# Interpersonal communication about climate change: How messages change when communicated through simulated online social networks

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**Abstract** Climate change communication research has mainly focused on how to communicate climate change effectively to the public. By contrast, how such information is then spread through interpersonal social networks has been neglected, despite being an essential component of cultural change. Using a Facebook-like format, we examined what types of climate change messages 'survive' when passed between individuals via communication network chains. We found that statements centred on conventional climate change topics (e.g., its impact on the natural world and human health) survived longer in communication chains than those with less conventional topics (e.g., its impact on societal competence, development, or communality). Moreover, statements about gains from mitigation (gain-frames) survived more than those about costs of non-mitigation (loss-frames) in initial communications, but loss-framed information survived more later in communication chains. In light of research showing that climate change messages focused on society and/or gain frames can motivate action, this research highlights a challenge by showing that these messages are less likely to be spread throughout society.

**Keywords** Climate change, serial reproduction, gain/loss framing, interpersonal communication, message framing, culture change

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## 1 Introduction

Greater public engagement is essential for an adequate response to climate change (e.g., Lorenzoni et al. 2007; Feygina et al. 2010), and climate change communication is a critical mechanism by which this engagement can occur (e.g., Moser and Dilling 2011; Whitmarsh et al. 2011). Existing climate change communication research has largely focused on the framing of mass communications to the general public, and the attitudinal and cognitive changes that can result (e.g., O'Neill and Nicholson-Cole 2009; Feinberg and Willer 2010; Feygina et al. 2010, Gifford and Comeau 2011; Spence and Pidgeon 2010; Scannell and Gifford 2013; for review, see Moser 2010) Attention is also increasingly turning to online climate change communication (Schäfer 2012), including the network structure of the climate change 'Twittersphere' (Pearce et al 2014; Williams et al. 2015) and how Twitter is used to mobilize climate protests (Segerberg and Bennet 2011). An under-examined area, however, is the micro-level interpersonal communication – what Moser (2010) called dialogic communication – between members of online social networks, and its potentially significant role in engaging the public with climate change.

### 1.1 The importance of online interpersonal climate change communication

There are several reasons why interpersonal climate change communication may be important. First, individuals can act as 'opinion leaders' who spread public messages through social networks via a 'two-step flow' of communication (Katz 1957). This is particularly important because friends and relatives are often trusted sources of climate change information (e.g., Poortinga and Pidgeon, 2003). Opinion leadership processes are evident in online social networks (e.g., Choi 2014), and have informed online climate change campaigns such as Al Gore's "We" initiative (Nisbet and Kotcher 2009). Second, in line with the theories of identity-protective cognition (Cohen 2003) and cultural cognition (Kahan et al, 2007), communicating about an issue within social networks that hold shared values may increase an issue's perceived importance. Third, interpersonal communication can shape perceptions of ingroup norms (e.g., Kashima et al. 2013b), which influence pro-environmental behavior (Cialdini et al. 1990). Finally, the transmission of secondhand information can be markedly different from the information received firsthand (e.g., Kashima 2000). Thus, if a mass-communicated climate change message is shared through extended social networks, the information passed on may differ from the original message. Therefore, it is critical to look specifically at interpersonal communication to identify the types of information that are likely to diffuse throughout society (e.g., Kashima 2000, 2008, 2014).

Interpersonal communication is now increasingly occurring online via social network sites such as Facebook. With over 800 million daily users (Facebook 2014), Facebook facilitates both engagement with social and political issues (e.g., Tang and Lee 2013; Zhang et al. 2010), and rapid information diffusion when messages go "viral" (Berger and Milkman 2012). Importantly, Facebook also provides a forum for more *interpersonal* communication by allowing more extensive and personal communication than the brief format of Twitter (Auer et al. 2014). A primary motivation of Facebook users is a desire for interpersonal interaction (Wilson et al. 2012), and communication via Facebook has been found to function similarly to face-to-face interaction *vis-à-vis* social and emotional support (Hampton et al. 2012), Examining communication processes in a context like Facebook can therefore provide important insights into interpersonal climate change communication.

### 1.2 Framing climate change in interpersonal communication

Climate change communication can be framed in diverse ways (O'Neill et al. 2015), and these framings have implications for individual responses (for review, see Nisbet 2009). We extended past work by investigating how the *content* and *gain/loss framing* of climate change communication affects the diffusion of climate change messages through a social network.

