The dual impact of online communication on older adults' social connectivity

Eveline Hage and Hans Wortmann
Faculty of Economics and Business, University of Groningen, Groningen, The Netherlands
Marjolein van Offenbeek
Department of Strategy and Innovation Management/Healthwise, Faculty of Economics and Business, University of Groningen, Groningen, The Netherlands, and
Albert Boonstra
Faculty of Economics and Business, University of Groningen, The Netherlands

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Abstract

Purpose – In today's aging world online communication is often viewed as a means to enhance social connectivity, and therefore well-being, of older adults. However, previous research on the influence of online communication on social connectivity largely disregards older adults, yields conflicting results and fails to assess the – debatable – causal direction of relationship. The purpose of this paper is to overcome these issues by developing four hypotheses related to who uses what, how, with whom.

Design/methodology/approach – The authors use a panel data study to test the hypotheses, including 302 older adults. Response rates are between 62 and 75 percent.

Findings – The authors find, first, that older adults differentiate between social connectivity with other village members, i.e., village connectivity, and connectivity with friends. Second, the impact of online communication varies among these two types of social connectivity. Where e-mail use has a negative impact on village connectivity, it does not affect connectivity with friends. Facebook use on the other hand has a negative impact on connectivity with friends, but not on village connectivity. The negative effects were not found among those older adults that were already well-connected on forehand, indicating a buffer effect.

Practical/implications – Policy makers' implementing online communication tools to strengthen social connectivity of older adults, may want to carefully select tools based on the type of connectivity they aim to enhance. Impact needs to be monitored.

Originality/value – The authors contribute by analyzing how characteristics of online communication tools, i.e., information richness and privacy protection, as well as social connectivity, i.e., geographical proximity and emotional closeness jointly shape older adults' social connectivity.

Keywords Panel data, Longitudinal data

Paper type Research paper

1. Introduction

In today's aging world, online communication is often believed to enhance the social connectivity, i.e., an "individual's perception of the interpersonal relationships and social roles in their life" (WHOQOL Group, 1995, p. 1405), of older adults (Ambient Assisted Living Joint Program, 2012; Cody *et al.*, 1999; Erickson, 2011; Shapira *et al.*, 2007; Saunders, 2004; Waycott *et al.*, 2013). Allegedly, online communication has the potential to enhance older adults' social well-being, and, as a consequence, improve health status (Berkman *et al.*, 2000; Fees *et al.*, 1999; Hawkley and Cacioppo, 2010; Holt-Lunstad *et al.*, 2010) and reduce healthcare costs associated with aging (Alemayehu and Warner, 2004; De Meijer *et al.*, 2013; Przywara, 2010). As such, online

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communication and the tools that allow for such communication form a noteworthy example of a social information system, especially given the alleged potential of making a substantial beneficial contribution to society at large (Hasan *et al.*, 2014).

As online communication tools enable social interaction, these applications may indeed enhance social connectivity. Nevertheless, conclusive evidence to support this argument is lacking. Arguments have been developed for both positive (Ellison *et al.*, 2007; Lampe *et al.*, 2006; Steinfield *et al.*, 2008) and negative (Dickinson and Gregor, 2006; Kraut *et al.*, 1998; Nie, 2001) effects. The nature of the online communication – social connectivity relationship is, therefore, uncertain.

Further, the causal direction of any relationship is debated (Dickinson and Gregor, 2006; Wagner *et al.*, 2010). On the one hand, online communication may extend or enhance the existing social network by lowering the barriers to forming relationships with others (Ellison *et al.*, 2007; Steinfield *et al.*, 2008). Similarly, online communication may play an important role in maintaining pre-existing offline relationships (Lampe *et al.*, 2006). On the other hand, recent work suggests a reversed relationship: that peer influence renders people with a large social network more prone to adopting information and communication technology (ICT) (Agarwal *et al.*, 2009; Chen, 2013; Ward, 2012). Given the scientific and societal relevance of the direction of this causality, the calls to more rigorously test the causality between online communication and social connectivity are hardly surprising (Dickinson and Gregor, 2006; Park, 2011; Steinfield *et al.*, 2008; Wagner *et al.*, 2010).

In this study we focus on older adults as a neglected yet increasingly relevant research population (United Nations, 2002). Earlier studies have mostly focussed on student populations (Steinfield *et al.*, 2012) that, in contrast to older adults, tend to be early adopters (Czaja *et al.*, 2006; Morrell *et al.*, 2000; Morris and Venkatesh, 2000). In summarizing the current situation, we can say that previous research findings are inconclusive and do not necessarily apply to older adults (Xie, 2008).

The research question of this paper is therefore:

RQ1. Can online communication enhance the social connectivity of an aging population?

In answering this, we analyzed the use of online communication tools, in particular e-mail and Facebook, and the social connectivity patterns of older adults. We have developed and tested four hypotheses related to who uses what to communicate, how and with whom. The hypotheses are tested using panel data, enabling causality to be assessed. Results underline the relevance of studying the effects of different types of online communication for different types of social connectivity among older adults.

In the remainder of this paper, we first review the literature, leading to the four hypotheses that explicitly address who uses what how and with whom. Second, we elaborate on our older adult sample and explain the data analysis. Third, the results section describes e-mail and Facebook use by our sample, followed by data analysis showing that older adults distinguish between two types of social connectivity: with people within their neighborhood, and with friends. Our panel data analysis shows how different online communication tools affect these types of social connectivity. Finally, in the discussion, we deliberate on the theoretical and societal implications of our findings.

