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It Takes at Least Two to Tango: A Population-Level Perspective on Interrelated Patterns of Media Use

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We introduce a population-level perspective on the longstanding debate on displacement versus complementarity by recognizing that an individual's social interactions are dependent on emerging media use patterns in the wider population. Our longitudinal, cross-regional analyses at the population-level and individual-level indicate that two opposing forces coexist: individual Internet use and individual face-to-face (f2f) interaction are positively correlated, suggesting complementarity. However, local peers' Internet use and individual f2f interactions are negatively related, suggesting displacement. Interestingly, when social networking site uptake is high, individual Internet non-use is associated with a more pronounced negative association between peers' Internet use and individual-level f2f interactions. We discuss the implications of coexisting individual-level complementarity and population-level displacement for both users and non-users.

Keywords: Internet Use, F2f Interaction, SNS Uptake, Peer Effects, Population Level.

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Despite three decades of research, computer-mediated communication scholars still heavily debate the effects of Internet use on face-to-face (f2f) interactions. On one hand, scholars have found that Internet use replaces f2f interactions, describing this transition as displacement (e.g., Kraut, Patterson, et al., 1998; Lee, 2009; Ruppel & Burke, 2015). On the other hand, studies have reported that Internet use goes hand in hand with f2f interactions, and concluded that f2f interactions were complemented, rather than displaced, by Internet use (e.g., Dienlin, Masur, & Trepte, 2017; Dutta-Bergman, 2004; Katz & Rice, 2002; Kraut, Kiesler, Boneva, Cummings, & Helgeson, 2002). This continued theoretical disagreement is problematic, because displacement and complementing processes shape the communication context in which social relationships are formed and maintained (Caughlin & Sharabi, 2013; Ledbetter, 2009).

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This longitudinal, cross-regional study set out to answer the following question: how does Internet use relate to f2f interaction frequency over time and space? We argue that the current debate has ignored two key factors. First, social interaction cannot occur in isolation of interaction partners (Etzioni, 1993, 1995). However, the displacement-complementarity debate has suffered from the "general individualism bias in the field of communication" (Zhang & Leung, 2015, p. 1016) and downplayed the role of the social environment (Parks, 2017). While tie-level theories have focused on interactions between two actual interaction partners, and thus recognized that for social interaction to take place it takes two to tango (Haythornthwaite, 2005), we assess how the behaviors of potential interaction partners shape f2f interactions. In other words, we argue it takes at least two to tango. Second, the contributors to the displacement-complementarity debate have suggested that the introduction of new online media allows for a more social use of the Internet (cf., Zhao, 2006), which then affects Internet use and f2f interaction patterns. However, empirical support for these ideas is limited, because the timespans adopted by earlier studies are often too short to assess how new online media, such as social networking sites (SNSs),[1] change the relationship between Internet use and f2f interaction.[2] We fill this gap by assessing how SNS introduction and uptake affected population-level and individual-level shifts in Internet use and f2f interaction between 2002 and 2010.

We contribute to the literature in three ways. First, we estimated the overall association between Internet use and f2f interaction at the population level, and showed that Internet use is negatively correlated with f2f interactions when SNS uptake is high. Second, we developed a mixed-level model to theoretically explore displacement and complementarity mechanisms at the individual and population levels. Our findings indicate that individual Internet use is positively related to f2f interaction, suggesting complementarity, while local peers' Internet use is negatively related with individual Internet use, suggesting displacement. As such, it seems that two opposing forces coexist: individual-level complementarity and population-level displacement. Third, we found a significant three-way interaction between individual Internet use, local peers' Internet use, and SNS uptake: the negative association between local peers' Internet use and individual f2f interaction is most pronounced when individual Internet use is low and SNS uptake is high. Overall, our findings suggest that, while f2f interaction decreased only moderately at the population level over time, individuals—especially within the group of Internet non-users—can be at risk of social exclusion in environments where Internet use and SNS uptake are both high.

Theoretical background and framework

The displacement-complementarity debate

The academic discussion about the relationship between Internet use and f2f interactions has been around for over 30 years. In their landmark study, Kraut, Patterson, et al. (1998) found that, despite serving communicative purposes, Internet use is associated with a drop in communication between family household members. They suggested that Internet users replace offline interactions (e.g., f2f interactions) with lower-quality online interactions. Drawing on Putnam (1995), they referred to this occurrence as displacement. The displacement argument relies on the relative constancy assumption (McCombs, 1972). This approach states that time spent on mass communication is constant (i.e., time spent online cannot be devoted to f2f interaction) and, consequently, f2f interactions are replaced. More recently, scholars have argued that online media are more likely to replace f2f interaction when they gratify a similar need (niche theory; Dimmick, 2002; Dimmick, Kline, & Stafford, 2000). In these cases, Internet use substitutes for, rather than reduces, f2f interaction. Displacement theory is supported by empirical studies (Nie & Erbring, 2000; Nie, Hillygus, & Erbring, 2002), became

well-established at the turn of the century, and continues to influence the debate (Ledbetter, 2009; Lee, 2009; Ruppel & Burke, 2015).

However, not long after their influential 1998 study, Kraut et al. (2002) conducted a follow-up study covering a longer time span. Surprisingly, they found that, rather than displacing f2f interactions, Internet use complements them. Here, complementing refers to a situation in which online interaction occurs in addition to f2f interactions. Theorists have suggested that, rather than viewing online interactions as being of a lower quality than f2f interactions (cf., Kraut, Patterson, et al., 1998), by providing opportunities for selective self-representation, idealization, and reciprocation, online interactions can be "hyperpersonal" (Walther, 1996). This conceptualization of online interactions led to the development of a more positive perspective on online media use. In contrast to niche theory, complementarity theorists have argued that "users of a medium who satisfy a particular functional need also use other media types to fulfill that need" (Dutta-Bergman, 2004, p. 659). Empirical findings show positive relationships between f2f interactions and both Internet use (Katz & Rice, 2002; Shklovski, Kiesler, & Kraut, 2006) and SNS use (Brandtzæg, 2012; Dienlin et al., 2017; Freberg, Adams, Mcgaughey, & Freberg, 2010). Interestingly, while the debate continues to evolve, the displacement-complementarity dispute has not been resolved. We argue that, in order to move beyond this theoretical impasse, the debate can benefit from the inclusion of group-level dynamics.

