Multiplying the Medium:

Tie Strength, Social Role, and Mobile Media Multiplexity*

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Abstract

Researchers studying digital communication typically focus on a single communication channel. However, research on media multiplexity shows that strong relationships tend to involve communication across a variety of channels such as texting messages, voice calls, social media, and in-person communication. This chapter identifies more specifically which dimensions of closeness are associated with media multiplexity by disentangling communication frequency, cognitive closeness, and social role (e.g. being family or coworkers). We use a unique data set that combines behavioral indicators of logged texting and calling with self-report measures. The results show that high communication frequency, cognitive closeness, or an important social role are all independently associated with media multiplexity.

Keywords: Media multiplexity, Tie strength, Log data, Smartphone, Mobile, Family, Work, Closeness, Communication frequency

<1>Introduction

Contemporary relationships are typically maintained and developed using a combination of communication channels, such as in-person communication, social media exchanges, phone calls, and other forms of mediated communication. This phenomenon is called media multiplexity (Haythornthwaite, 2005). Scholarship about media multiplexity has found that strong ties—those who communicate often and have close emotional bonds—communicate through a greater variety of channels than weak ties (Haythornthwaite, 2002). This finding contradicts concerns that communication technology is separating us from our close relationships by showing that communication technology tends to be used in conjunction with in-person interaction, helping us stay highly connected to strong tie relationships. However, researchers often only have access to data sources such as social media or mobile phone logs, and lack context about how these channels are used together. This chapter disentangles how communication frequency, cognitive closeness, and social role (e.g. being family or coworkers) are associated with media multiplexity. By identifying associations between these relational dimensions and multiplexity we can infer situations when multiplexity is likely or unlikely to be occurring, which can help researchers understand if they need to address multiplexity in their studies. When multiplexity is likely to occur, researchers must consider how these channels might affect the results of their analysis and may need to seek additional information regarding communication that occurs through these channels. Conversely, when multiplexity is unlikely, researchers can be more confident in the validity their findings.

Given that foundational work on media multiplexity was conducted before the widespread adoption of text messaging and similar types of mobile communication, the rise of these

technologies points to a need to revisit this work. Mobile devices are currently the most widely diffused means of mediated communication internationally, with even the most basic models allowing for media multiplexity by way of voice calling and text messaging. The proliferation of mobile communication technologies contributes to increasingly complex opportunities for people to weave together multiple channels.

The emergence of new communication technologies also open up the possibility of using data collection methods that utilize metadata such as the times and dates extracted from text message and voice calling logs. These datasets are valuable for accurately identifying patterns in mobile communication, but it has been argued that log data alone is insufficient for evaluating tie strength (Wiese et al., 2015). In this chapter, we investigate multiplexity using a combination of mobile log data and survey results collected from 195 adults living in the United States. This unique data set allows us to combine behavioral indicators of logged texting and calling with self-report measures of cognitive closeness, social role, and in-person communication. Given that texting and calling have been widely adopted in both economically developed and developing countries, this analysis provides important insight into the most prevalent forms of media multiplexity. We examine three factors that underlie the weaving together of calling and texting activities: cognitive closeness, communication frequency, and social role (i.e. whether ties are family members or known through work). In doing so we disentangle how these three closely related but clearly distinct aspects of social relationships contribute to the embedding of media multiplexity into personal networks.

The relationships examined in this study tend to be strong because the ties included in our analysis are those with whom respondents communicate fairly regularly. As a result, tie strength in this study ranges from very strong to less strong among generally close ties. We build upon

previous work by examining tie strength among this group in terms of both frequency of contact and feelings of closeness, or what we refer to as cognitive closeness. These two dimensions of tie strength have been shown to be the most salient in an empirical analysis of General Social Survey data conducted by Marsden and Campbell (1984).

Although tie strength is clearly important to understanding media multiplexity, social role may also play a critical part in this phenomenon given that kin and work institutions require mobile media to coordinate shared activities. For example, while adults are at work they may use mobile calling and texting to coordinate daily activities with kin, such as buying milk or picking up children on the way home (Ling, 2004; Christensen, 2009). And while at home, they may blur the boundary between family and work life by using their mobiles to exchange calls and texts regarding work related matters (Gluesing, 2008). One implication is that members of the same social institutions—such as family members or work colleagues—may be motivated to communicate using multiple communication channels to aid the coordination of activities. In some cases, text messaging may be the most useful way of communicating with kin and work ties throughout the day because it does not disrupt the activities of the recipient in the way that a voice call demands immediate attention. In other cases, a voice call may be the most efficient way of conveying complex information or it may be appropriate when the caller knows that the person they are calling is available.

Understanding the factors underlying media multiplexity requires a disentangling of tie strength and social role because they tend to be closely related. Individuals are typically close—both in terms of frequency of contact and feelings of connection—to their kin and work ties. This begs the question of whether it is really relational closeness driving media multiplexity or the fact that institutionalized social roles demand media multiplexity through the constant need to

coordinate daily activities. By considering multiple how dimensions of strong tie relationships including communication frequency, cognitive closeness, and social role are associated with multiplexity, this chapter has implications for researchers who want to assess whether multiplexity is likely to be occurring in their studies, and if it needs to be addressed in their analysis.