Five content domains were explored. The first domain linked climate change to *nature*, i.e., how climate change will affect plants, animals, and the likelihood of natural disasters. The other four content domains linked climate change to aspects of society. The second and third domains focused on two fundamental dimensions people use to evaluate their society and other groups: *competence* (our capabilities and skills) and *communality* (how caring and warm we are to each other; e.g., Cuddy et al. 2008; Fiske et al. 2007). Bain et al. (2012, 2013, 2015) showed that the communality domain is strongly and consistently linked to people's willingness to act on climate change. The fourth domain was *development*; relating climate change to the economy and technology (e.g., UNEP, 2011; Fabian, 2015; Nisbet, 2009), which is also an effective motivator of climate change behavior (Bain et al. 2012, 2015). The final domain was *health*, linking climate change to infectious diseases and the effects of airborne contaminants (e.g., Costello et al. 2009; Thurston, 2013).

Each content domain was presented in both gain- or loss-framed formats. Drawing on

prospect theory (Kahneman and Tversky, 1979), studies have shown that gain frames (focusing on the benefits of climate change mitigation) produce greater pro-environmental motivations than loss frames (focusing on the harms of non-mitigation; Morton et al. 2011; Spence and Pidgeon 2010). However, the effects of these frames on how people communicate about climate change to each other are not established. Further, climate change messages often contain a mix of gain and loss frames, typically with the threat (loss) established first, and the solutions and their benefits (gain) second (e.g., Flannery 2005; Bender et al. 2006; Mann 2012). How these "mixed" valence messages are communicated in social networks also needs to be established.

**2. The present research**

We address these questions using the method of serial reproduction (Bartlett 1932) within a simulated Facebook-like format. Serial reproduction involves passing messages through chains of communicators, similar to the children's game of 'Chinese whispers' or 'broken telephone'. Analyzing how information passes through such chains simulates how information is diffused through social networks (e.g., Kashima 2000, Bangerter 2000; for review see Kashima 2014). Here, we presented messages to participants as if they had been posted on Facebook, and participants were asked to imagine they had seen the messages shared by a friend. Participants were then asked to pass on the message from memory in their own words via text as if re-sharing it on Facebook with their own friends. The first participant in each chain read a prepared message, the second read the message as reproduced by the first, and the third read the message as reproduced by the second.[1] Participants' reproductions were coded and analyzed to test how content domains and gain/loss framing affected survival through serial reproduction chains.

A key finding of serial reproduction research is that ideas perceived as being shared within a community (more "conventional") are more likely to be passed on, while unconventional information is lost or changed (e.g., Kashima 2000; Lyons and Kashima 2003, 2006; Clark and Kashima 2007; Kashima 2014). This process gradually leads to a conventionalization of messages, and can play a central role in the maintenance of cultures by reinforcing shared understandings and marginalizing unconventional ones (Kashima 2008, 2014; Lyons and Kashima 2001).

Climate change is primarily perceived as an environmental issue (Leiserowitz 2005). Thus, nature-focused messages that link climate change to natural disasters and other environmental effects are arguably more conventional than society-focused messages. This suggests that as messages pass through social networks, nature-focused messages may be more likely than society-focused messages to spread, due to their relative conventionality. Nevertheless, of the four society-focused domains, health-focused messages may be the most conventional, because health effects of environmental degradation are a common public concern (e.g., Bickerstaff and Walker 2001). We therefore hypothesized that nature and health statements would survive more in communication chains than statements concerning competence, communality, and development, and this would be mediated by perceptions of conventionality.

Similarly, the pervasiveness of loss-framed climate change messages (Hulme 2008; O'Neill et al. 2015) may render gain-framed messages comparatively less conventional. There is a widespread public perception that climate change is a negative threat (Norgaard 2006), and when individuals have been asked for their conceptualizations of climate change, the responses have been overwhelmingly "negative and bleak" (O'Neill and Nicholson-Cole 2009, p.369). Thus, despite the relative advantages of gain-framed climate change messages among initial recipients (Morton et al. 2011; Spence and Pidgeon 2010), they too may be relatively unconventional, and therefore less likely to be spread via interpersonal communication. Thus, we hypothesized that gain-framed statements would survive less than loss-framed statements, and that this would also be mediated by perceptions of conventionality.