2. Literature review

Longitudinal and structural equation modelling studies have found contradictory effects of online communication on social connectivity (Brandtzæg, 2012; Burke *et al.*, 2011; Hampton, 2007; Lampe *et al.*, 2006; Miyata and Kobayashi, 2008; Park, 2011;

Steinfield *et al.*, 2008; Valkenburg and Peter, 2009; Vergeer and Pelzer, 2009). These conflicting findings may be explained by implicit differences in previous studies as to who uses what, how, and to communicate with whom. Here, we address these assumptions and formulate and test four hypotheses, recognizing that online communication and social connectivity are multifaceted.

First, "what" tool is used to communicate may affect social connectivity outcomes (Kim *et al.*, 2007; Miyata and Kobayashi, 2008; Xie, 2008). Miyata and Kobayashi (2008) found that e-mailing from a PC enhances network diversity whereas using a seemingly similar mobile phone e-mail application did not. As such, when studying a particular online communication tool, caution is required in generalizing results to other such tools:

H1. The type of online communication tool used affects social connectivity outcomes.

Second, "how" the tool is used influences outcomes. For example, Burke and her colleagues (Burke *et al.*, 2010, 2011) found that the social connectivity of users actively communicating with others through Facebook differs from that of users passively "consuming" information. Valkenburg and Peter (2009) found the positive effect on the quality of offline friendships of using instant messaging to be fully explained by the disclosure of information online, i.e., the particular way of use. Thus, research should differentiate between different types of use, such as between social and non-social use (Zhao, 2006; Steinfield *et al.*, 2012). We hypothesize that:

H2. The more social the use of online communication tools, the more positive the impact of online communication on social connectivity.

Third, "who" is communicating seems to make a difference. Paul and Stegbauer (2005) highlighted that heterogeneity among older populations should be taken into account when assessing the diffusion of the internet, including online communication tools. We argue that, in addition, the effect of online communication on older adults' social connectivity may differ among different categories of older adults. Hampton (2007) found that those with little initial contact with neighbors did not increase their neighborhood contacts after adopting a neighborhood e-mail list, whereas adopters who regularly participated in their community did see an increase. In a similar vein, Burke *et al.* (2011) found that initial communication skills and self-esteem influence social connectivity outcomes. These findings suggest that initial social connectivity reinforces the positive effect of online communication on subsequent social connectivity. This leads to our third hypothesis. Further, users with high levels of initial social connectivity:

H3. The use of online communication tools boosts the social connectivity of users with an already high social connectivity more than that of users with a low initial social connectivity.

Fourth, "with whom" one communicates online may influence outcomes. Hampton *et al.* (2011) showed that although social networking sites enhance general network diversity, they have a negative effect on neighborhood ties, i.e., the most local type of social connectivity. Hampton *et al.* (2009) also found that using online social networks reduces the likelihood of asking neighbors for help. These findings suggest that the influence of online communication depends on the type of connectivity. Especially for older adults who are dependent on their local network for physical support and care,

sharper distinctions are required in the levels on which online communication influences social connectivity. We therefore hypothesize that:

H4. Neighborhood contacts are negatively affected by online communication.

The conceptual model reflecting the four hypotheses is presented in Figure 1.

3. Methods

3.1 Population and sample

We conducted three survey rounds among the 65+ population of four villages (settlements with populations < 600) in the north of The Netherlands in the period between 2011 and 2014. The four included villages were characterized by low service levels as is common in rural areas. As such the villages participated in a project aimed at exploring how older adults can be enabled in living independently, among others the role of online communication tools was studied. This project allowed us access to the villages and data collection took place in close cooperation with the local community. The research project contributed €5 to a prominent local community organization for each completed survey. Volunteers were asked to personally distribute the surveys to all village members aged 65 and above. We chose 65 as a cutoff point, as it is the retirement age in The Netherlands. Volunteers were also asked to note reasons for non-response. In total, they approached 332 people in 2011 ($t0$), 381 in 2012 ($t1$) and 261 in 2014 ($t2$). In 2014, only those who had participated in a previous survey were approached. In total 337 participants filled out one ($n = 125$), two ($= 126$), or three ($n = 86$) questionnaires, yielding a total of 635 row entries in the panel dataset. The response rate was 60 percent in 2011, 70 percent in 2012, and 75 percent in 2014. Table I provides a description of the panel data.

To check for any systematic differences between respondents and non-respondents we compared their average ages, the gender composition, and the village using the χ^2 test (see Table II). While relatively more females completed the survey, the difference is not significant at the 0.05 percent level.

3.2 Measures

The dependent variables, i.e., the different types of social connectivity (with whom), were constructed through a principal component analysis (PCA) as reported in the results section. In the analyses we investigated the change in social connectivity between $t1$ and $t2$ for each social connectivity type. Turning to the independent variables, we included e-mail and Facebook, as the most commonly used tools in the sample, to assess "what" tools were being used. Moreover, we considered "how" the media were used by

