

# Microblogging and the Value of Undirected Communication

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Online social networks have become extremely popular, but what drives sharing through these channels? We demonstrate that one of the most popular features of online social networks, microblogging (e.g., tweeting or sharing Facebook status updates), is driven in part by its undirected nature. Microblogging allows people to simultaneously express themselves to a large number of potential communication partners without having to address anyone in particular. As a result, this communication channel is particularly valued when people feel socially apprehensive; it allows them to reach out without having to impose communication and potentially bother anyone in particular. These findings shed light on one reason why people use online social networks and provide insight into the value of undirected communication.

**Keywords** Online social networks; Social transmission; Microblogging; Social apprehension; Emotion

Online social networks have become a pervasive part of everyday life. They are revolutionizing the way we spend our time, communicate with others, and maintain social relationships. But while these networks allow users to keep in touch with friends, increasing feelings of social capital (Ellison, Steinfield, & Lampe, 2007; Hoffman & Novak, 2012), researchers and cultural critics suggest that these sites have detrimental effects on users' welfare and relationships (Buffardi & Campbell, 2008; DiSalvo, 2010; Forest & Wood, 2012). Specifically, some have argued that online social networks reduce face-to-face interaction, detracting from meaningful communication and leaving people depressed, anxious, and lonely (Kraut et al., 1998; Tonioni et al., 2012; Turkle, 2015).

Contributing to this debate, we suggest that a unique feature of these networks can actually offer a valuable outlet for expression and social sharing. One of the most popular features of Facebook, and the hallmark of Twitter, is the broadcasted sharing of short messages (i.e., status updates or tweets) about thoughts, feelings, or actions with other users who can read them and respond. While Facebook status updates and tweets vary in a number of ways (see General Discussion), academics and practitioners alike collectively call such short messages "microblogs" (Kaplan & Haenlein, 2011; Lee, 2011;

Walasek, Bhatia, & Brown, 2018). Microblogging is immensely popular. Each day there are over 500 million tweets (Internetlivestats, 2017) and more than 125 million Facebook status updates (Hampton, Goulet, Rainie, & Purcell, 2011).

The current research identifies one reason why people microblog. Specifically, we argue that microblogging is driven in part by its undirected nature, making it a unique channel of communication. Most communication methods (e.g., face-to-face and phone calls) require reaching out directly to a specific person who may feel obligated to respond. Microblogs, on the other hand, allow people to reach out without addressing anyone in particular. Such undirected communication, we suggest, allows people to reach out and elicit social interactions without having to worry about imposing unwanted communication on a particular person. Thus, while microblogs may be less personal than face-to-face interaction, their undirected nature may make this communication channel particularly desirable in some instances.

If one value of microblogs lies in their undirected nature, as we suggest, then microblogging should be particularly valuable when people want to avoid more directed communication, such as when they feel socially apprehensive. Social apprehension involves anxiety about communicating with others and concerns about being rejected (e.g., being at a party and not having anyone to talk to or feeling

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unwelcome; Horwitz, 2002; Schroeder, Wormworth, & Livesley, 1992; Wrench, Brogan, McCroskey, & Jowi, 2008). Importantly, the experience of social apprehension generates two contradictory impulses. First, it makes people feel inadequate or nervous, and these negative feelings heighten the need to reach out to others for comfort and social support (Rimé, 2009). Second, it makes people feel tentative about reaching out for fear of rejection. As a result, people who feel socially apprehensive may find microblogging a particularly useful channel of communication because it allows them to reach out broadly to elicit social interaction, while avoiding potentially bothering any given individual.

Six studies investigate how microblogging's undirected nature drives its use. We examine if and when the experience of social apprehension increases individuals' likelihood of microblogging. We also examine whether this increase in sharing is specific to microblogging (i.e., does not extend to other communication channels). Finally, we examine whether, as predicted, these effects are driven by the desire to reach out to others without imposing communication and potentially bothering anyone in particular.

### Online Social Networks

Online social networks allow people to quickly and easily connect with a broad set of social ties, even when those ties are geographically distant. A large body of research (Buffardi & Campbell, 2008; Ellison et al., 2007; Kraut et al., 1998; Tonioni et al., 2012; Wang et al., 2011; Verduyn et al., 2015) suggests that online social networks cater to a variety of needs such as affiliation, self-expression, signaling social status, and information dissemination (Back et al., 2010; Berger, 2014; Gosling, 2009; Hoffman & Novak, 2012; Naylor, Lambertson, & West, 2012; Toubia & Stephen, 2014; Wilson, Gosling, & Graham, 2012), for an overview see Buechel and Berger (2015).

That said, many more specific aspects of online social networking are still relatively poorly understood. First, most research in this area has been correlational. Online social network use has been linked to a variety of personality factors (e.g., Correa, Hinsley, & De Zuniga, 2010), but relatively little experimental work has provided evidence for causal relationships between personality variables and behaviors.

Second, there is little agreement on how and why communication on online social networks impacts users' welfare. On the one hand, online

friends are said to provide increased social capital (Ellison et al., 2007; Wilson et al., 2012). On the other, these sites have also been criticized for reducing meaningful face-to-face interaction (Forest & Wood, 2012; Kraut et al., 1998; Tonioni et al., 2012; Turkle, 2015) decreasing and subjective well-being (Kross et al., 2013; Verduyn et al., 2015).

Third, the relationship between online and offline behavior is unclear. Some researchers have argued that online behavior is merely an extension of behavior offline (Back et al., 2010). Narcissists share more self-indulgent content online (Buffardi & Campbell, 2008), and extraverts have more friends on Facebook and spend more time connecting with them (Gosling, Augustine, Vazire, Holtzman, & Gaddis, 2011; Ross et al., 2009). Other data, however, suggest that the online environment may encourage representations that differ from offline ones by allowing people to present themselves overly positively (Berger & Iyengar, 2012; Gonzales & Hancock, 2011; Wilcox & Stephen, 2013).

One reason for these differing findings may be that most online social networks provide not just one, but multiple methods of communication. Prior work often treats social networks as homogeneous entities, looking at the effect of Facebook use or why people use Twitter. But in reality, each of these sites encompasses multiple features and multiple communication methods (Wilson et al., 2012). Facebook users, for example, can post status updates or share on a friend's wall. Twitter users can send tweets or direct messages to particular social ties.

These different sub-channels vary in important ways. While direct messages on Twitter or sharing on a friend's Facebook wall are targeted to a particular user, microblogging features (i.e., status updates or tweets) allow people to share broadly without directing their communication at any one person in particular.

Consequently, to more deeply understand the utility of these online channels, we focus on the popular, common, and unique feature of online social networks: microblogging. We investigate how microblogs differ from other communication channels and how this difference can explain when and why people microblog.

