Growing Closer on Facebook: Changes in Tie Strength Through Social Network Site Use

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ABSTRACT
Scientists debate whether people grow closer to their friends through social networking sites like Facebook, whether those sites displace more meaningful interaction, or whether they simply reflect existing ties. Combining server log analysis and longitudinal surveys of 3,649 Facebook users reporting on relationships with 26,134 friends, we find that communication on the site is associated with changes in reported relationship closeness, over and above effects attributable to their face-to-face, phone, and email contact. Tie strength increases with both one-on-one communication, such as posts, comments, and messages, and through reading friends' broadcasted content, such as status updates and photos. The effect is greater for composed pieces, such as comments, posts, and messages than for "one-click" actions such as "likes." Facebook has a greater impact on non-family relationships and ties who do not frequently communicate via other channels.

Author Keywords
Tie strength; friendship; social relationships; relational closeness; families; social network sites; Facebook

ACM Classification Keywords
H.5.3 [Information Interfaces]: Group and Organization Interfaces - Collaborative computing, Web-based interaction, Computer-supported cooperative work.

INTRODUCTION
Social relationships are dynamic. Students make new friends in college, parents and teens negotiate the vagaries of adolescence, and coworkers depart for other companies. Communication drives the development and maintenance of relationships [10], at least off-line. Although social network sites (SNS) like Facebook and Google+ provide myriad ways to interact, their effect on relationships is ambiguous [24,28,36]. That people have very strong relationships online is not in dispute; 40% of SNS users have "friended" all of their closest offline confidants online [15], and tie

strength can be inferred from site use [14,24]. But whether these sites simply reflect relationships maintained through other channels, displace more meaningful interactions, or enhance relationships is an open question.

The present study examines the connection between Facebook use and changes in relationship strength. It examines how the frequency of phone, email, and face-to-face conversations and different styles of Facebook communication for 26,134 pairs of friends predict changes in self-reported relationship strength month-to-month. People grow closer the more they communicate on Facebook, over and above communication via other channels. Exchanging substantive messages and comments with friends on Facebook and reading friends' news are associated with increases in tie strength, while exchanging less content-filled, "one-click" communicative acts, such as "likes," does not. The effect is stronger for non-family and for friends who rarely communicate via other media.

RELATIONSHIP FORMATION AND MAINTENANCE
Regular contact is at the heart of relationships with friends [1]. Communication jump starts relationships; People like each other better when they communicate more. And communication keeps them going; Duck describes "centripetal forces" acting on friendships that pull them apart without regular communication [10]. As a result, maintaining a portfolio of relationships requires sizable investment [18]. In particular, friendships are at greatest risk of failure when they are new. Each new relationship is a potential competitor for time invested in existing friends. Therefore, when two people first meet, they look for clues to evaluate whether the relationship's benefits will be worth its effort [2]. Because of competition with existing ties, many potential relationships never get started and others fail quickly.

While friendships require injections of communication to thrive, family relationships are generally more resilient and require less communication [1,29]. Kinship ties are resilient because of biological selection pressures to favor those who share a genetic line [29], early childhood experiences that foster strong attachments [4], and social institutions including marriage and child custody laws that support kinship. In contrast, friendship ties are more dependent on communication "because there are no institutional pressures for permanence" [25].

Social Technology and Relationships
Social network sites like Facebook change the economics of relationship initiation and decay, by making communication with specific others and broadcasts to whole networks more efficient. On Facebook, after a person initiates a friend request that is accepted by another, both parties receive regular updates about the other's social news. Without an explicit "unfriending," the connection and exchange of news persists [16].

Even though these sites make communication easier, some critics believe they foster superficial relationships. A common concern is that technology instills a false sense of connection [32], or that cognitive capacity and time limit the number and quality of relationships we can maintain, a constraint not mitigated by the Internet [28]. Moreover, early Internet research argued that people may have difficulty maintaining relationships online because computer-mediated communication is less rich [31], more effortful to produce, and more subject to misunderstanding than spoken conversation [23]. However, even if the early Internet was less effective in supporting social relationships than phone calls or in-person contact [22], the technology, norms, and Internet-using population have changed. With 72% of online adults in the US using social network sites, people now have a critical mass of close friends online [15]. People typically use the Internet to communicate with friends with whom they have existing off-line relationships, and do so using a variety of media [17].

Because people tend to communicate with the same partners both off-line and online [17,36], determining whether social network sites affect interpersonal relationships requires understanding how they fit into a broader ecology of communication. Though much research has established that people talk to friends over a variety of channels, we do not know whether SNS add anything over in-person conversation, phone calls, and email. Therefore, this study is guided by the following research question:

RQ1. Is communication between two people on Facebook associated with changes in tie strength beyond the effects of their communication by other channels, such as email, the phone, and in-person conversation?