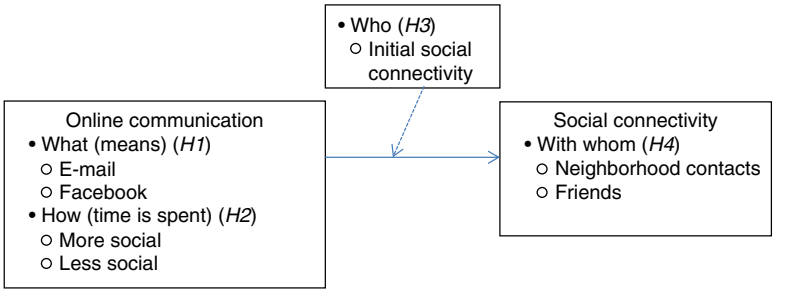

Figure 1.
Conceptual model

	n	%
Age		
65-69	247	39.1
70-74	167	26.5
80+	97	15.4
Gender		
Male	299	47.2
Female	335	52.8
Education		
Low	240	40.1
Middle	273	45.6
High	86	14.4
Living alone		
No	462	73.6
Yes	166	26.4
General health		
Poor	14	2.2
Fair	124	19.7
Good	287	45.6
Very good	120	19.1
Excellent	84	13.4
Year		
2011	198	31.2
2012	244	38.4
2014	193	30.4

Note: $n = 635$

Table I.
General descriptives

	Test	Value (df)
Age ($n = 388$)	Pearson χ^2 (minimum expected count is 32.85)	4.775 (3)
Gender ($n = 526$)	Continuity correction	5.935 (1)
Village ($n = 526$)	Pearson χ^2 (minimum expected count is 19.21)	3.052 (3)

Note: Comparing respondents and non-respondents

Table II.
χ^2 test for independence

considering the number of people contacted (interactive use = greater social use) and time spent (also including passive use, observing other users = less social use). For e-mail use, we made a distinction between no, moderate, and high use. As the number of Facebook users was small, we only distinguished between use and no use. Finally, "who" uses online communication tools was taken into account by looking at initial social connectivity at *t*1. Other relevant personal characteristics (i.e., computer use intensity (five categories), age (continuous scale), gender, education (three categories), living alone (dummy variable) and general health (five categories) were included as control variables.

3.3 Data reduction and analysis

First, in order to assess which types of social connectivity older adults distinguish, a principal component analysis (PCA Oblimin, recommended by Stevens, 1996) was

conducted. Here, we took heed of Wagner *et al.*'s (2010) warning that existing scales may not always be appropriate for older adults. PCA is used to explore underlying components in the data (Hair *et al.*, 2009), as we did in this study. We based our PCA on the *t*1 and *t*2 data. Second, to assess the causal relationship between "who uses what, and how" (i.e., which older adults use what online communication tools and how) to connect "with whom" (i.e., different types of social connectivity), we conducted a time-lagged regression analysis, in which we investigated whether the independent variables measured at *t*1 could explain changes between *t*1 and *t*2 in the dependent social connectivity variables. Such time lagged analysis is well suited to reduce concerns about endogeneity and assess causal relationships by studying the link between current personal characteristics and behavioral patterns and subsequent outcomes.

4. Results

4.1 Who uses what and how

The overview in Table III shows which online communication tools are used, and how, by the adults in our survey. Descriptives show that, by 2014, almost 61 percent of older adults were using a computer or a tablet (hereafter combined in one group "computer") on a daily basis and that this percentage had increased since the earlier surveys. Still, about one-third of the participants rarely or never used a computer. The popularity of online communication tools had also increased slightly over time, with e-mail and the social networking site Facebook being the most popular applications to communicate online. Nevertheless, the uptake of social networking sites (Boyd and Ellison, 2008), such as Facebook, remains relatively slow among this population.

Despite increasing levels of computer use, we still observe significant differences between the characteristics of users and non-users. In order to assess (non-)adoption patterns and get a better understanding of the overall computer literacy within the population, we conducted a logistic regression analysis. A logistic regression is conducted when the dependent variable is binary, i.e., use or non-use, and the independent variables are either metric or non-metric (Hair *et al.*, 2009). Based on the logistic regression analysis, we predicted the likelihood of computer use (at least once a week = 1), i.e., being a user, based on personal characteristics and the year the data were collected (Table IV). Our model is significant at the $p < 0.001$ level (and the Hosmer and Lemeshow Test is non-significant indicating an acceptable model fit) and predicts 76.2 percent of the cases correctly. Roughly, 30-40 percent of the variance is explained. Results indicate that the older, less educated and least healthy are least likely to use a computer.

4.2 With whom one connects

We conducted a PCA to differentiate between types of social connectivity. The sample consisted of 437 cases and we included 20 items related to social connectivity. We retained only those components that had an eigenvalue > 1 and passed the Catell scree test (Hair *et al.*, 2009). Moreover, we excluded items with a communality below 0.3. Finally, we assessed the reliability of the scales. The three components that were derived have a sufficiently high Kaiser-Meyer-Olkin score of 0.789 and the Bartlett's test shows significant results ($p < 0.001$). The oblique (correlated) factor solution using a Direct Oblimin is sufficiently low (0.031 to 0.224). Together, the components explain 80.07 percent of the variance, well above the suggested minimum of 60 percent (Hair *et al.*, 2009).