### Interpersonal Sharing and Social Apprehension

People have a high need for social interaction, and social relationships are critical for well-being (Bowlby, 1977; Burleson, 1998; Harlow, 1961). Social interactions are especially important during

stressful and negative times (Taylor, 2011) because attention, affection, and comfort from others can supply needed social support (Zech & Rimé, 2005). This can provide a so-called “socio-affective buffer,” which is said to temporarily reduce negative affect and enhance well-being by reducing feelings of anxiety or loneliness (Rimé, 2009).

Yet, social sharing is not always easy. Sometimes people feel “socially apprehensive,” a negative state that is marked by the experience of fear and/or anxiety due to real or anticipated communicative social interactions (McCroskey, 2001; Schroeder et al., 1992; see also Buss, 1980; Henderson, Gilbert, & Zimbardo, 2014). The state of social apprehension is often brought on by the situation. Being at a party and not having anyone to talk to, for example, can make people feel socially anxious and apprehensive. Some people are also more prone to feeling socially apprehensive than others (McCroskey, 1970; Kessler, Stein, & Berglund, 1998). Individuals who score high on Social Communication Apprehension (Wrench et al., 2008), for example, are particularly likely to feel anxious when communication is expected or desired. That is, while highly socially apprehensive individuals do not *always* experience social apprehension, the experience of state social apprehension is more easily triggered in these individuals, be it by external or internal factors. These individuals may be particularly likely to experience social apprehension when they feel external pressure to interact with others (e.g., at a party) but are apprehensive to do so. These individuals might also be more likely to experience social apprehension when they desire social interaction, such as when they are experiencing negative affect and feel an internal need to interact with others (i.e., they desire a “socio-affective buffer”), but are apprehensive to do so.

When triggered, the state of social apprehension generates two contradictory impulses. Experiencing social apprehension makes people feel inadequate and anxious. This negative feeling of distress increases the need to reach out and connect with others (Berger, 2011; Berger & Milkman, 2012; Peters, Kashima, & Clark, 2009) in an attempt to reduce their anxiety via the aforementioned socio-affective buffer (Rimé, 2009). At the same time, however, feeling socially apprehensive may make people wary of bothering others (Jones & Carpenter, 1986; Pilkonis, 1977). This should decrease their willingness to reach out to anyone in particular for fear that they will seem burdensome or be rejected, thus depriving themselves of the rewards of disclosure and social interaction/support (Calsyn, Winter,

& Burger, 2005; Tamir & Mitchell, 2012). Hence, feelings of social apprehension place people in a bind. It is a negative experience that makes people want to seek social interaction and reach out to others. At the same time, the experience of social apprehension makes them concerned about bothering those whom they reach out to. How can people resolve this conundrum?

### Microblogging: The Value of Undirected Communication

We suggest that *one* reason people microblog is because it alleviates this problem. Microblogging increases opportunities for desired social interaction while not having to impose communication and potentially bother anyone in particular.

Microblogs vary from other communication channels in important ways. They differ from face-to-face interactions in that they are written and in that they do not require making eye contact. Most important for our conceptualization, microblogs also differ from face-to-face and other forms of communications (e.g., texting, emailing) in that they are *undirected*. Initiating social interaction usually involves directed communication: reaching out to particular individuals and thus imposing social interactions onto them. Imagine you’re at work and want to connect with others. Before online social networks, you’d have to stop by someone’s office or call them on the phone, both of which involve reaching out to a specific person who might feel obligated to respond. Similarly, sending emails or messages to one or more people usually requires directing communication at selected recipients who might feel they should respond. All of this can feel difficult, especially when people feel socially apprehensive.

In contrast, by offering undirected communication, microblogs reduce the burden of bothering any particular person while still offering the possibility for social interaction. Rather than addressing a person (or people) in particular, microblogs (e.g., status updates or tweets) are broadcast to all (or many) users in one’s network who may or may not see the post in their newsfeed. Thus, while different online social networking platforms differ in many ways (see General Discussion) both status updates and tweets go out to a large number of online ties in an undirected manner. This undirectedness makes responding more voluntary. Because communication is not directed at them specifically, each recipient feels less obligated to respond. This, in

turn, should reduce a sender's concern about bothering others by imposing unwanted communication (i.e., presumably, only people who *want* to interact will respond). Somewhat ironically then, by communicating and reaching out to more people, microblogs reduce concerns about bothering each individual, thus making reaching out less threatening.

If the undirected nature of microblogs can facilitate sharing, as we suggest, then microblogs should be particularly valuable and useful when people want to reach out but feel socially apprehensive about doing so. The experience of social apprehension should increase sharing via microblogs because their undirected nature enables desired social interaction while minimizing anxiety about burdening others. The same is not true for directed communication. For directed channels, the experience of social apprehension should not increase sharing; indeed, it may even decrease willingness to share.

Note that we are not suggesting social apprehension to be the only driver of microblogging. Like any consumer behavior, microblogging is complex and driven by many factors. We use social apprehension to isolate and test microblogging's undirected nature, a feature specific to microblogs that has not been examined and that may lead to communication that differs in its antecedents from other communication channels. Indeed, pilot data highlight the importance of social apprehension in microblogging. Participants were asked whether they preferred sharing face-to-face or via microblog and completed a variety of personality scales (see Appendix for details). Results indicate that higher levels of social apprehension were associated with greater preference for microblogging ( $\beta = 0.35$ ,  $t(99) = 3.75$ ,  $p < .001$ ;  $R^2 = 0.13$ ). Importantly, this preference was better explained by social apprehension than other personality variables often linked to other online social networking behaviors (e.g., extraversion, narcissism, or self-esteem). Thus, while it is clear that social media use is driven by a number of factors, we examine how social apprehension shapes microblogging.

### Overview of Studies

Five studies investigate the value of undirected communication. Supporting our theorizing, they demonstrate that (a) social apprehension increases microblogging, (b) this increase does not hold

for more directed communication channels, and (c) these effects are driven by microblogging's undirected nature: Across platforms, consumers value microblogging because it allows them to connect with others without imposing unwanted communication and potentially bothering anyone in particular.

#### *Study 1: Sharing Via Microblogs*

Study 1 examines actual sharing. We manipulate social apprehension and give people the opportunity to use online social networks. We predict that social apprehension will increase the number of people who microblog.

#### *Method*

In total, 145 undergraduates (87 females and 57 males [one missing];  $M_{\text{age}} = 20.82$  years,  $SD = 2.34$ ) were randomly assigned to one of two between-subjects conditions (control vs. social apprehension).

First, we manipulated social apprehension, a negative state marked by feelings of anxiety about reaching out. In the social apprehension condition, participants wrote about a time they felt socially apprehensive. Specifically, they were asked to think and elaborate about a time when they had attended a party or social gathering and had not had anyone to talk to. In the control condition, participants wrote about office products. A pretest (see Appendices S1 and S2) confirmed that the social apprehension manipulation increased feelings of social apprehension.