A population-level perspective

While the displacement-complementarity debate has produced increasingly fine-grained and sophisticated studies of the interplay between multiple online media and f2f interaction, theorizing remains largely constrained to the individual level and focuses on a single population or population subset (Zhang & Leung, 2015). Such an individual-level focus is problematic, because an individual-level theory lacks context and assumes that "with respect to the constructs of interest, individual members of a group are independent of that group's influence. Thus, the value of a construct for an individual member of a group is independent of the value of the construct for other members of the same group" (Klein, Dansereau, & Hall, 1994, p. 200). This assumption is likely to be invalid, as social interaction cannot occur in isolation of interaction partners (Etzioni, 1993, 1995). Thus, the debate is likely to suffer from the "general individualism bias in the field of communication" (Zhang & Leung, 2015, p. 1016).

Media multiplexity theory (Haythornthwaite, 2005) partially addresses this concern by shifting scholarly attention to the tie level, recognizing that for social interaction to take place it takes two to tango. The central premise of media multiplexity theory is that individuals use a greater variety of media to interact with close ties than with distant ties. This has found strong empirical support (e.g., Caughlin & Sharabi, 2013; Ledbetter, 2009; Ledbetter & Keating, 2015; Ledbetter, 2009). A substantial body of empirical studies have found that tie closeness is dependent on the interaction frequency across multiple online and offline media (e.g., Caughlin & Sharabi, 2013; Ledbetter, 2009; Ledbetter & Keating, 2015; Ledbetter, 2009), the combination of media used (e.g., Caughlin & Sharabi, 2013), and interaction quality (e.g., Roberts & David, 2016). Haythornthwaite (2005, p. 130) has also observed that media use within a group conforms to what she has called a unidimensional scale: "those who use only one medium, use the same one medium, those who use two, tend to use the same second medium, etc." However, how interaction partners coordinate their media use has received little further scholarly attention (Parks, 2017; Taylor & Ledbetter, 2017). An empirical exception includes Taylor and Ledbetter's (2017) analysis of a tie member's responses to hypothetical changes in media use by the other tie member, which they have found is dependent on tie closeness.

While Haythornthwaite (2005) has noted the importance of social influence processes to media choices, in general, tie-level theories still assume that media choices at the tie level are independent from media choices made in the wider social network, which exists of both direct and indirect ties. However,

critical mass theories (Markus, 1987; Rohlfs, 1974) explicitly consider social influence processes and predict that the likelihood of individual medium adoption depends on the share of group members who have adopted the medium. The underlying rationale is that "interactive communication systems … have little value to one or two individuals, but have significant value when a large portion of a social community has access to and uses the system" (Rice, Grant, Schmitz, & Torobin, 1990, p. 33). Following this line of reasoning, and paraphrasing the tango metaphor, we argue that it takes at least two to tango. More specifically, the quality and intensity of the tango accelerates with the number of people tangoing.

To evaluate the relevance of group media use patterns to the displacement-complementarity debate, we developed a population-level model to theorize the overall association between Internet use and f2f interactions. Moreover, we explored how individual-level relationships are influenced by social and technological dynamics in the local population. We focused on local populations, defined by the geographical regions they occupy, for several reasons. First, our dependent variable, f2f interaction, requires geographical proximity between interaction partners (Festinger, 1950; Ledbetter & Keating, 2015). Second, local variations in social and technological factors—for example, local variations in Internet infrastructure and availability (Agarwal, Animesh, & Prasad, 2009)—shape how and which media are used (Niles and Hanson, 2003). Third, most online interaction occurs between people who live geographically close to each other (Lampe et al., 2006; Takhteyev, Gruzd, & Wellman, 2012; Tranos & Nijkamp, 2013). For example, Takhteyev et al. (2012, p. 81) found that "distance and related variables (language, country, and the number of flights) all have an effect on Twitter ties despite the seeming ease with which long range ties can be formed." For these reasons, local populations are conceptually relevant to explain variations in media use patterns.

Overall association between local Internet use and local f2f interaction

Because no population-level theory was available to predict the Internet use-f2f interaction relationship, we formulated two opposing hypotheses, based on our discussion of the displacement and complementarity literatures:

H1a: Local Internet use is negatively associated with local f2f interaction (displacement).

H1b: Local Internet use is positively associated with local f2f interaction (complementarity).

Moreover, we argued that how the Internet is used—for example, for social or non-social purposes (Zhao, 2006)—would affect the main relationship. Of particular relevance at the population level are SNSs. Not only are SNSs extremely popular in many populations (Rains & Brunner, 2015; Wilson, Gosling, & Graham, 2012; Zhang & Leung, 2015), but previous research has also shown that SNSs are used mainly to interact with geographically-close ties (Lampe et al., 2006; Subrahmanyam, Reich, Waechter, & Espinoza, 2008; Takhteyev et al., 2012). When SNS uptake is high, Internet use may be better able to gratify a need for interactive communication within the population. This either increases the competitiveness of the Internet, resulting in displacement of f2f interactions, or increases the complementarity of the Internet to f2f interactions. This dichotomy again resulted in two competing hypotheses:

H2a: The negative association between local Internet use and local f2f interaction is stronger when SNS uptake is higher (reinforcing displacement).

H2b: The positive association between local Internet use and local f2f interaction is stronger when SNS uptake is higher (reinforcing complementarity).

In addition to theorizing on the overall, population-level relationship, we aimed to better understand the underlying population-level and individual-level factors driving the relationship. In order to do so, we developed a mixed-level model (Klein et al., 1994) and explored how population-level dynamics influence the relationship between individual Internet use and individual f2f interaction.