	Year 2011		2012		2014[a]	
	n	%	*n*	%	*n*	%
Computer use						
Daily	82	44.32	128	54.01	115	60.85
About once a week	22	11.58	18	7.59	13	6.88
About once a month	4	2.11	2	0.84	3	1.59
Less than once a month	6	3.16	5	2.11	5	2.65
Never	71	38.38	84	35.44	53	28.04
Total	190		237		189	
E-mail						
People contacted						
No-use (= 0)	–	–	114	50.44	78	45.09
Moderate use (1-8p)	–	–	75	33.19	57	32.95
High use (> 8 p; max. = 90 p)	–	–	37	16.37	38	21.97
Total	–		226		173	
Time spent						
No-use (= 0)	–	–	111	49.12	75	42.86
Moderate use (> 0. < = 2.5 h)	–	–	79	34.96	66	37.71
High use (> 2.5 h; max. = 20h)	–	–	36	15.93	34	19.43
Total	–	–	226		175	
Facebook						
People contacted						
No-use (= 0)	–	–	202	89.0%	150	87.2%
Use (> 0; max. = 140 p)	–	–	25	11.0%	22	12.8%
Total	–	–	244		193	
Time spent						
No-use (= 0)	–	–	202	89.0%	150	86.2%
Use (> 0; max. = 12 h)	–	–	25	11.01%	24	13.8%
Total	–	–	227		174	

Notes: [a]Results of a one-way Anova show that computer use significantly increased between 2011 and 2014. A *t*-test shows that the increase in e-mail use between 2012 and 2014 is only significant at the 10 percent level. The number of Facebook users did not significantly increase in this period

Table III.
Changes in average computer use and weekly e-mail and facebook use

	B	Exp(B)	95% C.I. for Exp(B) Lower	Upper
Age	−0.159 (0.021)***	0.853	0.820	0.888
Female	0.034 (0.219)	1.035	0.674	1.588
Education level (ref: low education)				
Middle education	0.765 (0.220)***	2.148	1.396	3.304
Higher education	2.080 (0.469)***	8.002	3.189	20.080
Living alone	0.007 (0.258)	1.004	0.606	1.665
General health	0.509 (0.123)***	1.663	1.308	2.116
Year	0.18 (0.088)**	1.207	1.016	1.434
Constant	−368.696 (176.854)	0.000		
Wald χ^2 (df)	203.550 (7)***			
Cox and Snell R^2	0.296			
8Nagelkerke R^2	0.406			

Notes: Standard errors in parentheses. **$p < 0.05$; ***$p < 0.01$

Table IV.
Logistic regression of computer use (at least once a week = 1)

The results indicate that participants make a distinction between social connectivity within their neighborhood and in the wider region (Table V). In addition, these geography-based types of social connectivity are perceived as different from contacts with friends, who may be located anywhere in the world. However, in our further analyses, we used only two of these three social connectivity sub-constructs, i.e., neighborhood connectivity and connectivity with friends. This was because while people seem to generally have a shared understanding of the difference between neighbors (those living in the streets around them) and friends (those one has an emotional bond with), their conceptualizations of the "wider region" seemed less consistent. "Wider region connectivity" was therefore omitted from the subsequent regression analyses.

4.3 The causality between "who uses what and how" and "with whom"

To assess the causal relationship between online communication and social connectivity, we conducted a time-lagged regression analysis. Below we present the results for e-mail and for Facebook use.

	Pattern matrix			Structure matrix			
	Neighbor	Friends	Region	Neighbor	Friends	Region	Com.
Neighbors (Cronbach's $\alpha = 0.702$)							
How often do you participate in social/religious activities in the village?	0.844			0.812			0.679
How many fellow villagers do you know by name?	0.783			0.782			0.612
I have frequent contact with fellow villagers	0.718			0.787			0.711
Friends (Cronbach's $\alpha = 0.840$)							
I am very satisfied with the frequency with which I have contact with my friends		0.888			0.875		0.769
I am very satisfied with the quality of the contacts I have with my friends		0.884			0.871		0.764
I have frequent contact with my friends		0.818			0.851		0.745
Region (Cronbach's $\alpha = 0.832$)							
I am very satisfied with the frequency with which I have contact with fellow association members outside the immediate village			0.982			0.982	0.966
I am very satisfied with the quality of the contacts I have with fellow association members outside the immediate village			0.978			0.981	0.963
I have frequent contact with fellow association members outside the immediate village			0.969			0.970	0.942
How often do you participate in social/religious activities outside the immediate village?			0.926			0.923	0.855

Note: [a]Showing loadings > 0.5

Table V.
PCA pattern and structure matrix with connectivity with: neighborhood acquaintances (neighbors), friends (friends), and the region (region) components[a]

As shown in Table VI, e-mail use negatively impacts on neighborhood connectivity but has no effect on connectivity with friends. The results are consistent, both for more and for less social forms of e-mail use, i.e., number of persons contacted and the time spent on such activities. Further, we observe that the interaction between initial social connectivity and e-mail use is only positive for moderate users. Using margins plots (Figures A1 and A2) to interpret the findings, we see that, among respondents with low initial social connectivity, moderate e-mail use, when compared to non-use, negatively impacts on the predicted change in neighborhood connectivity.

Turning to the effects of using Facebook, Table VII shows that Facebook use does not impact on neighborhood connectivity, and has a negative effect on connectivity with friends. A high initial connectivity also has a negative effect on connectivity with friends once Facebook is adopted. However, because of a positive interaction effect between Facebook use and initial connectivity, the negative impact of Facebook use on connectivity with friends disappears for very high levels of initial social connectivity (Figures A3 and A4). As both the direct and the interaction effects are only significant at the 10 percent level one should be cautious, but the results do suggest that using Facebook reduces rather than stimulates connectivity with friends.