**3 Method**

3.1. Participants

[1] We also attempted to manipulate perceptions of social consensus about the reality of climate change. Half of the sample (randomly assigned) read that "74% of participants in a pilot study agreed with the statement 'Climate change is occurring and humans are largely causing it'". However, this manipulation had no effect over participants' perceptions of either their Facebook friends' or the general public's belief in climate change ($ps > .1$). Initial analyses included consensus as an additional 2-level between subjects factor, but it produced no significant main or interaction effects and its exclusion made no difference to the reported results, so is not reported.

Two hundred and nineteen US Facebook-using participants were recruited via Amazon's Mechanical Turk (www.mturk.com). Twelve participants were excluded: two for admitting to taking the study twice, and a further ten were excluded for not following instructions correctly (e.g., writing one-word message reproductions or verbatim copying the original message verbatim). Three further pairs of duplicate IP addresses were identified, but reported non-matching demographic information so were retained. The final sample comprised 207 participants (age 18-67, *M*=32.26, *SD*=10.14, 94 females). Participants' education levels were some high school (3), high school diploma (76), college/university degree (110), or postgraduate degree (18). Participants described their political affiliations as liberal (100), moderate (60), or conservative (46).

3.2 Materials and procedure

Participants completed an online survey. They were presented with a climate change message formatted like a Facebook post and asked to imagine it was posted by a Facebook friend (see online supplementary material). Participants were instructed that they would later reproduce the message from memory. Participants were randomly assigned to a framing condition: all gain, all loss, or mixed. All conditions originally contained ten statements; two from each content domain: nature, competence, communality, development, and health. The gain condition statements were all about benefits of climate change mitigation, the loss condition statements were all about costs of non-mitigation, and the mixed condition used one gain-framed and one loss-framed statement from each content domain). Statements are listed in Table 1.

The order of statements was randomized in the all gain and all loss conditions. In the mixed condition, five randomized loss-framed statements were presented first, followed by five randomized gain-framed statements. The loss-framed statements were presented before the gain-framed statements to reflect the typical pattern of climate change gain/loss information (e.g., Flannery 2005; Bender et al. 2006; Mann 2012). Two versions of the mixed condition message were created to counterbalance the framing of each individual statement. In one version, five statements (one from each domain) were framed as gain and the other five as loss, which was reversed in the second version (loss statements became gain statements).

After reading the messages, participants were instructed on the following webpage: "Imagine that you have now decided to share the message that you have just read with all of your Facebook friends. In the box below, please 're-post' the message that you have just read to your Facebook friends. Feel free to use your own words and add to the message as you wish." The messages that were reproduced by participants first in the chain were then presented to participants second in the chain, and the reproductions from participants second in the chain were presented to participants third in the chain using URL links. Once the data for the first chain position was complete, data collection for the second chain position commenced, and so on. Imagined interactions have been shown to produce similar content to actual interactions, and this method has been used in previous serial reproduction studies (Clark and Kashima, 2007; Kashima et al. 2013a).

To provide a measure of the conventionality of each statement, participants were next presented with the 10 statements from the original message used in their chain, and estimated the percentage of the general public who would agree with each statement. Participants were then provided the opportunity to give feedback and debriefed.

**Table 1** Gain and loss-framed statements by societal domain. Gain framed statements were preceded by "If we act on climate change now, in the future we will:", loss-framed statements were preceded by "If we don't act on climate change now, in the future we will:" (see Appendix A)

| Domain | Statements |
|---|---|
| Competence | "have learned (missed out on learning) new skills that could help us solve other societal problems" |
| | "be advancing and applying (fail to advance and apply) scientific knowledge" |
| Communality | "be more (less) community-minded when thinking about how our behavior impacts others" |
| | "be more (less) considerate because we will be thinking about others and not just (only be thinking about) ourselves" |
| Development | "be using efficient (inefficient) technologies that will benefit (weaken) our economy" |
| | "have a more prosperous society due to the creation (a lack) of new jobs and industries" |
| Nature | "have a reduced (an increased) risk of natural disasters, such as tornados and floods" |
| | "have protected (lose) some of our plant and animal species from (to) extinction" |

| | |
|---|---|
| Health | "be healthier (less healthy) because we will be breathing cleaner (dirtier) air" "have fewer (more) infectious diseases that will spread as a result of warmer temperatures" |

3.3 Coding

A coding manual and dictionary were developed in a pilot study, where 100 participants read and reproduced a message very similar to the mixed framing condition message. The five content domains provided an a priori basis for the coding dictionary. It was not possible to distinguish reproduction of individual statements within each content domain, but coders could reliably differentiate the content domains (e.g., communality from competence,) and framings (gain from loss).