Most previous work on this topic has been cross-sectional, simply measuring correlations between site use and tie strength, without being able to demonstrate causality. To overcome this problem, the present research uses longitudinal data, measuring both SNS use and tie strength at multiple points in time, to better infer causation from correlational data. Through these methods, the study then reveals the connection between Facebook use and *changes* in tie strength. While it is impossible to truly determine a causal relationship without random assignment—e.g., by randomly preventing some friends from communicating for a month—our method eliminates many confounds when inferring causation in observational studies.

CLASSES OF RELATIONAL COMMUNICATION
Online communication takes many forms, the details of which matter when considering its effect on relationships [6,12,35]. Most prior research on SNS has typically relied on self-report surveys, which tend to be inaccurate measures of interpersonal communication [3,19]. Furthermore, to reduce respondent burden these surveys generally fail to differentiate types of communication or partners, thus preventing researchers from conducting finer-grained analyses. The present study uses server data to avoid self-report biases and delve into specific types of communication and relationships.

Acts of communication can influence interpersonal ties though two routes. They deliver substantive content, such as self-disclosure, expression of support and simple small talk, which can directly influence tie strength. In addition, the mere act of communication independent of its content provides a symbolic message about the time and effort one person is willing to invest in another. On both of these dimensions, written exchanges targeted at specific partners are likely to have greater impact on relationship strength than untargeted broadcasts to a wider, undifferentiated circle of friends, passive monitoring of partners' broadcasts, and 'one-click' communication requiring little investment.

Directed, one-on-one communication
One-on-one communication strengthens relationships, both offline [4,10] and online (e.g., email and instant messenger) [17,33]. Similarly, Vitak [36] finds that geographically distant dyads or those for whom Facebook is their primary mode of communication report that Facebook has a positive impact on the closeness and stability of their relationship. One-on-one communication (hereafter "**directed communication**") is likely to strengthen relationships in part through self-disclosure and small-talk; revealing intimate thoughts and feelings increases liking [8]. And even small, seemingly trivial details, such as what someone had for lunch, "represents a form of communication that is critical to developing relationships," "a way of maintaining a sense of community or fellowship with others," a proving ground for both new and established relationships, and a prelude to deeper discussion [21] (p. 197-199). As Ellison and colleagues note, directed communication on Facebook also sustains relationships by signaling one person's level of caring about another. They term these exchanges "relationship maintenance behavior" that "signals attention and investment" in a friendship [12,36]. Writing on friends' walls or commenting on their photos is a form of social grooming that preserves connections between people [9]. Therefore, ties that exchange directed communication on Facebook should grow closer.

Different types of directed communication, both online and off, vary in the effort they demand and therefore their symbolic value. Consider the difference between a lengthy, handwritten letter and a postcard. Both provide information about the writer and indicate that the sender cares for the

recipient, but the letter contains more content and took more effort. Social signaling theory suggests that because the lengthier message "costs more" recipients are more likely to use it as a reliable signal of relationship worth [30,37]. Ties should grow closer when they exchange more content-full and effortful forms of communication.

SNS communication can also be categorized in terms of the amount of content it contains and the effort required to produce it. **Composed communication**, such as private messages, wall posts, or comments, contain more content and require more effort to produce than **one-click interactions**, such as Facebook's "like" button or Google's "+1" button. The latter may reduce the cost associated with initiating or maintaining relationships because they require little premeditated thought. However, the fact that they require less effort may reduce their value in signaling relationship closeness. Beyond the signal conveyed by the differing degrees of effort, composed and one-click communication also vary in content. One-click actions are textless, and thus cannot possibly contain the kind of language associated with strong ties, such as self-disclosure or details of daily life. Therefore, composed communication is likely to bring ties closer together, one-click communication less so.

H1. Tie strength (a) increases with directed communication exchanges on SNS; (b) the is effect stronger for composed communication than one-click exchanges.

Broadcasts and Consumption
Friendships entail an obligation to keep up with each others' lives [1]. Learning the details of a tie's life, however, does not necessarily require direct communication. Broadcasted messages, such as holiday letters or Facebook status updates, distribute personal news to a wide audience of friends, family, and acquaintances.

Keeping up with a tie's life may be meaningful in its own right for the details learned, and it may make future one-on-one interactions more efficient or satisfying by filling in the news that occurred since the last interaction. Facebook aggregates news in a stream known as the News Feed, which contains ties' recent photos, status updates, and notifications of their activity, such as new friendships or their posts on other friends' walls. This kind of activity is comparable to small talk, quick bursts of information about friends' daily lives [21]. Much of these social streams is "me now"-focused content. [27,34], yet even these mundane details are commonly considered the building blocks of close relationships [11,21]. Therefore, passively consuming the details of ties' lives should be associated with increases in tie strength.