5. Discussion

In answering our research question, we find that online communication in general does not enhance the social connectivity of older people. Rather, e-mail use negatively impacts on neighborhood connectivity, and Facebook use on connectivity with friends. These findings are surprising given that older adults are increasingly a target group for online communication design and diffusion projects aiming to improve health and

Lagged independent variables	People contacted		Time spent	
	Δ Neighbor	Δ Friends	Δ Neighbor	Δ Friends
E-mail use (ref: non-user)				
Moderate user	−0.828 (0.410)**	0.00845 (0.987)	−0.733 (0.414)*	−0.149 (1.001)
Heavy user	−0.693 (0.474)	0.867 (1.017)	−0.810* (0.470)	0.598 (0.944)
Initial social connectivity (SC)	−0.430 (0.0885)***	−0.733 (0.202)***	−0.424 (0.0893)***	−0.754 (0.204)***
Moderate user – initial SC	0.257 (0.105)**	0.0291 (0.221)	0.221 (0.104)**	0.0821 (0.225)
Heavy user – SC	0.185 (0.115)	−0.158 (0.228)	0.207* (0.119)	−0.0990 (0.218)
Computer use intensity	−0.0615 (0.0437)	−0.0693 (0.0520)	−0.0503 (0.0470)	−0.0797 (0.0536)
Age	−0.0169 (0.00859)*	−0.0124 (0.0106)	−0.0167 (0.00917)*	−0.0105 (0.0107)
Gender (female = 2)	0.128 (0.0787)	0.196 (0.121)	0.133 (0.0820)	0.201 (0.119)*
Education (3 cat.)	−0.0633 (0.0676)	−0.00202 (0.0903)	−0.0720 (0.0659)	0.00932 (0.0910)
Living alone	0.170 (0.0904)*	0.0861 (0.152)	0.160 (0.0950)*	0.0834 (0.143)
General health	0.0737 (0.0371)**	0.0524 (0.0506)	0.0639 (0.0402)	0.0466 (0.0524)
Constant	2.497 (0.798)***	3.866 (1.494)**	2.482 (0.805)***	3.825 (1.504)**
N	115	118	114	118
R^2	0.373	0.476	0.369	0.480

Notes: Robust standard errors in parentheses. *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

Table VI. Time-lagged regression of changes in neighborhood connectivity (neighbor) and connectivity with friends (friends) and two forms of weekly e-mail use among older adults

Table VII. Time-lagged regression of changes in neighborhood connectivity (neighbor) and connectivity with friends (friends) and two forms of weekly Facebook use among older adults

Lagged independent variables	People contacted		Time spent	
	Δ Neighbor	Δ Friends	Δ Neighbor	Δ Friends
Facebook use = yes	−0.258 (0.540)	−1.792 (0.891)**	−0.258 (0.540)	−1.792 (0.891)**
Initial social connectivity (SC)	−0.311 (0.0586)***	−0.772 (0.0902)***	−0.311 (0.0586)***	−0.772 (0.0902)***
Facebook use = yes − initial SC	0.107 (0.136)	0.409** (0.197)	0.107 (0.136)	0.409** (0.197)
Computer use intensity	−0.0508 (0.0292)*	−0.0431 (0.0452)	−0.0508 (0.0292)*	−0.0431 (0.0452)
Age	−0.0187 (0.00896)**	−0.0136 (0.0109)	−0.0187 (0.00896)**	−0.0136 (0.0109)
Gender (female = 2)	0.126 (0.0856)	0.195 (0.120)	0.126 (0.0856)	0.195 (0.120)
Education (3 cat.)	−0.0731 (0.0658)	−0.00111 (0.0834)	−0.0731 (0.0658)	−0.00111 (0.0834)
Living alone	0.126 (0.0988)	0.0168 (0.137)	0.126 (0.0988)	0.0168 (0.137)
General health	0.0419 (0.0395)	0.0413 (0.0510)	0.0419 (0.0395)	0.0413 (0.0510)
Constant	2.300 (0.777)***	4.159 (1.065)***	2.300 (0.777)***	4.159 (1.065)***
N	111	115	111	115
R^2	0.335	0.479	0.335	0.479

Notes: Robust standard errors in parentheses. *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

social well-being (Ambient Assisted Living Joint Program, 2012; Cody *et al.*, 1999; Erickson, 2011; Shapira *et al.*, 2007; Saunders, 2004; Waycott *et al.*, 2013). In addition, our findings have important theoretical implications regarding conceptualizations of online communication tools and social connectivity. Finally, we have demonstrated that initial social connectivity is an important explanatory variable.

Our results show that older adults' neighborhood connectivity is negatively affected by the use of e-mail, but not by social networking sites, in casu Facebook. In contrast, for connectivity with friends: Facebook and not e-mail use has a negative impact. As we hypothesized in *H1*, it is thus crucial to differentiate between types of online communication tools (the what). Although different types of social connectivity are affected differently, we did not find that neighborhood connectivity was more negatively impacted by online communication than more distant forms of connectivity. Rather, the impact depends on the combination of the online communication tool (the what) and the type of social connectivity (with whom). Thus *H4*, addressing the with whom, is partially supported: local forms of social connectivity can be more negatively affected, but this depends on the online communication tool in question. Further, users with high levels of initial social connectivity did not experience any negative effect of online communication on social connectivity, which supports *H3* (the who). This result implies that not only adoption patterns of online communication tools reinforce pre-existing structures of inequality, as is shown in the digital divide literature (Katz and Aspden, 1997), online communication itself also tends to have a disproportional negative effect on the older "have not's," i.e., less connected older adults. Finally, we did not find differences between the impact of more vs less social use of online communication tools, and therefore *H2* (the how) is not supported.