Disentangling population-level and individual-level dynamics

Key to our mixed-level model was the expectation that individual f2f interactions would be dependent on population-level media use patterns. Therefore, we explored peer effects, which are "present if the likelihood that a particular action will be used depends directly on the incidence of the action within some reference group" (Agarwal et al., 2009, p. 279). Peer effects have been studied within households (Kraut, Scherlis, Mukhopadhyay, & Manning, 1996), networks of friends (Lin & Lu, 2011), SNS networks (Lin & Lu, 2011; Onnela & Reed-Tsochas, 2010), and geographical regions (Agarwal et al., 2009). In our case, geographically close—that is, local—peers are an appropriate reference group when studying f2f interactions, as these interactions require geographical proximity (Festinger, 1950; Ledbetter & Keating, 2015). We are not aware of any empirical studies that have assessed the peer Internet use-individual f2f interaction relationship (but see Antoci, Sabatini, & Sodini, 2012, for a framework). Based on the literature, we started with two opposing baseline hypotheses at the individual level:

H3a: Individual Internet use is negatively correlated with individual f2f interaction (individual-level displacement).

H3b: Individual Internet use is positively correlated with individual f2f interaction (individual-level complementarity).

Next, we added a population-level factor to the model: local peers' Internet use. We argued that, at the population level, complementarity is unlikely, whereas displacement is more likely to occur. The complementarity perspective suggests that individuals who use one medium to "satisfy a particular functional need also use other media types to fulfill that need" (Dutta-Bergman, 2004, p. 659). It emphasizes differences across individuals with respect to some underlying functional needs and the observed differences in media use. This means that the underlying functional need drives both Internet use and f2f interaction. Therefore, the positive association between Internet use and f2f interaction should not be confused with a causal relationship. This also implies that, at the population level, an increase in Internet use does not result in more f2f interaction when the underlying functional needs remain constant. This is also true when, at the individual level, Internet use and f2f interaction are positively correlated, because at this level the correlation reflects differences between individuals rather than populations.

Instead, at the population level, displacement is likely to occur. As the total amount of time that can be spent on communication is eventually limited, we proposed that an increase in local peers' Internet use implied that peers would spend more time online and become less available for f2f interactions. This should be especially true when an increasing share of the population adopts the Internet, because the value of a medium within a community grows exponentially with the number of users (Markus, 1987; Rolhfs, 1974; Kraut, Rice, Cool, & Fish, 1998). Hence, the decreasing availability of peers for f2f interaction reduces individual f2f interactions. This mechanism can occur irrespective of an individual's own Internet use. We hypothesized that:

H4a: Local peers' Internet use is negatively correlated with individual f2f interaction (population-level displacement).

In addition, we expected that SNS uptake would reinforce the negative association between peers' Internet use and individual f2f interaction. Here, SNS uptake is indicative of the extent to which the Internet is used for social purposes (Zhao, 2006) and, hence, the extent to which SNS has a higher potential to satisfy the same functional need as f2f interaction. Peers will be more likely to allocate time to Internet use at the expense of f2f interaction when Internet adoption is high and the needs gratified by the Internet are more similar to those gratified by f2f interaction (cf., Dimmick, 2002; Dimmick et al., 2000):

H4b: The negative correlation between local peers' Internet use and individual f2f interaction is stronger when local peers' SNSs uptake is higher (reinforcing population-level displacement).

Furthermore, the strength of the association between local peers' Internet use and individual f2f interaction likely depends on individual Internet use. Here, the displacement and complementarity arguments provide two opposing perspectives. On one hand, the displacement perspective suggests that high individual Internet use within a high peer Internet use environment is more likely to be associated with lower individual f2f interaction. This is because when an individual is using the Internet relatively more often, her online availability can facilitate Internet-based interaction with those peers. To the extent that Internet-based interactions gratify a similar need as f2f interactions do, online interactions with local peers further reduce individual f2f interactions (cf., Dimmick, 2002; Dimmick et al., 2000). On the other hand, following complementarity reasoning, we argue that when an individual's Internet-based interactions with peers gratify a functional need that can also be fulfilled by f2f interaction, individuals might persuade online peers to also interact f2f (modality switching, Caughlin & Sharabi, 2013). We hypothesized that:

H5a: The negative correlation between local peers' Internet use and individual f2f interaction is stronger when individual Internet use is higher (reinforcing population-level displacement).

H5b: The negative correlation between local peers' Internet use and individual f2f interaction is weaker when individual Internet use is higher (buffering population-level displacement).

In either case, theoretically, these interactions become stronger when SNS uptake is high. This is because, first, SNS uptake enriches the functional needs that Internet use can potentially gratify. Second, once SNS uptake reaches a critical mass, the value of the Internet with respect to its ability to satisfy an underlying functional need increases (Markus, 1987; Rolhfs, 1974). As a result, individuals might either spend a growing amount of time interacting online as opposed to f2f (displacement) or increasingly use SNS to arrange f2f interactions (complementarity). To give an illustrative example of complementarity in this context, individuals may announce offline events through online postings, such as Facebook events. To the extent that offline activities are exclusively announced via SNSs, Internet non-users may become less aware of opportunities for f2f interactions and consequently experience a decrease in f2f interactions.

H6a: Reinforced population-level displacement (H5a) is stronger for higher levels of SNS uptake.

H6b: Population-level displacement buffering (H5b) is stronger for higher levels of SNS uptake.

Data and empirical approach

Data

We used the European Social Survey (ESS) for this study. This is a biennial, individual-level survey based on face-to-face interviews with newly-selected, cross-sectional samples that are representative of all persons aged 15 and older. The individuals in the samples are selected only by random probability methods, and quota sampling is not allowed. Our sample included a set of countries and individuals for whom all required variables were observed over the whole time period. The 13 countries included are Belgium, Finland, France, Great Britain, Hungary, the Netherlands, Norway, Poland, Portugal, Slovenia, Spain, Sweden, and Switzerland. Our dataset covers 106,841 individuals across 111 regions over 5 waves (2002–2010). Because there were no items on Internet use included in ESS waves 6 and 7, conducted in 2012 and 2014, respectively, we limited our analysis to waves 1 to 5. Our data set is unique in terms of both the timespan covered and the geographical information it includes. The time span we analyzed is especially interesting in this respect, as it covers the period in which SNSs were first introduced and then rapidly adopted across Europe. By covering a larger geographical area, our findings are less sensitive to local or cultural variations.