However, passive consumption is one-sided. Unlike in a bidirectional conversation, the recipients do not automatically indicate whether they have received a piece of news and can't easily engage in the back-channel communication that clarifies it. Therefore, the effect of directed communication, which notifies the recipient of the tie's interest and encourages responses, should be associated with greater increases in closeness than passive consumption.

H2. Tie strength (a) increases through passively consuming a tie's news on social network sites, but (b) the effect is weaker than receiving directed, composed communication from that tie.

Finally, broadcasting one's own news takes a one-size-fits-all approach that is inherently less intimate and requires less effort per-capita than writing an original letter or visiting each person in one's social circle. While these one-to-many missives may include self-disclosure—such as information about a family member's recent illness or feelings about a job—they are not focused at any particular recipient, and thus are less tailored to any given relationship and its history. Therefore, broadcasting may be less valuable for strengthening specific relationships than sending directed, composed communication.

H3. Tie strength (a) increases with broadcasting, but (b) less so than through sending directed, composed communication to that tie.

Interactions Between Tie Type and SNS Use
As previously reviewed, different kinds of ties are more or less susceptible to relationship decay [7,13], and so the link between SNS use and tie strength should differ by the type of relationship. Kin relationships have institutional support [25] and evolutionary pressure to persist [29], while non-kin relationships may need more regular interaction to survive. Similarly, ties who see each other frequently in person, or talk on the phone or email regularly may be less affected by their interactions on SNS. Indeed, Vitak found that ties for whom Facebook is their primary mode of communication report engaging in more relationship-maintenance behaviors on the site, and perceive Facebook as having a greater impact on their relationships [36]. However, for fledgling connections, social network sites may be more important. SNS provide the means and opportunity to communicate [17]; these ties may have no other ways of growing their relationships.

H4. Social network sites are more important among dyads at greater risk of relationship decay or among those that have few alternative communication mechanisms available, e.g., for non-kin ties, new relationships, and dyads not communicating over other channels.

METHODS
To analyze the relationship between SNS activity and changes in tie strength, we conducted a three-wave survey of Facebook users in June, July, and August 2011. The survey contained questions about their relationships with up to eight ties on Facebook. Survey responses were matched to the server logs of the participants' Facebook activity.

Participants

Participants ($N = 11{,}701$, 52% female, aged $13 - 90$) were recruited through a combination of Facebook ads and email invitations. Recruiting was targeted at English-speaking users around the world who had been active on the site in the previous 30 days, stratified by gender and activity level (login days in the past month). Participants who completed at least two consecutive waves of the survey ($n = 3{,}649$) were included in analysis. Compared to a random sample of Facebook users at the time of the first wave, survey takers were 13.5 years older and 11% more likely to be female, had approximately 70 more friends than average, and had about twice the likelihood of logging in during the week prior to the survey (all $p < 0.001$).

Survey: Tie Strength, Communication Frequency, and Relationship Type

Respondents completed an online survey about their relationships with 26,134 Facebook friends. First, they were presented with a name generator question from [26]: "*Who are the people you feel closest to? This might include people you discuss important matters with, really enjoy socializing with, or anyone else you feel especially close to. Select up to 6 people. It's also okay to select no one.*" They chose up to 6 close friends ($M = 4.4$) from the widget commonly used for event invitations. The survey tool augmented this list with two or more randomly selected ties (totaling 8).

For each alter in random order, the system presented a set of questions (see [5], Appendix A for complete version), including:

1. *How close do you feel to [name]? (7 pts: Not at all close ... Somewhat close ... Extremely close)*

2. *Over the PAST MONTH, about how often have you and [name] talked in person? On the phone? Online/email (not Facebook)? (5 pts each: None ... Once ... Few times per month ... Few times per week ... Daily)*

3. *Which of the following describe your relationship with [name]? (Checkboxes: Friend, Professional colleague, Current romantic relationship, Former romantic relationship, Family member, We live together, Friend of a friend, Friend from long ago, Someone I recently met, I don't know who [name] is, None of the above.*

4. *Has Facebook affected your relationship with [name]? If so, please explain how. (Open-ended)*

Ties in the study were relatively strong (M = 4.7 out of 7, Median = 5.0, SD = 2.2) but represented a wide variety of tie strengths (Min = 1, Max = 7). Ties that participants selected via the name generator were very strong (M = 6.0), compared to the randomly selected ties (M = 2.9).