<1>Media Multiplexity and Tie Strength

Media multiplexity refers to the phenomenon that relationships are developed and maintained through multiple communication channels (Haythornthwaite, 2005). Developments in communication technologies have increased the number of available communication tools, and contemporary relationships are typically mediated through a complex variety of channels (Boase, 2008; Haythornthwaite, 2005; Rui et al., 2015). Empirical work by Haythornthwaite and colleagues (Haythornthwaite, 2000; Haythornthwaite, 2001; Haythornthwaite, 2002; Haythornthwaite, 2003; Haythornthwaite, 2005; Haythornthwaite & Wellman, 1998; Haythornthwaite, Wellman, & Mantei, 1995) has shown that tie strength is a critical determinant of media multiplexity. This is because strong ties are more likely to desire opportunities for communication and variety in expression, which is likely to motivate them to utilize multiple communication channels (Haythornthwaite, 2002). In contrast, weak ties tend to meet their communication needs through passive opportunities for interaction such as hallway encounters (Haythornthwaite, 2005). This finding has been supported by a number of studies comparing media use among strong ties, such as close friends, to that among weaker ties (Baym & Ledbetter, 2009; Miczo, Mariani, & Donahue, 2011; Van Cleemput, 2010). Notably, using multiple communication channels has been found to be related to perceived emotional support (Wohn & Peng, 2015). This finding is congruent with scholarship indicating that strong ties tend

to provide emotional support, while weak ties provide opportunities for new information (Granovetter, 1973).

One of the purposes of Haythornthwaite's work was to explain how computer mediated communication (CMC) can simultaneously be "disengaging and engaging, disruptive of relationships yet also integrative across populations" (2005, p. 126). Previous scholarship, she noted, tended to focus on either the strengths or shortcomings of mediated communications. She urged that researchers move beyond focusing on a single communication medium, and to instead consider how multiple communication media are used in combination. Research has shown that new communication media are used to supplement, rather than replace, existing communication forms (Boase et al., 2006). By moving beyond a focus on a single medium to instead consider all available media, it is possible to address *personal communication systems* (Boase, 2008), in which individuals combine multiple media channels to connect with their personal networks. <1>Measuring Tie Strength

Granovetter's (1973) original definition of tie strength includes four dimensions, which he defines as, "a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie" (1973, 1361). Marsden and Campbell (1984) noted that much research using tie strength had failed to conceptualize how it could be measured, and responded to this by describing how tie strength could be assessed along several dimensions. Notably, they distinguished between indicators—variables that are components of tie strength—and predictors, which are related to, but not components of tie strength. Social roles such as kinship, for example, are often predictors of tie strength, but do not constitute it. By contrast, their analysis showed that a measure of "closeness"

was the best indicator of tie strength, which reveals that the cognitive element of how people feel about a relationship is a highly salient dimension of its strength. Fortunately, much of the work comparing media use to tie strength has measured tie strength in terms of closeness, identifying strong ties as friends or close friends and weak ties as acquaintances (Baym & Ledbetter, 2009; Haythornthwaite, 2005; Van Cleemput, 2010).

In another study, (Baym et al., 2007) respondents were asked to rate both relational closeness and quality on scales from 1 to 5. Additionally, while most studies have measured media multiplexity as the number of different media used to communicate with a tie, Baym et al. (2007) measured multiplexity as the percentage of the relationship's communication that took place across a medium. They found that media use was not an indicator of tie strength, but Ledbetter (2009) suggests relative proportion of media use may not be as important an indicator as frequency.

Although scholarship measuring tie strength mainly in terms of closeness has yielded valuable insights, tie strength can be measured in relation to multiple axes, and it may be valuable to study media multiplexity in relation to a more nuanced conception of tie strength. Communication frequency is another indicator of tie strength, and one that can be measured accurately using log data. However, Wiese, Min, Hong, and Zimmerman (2015) caution that measuring tie strength purely using frequency and duration of communication can lead to a significant number of strong ties being mislabeled as weak ties. They identified three explanations for these errors:

> 1) Individuals use many different communication channels, and phone and SMS logs are not representative of their overall communication patterns;
>
> 2) Face-to-face communication is important, but is not easily observed; and

> 3) Individuals feel a lingering sense of closeness to friends from a previous stage in their life, though communication has decreased. (2015, p. 2)

For these reasons, communication frequency alone is likely to be an incomplete measure of tie strength, but it may be valuable to consider communication frequency and closeness in combination.

This study builds upon previous scholarship by considering media multiplexity in relation to multiple dimensions of tie strength. Given that closeness itself is a nuanced concept and can be considered according to constituent variables such as trust, enjoying socializing, or discussing important matters (Marin & Hampton, 2007) our analysis will operationalize cognitive closeness using variables that measure each of these three dimensions. Moreover, as discussed earlier, media multiplexity might also be strongly related to frequency of communication, such that more frequently contact ties tend to be more multiplex. Accordingly, our first research question considers the implications of measuring tie strength in relation to both communication frequency and cognitive closeness.