Using pilot study data, two research team members tested the initial coding dictionary, and added categories to capture abstracted content (e.g., 'we will be healthier' rather than 'we will be healthier because we will be breathing cleaner air'), new content (statements relevant to one of the five domains but not clearly related to the original statements), and disagreements (where an original statement was reproduced, but disagreed with).

In the main study, two blind coders used the final coding dictionary (available in supplementary materials) to code whether statements of each combination of domain and framing were 1) reproduced; 2) abstracted; 3) new statements; or 4) disagreements. A research team member who had coded the pilot study reproductions acted as a lead coder. While the lead coder was not blind to the aims of the experiment, all coders including the lead coder were unaware of participants' experimental condition during coding.

We employed an iterative coding approach (MacQueen et al. 1998). Using the reproductions from the first position in the chain, inter-rater reliability was initially low for some codes, but resolution through discussion resulted in satisfactory reliability (Krippendorf's alpha >.70, $N$=71) by the third round of coding. Reproductions for the second and third chain positions required two rounds of coding to produce satisfactory inter-rater reliability ($N$s=70).[2]

**4 Results**

Reproductions largely mirrored the original message framings, consisting of gain-framed statements in the all gain condition, loss-framed statements in the all loss condition, and both gain- and loss-framed statements in the mixed condition (Figure 1). There were only a few new messages (23 gain-framed, 20 loss-framed) and disagreements (10). These were not clearly related to coding categories and were excluded from analyses.

[2] These sample sizes (71 and 70) do not match the final sample size (69) due to participant exclusions.

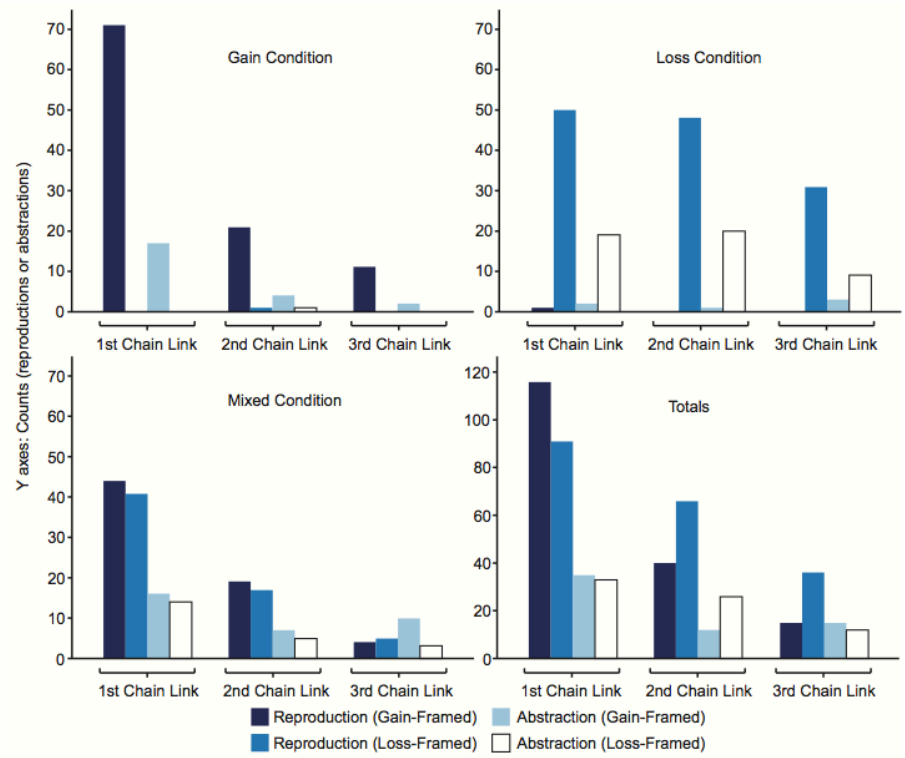


**Fig. 1** Gain- and loss-framed reproductions and abstractions in each chain position for each condition, as well as totals across conditions

To analyze statement survival across chains, we used three-person chains as the unit of analysis ($N$=69), and conducted a 3 message framing (all gain/all loss/mixed) × 3 chain position (first/second/third) × 5 content domain (competence/communality/development/nature/health) split-plot analysis of variance (ANOVA), with message framing condition as a between-subjects factor and chain position and statement domain as within-subjects factors. Statement survival was operationalized by the sum of gain or loss-framed reproductions and abstractions within each domain. Thus, for each chain in each position, statements from each domain were coded as having survived if they were either reproduced or abstracted.