The ESS data only include generic online media use measures. This is inherent to longitudinal data collection efforts when new phenomena emerge and become evident in hindsight, such as in the introduction of new online media. To address this issue, we complemented ESS data with regional-level Google trends data available from 2004 onward. Google trends data allow for assessing the relative popularity of a search term, such as "Facebook," on Google's search engine within a particular region over time. The key benefit of using Google trends data was that it enabled us to go back in time and analyze when and where a phenomenon emerged (through location- and time-specific Google searches). As such, Google trends data provided a unique ex-post opportunity to study emerging phenomena.

Variables

Table 1 summarizes the operationalization of our disaggregated variables. Our dependent variable, f2f interaction, was measured by assessing how often a person met socially with friends, relatives, or colleagues. The first central independent variable of interest was individual Internet use intensity. The second independent variable of interest was peer Internet use intensity. This was proxied by the aggregated, average Internet use intensity of local—that is, regional—peers of the focal individual. For this, we used the Nomenclature des unités territoriales statistiques (NUTS) classification, applied in the ESS. The third core independent variable concerned SNS uptake. We used the relative popularity of the search term "Facebook" in Google's search engine as a proxy for SNS uptake. We focused on Facebook because it was one of the best-studied SNSs (Rains & Brunner, 2015; Wilson et al., 2012) and has grown to become one of the, if not the, most popular online medium throughout the regions included in our dataset. SNS uptake was measured as the percentage of searches for Facebook out of the total searches in a specific region-year combination, relative to the region-year combination in which Facebook searches were most popular in the same country. A comparison between global Google Trends data and actual Facebook use indicated that Google trends data provided an accurate measure of actual Facebook use in the period of 2004–2010. As we did not have access to large-scale network data, our aggregated regional-level measures of peer effects—that is, peer Internet use and SNS uptake—are proxies that are likely to represent a lower-bound estimate and should be considered a first step toward a better understanding of individual embeddedness in societal contexts. Finally, the control variables covered socioeconomic characteristics that accounted for individual-level characteristics, household characteristics, and country characteristics.

Estimation strategy: regional level

Our methodological approach at the regional level was based on a region-level fixed-effects regression. We compared a change in f2f interaction between regions that differed in terms of SNS uptake and average Internet use. We estimated variations from the following equation:

Table 1 Overview of Variable Operationalization Based on the European Social Survey and Google Trends Data

Dependent variable		
Individual f2f interaction frequency	How often do you meet socially with friends, relatives or work colleagues?	7 point scale: 1 = never, 7 = every day
Independent variables		
Individual Internet use intensity	How often do you use the Internet, the World Wide Web, or e-mail—whether at home or at work—for your personal use?	8 point scale: 0 = no access, 1 = never use, 7 = every day
Local (peers') Internet use	Average Internet use within a region	Aggregated data (see individual Internet use)
SNS uptake	The relative popularity of the search term "Facebook" in Google's search engine within a region in a particular year in a country, relative to the most popular region/year combination within that country.	0–1; 1 = region/year combination with most Facebook searches in the country
Controls		
Age	Year of birth	Years
Years of education	Full-time equivalents of years of schooling	Years
Working hours	Hours normally worked per week (in main job), including paid or unpaid overtime	Hours/Week
Gender	Male, female	0 = female, 1 = male
City (1 = Yes)	Living in city.	0 = other, 1 = city
Unemployed (1 = Yes)	Unemployed and actively looking for a job in the last 7 days	0 = other, 1 = unemployed
Partner in household	Lives with husband, wife, or partner	0 = no, 1 = yes
Number of other household members	Number of people—including children—living regularly as members of household	Count variable (0 indicates no other household members)
GDP per capita	GDP per capita in the country of the focal individual	in 100,000 €

Note: F2f = face-to-face; GDP = gross domestic product; SNS = social networking site.

$$\Delta f2f_{r,t} = \beta_0 + \beta_1 IU_{rt} + \beta_2 SNS_{rt} + \beta_3 IU_{rt} SNS_{rt} + Z_{rt} + \alpha_r + \delta_t + \theta_i t + \varepsilon_{rt} \quad (1)$$

where $\Delta f2f$ represents the biennial change—that is, from t to t_{+2}—in f2f interaction in region r at time t. *IU* displays average Internet use, *SNS* is a proxy for SNS uptake, and Z is a vector of variables that aims to control for time-variant regional socioeconomic characteristics. A region-specific fixed-effect α was included to control for time-invariant unobserved heterogeneity across regions. To prevent our central variables of interest from simply capturing the influence of aggregate trends, we included a year fixed effect, as indicated by δ_t in the equation above. We did so to avoid the variables of interest being spuriously related simply because of the rising magnitude of aggregate variables more generally. Moreover, regional Internet use and SNS uptake could be a reaction to past f2f interactions. While α_r allows SNS uptake to be dependent on a region-level effect, SNS uptake may also correlate with specific time trends that differed across countries. To deal with this issue, we introduced heterogeneous country trends $\theta_c t$. Inclusion of these time trends implies that the term δ_t captures the non-linear components of the average time trend. This means that we removed country-specific time trends, as well as period effects.

Estimation strategy: individual level

The empirical approach outlined below aimed to disentangle the relationship between individual Internet use, local peers' Internet use, and individual f2f interaction. We modeled differences in individual f2f interactions and considered individual Internet use, local peers' Internet use, and SNS uptake by introducing a three-way interaction. This allowed us to assess how individual and local peers' Internet use was related to individual f2f interactions at different levels of SNS uptake. The associated equation is:

$$\begin{aligned} f2f_{ir} = {} & \beta_0 + \beta_1 IU_i + \beta_2 \overline{IU}_{(-i)r} + \beta_3 SNS_r + \beta_4 IU * \overline{IU}_{(-i)r} \\ & + \beta_5 SNS_r * IU_i + \beta_6 SNS_r * \overline{IU}_{(-i)r} + \beta_7 SNS_r * IU_i * \overline{IU}_{(-i)r} + Z_i + \varepsilon_i \end{aligned} \quad (2)$$

where *f2f* represents the f2f interaction of individual i living in region r; IU_i is the Internet use of the individual; and $\overline{IU}_{(-i)r}$ represents the Internet use of peers located in the same geographical area as individual i, referred to as local peers. *SNS* refers to SNS uptake. Z denotes a vector of control variables. We included the following interaction terms: the coefficient $\beta 4$ indicates the presence of an interaction between individual and peers' Internet use; $\beta 5$ represents the deviation in the association between individual Internet use and f2f interaction when SNS uptake increased; $\beta 6$ accounts for differences in the association between peers' Internet use and f2f interaction when SNS uptake increased; and $\beta 7$ indicates whether joint increases of individual and peers' Internet use affected individual f2f interaction differently with increasing regional levels of SNS.