Second, participants who indicated having an online social network account were asked to open a new tab, log into their preferred online social network account (e.g., Facebook or Twitter) and spend the next 2 min on their online social network. They were allowed to choose which online social network to visit, but were asked to only visit one. After 2 min, they would hear an alarm, at which point they should return to the survey.

Upon returning to the survey, participants were asked whether they had microblogged (e.g., tweeted or posted a status update). Specifically, we asked, "Microblogs are short messages shared on online social networks (tweets, status updates, etc.) Did you share a microblog while you were on your online social network?" [*Yes, No*]. Finally, in this and all reported studies, participants indicated their age and gender.

### Results

As predicted, the experience of social apprehension increased microblogging,  $\chi^2(1, N = 142) = 5.05$ ,  $p = .02$ ,  $r = 0.18$ . Compared to the control condition (2.8%), people made to feel socially apprehensive were more likely to microblog (12.9%). Logistic regressions including dummy variables for visited online social network did not reveal any significant effects or interactions due to platform (all  $ps < .28$ ), indicating that similar results held across platforms (see Appendices S1 and S2 for ancillary analyses and robustness checks).

### Discussion

Study 1 provides preliminary support for our suggestion regarding the link between social apprehension and microblogging. Participants made to feel socially apprehensive were more likely to microblog. By directly manipulating social apprehension and measuring real behavior, the present study offers internal and external validity for our proposed effect.

#### Study 2: Underlying Process

Study 2 compares microblogging to offline sharing and begins to test the hypothesized process through mediation. Similar to Study 1, we make half of the participants feel social apprehensive. We then ask everyone about their likelihood of expressing themselves to others, either in person (i.e., face-to-face) or via microblog (i.e., status update or tweet). Finally, we measure the degree to which participants did not want to bother anyone in particular.

We expect the experience of social apprehension to increase willingness to microblog but not to increase willingness to share face-to-face. Note that we are not suggesting that socially apprehensive individuals should be more likely to express themselves via microblog than face-to-face. Over 80% of word of mouth is face-to-face (Keller & Fay, 2012), and overall people are much more likely to express themselves face-to-face than online (Berger & Iyengar, 2012; Keller & Libai, 2009). If our theorizing is correct about the value of undirected communication, however, then experiencing social apprehension should increase willingness to share via microblog.

Furthermore, if our theorizing is correct that not wanting to bother anyone in particular is driving these effects, we should find evidence for

moderated mediation. Social apprehension should increase concerns about not bothering anyone in particular, which should increase microblogging but not face-to-face communication.

### Method

In total, 140 Mturkers (78 females and 60 males [two missing];  $M_{\text{age}} = 36.86$  years,  $SD = 14.16$ ) were randomly assigned to a condition in a 2 (Social apprehension: control vs. social apprehension)  $\times$  2 (Channel: face-to-face vs. microblog) between-subjects design.

First, we manipulated social apprehension. Participants either wrote about a time they had felt socially apprehensive (social apprehension condition) or about office products (control condition), see Study 1.

Second, we manipulated communication channel. Participants were asked how likely they were to express themselves to others (1 = *Very Unlikely*; 9 = *Very Likely*). In the microblog condition, they were asked about their likelihood to microblog (i.e., tweet or post a status update) if they had the opportunity to do so. In the face-to-face condition, they were asked about their likelihood to express themselves in person if they had the opportunity to do so.

Third, we measured our hypothesized process. To test whether the effects are driven by the undirected nature of microblogging, we asked participants how much they agreed with the statement "I don't want to bother or burden anyone in particular" (1 = *Strongly Disagree*; 7 = *Strongly Agree*).

### Results

In addition to a main effect of Channel,  $F(1, 136) = 27.65$ ,  $p < .01$ ,  $\eta_p^2 = 0.17$ , a 2 (Social apprehension)  $\times$  2 (Channel) between-subjects ANOVA revealed only the predicted Social apprehension  $\times$  Channel interaction,  $F(1, 136) = 6.20$ ,  $p = .01$ ,  $\eta_p^2 = 0.05$ , see Figure 1. Note that in this and all remaining studies, we only report marginally significant ( $p < .1$ ) and significant effects ( $p < .05$ ) for the omnibus tests.

Simple effects revealed that, compared to control participants ( $M = 2.60$ ,  $SD = 1.88$ ), inducing social apprehension increased participants' likelihood of sharing via microblog ( $M = 4.02$ ,  $SD = 2.66$ ),  $F(1, 136) = 5.60$ ,  $p = .02$ ,  $\eta_p^2 = 0.05$ . The same effect was not observed for face-to-face communication ( $F = 1.60$ ,  $p > .20$ ).

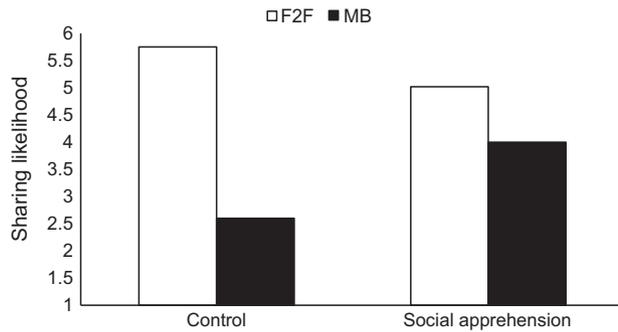


Figure 1. State social apprehension and sharing across channels.

*Moderated Mediation.* We expected the moderation to occur for the IV–DV path and the Mediator–DV path, but not on the IV–Mediator path, leading us to test moderated mediation using Model 15 (Hayes, 2012). The analysis revealed that the effect of social apprehension on likelihood of sharing was driven by these individuals’ concern about “not wanting to bothering anyone in particular.” The direction of these effects, however, depended on communication channel. Social apprehension always increased the desire not to bother anyone in particular,  $B = -2.18$ ,  $SE = 0.98$ ;  $t(136) = -2.23$ ,  $p = .03$ , but while this sentiment marginally decreased the likelihood of sharing face-to-face (negative indirect effect,  $B = -0.80$ ,  $SE = 0.56$ ; 95% CI = 0.00 to 0.43), as predicted, it *increased* the likelihood of sharing via microblog (positive indirect effect,  $B = 1.24$ ,  $SE = 0.59$ ; 95% CI = 0.02 to 0.77).

### Discussion

Study 2 again demonstrates how social apprehension affects microblogging and provides preliminary evidence for underlying process. First, social apprehension only increased the likelihood of sharing via microblogs. The fact that it did not have the same effect on face-to-face communication suggests that social apprehension driven sharing may be unique to microblogs.

Second, mediation analysis supports the hypothesized process underlying these effects. As predicted, the effect of social apprehension on microblogging was driven by feelings of not wanting to bother anyone in particular.