In summary, the effect of online communication depends on the type of online communication tool used (technological characteristics) in combination with the type of social connectivity (social characteristics) and the initial social connectivity levels of the individual (personal characteristics). Below, we provide a theoretical interpretation of our results.

5.1 *It is all in the mix*

The findings imply that the type of online communication tool used (*H1*) and initial social connectivity (*H4*) jointly influence how online communication impacts on social connectivity. In order to explain these findings, we draw on characteristics of online communication tools: their information richness and privacy risks, and two characteristics of older adults' social contacts: geographical proximity and emotional closeness.

Concerning the first characteristic of online communication tools, information richness, we see the information richness of e-mail – a written, asynchronous form of communication – as low (Daft and Lengel, 1984, 1986; Markus, 1994). As Facebook can be used to share written text, videos, and images, both asynchronously and synchronously, we consider the information richness of this medium as mixed, i.e., not as a defining characteristic. Turning to privacy risks, Facebook is seen as more public than e-mail, i.e., as more risky (see also Newman *et al.*, 2011). The core feature of Facebook is based on the idea that users view all the posts of all their friends and vice versa. E-mail use is more selective, although privacy risks still exist. These differences are summarized in Table VIII.

Turning to characteristics of social connectivity, we argue that geographical proximity is a defining characteristic of neighborhood contacts. Friends, on the other hand, may live close to each other but this is not a required condition. What defines friendship is the level of emotional closeness between two people (Amichai-Hamburger *et al.*, 2013) (see Table IX). Based on these characterizations of e-mail vs Facebook and of neighborhood connectivity vs connectivity with friends, we now explain our findings.

Information richness and geographical proximity. Face-to-face communication mostly takes place between people that reside close to each other (Festinger, 1950). Further, there is a significant overlap between offline and online social contacts (Lampe *et al.*, 2006; Takhteyev *et al.*, 2012; Tranos and Nijkamp, 2013).

Table VIII. Characteristics of online communication tool

	E-mail	Facebook
Information richness	Low	Mixed
Privacy risks	Mixed	Low

Table IX. Characteristics of older adults' social connectivity

	Neighborhood connectivity	Connectivity with friends
Geographical proximity	Required	Mixed
Emotional closeness	Mixed	Required

The time displacement theory (Finholt and Sproull, 1990; James *et al.*, 1995; Putnam, 2000) posits that time spent online cannot be spent on "real" social interactions and, therefore, that internet use reduces social connectivity. This theory has been criticized by scholars who observe that time online could be being spent on social interactions (DiMaggio *et al.*, 2001; Witte *et al.*, 2013) and, therefore, internet use does not necessarily reduce social connectivity. However, even if online communication makes up a significant proportion of all online activity, this does not imply that the total amount of time spent communicating increases proportionally with the time spent on online communication. It is likely, at least to some extent, that online communication replaces other forms of communication.

Based on these notions, we suggest that, once an older adult starts communicating with nearby contacts through e-mail, e-mail communication will to some extent replace face-to-face communication. If older adults then experience e-mail communication as less rich and socially rewarding than face-to-face communication (Markus, 1994), this increased e-mail use could reduce neighborhood connectivity. This would also explain why we do not find a negative impact of e-mail use on connectivity with friends. Friends may, or may not, live close to each other, and when friends live some distance apart the opportunities to engage in face-to-face communication reduce, increasing the added value of e-mail. This may be especially so among older, less mobile, populations. We would expect e-mail use to have a positive impact on connectivity with distant and a negative impact on connectivity with close friends. In our survey, we looked at friends in general so these contradictory effects may have balanced out.

Privacy risks and emotional closeness. Next, we seek an explanation for the negative impact of Facebook use on older adults' connectivity with friends. Facebook users face a dilemma. On the one hand, they may have specific social needs that they want to share, on the other, users want to manage their self-presentation in this public online space (Newman *et al.*, 2011). An illustration of this is a comment made by a participant in Newman *et al.*'s (2011) study : "It's not that I don't have problems, I'm just not putting them on Facebook." Our research population also experienced this dilemma. In a qualitative follow-up study, we found that older adults were worried about their online privacy and, because of this, particularly hesitant about disclosing personal information on Facebook. As a result of this social needs – privacy dilemma, users may decide not to share their particular social needs online. Such decisions to reduce online self-disclosure can hinder friendship maintenance (Valkenburg and Peter, 2009) as limited disclosure may negatively influence dimensions of friendship such as intimacy, companionship, and social support (Amichai-Hamburger *et al.*, 2013). If Facebook communication replaces other, more private, forms of communication between friends, the connectivity between older adults and their friends is likely to be reduced. Although emotional closeness in the form of intimacy, companionship, and social support is, by definition, expected of friends, this is not necessarily so for neighborhood acquaintances. Older adults' neighborhood connectivity is, therefore, not affected by Facebook use.

5.2 Initial connectivity

We found that users with high initial levels of social connectivity did not experience a negative effect of online communication on their social connectivity. This suggests that the socially well-connected are better able to buffer the negative effects of online communication on social connectivity. Thus, rather than helping the socially rich get

richer (Kraut *et al.*, 2002), online communication is impoverishing the socially poor. These findings indicate that online communication does not only reflect, it also reinforces, preexisting inequalities in social connectivity.