Results

Our regional-level models were based on regional fixed-effects regressions (Table 2). Correlation tables are provided in Appendix A. Model 1 included only control variables and an additional set of year fixed effects. We observed that only average working hours, gender, and the share of people with partners in the region were significantly correlated to regional f2f interaction. Model 1 explained about 9% of the within-region variation in changes of regional f2f interaction. Model 2 introduced average Internet use, which turned out to be insignificant. In Model 3, we introduced our proxy for SNS uptake, which is positive and significant. In Model 4, we introduced an interaction term between

Table 2 Regional Fixed Effects Regression of Average Face-to-Face Interaction

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Average Internet use		0.03 (0.07)	0.05 (0.06)	0.08 (0.06)		0.10 (0.07)
SNS uptake			0.44** (0.19)	1.87** (0.72)		3.05*** (0.98)
Average Internet use*				−0.31** (0.14)		−0.53*** (0.18)
SNS uptake						
Average age	−0.01 (0.01)	−0.00 (0.02)	−0.01 (0.02)	−0.01 (0.01)	−0.01 (0.01)	−0.02 (0.01)
Average years of education	−0.01 (0.04)	−0.02 (0.04)	−0.02 (0.04)	−0.01 (0.04)	0.00 (0.04)	−0.01 (0.04)
Average working hours	−0.02* (0.01)	−0.02* (0.01)	−0.02* (0.01)	−0.02** (0.01)	−0.02** (0.01)	−0.03*** (0.01)
Share of males	0.94* (0.57)	0.92 (0.57)	0.87 (0.54)	0.82 (0.54)	1.13** (0.55)	0.94* (0.54)
Share of people living in city	−0.59 (0.53)	−0.60 (0.53)	−0.57 (0.51)	−0.64 (0.52)	−0.65 (0.55)	−0.63 (0.52)
Unemployment rate	0.01 (1.15)	0.06 (1.16)	0.02 (1.14)	−0.44 (0.98)	0.72 (1.28)	0.38 (1.13)
Share of people with partner	−0.86** (0.35)	−0.87** (0.35)	−0.90*** (0.34)	−0.86** (0.34)	−0.92*** (0.35)	−0.72** (0.35)
Average number of other HH members	−0.13 (0.09)	−0.12 (0.09)	−0.12 (0.10)	−0.11 (0.10)	−0.14* (0.08)	−0.13 (0.08)
GDP per capita	−0.19 (0.32)	−0.15 (0.33)	−0.08 (0.34)	0.47 (0.45)	1.08 (1.17)	−1.21 (0.95)
Constant	1.58 (1.06)	1.43 (1.08)	1.44 (1.08)	1.56 (1.03)	−9.51 (35.13)	−161.84** (65.30)
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-specific time trends	No	No	No	No	Yes	Yes
R-squared within	0.09	0.09	0.10	0.15	0.12	0.21
AIC (ΔAIC to previous model)	282.28	284	279.37	256.3	286.5	248.25
	(/)	(1.72)	(4.63)	(23.07)	(/)	(38.25)

Note: Fixed-effects regression with robust standard errors in parentheses. The total number of observations = 441. AIC = Akaike information criterion; GDP = gross domestic product; HH = household; SNS = social networking site. *$p < .1$, **$p < .05$, ***$p < .01$.

average Internet use and SNS uptake. This interaction term turned out to be negative and significant. Models 5 and 6 considered the same set of variables as Models 1 and 4, respectively, plus an additional set of country-specific time trends to account for heterogeneous country trends in f2f interaction. Also in Model 6, SNS uptake was positive and significant, while the interaction term with average Internet use was negative and significant. We observed that, in terms of relative quality of the statistical model, measured with the Akaike information criterion (AIC), the most substantial improvement was when considering the interaction term between average Internet use and SNS uptake (e.g., Models 4 and 6). Model 4 explained about 15% of the variance of the within-region variation in f2f interaction change, an increase of about 6.7% as compared to the baseline model.

In the presence of an interaction term, we cannot interpret the coefficients of SNS uptake and average Internet use independently of each other. Therefore, we display marginal effects and 95% confidence intervals based on Model 6 in Figure 1. The vertical axis displays the associated change in average regional f2f interaction for a unit increase in average Internet use over different levels of SNS uptake. We observed that for higher values of SNS uptake, an increase in regional Internet use was associated with decreasing regional f2f interaction. This negative association was significant at the 10% level for SNS uptake of 0.54 and larger (a value that was present in almost 60% of all sample regions in 2010) and significant at the 5% level for values of SNS uptake larger than 0.67 (43% of all sample regions in 2010). Regarding our hypotheses, we only found support for the displacement hypothesis, H1a, for relatively higher levels of SNS uptake. We found support for H2b, as the negative association between regional Internet use and regional f2f interaction was more pronounced when SNS uptake increased.