Behavioral Log Data

Site activity was collected for respondents and their ties beginning one month prior to the first survey through the date of the final survey, three months later. All data are anonymized counts. In the following sections, the term "ego" refers to the person who took the survey and "alter" refers to one of the people the respondent rated. Activity variables were divided into three categories (see Table 1): directed communication (by ego or alter), passive consumption of alter's news, and broadcasting (by ego or alter). Within each category variables are highly correlated with each other and so are collapsed into a single composite scale representing the entire category.

Directed communication consists of counts of targeted, one-on-one exchanges between ego and alter, such as wall posts, private messages, or comments. It only includes activity within the dyad, not with other ties. Directed communication is further separated into **one-click interactions**, when someone presses a single button ("like" or "poke"), and **composed interactions**, in which someone composes original text, such as a message or comment.

Broadcasting is the wider-audience posting a user performs, including photo uploads and status updates. This scale includes anything that is not targeted at a single friend. While some users have privacy settings enabled so that their broadcasts go to a limited number of Facebook friends, these actions are still counted as broadcasting to distinguish them from the single-friend focus of directed communication. Broadcasting by both ego and alter are included (separately) in models.

Passive consumption is comprised of viewing and reading other friends' broadcasted content, usually as feed stories, but also looking at a friend's profile and photos. This scale measures the extent to which a user consumes content, but does not communicate with the content owner about it.

Broadcasting and passive consumption are related but separate: A person may passively consume some, but not necessarily all of the content a friend broadcasts, depending on how often she logs in, how many other friends' stories are competing for space in her feed, and whether she visits her friend's profile to view older content.

Method of Analysis

To determine how site use relates to changes in tie strength, a multilevel linear model was created with ego's response to "*How close do you feel to [name]?*" as the dependent variable and communication measures as independent variables. The model includes a lagged dependent variable (reported tie strength last month) as a control. That is, the model predicts reported tie strength at time t as a linear combination of reported tie strength thirty days prior and communication activities during the intervening month, on Facebook and via other channels (email, face-to-face, or phone, as self-reported). Static data about the dyad (e.g., ages, sexes, whether they live in the same city) are included as controls (see Table 2). The model was grouped at the ego and alter levels to account for non-independence of the ego's responses, both about his or her alters and about the same alter on multiple occasions.

Facebook activity scales and items
Directed communication (by ego or alter)
(scale alphas: ego to alter = 0.66, alter to ego = 0.65)
Messages written to tie[‡]
Comments written on tie's content[‡]
Posts written on tie's wall[‡]
Likes[†]
Pokes[†]
Passive consumption by ego (scale alpha = 0.51)
Profile views
News Feed story clicks
Photo views
Broadcasting (by ego or alter)
(scale alphas: ego = 0.73, alter = 0.72)
Photos posted
Content posted to own wall
Status updates

‡ Composed communication
† One-click communication

Table 1. Classes of Facebook use. All activities are within dyads, e.g., "comments written" means comments written by ego to alter, or by alter to ego. All variables are log-transformed and standardized.

By including the lagged dependent variable, the model measures *changes* in tie strength associated with communication that took place in the month between surveys. Autoregressive lag models are common in econometrics and appropriate here, because the dependent variable is stationary and model residuals are not highly autocorrelated. Lagged independent variables (communication the previous month) are not included because they are highly collinear, and thus would produce biased estimates [20]. The three-wave design means that dyads are observed at least twice. This design produces measurements that are more robust to one-time, exogenous events such as holidays or birthdays, which may increase both Facebook activity and feelings of closeness.

RESULTS AND DISCUSSION
First we consider how Facebook use compares with other channels. Dyads who communicate regularly on Facebook also communicate over other channels: There is a modest positive correlation between directed communication on Facebook and on the phone ($r = 0.26$), online (outside of Facebook) ($r = 0.26$), and face-to-face ($r = 0.24$). Similar correlations are found between passive consumption on Facebook and communication via other channels.

