limitations of the study include a single social media platform (Twitter), the present implementation of persuasive features, and a relatively narrow sample size. However, the proposed model and reviewed theoretical concepts, as well as the design of particular social influence features, seem likely to have application in multiple contexts.

This study provides valuable information for further research on the effects of social influence on user behavior, highlighting some important issues for designers of persuasive systems. Equally, business organizations and educational institutions could benefit directly by designing and launching similar on-site systems to promote social interaction and collaboration. Future research should focus on the extension of the research model to other social influence design principles, testing it in other contexts, and on improvement of the measurement instrument, refinement of the design of persuasive software features, and examination of the system in conjunction with other social media tools.

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Appendix A. Measurement Items and Combined Loadings

Construct	*Indicators*		*Loadings*
Social Facilitation	SF1	The system displayed the number of participants.	.766
	SF2	I saw the names and/or pictures of other users in the system.	.869
	SF3	The system showed what other participants do.	.777
Social Learning	SL1	The system allowed me to learn from others.	.839
	SL2	I was able to learn from tweets provided by others in the system.	.898
	SL3	Tweets showed by the system helped to create my own tweets.	.739
Cooperation	CR1	The system allowed its users to cooperate.	.793
	CR2	The system displayed the result of cooperative efforts among users.	.801
	CR3	I was able to cooperate with other users while using the system.	.846
Perceived Persuasiveness	PP1	The system motivated me to tweet.	.866
	PP2	The system involved me to participate.	.790
	PP3	The system influenced my thoughts.	.724
Behavioral Intention	BI1	I would use such system in the future.	.949
	BI2	I would be willing to try such system in the future.	.933
	BI3	I would like to use such system in the future.	.958
All items employed a seven-point Likert-type scale for assessing attitudes with the following response options: 1) strongly disagree, 2) disagree, 3) disagree somewhat, 4) undecided, 5) agree somewhat, 6) agree, 7) strongly agree.			