Third, ancillary analyses cast doubt on other potential alternative explanations. We suggested that social apprehension increases microblogging because it does not require addressing and potentially bothering one individual in particular. That said, one could argue that microblogging is

appealing because it does not require making eye contact or because it involves written (rather than oral) expression. To rule out these accounts, we had also asked participants how much they agreed with the statement “I’d rather not have to make eye contact” and “I’d rather express myself in writing.” Contrary to these accounts, neither preference for “non-face-to-face communication” (95% CI<sub>F2F</sub> =  $-0.15$  to  $0.07$  and CI<sub>MB</sub> =  $-0.39$  to  $0.05$ ) nor “written expression” mediated the effects (95% CI<sub>F2F</sub> =  $-0.06$  to  $0.55$  and CI<sub>MB</sub> =  $-0.10$  to  $0.13$ ). Furthermore, the fact that social apprehension did not increase face-to-face sharing rules out the possibility that the manipulation increased sharing in general, independent of channel.

*Ancillary Study.* A follow-up study demonstrates that these results generalize across the two main social media platforms (i.e., Facebook and Twitter). Using the same procedure as Study 2, we first manipulated social apprehension and then manipulated communication channel. Rather than asking about microblogging in general, this study asked about sharing via microblog on Facebook or Twitter specifically, in a 2 (Social apprehension: control vs. social apprehension)  $\times$  3 (Channel: face-to-face vs. Facebook vs. Twitter) between-subject design. Social apprehension again had no effect on willingness to share face-to-face,  $F < 1$ , but increased willingness to microblog on both Twitter,  $F(1, 460) = 4.48$ ,  $p = .03$ ,  $\eta^2 = 0.01$ , and Facebook,  $F(1, 460) = 3.23$ ,  $p = .07$ ,  $\eta^2 = 0.01$ . Note that, while directionally stronger for Twitter, there was no difference in willingness to share between Facebook and Twitter ( $F < 1$ ), suggesting that the effect of social apprehension on microblogging is similar across the two platforms.

### Study 3: Trait Social Apprehension and Sharing Across Channels

To further understand when and why the undirected nature of microblogging drives sharing, Study 3 uses individual differences in social apprehension and manipulates negative affect to activate the (internal) need to share (i.e., we activate the experience of social apprehension, see Rimé, 2009).

If the value of microblogging lies in its undirected nature, as we suggest, then individuals who are prone to feeling socially apprehensive should be more inclined to share via microblogs. Importantly, however, this does not necessarily mean that these individuals will be more likely to microblog at any given point in time. Instead, individual differences in social apprehension should be particularly likely

to impact the likelihood of microblogging when that trait is activated, for example via negative affect (Andersen & Guerrero, 1997; Rimé, 2009). As discussed earlier, the undirected nature of microblogging should make this channel particularly valuable when people (a) want or need to reach out (e.g., sharing is expected or beneficial due to the “socio-affective buffer”) but (b) feel apprehensive about doing so offline or in a more directed manner. Individual differences in social apprehension generate the second condition, but not necessarily the first. While socially apprehensive individuals might generally be more hesitant about reaching out in person and thus prefer microblogs (as the pilot data suggest), they do not always feel the need or desire to share. Negative affect, however, should activate socially apprehensive individuals’ desire to share and reach out. Negative affect elicits the desire to generate social interaction via the “socio-affective buffer” (i.e., to receive attention and social support to buffer their negative experience; Rimé, 2009). At the same time, reaching out is particularly difficult for socially apprehensive individuals; they might worry about imposing communication and bothering anyone in particular. Thus, highly socially apprehensive individuals’ increased sharing via microblog should be more likely to manifest itself when they feel negative. Negative affect alone, however, should not increase microblogging and should therefore not increase sharing for low socially apprehensive individuals (i.e., the effect of social apprehension on sharing is driven by feeling both, negatively and socially apprehensive about reaching out).

In addition to examining the effect with individual differences in social apprehension, this study further tests whether our effect is unique to microblogging. We examine an additional communication channel (i.e., direct messaging) that is directed but not face-to-face or spoken. Sending a message to a particular person by direct message on online social networks, chat, email, or text is similar to microblogging in that it is written and not face-to-face, but different in that it is directed at someone specific. If the preference for microblogging is driven by its undirected nature, as we suggest, then we should not observe the same results for direct messaging, and direct messaging should resemble face-to-face communication.

Overall then, if part of the value of microblogging comes from its undirected nature, as we suggest, then negative affect should activate the experience of social apprehension and increase

socially apprehensive individuals’ likelihood to share via microblog. While they may feel apprehensive about sharing face-to-face or direct message, the undirected nature of microblogging should provide a reduced risk way to reach out to others.

### Method

In total, 139 participants recruited from a paid subject pool (70 females and 68 males [one missing];  $M_{\text{age}} = 33.28$  years,  $SD = 12.67$ ) were randomly assigned to a condition in a 2 (Affect: control vs. negative)  $\times$  3 (Channel: face-to-face vs. direct message vs. microblog) between-subjects design with social apprehension as a measured variable.

First, we manipulated affect. Participants watched video clips used in prior work to reliably evoke either negative affect or no affect. In the negative affect condition, participants watched a short clip from a scene in *Silence of the Lambs* (Hewig et al., 2005); in the control condition, participants watched a short clip with images from space (Buechel, Zhang, Morewedge, & Vosgerau, 2014).

Second, we manipulated communication channel. Similar to Study 2, participants were asked how likely they were to express themselves to others (1 = *Very Unlikely*; 9 = *Very Likely*), and depending on condition, they indicated their likelihood of sharing via microblog (e.g., status update or tweet), direct message (e.g., private message on online social network), or in person (i.e., face-to-face).

Finally, we measured social apprehension (Social Communication Apprehension Scale; Wrench et al., 2008), which measures anxiety associated with (offline) communication. Typical scale items include “I can communicate with people in social settings without experiencing anxiety (R),” “I am usually anxious when talking to people in a bar,” and “Social interaction is the best part of my day (R).” Scale responses were not impacted by the manipulations,  $F_s < 1$ .

### Results

Given that the channel condition has three levels, we used two dummy variables (face-to-face and direct message) to compare how they differed from the microblog condition. Multiple regression examined how affect (control vs. negative), communication channel, measured social apprehension, and their interactions influenced sharing likelihood.

In addition to a main effect of face-to-face,  $\beta = 0.28$ ,  $t(128) = 2.14$ ,  $p = .03$ , and a *Affect*  $\times$

Channel interaction,  $\beta = 0.59$ ,  $t(128) = 2.78$ ,  $p = .006$ , the analysis revealed the predicted three-way Affect  $\times$  Channel  $\times$  Social Apprehension interaction for both microblogging versus face-to-face,  $\beta = -0.44$ ,  $t(128) = -2.36$ ,  $p = .02$ , and microblogging versus direct messaging,  $\beta = -0.39$ ,  $t(128) = -2.46$ ,  $p = .02$ , see Figure 2. To shed more light on the pattern of results, we discuss each affect condition separately.