There was a main effect for content domain, $F(4,264)=8.32, p<.001, \eta_p^2=.11$ (Figure 2). Planned comparisons showed that nature and health statements survived significantly more often than competence, communality, and development statements, $p<.05$. Survival rates did not significantly differ between competence, communality and development domains, or between nature and health domains. No other main effects or interactions for content domain were significant.

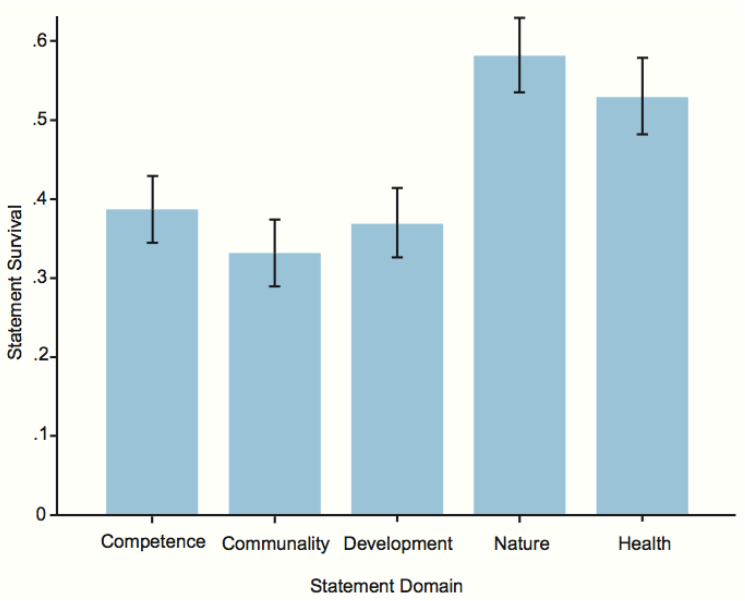


**Fig. 2** Statement survival by domain across all original message framing conditions. Bars indicate ±1 *SEM*

There was also a significant main effect for chain position, $F(2,132)=77.29$, $p<.001$, $\eta_p^2=.54$. Planned comparisons showed a significant decrease in statement survival in each successive chain position, $p$s<.001. However, this was qualified by a significant interaction between chain position and message framing, $F(4,132)=9.33$, $p<.001$, $\eta_p^2=.22$ (Figure 3). Post hoc comparisons (Fisher's LSD) of the effects of framing condition within each chain position showed that the gain condition had higher statement survival than the loss condition in the first chain position, $p<.05$, but the loss condition had higher statement survival than both the gain and mixed conditions in the second and third chain positions, $p<.05$.