These results are in line with the soft-deterministic perspective on technology use (Barley, 1986, 1990; Orlikowski, 2000). In this perspective, pre-existing social structures are seen as important determinants of technology-enabled change. However, actors are also reflective beings that have a free will with which they can challenge or reinforce structures. Through collective processes of reflectivity, actors shape change outcomes (Boonstra and van Offenbeek, 2010). We therefore argue that, without reflective action to shape change outcomes, online communication reinforces pre-existing structures of inequality (Hage *et al.*, 2013).

5.3 Methodological considerations

The information technology literature on causality is sparse (Gregor, 2006; Gregor and Hovorka, 2011; Mithas *et al.*, 2009; Lee *et al.*, 1997; Markus and Robey, 1988) and this is also the situation for studies on online communication and social connectivity (Park, 2011; DiMaggio *et al.*, 2001). The design of our study begins to take these important considerations into account. Applying panel data analysis reduces the risk of omitted variables bias and comes closer to establishing a causal reasoning regarding the correlation between online communication and social connectivity.

5.4 Social(izing) information system

Instead of realizing their potential to make a substantial beneficial contribution to older adults' social well-being, and therefore to our aging society, we found the online communication through e-mail and Facebook use had a negative effect on the social connectivity of already less connected older adults. We found the quantitative research methods applied in this study well equipped to expose these policy relevant, community wide effects of online communication. The findings underline that this specific kind of social information systems can have both a positive and negative impact on society. How online communication changes a society depends on the combined what, who and with whom of technology use. Therefore, we suggest that rather than studying social information systems an sich, the socialization of information systems through social forces and practices within the societal domain requires research.

5.5 Policy implications

Our research findings suggest that different types of online communication have distinct impacts on different types of social connectivity. Therefore, policymakers need to consider carefully which types of older adults' social connectivity they should be aiming to enhance. For example, in aging, dual-career societies, policymakers often express the need for friends and close family members, irrespective of geographical proximity, to play a meaningful part in the social life of an older adult, and when necessary become part of the older adult's care network. With these goals, policymakers should maybe stimulate e-mail use between older adults and their friends and family, rather than sharing pictures on Facebook. In contrast, to connect on the most local level, within their neighborhood, older adults may benefit more from using Facebook. Enhancing older adults' social connectivity thus requires a package of differentiated policy measures. Finally, the pattern of social impacts from

implementing online communication tools needs to be carefully studied in order to quickly detect negative effects and to determine which positive effects should be strengthened. Again, we find that the oldest adults, the least healthy, and the least educated, and therefore the most vulnerable, are the least likely to benefit from online communication. Given this situation, policymakers may want to rethink the role online communication tools can play in the lives of these vulnerable older adults.

5.6 Limitations and future research

As with any study, the empirical analyses on which we base our conclusions have some limitations. First, we took into account only two forms of online communication and two levels of social connectivity. E-mail and social networking sites, in casu Facebook were by far the most popular online communication tools among the participants in the study and, therefore, other options were excluded from the analyses. The PCA yielded two clearly different types of social connectivity. Future research could set out to develop constructs for more types of social connectivity, based on the dimensions geographical proximity and emotional closeness. In addition, future research could assess whether other online communication tools that are, like e-mail, privacy sensitive, but not information rich negatively affect neighborhood connectivity. Similarly, studies could investigate if information rich and privacy insensitive online communication tools other than Facebook also negatively impact connectivity with friends. Moreover, such research could establish how privacy risky online communication tools with low (high) privacy sensitivity and information richness, e.g., Twitter (e.g. Skype) impact social connectivity. Second, the current study does not explain how and why online communication impacts on social connectivity. Longitudinal qualitative studies could be conducted to increase our understanding of these mechanisms. Third, our results related to different forms of Facebook use should be interpreted with caution due to the small number of Facebook users in our sample. Future research, with a larger sample, could apply more sensitive measures to assess the differential impacts of various forms of Facebook use among older adults. Finally, our study included one rather homogeneous group of older adults, namely retired persons aged 65+, living independently in villages in the north of The Netherlands. Moreover, the main analyses were based on two rounds of survey data. This limits the generalizability of the findings as we do not know whether online communication also has a negative effect on poorly connected older adults' social connectivity under different circumstances and in different contexts, e.g., among working older adults and older adults living in care accommodations. Moreover, we do not know the role of time trends related to, e.g., the technological maturity of online communication tools as well as of the cultural acceptance of online communication among the wider population. Future research could usefully address these issues.

6. Conclusions

The impact that online communication tools have on older adults' social connectivity appears to be mixed: positive or non-existent under some conditions but negative under others. In seeking to explain this mixed impact, this study first highlights the importance of carefully considering the characteristics of online communication tools, such as their information richness and privacy riskiness, as well as characteristics of the social contact, including geographical proximity and emotional closeness. Second, our results indicate a buffering effect, with older adults that are initially well connected

apparently immune to the negative implications of online communication seen in others. This seems to imply that online communication reinforces the social differences between the haves and the have nots. Finally, the findings in this study demonstrate the relevance of taking the heterogeneity in populations of older adults into account. We highlighted a number of factors that deserve focussed attention both of researchers and policymakers. Although the relevant factors may differ per older adult population, the significant factors in our population form a good starting point.