**Control Condition.** For control participants, there was only a main effect of face-to-face,  $\beta = 0.27$ ,  $t(67) = 2.01$ ,  $p = .05$ . As in Study 2 and prior work, participants were more likely to share in person ( $M = 5.92$ ) than via microblog ( $M = 4.58$ ). Control participants were no more likely to share via private message ( $M = 4.90$ ) than via microblog,  $t < 1$ . No other effects were significant.

**Negative Affect Condition.** When participants experienced negative affect (which should activate the need to share), however, the pattern differed. In addition to a main effect of Social Apprehension,  $\beta = 0.92$ ,  $t(61) = 3.86$ ,  $p < .001$ , and a marginal main effect of face-to-face,  $\beta = 0.22$ ,  $t(61) = 1.72$ ,  $p = .09$ , this condition revealed the predicted Channel  $\times$  Social Apprehension interactions for both microblogging versus face-to-face,  $\beta = -0.84$ ,  $t(61) = -4.22$ ,  $p < .001$  and microblogging versus direct messaging,  $\beta = -0.61$ ,  $t(61) = -3.47$ ,  $p = .001$ . Slope analysis (Aiken & West, 1991) showed that low socially apprehensive individuals ( $-1$  SD) exhibited a similar pattern to the control condition. They were more likely to share face-to-face ( $M = 6.85$ ) or via direct message ( $M = 5.88$ ) than via microblog ( $M = 2.78$ ),  $\beta = 0.86$ ,  $t(61) = 4.51$ ,  $p < .001$  and  $\beta = 0.64$ ,  $t(61) = 3.70$ ,  $p < .001$ ,

respectively, making microblogging the least likely channel for sharing. The pattern reversed, however, for highly socially apprehensive individuals. Highly socially apprehensive individuals ( $+1$  SD) were more likely to share via microblog ( $M = 6.53$ ) than face-to-face ( $M = 5.16$ ),  $\beta = -0.43$ ,  $t(61) = -2.16$ ,  $p = .03$ , or direct message ( $M = 5.11$ ),  $\beta = -0.42$ ,  $t(61) = -1.93$ ,  $p = .06$ .

Looked at another way, negative affect did not change highly socially apprehensive ( $+1$  SD) participants' likelihood of sharing face-to-face ( $M_{\text{negative}} = 5.16$ ;  $M_{\text{control}} = 5.32$ ;  $t < 1$ ) or via direct messaging ( $M_{\text{negative}} = 5.11$ ;  $M_{\text{control}} = 4.88$ ;  $t < 1$ ), but, consistent with our theorizing, it did increase their likelihood of sharing via microblog ( $M_{\text{negative}} = 6.53$ ;  $M_{\text{control}} = 4.77$ ),  $\beta = 0.51$ ,  $t(45) = 2.34$ ,  $p = .02$ .

### Discussion

Study 3 provides further evidence that the undirected nature of microblogging is one reason why people use this communication channel. Again, consistent with prior work (Berger & Iyengar, 2012; Keller & Libai, 2009; Keller & Fay, 2012), people generally reported being more likely to share face-to-face than via microblog. More importantly, however, for socially apprehensive individuals whose trait had been activated through negative affect, this pattern reversed. Negative affect increased their likelihood of sharing via microblog and did so to such a degree that they even preferred microblogging to face-to-face sharing.

Moreover, these effects were only observed for the microblogging condition and did not emerge for direct messaging. The fact that the increase

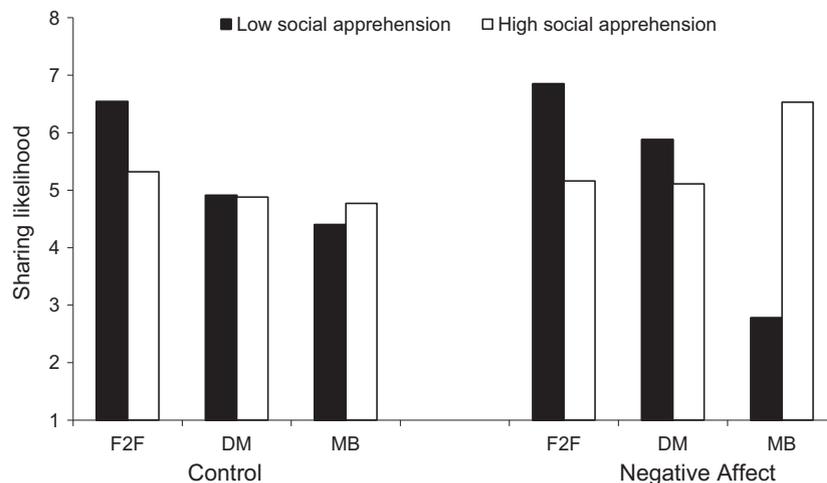


Figure 2. Trait social apprehension and sharing across channels.

in sharing was specific to microblogs underscores the notion that part of the appeal of microblogging lies in its undirected nature. While neither microblogs nor direct messages involve face-to-face communication and both involve written communication, inducing negative affect only increased socially apprehensive people's sharing via microblogs. This pattern of results is consistent with our suggestion that the undirected nature of microblogging (and not its written or non-face-to-face nature) makes it particularly useful when people want to reach out but feel tentative about bothering others.

*Ancillary Analyses.* Ancillary analyses (Appendices S1 and S2) cast doubt on alternative explanations based on generalized (i.e., positive) affect and provide further evidence that the main study results are driven by a desire for social interaction when reaching out is difficult.

#### *Study 4: Testing the Value of Undirected Communication via Moderation*

The first three studies demonstrate that social apprehension, whether measured or manipulated, increases microblogging. Unlike face-to-face interactions or other types of directed communication (e.g., direct messages), we have argued that microblogs allow people to reach out without potentially bothering others by imposing unwanted communication. To further test this suggestion, we next examine whether diminishing socially apprehensive individuals' fears of imposing unwanted communication decreases microblogging.

If microblogging is driven by not wanting to impose on others, as we suggest, then the appeal of microblogs should diminish when socially apprehensive individuals feel that their offline communication is welcome. Thus, in Study 4, in addition to inducing negative affect and manipulating communication channel, we manipulate concern of imposing unwanted communication by telling half the participants that their communication is welcome. If our theorizing is correct, this should moderate our effect. Among participants told that their (offline) communication is welcome, social apprehension should no longer increase microblogging.

#### *Method*

In total, 128 participants recruited from an online panel (83 females and 45 males;  $M_{\text{age}} = 35.74$  years,  $SD = 11.64$ ) were randomly assigned to a condition in a 2 (Communication encouraged: control vs. yes)  $\times$  2 (Channel: face-to-face vs. microblog)

between-subjects design with social apprehension as a measured variable.