> **RQ1:** To what extent are communication frequency and cognitive closeness associated with media multiplexity?

<1>Social Roles and Institutions

Another dimension of tie strength is social role, such as whether a tie is a member of family or work institutions. Although role is not an indicator of tie strength, it is a predictor because ties of certain roles are more likely to have a high tie strength than others (Marsden & Campbell, 1984). Some of the most significant social institutions are school, work, and family. This study describes communication patterns of adult respondents and focuses on work and family. In addition to being a predictor for tie strength, ties in different roles may have particular goals for

their communication, such as participating in shared activities. Institutions such as families or workplaces can act as foci "around which joint activities are organized" (Feld, 1981, 1016). As a result, one of the purposes of communication among family and work ties is to facilitate those activities, and this may shape their use of different media for communication. Our second research question addresses the relationship between social role and media multiplexity:

> **RQ2:** To what extent is social role predictive of media multiplexity, particularly pertaining to family and work ties?

Finally, given that social role may be highly associated with both frequency of contact and cognitive closeness, our final research question asks:

> **RQ3:** When taken together, what is most associated with media multiplexity: communication frequency, cognitive closeness, or social role?

The purpose of RQ3 is to assess the extent to which any associations identified in RQ1 and RQ2 might better explained by other variables—for example whether social role becomes more or less relevant when considered alongside communication frequency and cognitive closeness. When investigating this and our other research questions, we do not point to 'mechanisms' of causality among these variables. Instead, by assessing the independence of these variables we examine which are important for investigating multiplexity.

<1>Data and Methods

The study described in this chapter used a combination of anonymized smartphone log data and survey data, both collected using the same Android application, *Communication Explorer.*[1] Using call and text messaging logs allowed the researchers to access accurate data about when and to whom respondents communicated using their smartphones. Logged communication data

is much more accurate than self-report accounts, in which people tend to under-report or over-report communication frequency (Boase & Ling, 2013; Kobayashi & Boase, 2012). This is a significant strength, but there are also several considerations researchers must make when working with this type of log data. Significantly, when working with this sort of data, researchers must address potential privacy concerns of their respondents. To this end, the Communication Explorer application was designed to only record data that was necessary to the project; it did not copy the content of text messages or email, it stored data in an encrypted format on a secure server, and it masked identifying information from phone numbers and email addresses using anonymous numeric codes. Another consideration when using log data is how to incorporate necessary context to make sense of the data. The log data alone could not provide information about cognitive closeness or social role between respondents and their ties, so was combined with questionnaire results describing these aspects of respondents' relationships. In this respect, the application was designed to utilize the strengths of log data in terms of accurately counting communication events and the strengths of self-report data in providing context for the logs.

This paper uses data collected from 195 adults living in the United States of America in the winter and spring of 2011. This sample was randomly selected from a larger panel maintained by a research company that specializes in Internet surveys. Participation was limited to adults between the ages of 20 to 69 who used Android smartphones and Gmail on a daily basis. Respondents were paid a small amount of money to complete an online survey then install the Communication Explorer application on their smartphones, which collected non-identifying voice call, texting and email[2] data, and administered a series of on-screen questionnaires every day for approximately one month.

The application collected log data for the full length of stored records on the smartphone. Although log data is more accurate than self-report accounts of communication patterns, there are some limitations resulting from how Android-based smartphones store such data. By default, Android phones store the most recent 500 calls in a user's log, and usually limit the logged SMS messages to 200 per contact. Because of this, there were significant differences in length for each respondent's log history (ranging from 2 days to 544 days). Given that different log lengths would hinder comparability among respondents' data, logs were reduced to a consistent length across all respondents. More than 95% of respondents had communication logs spanning at least 28 days, so respondents with shorter logs were excluded from the analysis, leaving 188 respondents. Some respondents began and concluded the study at different times than others, so for each respondent, the analysis focuses on logged events within the 28 days preceding the conclusion of the application's data collection.

As well as collecting log data, the application displayed daily pop-up surveys to respondents for at least 30 days. Each day, the application randomly selected a contact with whom the respondent had at least one logged communication in the previous 24 hours and asked several questions about that tie. Only one tie would be selected and used in the on-screen survey for that day, and ties that were contacted frequently would have a higher chance of being selected during a 30-day period than those that were only contacted once or twice. The tie's name was displayed on the screen and questions about topics including the social role of the tie (e.g. whether the tie was a family member), the respondent's cognitive closeness to the tie (e.g. whether the respondent enjoyed socializing with the tie), and whether the respondent regularly talked to that tie in person. Respondents were required to respond to 30 popup surveys in order to receive a small monetary incentive. Data collection generally took 30 days (for 30 surveys) and took

longer than 30 days in some unusual cases where respondent chose not to respond to a popup survey question on a particular day or failed to have any logged calling, texting, or email activity in a 24-hour period.

In our analysis, only ties for whom there is survey data were considered. Because surveys were only displayed for ties the respondent contacted during the study period, the selected ties tended to be relatively strong. Ties with whom the respondent might communicate every few months, but who were not contacted during the 30-day study period had no chance of being selected for a survey. Additionally, ties who with whom the respondent communicated on multiple days were more likely to be randomly selected than ties who only appeared in the communication logs for one day. As a result, this study uses data from ties with whom there was logged calling, texting or email during data collection period, and it is likely that these ties are stronger and more active than ties for whom not survey data was collected.