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Appendix. Margins plots

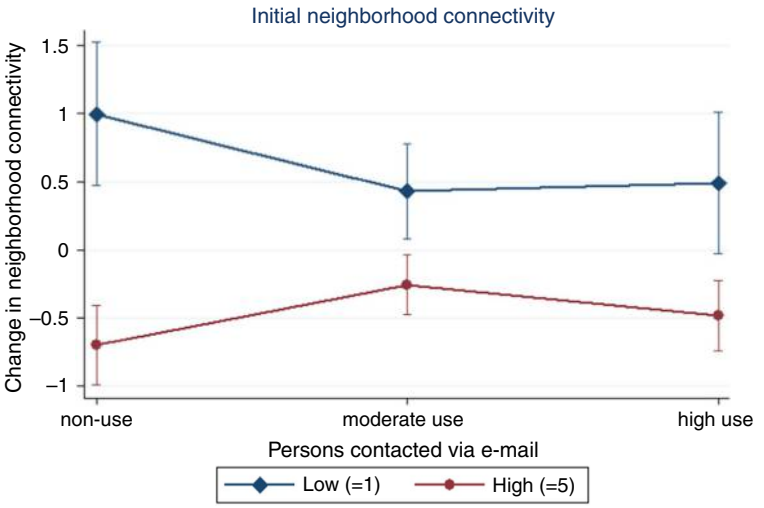

Figure A1. Margins plot of neighborhood connectivity and persons contacted via e-mail

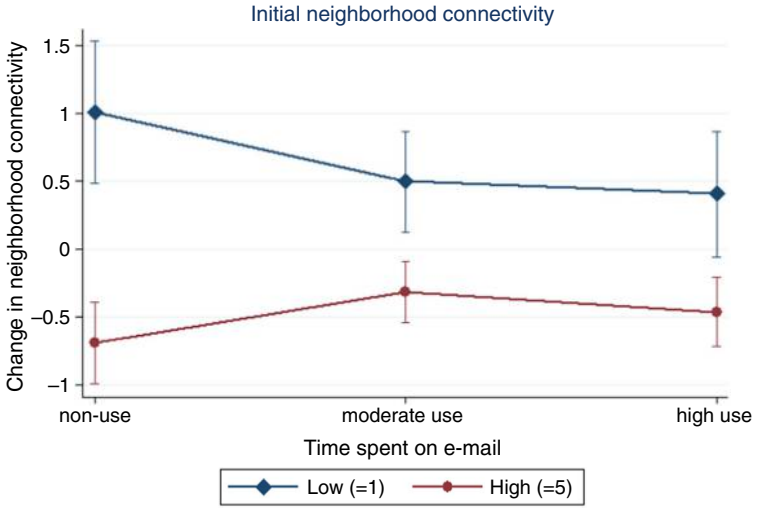

Figure A2. Margins plot of neighborhood connectivity and time spent on e-mail

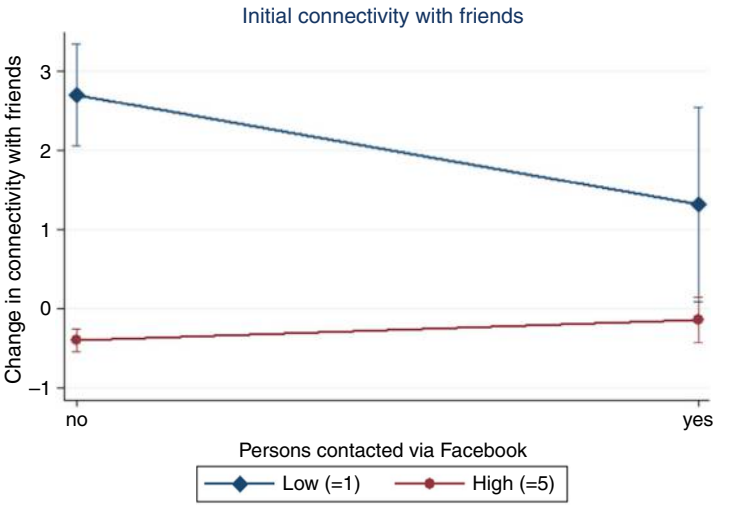

Figure A3.
Margins plot of connectivity with friends and persons contacted via Facebook

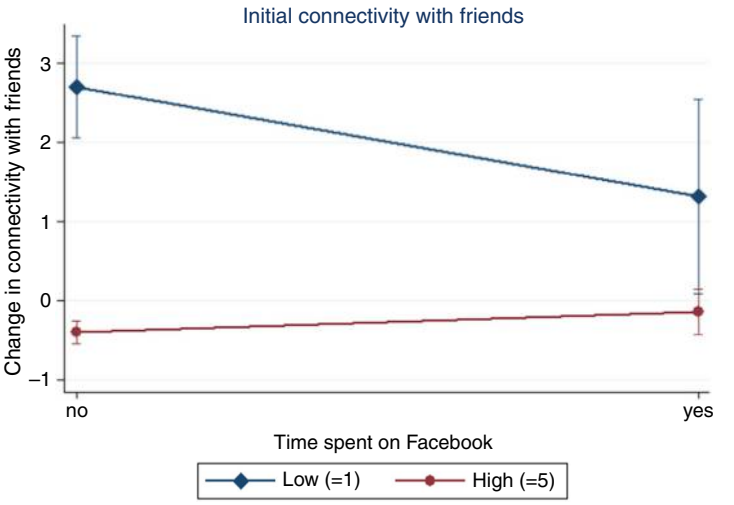

Figure A4.
Margins plot of connectivity with friends and time spent on Facebook

Corresponding author
Eveline Hage can be contacted at: m.l.hage@rug.nl