Our main analysis examines how communication is associated with changes in tie strength month-to-month. Table 2 contains three sections: controls, including the lagged dependent variable (which together account for 85% of the variance), general communication variables (which increase R^2 to 86%), and Facebook communication variables ($R^2 = 87\%$). Each section progressively improves the model ($p < 0.001$). Notice that the control portion

	Reported tie strength		
	Value	SE	p-value
(Intercept)	4.50	0.01	0.00***
Controls			
Reported tie strength last month	0.76	0.00	0.00***
Ego age (decades)	0.05	0.01	0.00***
Age difference (decades)	0.00	0.01	0.67
Ego is male[†]	0.04	0.01	0.00**
Same gender[†]	0.02	0.01	0.01**
Ego's friend count[‡]	0.00	0.03	0.99
Alter's friend count[‡]	-0.03	0.01	0.00***
Number of mutual friends	0.01	0.03	0.69
Is family[†]	0.27	0.01	0.00***
In a relationship together[†]	-0.13	0.03	0.00***
Same work[†]	-0.09	0.03	0.01*
Same school[†]	0.00	0.01	0.77
Same city[†]	-0.06	0.03	0.02*
General communication			
In-person contact	0.08	0.00	0.00***
Phone contact	0.10	0.01	0.00***
Online contact (not incl. Facebook)	0.11	0.00	0.00***
Facebook communication			
Directed communication			
Composed (alter to ego)	0.02	0.00	0.00***
Composed (ego to alter)	0.01	0.00	0.00**
One-click (alter to ego)	0.01	0.00	0.24
One-click (ego to alter)	0.00	0.00	0.95
Passive consumption by ego	0.02	0.00	0.00***
Broadcasting (by ego)	-0.02	0.01	0.03*
Broadcasting (by alter)	-0.03	0.01	0.00***

*** $p < 0.001$ ** $p < 0.01$ * $p < 0.05$ $R^2 = 0.87$

N=40,521 Egos=3,643 Alters=26,103
[†] Binary variable
[‡] Continuous variable logged (base 2) and standardized
All continuous variables are centered at their means.

Table 2. Model of changes in ego-reported tie strength. Communicating on Facebook is related to changes in tie strength over and above changes attributable to other communication channels.

explains most of the variance (because tie strength does not change much month-to-month). With only 15% of the variance left to explain, the general communication variables explain 6.7% of this residual, and Facebook communication explains 7.1% of the remaining variance.

The intercept (4.50) in Table 2 represents the tie strength of the average dyad—one in which all continuous variables are at their means and all binary variables are zero. Therefore, the intercept represents a dyad where both the ego and alter are 43 years old, ego is female and alter is male, they have the average number of friends, are not family members, etc. Recall that tie strength is measured on a 7-point scale, so the closeness of the average dyad is above the midpoint of the scale. For every one-point

increase in an independent variable, the estimated tie strength increases by the coefficient in the Value column. So, for every one point higher their tie strength was the previous month, their current tie strength is 0.76 points higher. (Tie strength one month correlates highly with tie strength the previous month, $r = 0.91$.) After accounting for this lagged dependent variable, all of the other coefficients represent the change in tie strength month-to-month associated with the other independent variables. A one-point increase in frequency of in-person contact (e.g., from a few times per month to a few times per week) is associated with a 0.08 point increase in tie strength. Phone and online contact (outside of Facebook) are also associated with increases in tie strength, consistent with previous research [17].

Directed Facebook Communication
Communication on Facebook was associated with increases in tie strength, beyond the effects of these other variables. H1a and b are confirmed: Directed communication was associated with significant increases in tie strength. However, the effect is only for composed communication (comments, messages, wall posts), not one-click communication ("likes" and "pokes"). A post-hoc test confirms that tie strength increases more with composed than one-click interactions ($\beta = 0.02$, $p < 0.001$). Notice this estimate is very conservative because the model also included communication initiated by ego, which may be a lead indicator of tie strength. When ego likes alter, ego is likely to comment and write more on alter's wall ($\beta = 0.01$, $p = 0.003$). Alter's communication toward ego seems to affect ego's reported closeness even when ego's communication toward alter is held constant.

The magnitude of these coefficients is smaller than the coefficients for non-Facebook communication (in-person, phone and other online). However, this comparison is misleading, because the coefficients for the non-Facebook communication measures are inflated from common-method biases. The non-Facebook communication measures are based on self-reports, which are generally inaccurate [3], while the measures of Facebook communication are based on more accurate server logs. When people report communication frequency with a partner, they compute this estimate based partly on their attachment to the partner, thus inflating the relationship between the two measures.

In their open-ended responses, respondents identified the connection between directed communication on Facebook and growing closer to ties.[1]

"Photos and comments and messaging allow us to be very close still even though we're 800 miles away."

"We got to 'know' each other through FB. We knew that both of us existed (she is daughter of my favorite cousin) but it was communication/comments/photos etc via FB that brought us little closer. we have never me personally but now we will. Thanks, in part, to fB."

In addition to offering a channel to share news, Facebook also allows the exchange of emotional support, which brings people closer:

"We have sent messages either on our wall posts or messages. I originally sent her a long supportive message regarding her struggles with her sick father and other issues. She was very grateful and over time we struck up a more meaningful relationship. We have given each other support via phone, email, fb, and have found that we have much in common and are working towards something longer term."