First, to activate social apprehension, similar to Study 3, we induced negative affect, this time by having all participants write about a negative customer experience. For 4 min, they elaborated on the circumstances and how it made them feel in detail.

Second, we manipulated concerns about imposing unwanted communication. We told participants to think about someone in their broader friend group (e.g., a classmate or co-worker). In the "communication encouraged" condition, they were told that this person had recently opened the door for (offline) communication (i.e., they told them that they liked listening and would happily "lend an ear"). In the control condition, there were no additional instructions.

Third, we manipulated communication channel (see face-to-face and microblogging conditions in Study 3). In a seemingly unrelated study about communication, participants were asked how likely they were to express themselves to others in general (1 = Very Unlikely; 9 = Very Likely), and depending on condition, they indicated their likelihood of sharing via microblog (e.g., status update or tweet) or in person (i.e., face-to-face).

Finally, we measured social apprehension (Social Communication Apprehension; Wrench et al., 2008). Scale responses were not impacted by the manipulations,  $F_s < 1.8$ ,  $p > .18$ .

#### *Results*

Multiple regression analyses examined how the encouraged communication manipulation, communication channel manipulation, social apprehension measure (continuous), and their interactions influenced sharing likelihood.

Results revealed a main effect of Social Apprehension,  $\beta = 0.42$ ,  $t(121) = 4.03$ ,  $p < .001$ , a marginal Communication encouraged  $\times$  Social Apprehension interaction,  $\beta = -0.30$ ,  $t(121) = 1.80$ ,  $p = .08$ , a Communication encouraged  $\times$  Channel interaction,  $\beta = 0.44$ ,  $t(121) = 3.37$ ,  $p < .001$ , and a Channel  $\times$  Social Apprehension interaction,  $\beta = -0.71$ ,  $t(121) = -3.87$ ,  $p < .001$ . Most important, as expected, the analysis revealed a three-way Communication encouraged  $\times$  Channel  $\times$  Social Apprehension interaction,  $\beta = 0.48$ ,  $t(121) = 2.77$ ,  $p = .006$ , see Figure 3. For clarity and to shed more light on the pattern of results, we analyze and discuss each sharing condition separately. The results hold and are stronger when analyzed with the full sample (using Model 3; Hayes, 2012).

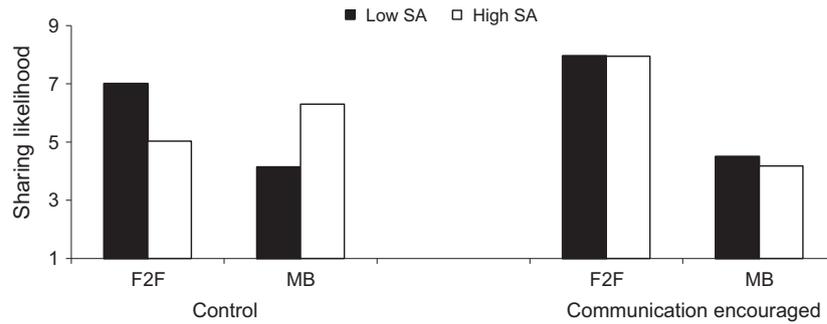


Figure 3. Trait social apprehension and sharing across channels.

*Control Condition.* The control condition revealed a main effect of Social Apprehension,  $\beta = 0.50$ ,  $t(59) = 2.38$ ,  $p = .02$ , and a marginal main effect of Channel,  $\beta = 0.19$ ,  $t(59) = 1.74$ ,  $p = .09$ . Consistent with the negative affect condition in Study 2, there was a Channel  $\times$  Social Apprehension interaction,  $\beta = 0.51$ ,  $t(59) = 4.03$ ,  $p < .001$ . Slope analyses (Aiken & West, 1991) illustrate that while low socially apprehensive individuals ( $-1$  SD) were more likely to share face-to-face ( $M = 7.01$ ) than via microblog ( $M = 4.14$ ),  $\beta = -0.66$ ,  $t(59) = -4.62$ ,  $p < .001$ , the pattern reversed for highly socially apprehensive individuals ( $+1$  SD). Highly socially apprehensive individuals were more likely to share via microblog ( $M = 6.30$ ) than face-to-face ( $M = 5.03$ ),  $\beta = 0.49$ ,  $t(59) = 2.23$ ,  $p = .03$ .

*Communication Encouraged Condition.* When participants were told that communication was welcome, however, the Channel  $\times$  Social Apprehension disappeared and there was only a main effect of Channel,  $\beta = -0.64$ ,  $t(62) = 6.47$ ,  $p < .001$ , suggesting that, consistent with prior work, participants were more likely to share in person ( $M = 7.96$ ) than via microblog ( $M = 4.35$ ).

Looked at another way, eliminating fear of imposing unwanted communication decreased highly socially apprehensive participants' likelihood of sharing via microblog ( $M_{\text{control}} = 6.30$ ;  $M_{\text{encouraged}} = 4.18$ ),  $\beta = -0.48$ ,  $t(69) = -1.75$ ,  $p = .08$ . Eliminating fear of unwanted communication did not affect low socially apprehensive individuals' likelihood of sharing face-to-face or via microblog,  $F_s < 1$ .

### Discussion

Study 4 extends the prior studies by further testing the underlying process. When people wanted to reach out but felt apprehensive about bothering others, they found microblogs particularly attractive. However, eliminating the fear of unwanted

communication for socially apprehensive individuals decreased microblogging and made them behave like low socially apprehensive individuals.

These results also cast doubt on an alternative explanation for the effect. While one could argue that highly socially apprehensive individuals might microblog simply to self-express as opposed to seeking social interaction (i.e., the value lies in microblogs' unidirectional [vs. undirected] communication), this cannot explain why encouraging communication shifts them toward face-to-face communication. Instead, this pattern suggests that microblogs are appealing because they allow for interaction (or at least potential interaction) without having to worry about imposing unwanted communication and potentially bothering anyone in particular.

### Study 5: Undirectedness or Audience Size?

The studies so far have provided consistent evidence that social apprehension increases microblogging, and that this is driven by microblogging's undirected nature. That said, one could wonder whether microblogs reaching a greater audience might explain the effect.

While such an alternative has difficulty explaining the mediation via concerns of bothering others in Study 2 and the moderation by welcome communication in Study 4, Study 5 further tests this possibility by manipulating both the directedness of communication channel (i.e., microblog vs. face-to-face) and the audience size. If audience size is driving the effect, it should increase sharing, regardless of whether the communication is directed or undirected. In contrast, if the effects are driven by the undirected nature of microblogging, as we suggest, then socially apprehensive individuals should prefer microblogging over directed channels (as in Study 1 and Study 2), and audience size should not

increase sharing via direct messages. In fact, direct messaging more people requires targeting and potentially bothering more individuals. Therefore, if our theorizing is correct that socially apprehensive individuals want to avoid bothering others, direct messaging may actually *decrease* as a function of audience size.