Of the individual-level regressions (Table 3), our baseline Model 1 included control variables only. Age, working hours, number of household members, having a partner, living in a city, being unemployed, and gross domestic product per capita were negatively associated to f2f interaction. The negative associations of having a partner and the number of additional household members indicated that the possibility of interacting within one's own household was a close substitute for f2f interaction outside the household. Years of education had a significant and positive association with f2f interaction in the baseline regression only. We also observed that, on average, males had higher levels of f2f interaction. However, additional analyses, available on request, suggest that the gender effect varies substantially across countries. In Model 2, we introduced individual and peer Internet use. Individual

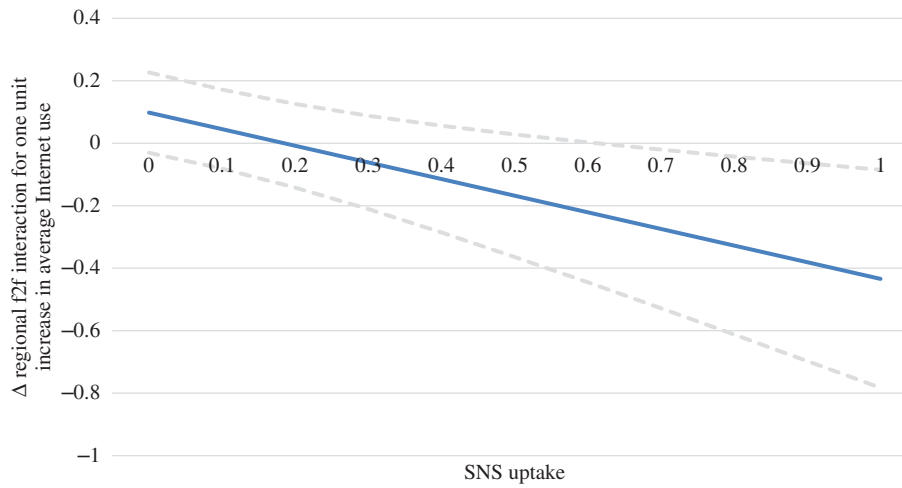

Figure 1 Marginal effect of regional Internet use on regional face-to-face interaction.

Table 3 Regression Analysis of Individual-Level Face-to-Face Interaction

	Model 1	Model 2	Model 3	Model 4	Model 5
Individual Internet use		0.04*** (0.00)	0.04*** (0.00)	0.05*** (0.01)	0.06*** (0.01)
Regional peers' Internet use		−0.08*** (0.01)	−0.08*** (0.01)	−0.07*** (0.01)	−0.05*** (0.01)
SNS uptake			−0.11*** (0.04)	−0.11*** (0.04)	0.61*** (0.19)
Individual Internet use*				−0.00* (0.00)	−0.00** (0.00)
Regional peers' Internet use					
Individual Internet use * SNS uptake					−0.09*** (0.03)
Regional peers' Internet use * SNS uptake					−0.16*** (0.04)
Individual Internet use * Regional peers'					0.02*** (0.01)
Internet use * SNS uptake					
Age	−0.02*** (0.00)	−0.02*** (0.00)	−0.02*** (0.00)	−0.02*** (0.00)	−0.02*** (0.00)
Years of education	0.01*** (0.00)	0.00 (0.00)	0.00 (0.00)	−0.00 (0.00)	0.00 (0.00)
Working hours	−0.00*** (0.00)	−0.00*** (0.00)	−0.00*** (0.00)	−0.00*** (0.00)	−0.00*** (0.00)
Gender (1 = male)	0.08*** (0.01)	0.06*** (0.01)	0.06*** (0.01)	0.06*** (0.01)	0.06*** (0.01)
City (1 = Yes)	−0.03*** (0.01)	−0.03** (0.01)	−0.03** (0.01)	−0.03** (0.01)	−0.03** (0.01)
Unemployed (1 = Yes)	−0.12*** (0.03)	−0.10*** (0.03)	−0.10*** (0.03)	−0.10*** (0.03)	−0.10*** (0.03)
Partner in household (1 = Yes)	−0.42*** (0.01)	−0.43*** (0.01)	−0.43*** (0.01)	−0.43*** (0.01)	−0.43*** (0.01)
Number of other household members	−0.02*** (0.00)	−0.02*** (0.00)	−0.02*** (0.00)	−0.02*** (0.00)	−0.02*** (0.00)
GDP per capita	−0.29** (0.12)	−0.28** (0.12)	−0.68*** (0.18)	−0.67*** (0.18)	−0.90*** (0.19)
Constant	−30.34** (12.44)	−46.74*** (13.55)	−82.62*** (18.34)	−82.52*** (18.34)	−95.80*** (18.40)
R-squared	0.19	0.20	0.20	0.20	0.20
AIC (ΔAIC to previous model)	373710.1	373165	373158.6	373156.7	373135.5
	(/)	(−545.1)	(−6.4)	(−1.9)	(−21.2)

Note: Ordinary least squares regression with robust standard errors in parentheses. All models include country specific time trends. The total number of observations = 106,841. AIC = Akaike information criterion; GDP = gross domestic product; SNS = social networking site. *$p < .1$, **$p < .05$, ***$p < .01$.

Internet use was positively related and peer Internet use was negatively related to f2f interaction. When adding SNS uptake (Model 3), we observed a significant negative association with individual f2f interaction. Model 4 introduced the interaction term between individual and peers' Internet use, which was only weakly significant at the 10% level. Model 5 presented the results of a three-way interaction between individual Internet use, regional peer Internet use, and SNS uptake. In contrast to the regional-level regression, the explained variance did not change substantially across models.[3] Based on the AIC and further likelihood ratio tests, we observed substantial model improvements when we moved from Model 1 to Model 2 and when introducing the three-way interaction in Model 5. Jointly, this indicated that at the individual level, our proposed model did not have more explanatory power but had an improved model fit.

Our variables of interest cannot be interpreted separately, given the interaction terms between own Internet use, Internet use of peers, and SNS uptake. Therefore, we report the estimated predictions for different scenarios (Figure 2), consisting of two types of individuals: an individual with high Internet use (i.e., daily use) and an individual who does not use the Internet, living in regions with different use environments, ranging from an average regional use of several times a month to several times a week. The third relevant dimension, SNS uptake, differentiates between the two scenarios as low SNS uptake (before the rise of SNS) and high SNS uptake (the relative regional peak in our data).