"facebook has given my granddaughter and myself the opportunity to talk about her fears of her mothers cancer privately she is only 13, and needs all the support I can give her only between her and I"

Moreover, they remarked on the lack of directed communication as a reason for concern:

"At least he could put in a comment or two making me realize that he's there."

In contrast, respondents rarely remarked on ties "liking" their content. The one exception mentioned a progression from "likes" to more content-filled interaction:

"my sister Theresa wasn't talking to me for 2 years...some falling out that was never forgiven...then one day she asked me to be her friend...slowly our conversation grew from her liking a few of my pics etc. to small comments to small messages and last week she messaged me to come and visit. So next week I will see her/speak with her for the first time in 2 years. I'm thankful for the non-threatening vibe of FB and hope we can communicate as easily in person...=)"

Overall, communication actions in which a tie takes the time to write a brief piece of text are linked with increases in tie strength, while one-click actions are not.

Passive Consumption and Broadcasting
We had predicted (H2a) that passive consumption—reading a tie's social news, looking at her photos and profile—would be associated with increases in tie strength. It is. When ego passively consumes news about alter, ego feels closer to alter, ($\beta = 0.02$, $p < 0.001$, Table 2). However, H2b is not confirmed: There is no difference between passively consuming a tie's news and receiving directed, composed communication from that tie ($\beta = 0.00$, $p = 0.99$). Reading and writing are both associated with increases in tie strength.

Why is passive consumption as effective as talking? Friends have an obligation to keep up with each others' lives [1],
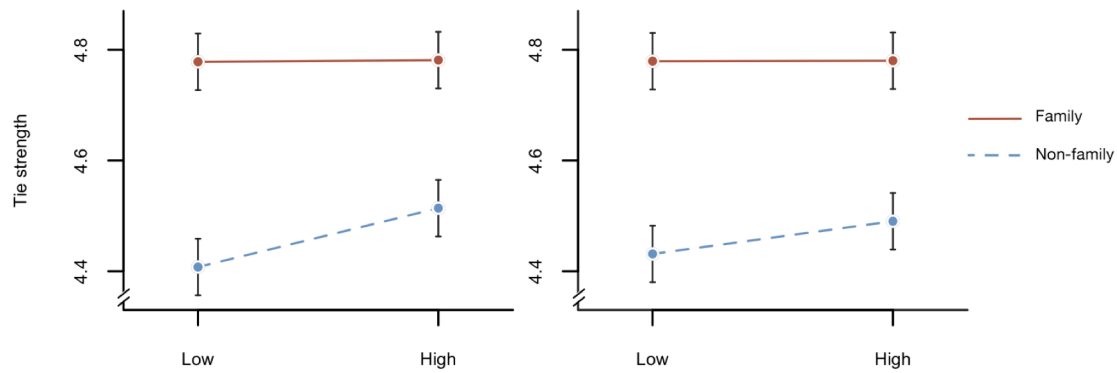
Figure 1. Different effects of Facebook on family and non-family relationships. For non-family members (dashed blue lines), increased Facebook use (directed communication or passive consumption) is associated with increases in tie strength. Neither activity significantly affects tie strength with family members (solid red lines).

and passive consumption allows friends and family members to keep up with small news and big events:

"With facebook we are able to keep up with what is going on with one another simply by reading the posts. It keeps us in touch without always having to talk."

"I get to see pictures and news of her children that have now graduated from college. I have known her and her family since her children were small. It's great to stay up on your friend's lives when you don't have time to see them."

What about broadcasting? After taking into account how much ego and alter directly communicated with each other, and how much content ego read about alter, ties appear to grow less close the more each one broadcasts content to a wider, undifferentiated circle. H3a is disconfirmed. Table 2 shows that as ego broadcasts more, she reports growing less close to any given alter; roughly one additional status update per month is associated with a 0.02 decline in tie strength ($p = 0.03$). Similarly, the more that alter broadcasts (but that ego does not necessarily read), ego reports growing less close ($\beta = -0.03$, $p < 0.001$). A post-hoc test confirms H3b: Receiving composed communication from alter is associated with greater increases in tie strength than alter's broadcasts, $\beta = 0.04$, $p < 0.001$, and ego's sending composed communication to alter is associated with greater increases in ego's reported tie strength with alter than ego's broadcasting, $\beta = 0.03$, $p = 0.005$ (all previous p's adjusted for multiple comparison). While broadcasting may be an efficient way to spread news to a large number of ties at once, merely having more information available about one's ties does not increase tie strength with any individual friend. The news must reach those ties (they need to consume it and/or directly talk with each other about it). Ego may see traces indicating the frequency of alter's broadcasts without actually reading all of those broadcasts; for example, you might not look at all of the photos in a friend's new photo album, but might see stories indicating that other friends commented on lots of photos within it.