<2>Dependent Variable

The dependent variable for our analyses is the amount of media multiplexity between ties. Media multiplexity is measured as the number of communication channels used to communicate with a tie. For each tie, media multiplexity was measured as a scale from one to three, indicating the number of channels used to communicate with that tie. In-person communication, phone calls, and text messages were considered as follows:

Phone calls: Included if there was at least one phone call logged between the pair in the 28 days preceding their final in-app survey.

Text messages: Included if there was at least one text message logged between the pair in the 28 days preceding their final in-app survey.

In-person communication: Included if the respondent answered "yes" to the question, "Do you talk to [this tie] in-person during a typical day?

As explained earlier, only ties for whom survey data was collected were included, and respondents only received a survey for ties with whom they had communicated at least once with their mobile phones. As a result, each tie had a media multiplexity score of at least one. Additionally, ties with whom there were not at least two logged communications were excluded so each tie had a theoretical possibility of having a multiplexity score of three (two logged communication channels plus in-person communication). Setting this minimum threshold for the scale allows us to avoid inflated correlations with the independent frequency of contact variables described below.

Measuring multiplexity using a combination of log and survey data had both advantages and limitations. Self-report data has the advantage of addressing in-person communication, which is not logged by the app. However, as discussed earlier self-report responses tend to be inaccurate with regard to communication frequency. As a result, there were important differences in the precision with which in-person communication was measured according to self-report, and calls and text messages were measured using log data. Using the self-report questionnaire data, in-person communication is measured as a binary variable based on whether or not the respondent answered that they talk to the tie in-person "during a typical day." As a result, it was not possible to measure in-person communication more comprehensively such as adjusting for ties that talk in person weekly or monthly. An alternate way of measuring in-person communication is to use phone sensors to measure physical proximity between respondents, but this is only possible in a closed network where all measured ties have a monitoring software installed (see for e.g. Hristova, Musolesi, & Mascolo, 2014). This would allow greater precision than the survey

measure utilized in our study, but would pose significant logistical barriers for studying communication across multiple institutions as is necessary to evaluate the significance of social role. Dichotomizing the calling and texting data allows us to develop a scale in which an amount of calling, texting, or in-person contact greater than zero per tie would be factored into the scale. The resulting scale was balanced enough to capture a reasonable degree of variability in mobile media multiplexity of ties. Of the 1,383 ties in our analysis, 475 (34 percent) have a media multiplexity score of one, 569 (41 percent) have a score of two, and 339 (25 percent) have a score of three.

<2>Independent Variables

Independent variables were created measuring three dimensions of tie strength among each respondent-tie dyad: communication frequency, social role, and cognitive closeness.

Communication frequency was measured using the logged number of phone calls and text messages exchanged with ties over the 28 days preceding their final in-app survey. In-person communication was not included as an independent variable because a value of one in this variable will necessitate a value of one added to the scale in the dependent variable indicating media multiplexity. By contrast, the calling and texting variables were continuous and any variations in these variables would not necessarily necessitate a change in the dependent variable. There is a median of 6 calls and 8 texts for each tie. However, the distributions for these scales are positively skewed. As a result, there are a mean of 19.8 calls and 72.1 texts for the ties examined in this analysis.

Social role and cognitive closeness variables were created based on responses to the application's popup surveys. The social role of each tie was determined based on responses to questions about whether that tie was a family member or someone known from work. 539 (39

percent) of the ties are kin, 309 (22 percent) of the ties are work based, and 549 (39 percent) are non-kin and non-work ties. Given these variables are mutually exclusive, we use kin and work ties as dummy variables in our regression analyses and the "other" (non-kin, non-work) ties as the reference category.

Three variables were used to represent different dimensions of cognitive closeness: whether the respondent trusts the tie a lot, whether the respondent talks to the tie about important matters, and whether the respondent enjoy socializing with the tie. 1,120 (81 percent) are trusted ties, 1,088 (79 percent) are ties with whom the respondent discusses important matters, and 1,196 (87 percent) are ties with whom the respondent enjoys socializing. It should be kept in mind that the app tended to select ties that were strong in nature, which is likely why the large majority of ties examined in this analysis tended to show high levels of cognitive closeness.

<2>Respondent Demographics and Control Variables

The demographics of the 188 respondents in this sample were as follows: 63% were female, 69% college educated, 55% married, 40% married with children, and 61% had a full-time job. The mean age of respondents was 36 years old. To control for any possible influence of these traits in our analysis we use them as control variables. Additionally, a dyadic level variable indicating whether ties lived more than one hour away from respondents was used as a control, since this would influence the potential of in-person interaction to occur. 27% (N = 370) of ties lived more than one hour away from the respondent.