Generally, we observed that individual Internet use was positively correlated with f2f interaction. This indicated the presence of individual-level complementarity, suggesting support for hypothesis

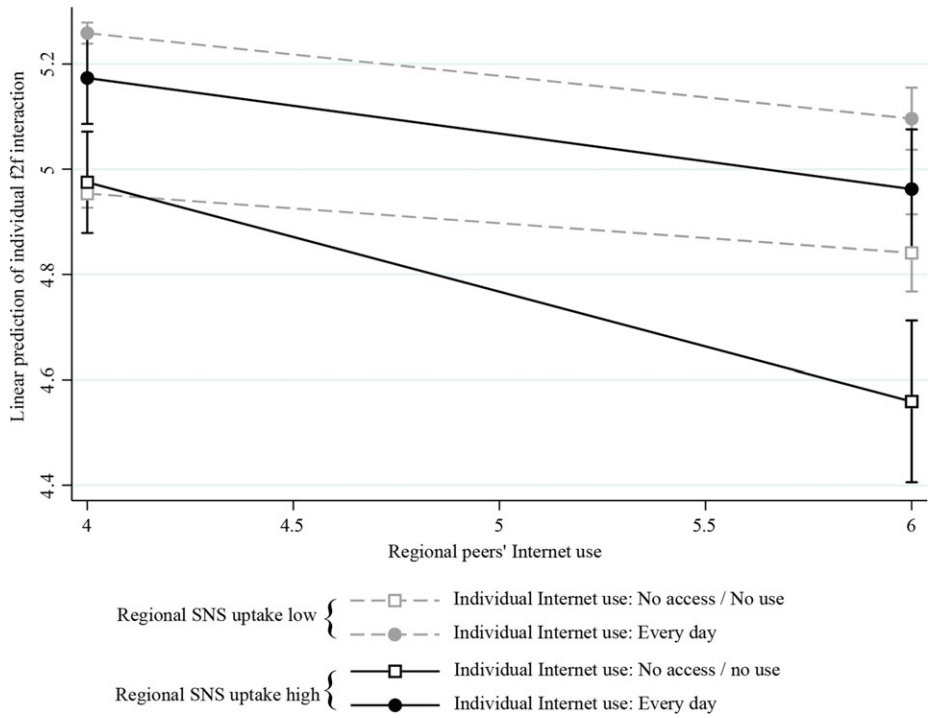

Figure 2 Individual Internet use-individual face-to-face interaction relationship, depending on regional peers' Internet use and social networking site uptake, with 95% confidence intervals.

H3b, but not H3a. Next, we found that f2f interaction in low-use environments did not differ before and after SNS uptake among non-users and those who used the Internet every day, respectively. Moreover, a high-use environment could reduce f2f interaction significantly, suggesting population-level displacement. This was especially the case for individuals who did not use the Internet and lived in environments with high SNS uptake. In terms of our hypotheses, this means we found general support for H4a and partial support for H4b. Moreover, we found support for H6b. Only f2f interactions of non-Internet users living in high-use environments were significantly lower when SNS uptake is high. The same was true for individuals who used the Internet relatively less often, but the relationship became less pronounced with increasing use.

Additional post-hoc analyses, available on request, revealed that not only the frequency of f2f interactions, but also the quality of such interactions, was related to individual and regional peers' Internet use. For this additional analysis, we used a different dependent variable that measured whether an individual had someone to discuss intimate and personal matters with. We found that Internet non-use was especially associated with a decrease in the likelihood of having such a person in high-use environments after the rise of SNS. This finding remained once we controlled for f2f interaction frequency. Not surprisingly, f2f interaction frequency was also strongly associated with interaction quality.

Discussion

We were intrigued by the continued debate between displacement and complementarity theorists. This paper contributes to the literature by explicitly considering two factors that have been ignored in the debate: first, social dynamics, and second, changes in media use patterns over time. We propose that contradicting arguments based on complementarity theory (Dutta-Bergman, 2004) and displacement theory (Dimmick, 2002; Dimmick et al., 2000; Kraut, Patterson, et al., 1998) may both hold true, depending on the level of theorizing. Specifically, we argue that individual-level complementarity coexists and interacts with population-level displacement.

We found that the overall association between local Internet use and local f2f interactions was only negative and significant at high levels of SNS uptake. Based on this finding, it might be tempting to dismiss displacement as less relevant. However, the majority of regions fell within this category of high–SNS uptake environments at the end of our observational period. Moreover, although our analyses did not allow us to make causal claims, the individual-level analyses suggested support for three theoretical arguments. First, our findings are in line with the prediction that individual Internet use complements individual f2f interactions. Second, our findings show a negative relationship between individual f2f interaction and peer Internet use, suggesting the relevance of peer behavior. Third, the findings suggest that the interplay between Internet use and f2f interaction changed when SNS uptake increased, further indicating the relevance of peer behavior.

These findings are not only of theoretical importance, but also of empirical importance, especially for the slowly decreasing yet still substantial group of Internet non-users. Among non-users living in areas where SNS uptake was high, we observed a particularly pronounced negative correlation between local peers' Internet use and their f2f interactions. This observation may imply that once Internet use reaches a critical mass (Kraut, Rice, et al., 1998; Markus, 1987; Rolhfs, 1974), non-users are socially excluded. Future research could further disentangle such relationships.

Limitations

This study has limitations. First, because of endogeneity concerns, a causal interpretation of our empirical analyses is not appropriate. Second, we acknowledge that our measures of actual online

interaction are imprecise, particularly at the individual level. When studying an emergence of a phenomenon (SNS uptake) with representative survey data over time, the phenomena of interest is commonly considered ex-post because, when designing the survey, the future relevance of the phenomena was unknown. Consequently, studying online interaction over a longer period of time required us to make use of a higher-order construct that allowed us to cover the whole time period (i.e., Internet use). Moreover, while we used complementary data sources to measure SNS use, this procedure came with the limitation that we could only proxy SNS use at the population level. A direct assessment of SNS use at the individual level via the survey would have been preferable. Third, while the regions and societies included in the study are profoundly diverse, our data—and therefore our conclusions—are limited to the European context.