Facebook users may also hide a friend from their feed when they feel that friend's stories are too frequent, spammy, or political. In both of these cases, additional stories broadcast by alter but unseen by ego may account for ego's feelings of reduced closeness toward alter. The results speak to the importance of feed prioritization: Broadcasts have to make it in front of the right audience, or they have little value.

Facebook Communication with Different Kinds of Ties
Now we examine whether the effect size of Facebook communication differs by the type of tie. It does.

Family vs. non-family
Facebook communication is more strongly related to changes in tie strength for non-family than family (see Figure 1). A regression like that in Table 2 with an additional interaction term between directed communication and a binary variable representing family status bears this out.[2] Family members are less affected by directed communication (interaction: $\beta = -0.05$, SE = 0.01, $p < 0.001$) and passive consumption ($\beta = -0.03$, SE = 0.01, $p < 0.001$) than are non-family members; family status basically wipes out the gains from either activity. In Figure 1, the solid red line at the top represents family members, and the bottom dashed line represents non-family. The x-axis is split, showing directed communication one standard deviation below the mean and one standard deviation above the mean. Regardless of the amount of directed communication ego does with a family member, reported tie strength does not change. In contrast, tie strength increases with non-family members with directed communication (as shown by the upward slope of the dashed line).

Though neither directed communication nor passive consumption were associated with increases in tie strength

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[2] See http://tinyurl.com/burkechi2014supp for these additional regressions omitted for space.

for family members (only non-family), respondents frequently remarked that Facebook allowed them to see other sides of their family, revealing personalities they do not get to see as a sibling or child.

"Yes, I get to see how she wants to present herself to her social world, which is different from how I get to interact with her in person as her cousin.""[My dad] is only on Facebook to see and share pictures of his grandkids, but it is interesting to read posts from his friends and see my dad as a social person rather than dad/grandpa."

"Josh is my son. I have been able to find out more about his friends and things he has been doing without having to feel like I am 'interogating or drilling' him about his personal life.."

These quotes center on passive consumption rather than directed communication—one's closest relationships may not require Facebook for one-on-one communication; they have other channels for that. Instead the site's value is in revealing the tie's wider interests and interactions with others, providing another lens on the family member's life.

Frequent versus infrequent contacts
As with kin, dyads who frequently communicate in person, on the phone, or over email do not report growing closer with increased Facebook communication. Frequent contacts—including ties who are in a romantic relationship, live together, or report talking a few times per week or more via the phone, email, or in person—are less affected by directed communication on Facebook (β = -0.05, p < 0.001) than infrequent contacts (everyone else). In contrast, passive consumption does not affect these two groups differently (p = 0.29). This confirms previous work based on self-reports of Facebook usage showing that SNS are more important for ties who do not have other regular means of communication [36].

The open-ended comments suggest that when dyads directly communicate on Facebook in addition to their regular face-to-face interaction, they use Facebook for photos, videos, and games:

"We see each other almost everyday so we do not use Facebook to chat or keep up to date, but we are able to share pictures of our adventures and it is an easy way to share links, websites, and videos."

Moreover, even though these strong ties use Facebook more for games and photos than for substantive communication, many respondents commented that they used Facebook for the next step in their relationship development after meeting their strong-tie partner for the first time. While Facebook may not be not important in maintaining a current relationship among strong ties, it seemed to have been important in achieving it in the first place.

"It's part of the reason we got together and ultimately got married. She found me on Facebook in college and sent a message, and we connected from there to begin our romantic relationship."

"Actually, it's how he got my phone number. We met through a friend and he didn't get my number, so he sent me a facebook message the next day. We now have been dating for over a year. But since then, no. We're not big on using FB to communicate."

"Charles and I were partners on many projects in college. We always meant to become better friends (e.g., 'We should go out to coffee sometime.' But, we never did. Ergo, we found each other on FB a few years later and started messaging each other. When I moved near him in recent years, we have become very close friends. It all started with Facebook."