<1>Analysis and Results

Using Stata, ordered logistic regressions were conducted to identify relationships between three dimensions of tie strength and media multiplexity. A cluster option was used to account for non-independence within respondent-level clusters, because independent and dependent

variables were at the tie level and demographic control variables were at the respondent level. The results of these regression analyses are presented in Table 1. Models 1-3 tested communication frequency, cognitive closeness, and social role individually to assess their associations with media multiplexity. Model 4 tested all three sets of independent variables together to assess which of the independent variables had the strongest associations with multiplexity.

RQ1 asked, "To what extent are communication frequency and cognitive closeness associated with media multiplexity?" This question is addressed in Model 1 and Model 2.

Model 1 shows that ties with whom a respondent had exchanged a large number of text messages are significantly ($p < .01$) more likely to have high media multiplexity than other ties. Text messages count had a low unstandardized coefficient ($b = 0.00$) because a difference of one text message is unlikely to have a large relation to multiplexity. However, the standardized coefficient for text messages is much higher (standardized $b = 0.24$), suggesting that a larger variation in text message count is viable predictor of media multiplexity. The number of phone calls exchanged between ties was also significant, but to a lesser degree ($p < .05$).

Model 2 evaluates how three cognitive closeness variables predict to media multiplexity: trust, discussing important matters, and enjoying socializing. Because there is some correlation among these variables a variance inflation test was run to ensure that the three cognitive closeness variables did not have significant collinearity, which would compromise the regression model. A variance inflation test returns a tolerance and a variance inflation factor (VIF) for each variable. A VIF value of greater than 10 or a tolerance lower than 0.1 would indicate collinearity (Chen et al., 2003). The test showed that the three cognitive closeness variables were not did not exhibit collinearity that would compromise the regression analysis (Trust: Tolerance = 0.65, VIF

= 1.55; Important matters: Tolerance = 0.74, VIF = 1.35; Enjoy socializing: Tolerance = 0.75, VIF = 1.33). A second variance inflation test was conducted in which the control variables were added, and the results were almost the same.

The results of Model 2 show that ties with whom respondents discuss important matters ($p < .001$) and ties with whom respondents enjoyed socializing ($p < .01$) were significantly likely to have a higher media multiplexity than other ties, but trust was not a significant predictor of media multiplexity ($p > .05$).

The results presented in Model 1 and Model 2 illustrate that both cognitive closeness and communication frequency are positively associated with media multiplexity. However, this was not the case for all components of these variables. With regard to cognitive closeness, discussing important matters and enjoying socializing are positive predictors of media multiplexity in Table 1, but trust was not significant. And of the communication frequency variables, both text messages and phone calls were found to be significant predictors of media multiplexity.

RQ2 asked, "To what extent is social role predictive of media multiplexity, particularly pertaining to family and work ties?" Model 3 shows that respondents are significantly more likely to have higher media multiplexity with ties that are family members ($p < .001$) and ties that they know from work ($p < .01$) when compared to the reference category of other ties. One explanation for this may be the larger amount of in-person communication with kin and work ties. Respondents indicated that they talked in-person to 55% of family ties and 59% of work ties on a typical day, but only 21% of other ties from their phone logs.

RQ3 asked, "When taken together, what is most associated with media multiplexity: communication frequency, cognitive closeness, or social role?" This question is addressed in Model 4, which combines all of the independent variables tested in the previous models. We

performed an ordered logistic regression analysis of all these variables to address overlaps between the three dimensions. Would the associations identified in RQ2 between social role and multiplexity still be significant when tested together with the tie strength variables? If so, it would suggest that the association between social role and multiplexity is significant independent of communication frequency and cognitive closeness. The results of Model 4 show that communication frequency, cognitive closeness, and social role remain significant predictors and are therefore independently associated with media multiplexity.

[INSERT TABLE 1 AROUND HERE]

In Model 4, like in Model 1, the number of text messages exchanged with a tie is significantly ($p < .01$) predictive of media multiplexity. Additionally, like in Model 1 the low unstandardized coefficient ($b = 0.00$) for text messaging should be understood in relation to the standardized coefficient (standardized $b = 0.24$). Although a difference of only one text message has only a small association with media multiplexity, larger variations have a greater predictive capacity. The number of phone calls exchanged between ties is not a significant indicator in Model 4 ($p > .05$). The cognitive closeness variables about discussing important matters ($p < .05$) and enjoying socializing ($p < .01$) are also significant in Model 4. It is notable, however, the significance and coefficient for discussing important matters are less than in Model 2. It is possible that some of the importance of discussing important matters in Model 2 is better explained by other variables. In Model 4, the social role variables have the highest significance of all the independent variables. Kin ties ($p < .001$) and work ties ($p < .01$) are both likely to have a higher multiplexity than other ties. The only variables that had a greater effect were enjoying socializing ($b = 0.695$, $p < 0.01$) and the control variable for ties that live farther than 1 hour away ($b = -1.278$, $p < .001$).

<1>Discussion and Conclusion

Haythornthwaite and colleagues (Haythornthwaite, 2000; Haythornthwaite, 2001; Haythornthwaite, 2002; Haythornthwaite, 2003; Haythornthwaite, 2005; Haythornthwaite & Wellman, 1998; Haythornthwaite, Wellman, & Mantei, 1995) have shown that tie strength is associated with media multiplexity. However, much of this work was conducted before the widespread adoption of text messaging. This paper has built upon their work by considering multiple dimensions of tie strength including communication frequency and cognitive closeness, as well as examining how social role relates to mobile media multiplexity.