### Method

In total, 400 Mturkers (233 females and 141 males [28 missing or other];  $M_{\text{age}} = 27.78$  years,  $SD = 4.60$ ) were randomly assigned to a condition in a 2 (Audience size: 20 vs. 200)  $\times$  2 (Channel: direct message vs. microblog) between-subjects design.

First, we induced social apprehension. Similar to Study 1 and Study 2, all participants wrote about a time when they had felt socially apprehensive.

Second, we manipulated audience size. Participants were asked to imagine they were using a new online social network and, depending on condition, were told that they either had 20 or 200 connections.

Third, we manipulated communication channel. In the microblogging condition, participants were told that the new online social network allowed for easy sharing of undirected messages. Messages would be pushed to their online social network connections, who would see the message in a News Feed and who would be able to respond. In the direct message condition, participants were told that the new online social network allowed for easy sharing of directed messages. Messages would be sent to some or all of their social connections, who would be notified about the message in their inbox and who would be able to respond.

Participants were then asked to think about sharing a message with *all* of their connections, and they were asked how likely they were to express themselves to their social connections (1 = *Very Unlikely*; 9 = *Very Likely*), either via microblog (microblog condition) or direct message (direct message condition).

Finally, as manipulation checks, participants were asked about their perceived number of individuals who would be recipients of their message (1 = *Very Few*; 7 = *Very Many*).

### Results

**Manipulation Check.** As expected, a 2 (Audience size)  $\times$  2 (Channel) ANOVA on perceived audience size revealed only a main effect of Audience size; perceived audience size was greater in the 200 social connections condition ( $M = 4.40$ ,

$SD = 1.92$ ) than in the 20 social connections condition ( $M = 3.69$ ,  $SD = 1.88$ ),  $F(1, 388) = 13.46$ ,  $p < .001$ ,  $\eta_p^2 = 0.03$ .

**Sharing Likelihood.** Consistent with our suggestion that social apprehension increases microblogging, a 2 (Audience size)  $\times$  2 (Channel) ANOVA revealed the predicted main effect of Channel, such that participants were more likely to microblog than direct message,  $F(1, 396) = 4.96$ ,  $p = .03$ ,  $\eta_p^2 = 0.01$ . Interestingly, there was also a marginally significant Audience size  $\times$  Channel interaction,  $F(1, 396) = 3.19$ ,  $p = .07$ ,  $\eta_p^2 = 0.01$ , see Figure 4. While microblogging did not differ as a function of audience size ( $F < 1$ ), participants were less likely to direct message when the audience size was 200 ( $M = 3.19$ ,  $SD = 2.41$ ) than when it was 20 ( $M = 4.01$ ,  $SD = 2.64$ ),  $F(1, 396) = 4.85$ ,  $p = .03$ ,  $\eta_p^2 = 0.01$ . Thus, when larger audience size means bothering more people, as it does in direct messaging, it actually decreases socially apprehensive individuals' willingness to share, consistent with our suggestion that not bothering others is part of what drives microblogging among these individuals.

### Discussion

Study 5 provides further evidence that microblogging among socially apprehensive individuals is driven by its undirected nature and casts doubt on an alternative explanation based on audience size. First, as theorized and consistent with the first four studies, socially apprehensive participants were more likely to share on a hypothetical new online social network when sharing was undirected (i.e., microblog) than when it was directed (i.e., direct message). Second, while an explanation based on wanting to share with more others would suggest audience size should increase sharing across

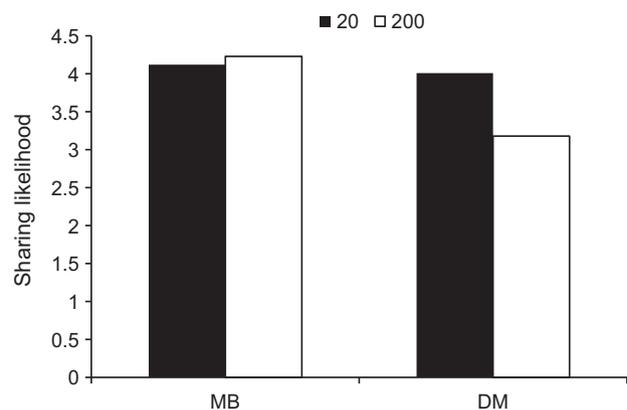


Figure 4. Sharing across channels as a function of audience size.

channels, that was not the case. In fact, audience size actually had a negative effect on willingness to share via direct message, consistent with the notion that socially apprehensive individuals want to avoid bothering others.

### General Discussion

This paper examines when and why people microblog (e.g., tweet or share status updates). We demonstrate that part of microblogging's appeal lies in its undirected nature. By allowing users to send undirected communication to multiple others, some people value microblogging when they feel socially apprehensive because it allows them to reach out when they desire social interaction and support without having to bother anyone in particular.

Five studies support this theorizing. Whether measured (Studies 3 and 4) or manipulated (Studies 1, 2, and 5), social apprehension increases microblogging. Consistent with the notion that these effects are driven by microblogging's undirected nature, the same effects were not observed for more directed communication channels such as face-to-face sharing (Study 2) or direct messaging (Study 3). Supporting the idea that microblogging is driven by not wanting to impose unwanted communication, the preference for microblogging disappears when communication is welcome (Study 4), and it is mediated by feelings of not wanting to bother anyone in particular (Study 2). The studies rule out a host of alternative explanations, including a preference for written communication, avoiding eye contact, a general desire to share, negative affect, the need to self-express, and audience size.

The present research thus reveals one reason why people value communicating through online social networks. By allowing people to reach out to others without having to impose and potentially bother anyone in particular, undirected communication channels may provide an easily accessible social support system when such support is needed.

### *Theoretical Implications*

The current research contributes to understanding online transmission in three key ways. First, it speaks to the upsides and downsides of online social networks. Although online social networks can encourage social connections by enabling users to conveniently stay in touch with more friends (Ellison et al., 2007), they have also been criticized for reducing personal interaction (Kraut et al., 1998;

Tonioni et al., 2012). By demonstrating how online social networks can foster connections for people who otherwise feel apprehensive about sharing, we illustrate how online social network use can encourage communication *because* of how it differs from face-to-face interaction. Unlike personal interaction, microblogs allow people to foster social connections without having to reach out to anyone in particular.

Second, we shed more light on when and why people share online. Specifically, while microblogs certainly share antecedents of other communication channels/online social network features and are surely used to share information (Hoffman & Novak, 2012), communicate identity (Nadkarni & Hofmann, 2012), and establish social status (Toubia & Stephen, 2014), we isolate a new and unique feature that provides additional benefits. In particular, the undirected nature of microblogging allows people to reach out without feeling that they are imposing or bothering anyone. Thus, while previous research suggests that users share online because it allows them to avoid eye contact, share anonymously, and write rather than engage in oral expression (and thus have more time to think about what to say; Berger & Iyengar, 2012; Forest & Wood, 2012), the present research suggests that some online environments can provide a valuable communication channel because the communication is undirected.