New ties versus longstanding ties
Though respondents described using Facebook for the early steps in relationships, the quantitative data do not show different effects of Facebook use for new ties versus long-established ones. For ties the respondents marked as "someone I just met" (approximately 2% of ties, n = 1480), or for ties "friended" on Facebook in the last two months (approximately 9% of ties, n = 7366), the effect of directed communication on Facebook on tie strength is no different than for ties that have been connected longer (p = 0.61). Passive consumption also does not appear to affect new ties differently (p = 0.31). However, the present study does not include tie strength reports for extremely nascent ties— people with whom the respondents had not yet created a Facebook friendship. Therefore, it is possible that Facebook plays a role in uncertainty reduction with new ties, facilitating discreet lookups of each others' profiles and mutual friends, but this stage happens before one person initiates the friend request. After the tie is articulated on Facebook, use of the site is associated with increased tie strength, but the effects are no greater for new friends than more established ones.

CONCLUSION
This study examined the types of interaction on Facebook that are associated with changes in closeness over time. It demonstrates that social network sites like Facebook are a meaningful component in a portfolio of communication channels between friends.

This work demonstrates how social network sites fit into the ecology of communication media, showing changes in tie strength associated with Facebook use over and above the use of other channels. Table 3 summarizes the findings. Directed, composed communication is linked with increases in tie strength. So does passively reading a partner's posts. In contrast, both broadcasting by oneself and of one's partners is linked with declines in tie strength when those stories are not read. In this way, Facebook activity is both a reflection of tie strength as it is maintained elsewhere and a tool for nurturing relationships. Furthermore, the study unpacks different classes of communication common on

	Feature	Hypothesis	Confirmed
1a	Directed communication	Increases in tie strength	Y
b	Composed vs. one-click communication	Composed > one-click	Y
2a	Passive consumption	Increases in tie strength	Y
b	Passive consumption vs. receiving composed comm.	Passive < Receiving composed	N
3a	Broadcasting	Increases in tie strength	N
b	Broadcasting vs. sending composed communication	Broadcasting < Sending composed	Y
4	Kinship / frequent comm. elsewhere / longtime friend	SNS use less valuable for these relationships	Partial

Table 3. Summary of hypotheses and results

social network sites. We find that passive consumption—reading about ties without actually contacting them—is as strongly associated with growing closer to those ties as is directly receiving messages from them. Even though interpersonal communication literature indicates frequency of interaction and communication exchanges are the building blocks of relationships, the present study shows that two people may not have to synchronously interact or direct messages at each other to grow closer. Quietly taking in the mundane details of another's life also works.

Consistent with media multiplexity arguments that people use many channels to maintain relationships, this research suggests that Facebook supplements other channels. Communicating via Facebook is associated with changes in tie strength beyond communication in person, by phone or by email, although its influence is smaller for dyads that interact frequently via other media. Although family ties are less affected by Facebook activity than non-family, the qualitative data suggest that Facebook communication is valuable even for them. Siblings, children, and parents appreciate that the site reveals a different side of their kin. They see cousins talking candidly about politics, children interacting with peers, and grandparents as "social people" rather than simply fulfilling a grandparent role. Many parents valued learning about their teens' lives without intruding. Facebook can provide a different perspective on kin, even if it doesn't bring them closer.

Limitations and future work
The timeframe in the present study is short. Relationships take years to develop, and changes in tie strength may happen gradually over months or years, rather than the month-to-month window used here. However, despite the short window and the infrequent communication within dyads on Facebook, we do see substantive increases in tie strength, over and above those expected from numerous baselines, such as living together or talking on the phone. The sample is also biased toward strong ties, with more than half of the ties selected by participants as close friends. However, the sample includes a wide range of tie strengths and the sample size is much larger than previous survey-based studies, allowing in-depth examination of how Facebook affects different kinds of relationships.

Although we have suggested that the content of communication on Facebook drives some of the effects we observed, such as greater increases in tie strength for composed versus one-click communication, the research provides no direct evidence about communication content. A thorough, automated analysis of text exchanges may reveal linguistic markers of closeness missed in the present study. The relative impact of small talk is an open question in the literature, and the present study does not distinguish between chatty, mundane news, weightier disclosures and exchanges of support; it simply distinguishes between those directed at a specific tie or broadcast to all friends. Similarly, "composed" pieces differ in length and content, and it may be the case that shorter, more generic composed pieces (such as writing "happy birthday") are comparable to one-click actions: less powerful in eliciting feelings of closeness than longer, more meaningful messages.

Like all observational studies, this work is limited in its ability to infer causality. Participants were surveyed over time, but we cannot determine whether their communication patterns cause their relationships to grow closer, or if other underlying variables cause people to grow closer and to talk more. By unpacking different kinds of relationships, including kin and non-kin, frequent contacts and less frequent contacts, and new ties, as well as controlling for communication via other channels, we account for many other possible causal factors, but the study design cannot completely demonstrate causality.

Whether social technology brings us closer or provides a false sense of connection has been widely debated. The present study demonstrates that on average relationships improve when people use Facebook to communicate with each other.

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