RQ1 asked about the extent to which communication frequency and cognitive closeness were associated to media multiplexity. The results showed that both measures of tie strength were indicators of media multiplexity. This supports Haythornthwaite (2005) and shows that her findings about multiplexity and tie strength remain consistent across multiple periods of time with different available communication media. Additionally, our findings suggest that future studies of media multiplexity may benefit from including both communication frequency and cognitive closeness as measures of tie strength. The association between communication frequency and multiplexity is not a surprising result, as previous scholarship has argued that one explanation for high levels of media multiplexity is a desire to seek out opportunities for communication (Haythornthwaite 2005). This desire is likely to be related to both frequency of communication and the use of multiple communication channels. Interestingly, in Model 4 where communication frequency was considered alongside cognitive closeness and social role, only text messages (not phone calls) had a significant association with media multiplexity. This suggests that frequency of text messaging is a stronger predictor of multiplexity than frequency of calling. One explanation for the significance of text messages is that they are often used for

expressive communication designed to establish virtual co-presence and emotional bonding (Ito & Okabe, 2005; Ling & Birgitte, 2002), so exchanging a large number of texts may be linked with emotional closeness.

RQ2 investigated the significance of social roles (i.e. kin and work ties) as predictors of media multiplexity. The results showed that kin and work ties had higher media multiplexity than other ties. The significance of social roles was also evident after addressing RQ3, which examined the significance of communication frequency, cognitive closeness, and social role when compared against each other. The results showed that each relational dimension, including social role, was independently predictive of media multiplexity. The fact that kin and work ties were significantly associated with media multiplexity even when the other independent variables were included in the model warrants further discussion. One explanation for the significance of social role is that kin and work ties are likely to participate in shared activities through their common institutional focus (Feld, 1981). We posit that coordinating these shared activities may encourage communication across a range of channels. As noted earlier, particularly significant is that family and work ties are significantly more likely to regularly speak in-person than other ties. This supports our assumption that membership in the same family or work institutions requires daily focused activities. Additionally, kin and work ties may weave calls and texting into their daily routines, achieving a sort of perpetual contact even when physically apart (Katz & Aakhus, 2002). This is consistent with scholarship discussing ways that mobile phones are used to communicate with family ties while at work and with work ties when at home (Christensen, 2009; Gluesing, 2008; Ling, 2004; J. Wajcman, Bittman, & Brown, 2008; Judy Wajcman et al., 2007). Furthermore, close institutional ties, especially family, may have enough

knowledge of each other's schedules to know whether it is appropriate to call or to text at different times of day, and may vary their choice of communication channel accordingly.

A limitation of this study is that only three types of media use were examined, phone calls, text messages, and in-person communication. At the time of data-collection, voice calls and text messages dominated mobile phone communications, but in the relatively short period of time since the data for this study was collected, social media and other messaging apps have become increasingly common among smartphone users. Many of these apps function similarly to texting, so it is likely that results of this study would be similar to an updated study that included data about these texting apps. Nonetheless, it is clear that current and future studies would be missing crucial information if they failed to address the importance of communication apps such as Facebook Messenger, WhatsApp, Line, and Snapchat. However, these apps pose significant challenges for accessing communication log data. First, these applications may store their log data in different formats so researchers aiming to collect data from these logs must navigate the requirements of each app individually. Additionally, software updates may lead to changes in data structure or policies, so a method used to retrieve log data from version 1.0 may not work with version 1.1. Moreover, because user data is a valuable commodity for social networking platforms, there are cases where this data may be intentionally inaccessible so as to maintain a competitive advantage for the platform owners (Manovich, 2012). As a result, although logged communication data has great potential for researchers it is virtually impossible for researchers to capture all of the communication channels used by the people they study.

This is why identifying variables associated with multiplexity is so important—if multiplexity is occurring, researchers are unlikely to have access to information about all relevant communication channels. This study has contributed to scholarship about media

multiplexity by showing that communication frequency, cognitive closeness, and social role are each independently associated with multiplexity. If researchers identify these variables they can infer whether multiplexity is likely to be important for their study. There are several possible ways multiplexity can be addressed by researchers. It may be possible to seek access to additional data sources, such as logs from communication apps. Researchers may supplement log data by asking respondents to describe if and how they use additional communication channels. And following our proposal that organizing around shared activities may be the reason for the strong association between social role and media multiplexity, studying these shared activities may be important for relationships involving institutional bonds such as family or work. Conversely, multiplexity is less likely to be significant in relationships that do not involve high communication frequency, cognitive closeness, or shared social roles, and so data from a single communication channel may be sufficient for investigating these cases. In either case, identifying the likelihood of multiplexity is important for understanding contemporary communication practices.