Third, the present work contributes to prior work investigating how personality factors predict online and offline behavior. Some work suggests that what people do online is merely an extension of their offline personality (Back et al., 2010). We show an important instance where online and offline behaviors diverge. We find that while social apprehension decreases willingness to share face-to-face (see also Wrench et al., 2008), it increases willingness to share via microblog.

Overall then, the present research suggests that online channels can provide important communication opportunities for people who might not otherwise feel comfortable sharing (see also McKenna & Bargh, 1998). By isolating and highlighting the benefits of undirected communication, this work can help explain the underlying mechanism of related findings, such as why anxiety is related to increased Internet use (Caplan, 2006) or why individuals who score low on self-esteem (a personality variable associated with social apprehension; Leary & MacDonald, 2003) are more likely to gain social capital from Facebook and find Facebook a safe environment to express themselves (Forest & Wood, 2012; Steinfield, Ellison, & Lampe, 2008).

### *Limitations and Future Directions*

As with any new topic, many important questions remain. One important question is what socially apprehensive individuals share when they microblog. While one might assume that people talk about their social apprehension or negative emotions they are experiencing, the main goal of sharing in these situations is likely to gain social support via attention, affection, and comfort. This suggests that savvy posters may not necessarily post negative emotion, but they might share whatever is most likely to generate a response from the audience, even if that has nothing to do with how the sharers themselves are feeling at the moment. Consequently, more work is needed to thoroughly investigate what people share and how socially apprehensive individuals use online social networks to meet their social desires and goals.

Another important question is to what extent our findings generalize across various platforms and types of post. As mentioned in the introduction, the term “microblogging” is used to describe the sharing of short messages with other online social network users, independent of the platform used to share (i.e., Twitter, Facebook, etc.). In line with this platform independent terminology, our studies reveal that the effect of social apprehension on microblogging manifests itself similarly across the two major networks, Facebook and Twitter, and extends to hypothetical online social networks. Still, it is important to keep in mind that the various online social networks are dynamic and that they differ on many dimensions such as the number of network ties, tie strength, norms, character restrictions, privacy settings, etc. (Hampton et al., 2011). Thus, future conceptual and empirical work is needed to further understand how the microblogging feature differs across platforms and how these differences affect socially apprehensive driven microblogging. The content of socially apprehensive driven microblogging—as well as the resulting interpersonal and psychological effects—may differ for Twitter, Facebook, and other online social network, for example. Future work should also test whether our effect generalizes to posts that do not fall into the narrow definition of text-based microblogs, namely whether it increases posting of stories on Snapchat or photos on Instagram. Discovering similarities and differences in sharing across platforms could provide important insights into the use of the microblogging feature, and it may provide a more nuanced understanding of the motivational

forces behind socially apprehensive driven microblogging.

### *Implications for Well-Being and Practice*

The present research suggests that microblogs may provide valuable benefits for some individuals and populations (e.g., clinical populations with conditions that are associated with social apprehension). Their undirected nature allows people to reach out and potentially receive social support from online friends when they might not feel comfortable doing so offline. This could deepen social bonds and generate future offline interactions. It could also bolster well-being after negative affective experiences because it generates real and anticipated social support (Buechel & Berger, 2012; Rimé, 2009). Importantly, there is evidence that these benefits accrue even before social support is provided. Initial research shows that anticipating social support alone can boost well-being (Buechel & Berger, 2012). It is possible, then, that the anticipation of responses from online friends might outperform offline social support. The number of responses is less finite and less certain in an online environment, and the prolonged (optimistic) anticipation of potential responses might help mitigate negative feelings associated with social apprehension (Tormala, Jia, & Norton, 2012).

In conclusion, while online social networks have changed the way people communicate, we still know relatively little about their appeal and their impact. Rather than being homogenous, sites such as Facebook and Twitter provide multiple sub-channels or methods of communication. Each of these may have different benefits and downsides. We have shown that the microblogging feature on online social networks provides an avenue for people to connect with others even when they might feel apprehensive about doing so via traditional channels. Microblogs therefore provide a unique and valuable channel of communication.

### **Appendix Pilot Study**

In total, 100 participants recruited from an online panel (52 females and 48 males;  $M_{\text{age}} = 35.78$  years,  $SD = 12.51$ ) completed the study. Participants filled out a short survey asking them how they preferred reaching out to friends (1 = Much prefer face-to-face; 7 = Much prefer microblogging).

We also measured individual differences in social apprehension (Wrench et al., 2008).

Lastly, to test whether other constructs can explain any observed relationship between social apprehension and microblogging, participants completed the Ten Item Personality Inventory (Gosling, Rentfrow, & Swann, 2003), the Narcissistic Personality Inventory (Raskin & Terry, 1988), and the Rosenberg Self-Esteem Scale (Rosenberg, 1965).

## Results

As predicted, higher levels of social apprehension were associated with higher relative preference for microblogging (as opposed to personal communication),  $\beta = 0.35$ ,  $t(99) = 3.75$ ,  $p < .001$ ;  $R^2 = 0.13$ .

This relationship was not driven by extraversion, narcissism, or self-esteem. Even when measures of extraversion (Gosling et al., 2003;  $\beta = 0.04$ ,  $t < 1$ ), narcissism (Raskin & Terry, 1988;  $\beta = 0.18$ ,  $t(95) = 1.76$ ,  $p = .08$ ), and self-esteem (Rosenberg, 1965;  $\beta = -0.02$ ,  $t < 1$ ) were included in the model ( $R^2 = 0.14$ ), the link between social apprehension and microblogging still persisted,  $\beta = 0.40$ ,  $t(95) = 2.55$ ,  $p = .01$ . This indicates that while extraversion, narcissism, and self-worth may explain certain aspects of online behavior, microblogging is most closely linked to social apprehension, pointing to a unique link between social apprehension and microblogging. In fact, looked at individually, extraversion alone negatively predicted a preference for microblogging ( $\beta = -0.21$ ,  $t(99) = -2.12$ ,  $p = .04$ ), and narcissism alone was not related to microblogging ( $\beta = 0.09$ ,  $t < 1$ ,  $p > .37$ ). Thus, while extraverts may certainly use online social networks to maintain social ties (Gosling et al., 2011; Ross et al., 2009), and narcissists may use them for self-promotion (Buffardi & Campbell, 2008), the microblogging feature of online social networks does not seem to provide unique appeal to these individuals above and beyond the offline environment. Instead, microblogging seems to be driven by social apprehension.

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### Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's website:

**Appendix S1.** Auxiliary Study Details.

**Appendix S2.** Methodological Details.