Theoretical implications and suggestions for future research

Scholars have suggested that theories on media use can be enriched by including social dynamics: that is, social coordination (Parks, 2017) or peer effects (Taylor & Ledbetter, 2017; Zhang & Leung, 2015). Indeed, our assessment of population-level trends and the role of peer behaviors in individual media use suggests future research directions. While media multiplexity theory indicates that media contribute separately to relationship closeness, research has also suggested they do not all contribute equally (Caughlin & Sharabi, 2013; Ledbetter, 2009). Previous research has found that f2f interaction might contribute more to relationship closeness than online interaction (Caughlin & Sharabi, 2013; Chan & Cheng, 2004; Ledbetter, 2009). This seems to indicate a higher ranking of f2f interaction on Haythornthwaite's (2005) unidimensional scale. However, increased SNS uptake may indicate a relative increase in medium value (i.e., relative to other media; cf., Haythornthwaite, 2005; Markus, 1987; Rolhfs, 1974). Perhaps, as SNSs gain value through peer adoption, the relative value of f2f interaction could be reduced. Future research might assess whether and when online media surpass f2f interaction on the group's unidimensional scale. Furthermore, future research could address the question of whether particular online interaction behaviors that decrease f2f interaction quality could further reduce the relative value of f2f interactions. Drops in interaction quality might occur, for example, when one's online interactions interrupt f2f interaction, referred to as phubbing (Roberts & David, 2016). Finally, modality switching from solely online interactions to a mix of f2f and online interactions has been found important to the development of close relationships (Caughlin & Sharabi, 2013). Our findings suggest that in high Internet and SNS use environments, the reverse relationship also holds true. Therefore, future research may well study whether, in areas where local peers' Internet use and SNS uptake is high, an inability to extend initial f2f interactions via online interactions also hampers the development of close relationships.

The dark side of population-level displacement: social exclusion

One important finding from this study is that non-users have significantly fewer f2f interactions than users, in particular when both local peers' Internet use and SNS uptake are high. Since Internet non-users are unable to complement f2f interactions with online interactions, increased Internet use among their local peers might put them at risk of social exclusion. This might imply that SNSs not only improve connectivity between users, but also worsen the connectivity of non-users. This, in turn, may hamper the overall well-being of this group. Further investigation of the antecedents and outcomes of social exclusion among non-users is crucial; as Witte, Kiss, and Lynn (2013, p. 69) explain, "there are real and significant costs to being excluded from networks … as the advantages of inclusion are growing, the disadvantages associated with exclusion may be growing at an even faster rate." The social exclusion of non-users is all the more worrisome when not only social communication, but also societal participation and services, are shifting toward using the online domain.

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Notes

1 SNSs "are web-based services that allow individuals to (1) construct a public or semi-public profile within a bounded system, (2) articulate a list of other users with whom they share a connection, and (3) view and traverse their list of connections and those made by others within the system. The nature and nomenclature of these connections may vary from site to site" (boyd & Ellison, 2008, p. 211).

2 To the best of our knowledge, the published longitudinal studies cover 1 year to a maximum of 4 years: Brandtzæg, 2012; Dienlin et al., 2017; Hampton, 2007; Kraut et al., 2002; Kraut, Patterson, et al., 1998; Lampe, Ellison, & Steinfield, 2006; Valkenburg & Peter, 2009.

3 Regressions that do not include time effects result in substantially lower R^2 values, suggesting that aggregate changes do play a pronounced role in explaining f2f interaction. A baseline model only considering control variables had an R^2 of 0.116 and one with the additional Internet use and SNS uptake had an R^2 of 0.126.

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Appendix A

Table A1 Regional-Level Data, Summary Statistics, and Correlation

	Variable	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12
1	Δf2f interaction	0.01	0.35	1											
2	Average Internet use	3.76	1.22	−0.05	1										
3	SNS uptake	0.18	0.28	0.06	0.45	1									
4	Average age	46.81	3.42	−0.05	0.04	0.19	1								
5	Average years of education	11.98	1.52	−0.09	0.63	0.15	−0.15	1							
6	Average working hours	35.95	4.16	−0.11	−0.01	−0.00	−0.13	0.19	1						
7	Share of males	0.47	0.06	0.06	0.22	0.03	−0.22	0.19	0.28	1					
8	Share living in city	0.15	0.14	−0.02	0.05	−0.02	−0.29	0.20	0.05	−0.02	1				
9	Share of unemployed	0.04	0.03	0.06	−0.25	0.11	−0.24	−0.20	0.05	−0.04	0.08	1			
10	Share of people with partner	0.59	0.07	−0.08	0.05	−0.04	0.17	−0.05	0.17	0.17	−0.12	−0.13	1		
11	Average number other HH members	2.29	0.48	0.07	−0.43	−0.12	−0.63	−0.20	0.18	0.08	0.08	0.37	−0.08	1	
12	GDP per capita (in 100,000 €)	0.34	0.19	−0.08	0.69	0.17	0.25	0.38	−0.18	0.21	−0.18	−0.35	0.12	−0.61	1

Note: F2f = face-to-face; GDP = gross domestic product; HH = household; SD = standard deviation; SNS = social networking site.

Table A2 Individual-Level Data, Summary Statistics, and Correlation

	Variable	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13
1	F2f interaction	5.10	1.55	1												
2	SNS uptake	0.16	0.28	0.01	1											
3	Individual Internet use	3.75	3.04	0.20	0.18	1										
4	Local peer Internet use	3.74	1.21	0.11	0.45	0.40	1									
5	Age	46.97	18.41	−0.23	0.04	−0.46	0.01	1								
6	Years of education	12.01	4.21	0.06	0.05	0.47	0.23	−0.29	1							
7	Working hours	36.18	17.46	−0.13	−0.00	−0.04	−0.00	0.18	0.10	1						
8	Gender (1 = male)	0.47	0.50	0.01	0.00	0.09	0.03	−0.04	0.05	0.25	1					
9	City (1 = Yes)	0.16	0.37	0.00	0.01	0.06	0.01	−0.03	0.10	−0.01	−0.01	1				
10	Unemployed (1 = Yes)	0.04	0.19	0.01	0.02	−0.01	−0.04	−0.10	−0.01	−0.01	0.01	0.01	1			
11	Partner in household (1 = Yes)	0.60	0.49	−0.16	−0.01	−0.01	0.01	0.15	0.05	0.19	0.06	−0.07	−0.05	1		
12	Number of other household members	2.16	1.37	0.05	−0.03	0.15	−0.13	−0.47	0.04	−0.16	0.01	−0.05	0.05	−0.08	1	
13	GDP per capita (in 100,000 €)	0.35	0.18	0.18	0.20	0.31	0.77	0.03	0.15	−0.03	0.03	−0.07	−0.05	0.02	−0.16	1

Note: F2f = face-to-face; GDP = gross domestic product; SD = standard deviation.