Table 1: Ordered logistic regression results predicting to media multiplexity

	Model 1		Model 2		Model 3		Model 4	
Communication frequency								
Phone calls	0.01	*					0.01	
	(0.01)						(0.01)	
Text messages	0.00	**					0.00	**
	(0.00)						(0.00)	
Cog. Closeness								
Trust			0.23				0.20	
			(0.18)				(0.20)	
Discuss important matters			0.81	***			0.44	*
			(0.19)				(0.19)	
Enjoy socializing			0.72	**			0.69	**
			(0.21)				(0.20)	
Social Role								
Reference = not a kin or work tie								
Kin ties					0.94	***	0.62	***
					(0.14)		(0.15)	
Work ties					0.56	**	0.56	**
					(0.16)		(0.18)	
Control variables								
Live >1hr away	-1.15	***	-1.24	***	-1.19	***	-1.28	***
	(0.12)		(0.13)		(0.12)		(0.13)	
Female	-0.04		-0.04		-0.01		-0.05	
	(0.15)		(0.16)		(0.01)		(0.16)	
College Degree	0.18		0.07		0.12		0.14	
	(0.14)		(0.14)		(0.13)		(0.15)	
Married	0.36	*	0.23		0.10		0.23	
	(0.17)		(0.18)		(0.17)		(0.17)	
Married with Children	0.15		0.14		0.22		0.14	
	(0.17)		(0.19)		(0.18)		(0.17)	
Full-time Job	0.29		0.21		0.14		0.23	
	(0.16)		(0.16)		(0.16)		(0.16)	
Age	-0.01		-0.02		-0.02	*	-0.01	
	(0.01)		(0.01)		(0.01)		(0.01)	
Wald chi squared	172.58	***	167.79	***	178.84	***	250.66	***
N	1375		1361		1373		1359	

Unstandardized coefficients. Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[1] Communication Explorer was designed by two of this chapter's authors, Boase and Kobayashi. Researchers may also be interested in the E-Rhythms software, which can be used to collect similar data as the Communication Explorer but also allows for more flexibility. Information about both the Communication Explorer and E-Rhythms is available at http://erhythms.utm.utoronto.ca/software.html.

[2] Although the Communication Explorer application also logged email communications sent or received using the Gmail app on respondents' smartphones, only 62% (n=117) of respondents reported that Gmail was their main email address. As a result, the email data was omitted from this study because it did not represent email use for a significant number of respondents.

<1>Bibliography

Baym, Nancy K., and Andrew Ledbetter. 2009. "Tunes That Bind?: Predicting Friendship Strength in a Music-Based Social Network." *Information, Communication & Society* 12 (3): 408–27. doi:10.1080/13691180802635430.

Baym, Nancy K., Yan Bing Zhang, Adrianne Kunkel, Andrew Ledbetter, and Mei-Chen Lin. 2007. "Relational Quality and Media Use in Interpersonal Relationships." *New Media & Society* 9 (5): 735–52.

Boase, Jeffrey. 2008. "Personal Networks and the Personal Communication System: Using Multiple Media to Connect." *Information, Communication & Society* 11 (4): 490–508. doi:10.1080/13691180801999001.

Boase, Jeffrey, John B. Horrigan, Barry Wellman, and Lee Rainie. 2006. "The Strength of Internet Ties." Pew Internet and American Life Project. http://www.pewinternet.org/files/old-media/Files/Reports/2006/PIP_Internet_ties.pdf.pdf.

Boase, Jeffrey, and Rich Ling. 2013. "Measuring Mobile Phone Use: Self-Report versus Log Data." *Journal of Computer-Mediated Communication* 18 (4): 508–19. doi:10.1111/jcc4.12021.

Chen, Xiao, Philip B. Ender, Michael Mitchell, and Christine Wells. 2003. "Regression Diagnostics." In *Stata Web Books: Regression with Stata*. http://www.ats.ucla.edu/stat/stata/webbooks/reg/chapter2/statareg2.htm.

Christensen, Toke Haunstrup. 2009. "'Connected Presence' in Distributed Family Life." *New Media & Society* 11 (3): 433–51. doi:10.1177/1461444808101620.

Feld, Scott L. 1981. "The Focused Organization of Social Ties." *American Journal of Sociology* 86 (5): 1015–35.

Gluesing, Julia C. 2008. “Identity in a Virtual World: The Coevolution of Technology, Work, and Lifecycle.” In *Mobile Work, Mobile Lives: Cultural Accounts of Lived Experiences*, edited by Tracy L. Meerwarth, Julia C. Gluesing, and Brigitte. Jordan, 70–88. Malden, MA: Wiley-Blackwell.

Granovetter, Mark. 1973. “The Strength of Weak Ties.” *American Journal of Sociology* 78 (6): 1360–80.

Haythornthwaite, Caroline. 2000. “Online Personal Networks Size, Composition and Media Use among Distance Learners.” *New Media & Society* 2 (2): 195–226.

Haythornthwaite, Caroline. 2001. “Exploring Multiplexity: Social Network Structures in a Computer-Supported Distance Learning Class.” *The Information Society* 17 (3): 211–26.

Haythornthwaite, Caroline. 2002. “Strong, Weak, and Latent Ties and the Impact of New Media.” *The Information Society* 18 (5): 385–401.

Haythornthwaite, Caroline. 2003. “Supporting Distributed Relationships: Social Networks of Relations and Media Use over Time.” *Electronic Journal of Communication* 13 (1).

Haythornthwaite, Caroline. 2005. “Social Networks and Internet Connectivity Effects.” *Information, Communication & Society* 8 (2): 125–47. doi:10.1080/13691180500146185.

Haythornthwaite, Caroline, and Barry Wellman. 1998. “Work, Friendship and Media Use for Information Exchange in a Networked Organization.” *Journal of the American Society for Information Science* 49 (12): 1101–14.

Haythornthwaite, Caroline, Barry Wellman, and Marilyn Mantei. 1995. “Work Relationships and Media Use: A Social Network Analysis.” *Group Decision and Negotiation* 4 (3): 193–211. doi:10.1007/BF01384688.

Hristova, Desislava, Mirco Musolesi, and Cecilia Mascolo. 2014. “Keep Your Friends Close and Your Facebook Friends Closer: A Multiplex Network Approach to the Analysis of Offline and Online Social Ties.” *arXiv Preprint arXiv:1403.8034*. http://arxiv.org/abs/1403.8034.

Ito, Mizuko, and Daisuke Okabe. 2005. “Technosocial Situations: Emergent Structuring of Mobile E-Mail Use.” In *Personal, Portable, Pedestrian: Mobile Phones in Japanese Life*, edited by Mizuko Ito, Daisuke Okabe, and Misa Matsuda, 257–76. Cambridge, Mass.: MIT Press.

Katz, James E., and Mark Aakhus. 2002. *Perpetual Contact: Mobile Communication, Private Talk, Public Performance*. Cambridge University Press.

Kobayashi, Tetsuro, and Jeffrey Boase. 2012. “No Such Effect? The Implications of Measurement Error in Self-Report Measures of Mobile Communication Use.” *Communication Methods and Measures* 6 (2): 126–43.

Ledbetter, Andrew M. 2009. “Patterns of Media Use and Multiplexity: Associations with Sex, Geographic Distance and Friendship Interdependence.” *New Media & Society* 11 (7): 1187–1208.

Ling, Rich. 2004. *The Mobile Connection: The Cell Phone’s Impact on Society*. Morgan Kaufmann.

Ling, Rich, and Yttri Birgitte. 2002. “Hyper-Coordination via Mobile Phones in Norway.” In *Perpetual Contact: Mobile Communication, Private Talk, Public Performance*, edited by James E. Katz and Mark Aakhus, 139–69. Cambridge University Press.

Manovich, Lev. 2012. “Trending: The Promises and the Challenges of Big Social Data.” In *Debates in the Digital Humanities*, edited by Matthew K. Gold. U of Minnesota Press. http://manovich.net/content/04-projects/067-trending-the-promises-and-the-challenges-of-big-social-data/64-article-2011.pdf.

Marin, A., and K. N. Hampton. 2007. “Simplifying the Personal Network Name Generator: Alternatives to Traditional Multiple and Single Name Generators.” *Field Methods* 19 (2): 163–93. doi:10.1177/1525822X06298588.

Marsden, Peter V., and Karen E. Campbell. 1984. “Measuring Tie Strength.” *Social Forces* 63 (2): 482. doi:10.2307/2579058.

Miczo, Nathan, Theresa Mariani, and Crystal Donahue. 2011. “The Strength of Strong Ties: Media Multiplexity, Communication Motives, and the Maintenance of Geographically Close Friendships.” *Communication Reports* 24 (1): 12–24. doi:10.1080/08934215.2011.555322.

Rui, J. R., J. M. Covert, M. A. Stefanone, and T. Mukherjee. 2015. “A Communication Multiplexity Approach to Social Capital: On- and Offline Communication and Self-Esteem.” *Social Science Computer Review* 33 (4): 498–518. doi:10.1177/0894439314552803.

Van Cleemput, K. 2010. “‘I’ll See You on IM, Text, or Call You’: A Social Network Approach of Adolescents’ Use of Communication Media.” *Bulletin of Science, Technology & Society* 30 (2): 75–85. doi:10.1177/0270467610363143.

Wajcman, J., M. Bittman, and J. E. Brown. 2008. “Families without Borders: Mobile Phones, Connectedness and Work-Home Divisions.” *Sociology* 42 (4): 635–52. doi:10.1177/0038038508091620.

Wajcman, Judy, Michael Bittman, Paul Jones, Lynne Johnstone, and Jude Brown. 2007. “The Impact of the Mobile Phone on Work/life Balance.” *Canberra: Australian Mobile Telecommunications Association & Australian National University*.

Wiese, Jason, Jun-Ki Min, Jason I. Hong, and John Zimmerman. 2015. “‘You Never Call, You Never Write’: Call and SMS Logs Do Not Always Indicate Tie Strength.” In , 765–74. ACM Press. doi:10.1145/2675133.2675143.

Wohn, Donghee Yvette, and Wei Peng. 2015. “Understanding Perceived Social Support through Communication Time, Frequency, and Media Multiplexity.” In , 1911–16. ACM Press. doi:10.1145/2702613.2732866.