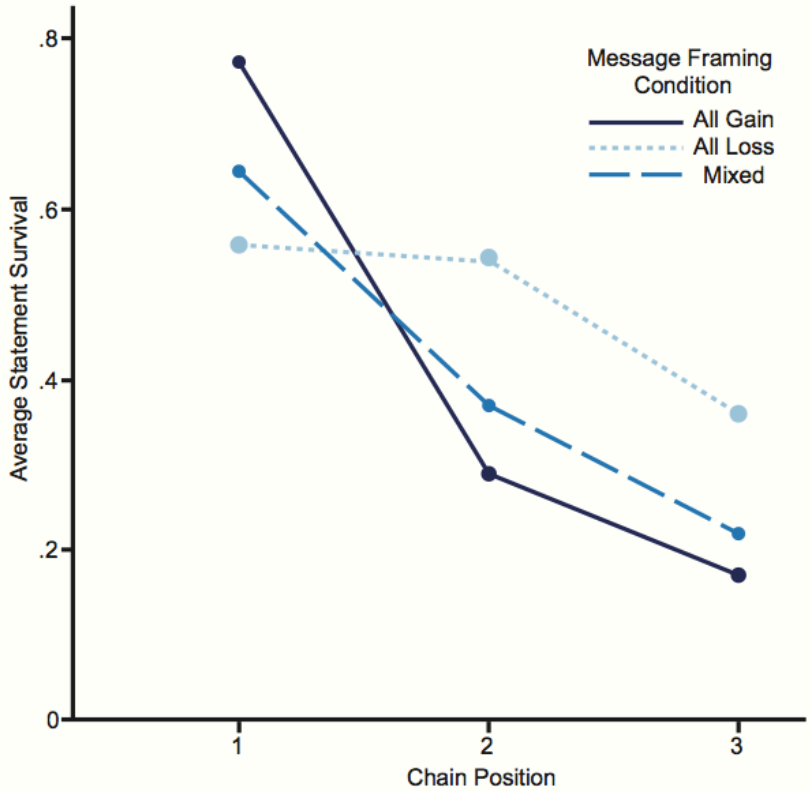


**Fig. 3** Interaction between original framing condition and chain position on statement survival

To test whether the effects were driven by the conventionality of the climate change statements, we first fit a 3 message framing × 3 chain position × 5 content domain split-plot analysis of covariance (ANCOVA) adding participants' average conventionality ratings of statements from each domain (0-100%) as a time-varying covariate (see Table 2) following the procedure outlined by Page et al. (2003). Conventionality was a significant positive predictor of the within-individuals variance (i.e., variance attributable to domain), B=.30, $t$=2.66, $p$<.01,$\eta_p^2$ =.03, and adding conventionality to the model reduced the effect size of content domain by 58%, from $\eta_p^2$=.11 to $\eta_p^2$=.05. We inferred that conventionality partially mediated the effect of content domain, accounting for over half of its effect. Conventionality did not significantly predict other variance components within the model, and did not meaningfully affect the proportion of variance accounted for by chain position or the interaction between chain position and framing. This suggests that conventionality did not mediate these effects.

**Table 2** Ratings of conventionality (perceived agreement among general public)

| Framing | Domain | M | *SE* | 95 % CI | |
|---|---|---|---|---|---|
| | | | | Lower bound | Upper bound |
| Gain | Competence | 48.62 | 2.7 | 43.29 | 53.96 |
| | Communality | 49.18 | 2.68 | 43.89 | 54.48 |
| | Development | 49.05 | 2.66 | 43.8 | 54.31 |
| | Nature | 51.46 | 2.86 | 45.8 | 57.12 |
| | Health | 50.9 | 2.7 | 45.56 | 56.24 |
| Loss | Competence | 37.65 | 2.64 | 32.43 | 42.86 |
| | Communality | 36.4 | 2.62 | 31.22 | 41.58 |
| | Development | 37.28 | 2.56 | 32.15 | 42.42 |
| | Nature | 52.25 | 2.8 | 46.72 | 57.79 |
| | Health | 48.43 | 2.64 | 43.2 | 53.65 |

The high proportion of political liberals in our sample is unlikely to have affected results. We re-ran analyses assigning weights to chains to model a balanced sample with equal proportions of liberals, moderates, and conservatives. Weights were calculated for each possible combination of liberals, moderates and conservatives by dividing the ideal balanced proportion for that combination by the actual proportion in our dataset.[3] All reported effects remained significant at the same level and in the same direction. Second, adding political affiliation as a covariate (coded as two dummy variables representing liberal and moderate affiliation respectively) in a 3 (message framing condition) × 3 (chain position) split-plot ANCOVA predicting statement survival (collapsed across domains) showed that political affiliation did not significantly predict statement survival, or meaningfully change any effects.

## 5 Discussion

The present study examined which climate change messages were more likely to spread throughout simulated online social networks via interpersonal communication. Results showed that statements concerned with the impact of climate change over nature and health were more likely to survive when passed through three-person communication chains than statements concerned with societal competence, communality or development. This finding was largely explained by the greater conventionality of the nature and health statements. We also found that gain-framed statements survived more than loss-framed statements in the first position of communication chains, but that loss-framed statements survived more than gain-framed statements later in communication chains.

The finding that conventionality influenced the content passed on through chains is consistent with past interpersonal communication research. Serial reproduction generally produces a gradual conventionalization of messages, with messages perceived as widely endorsed passed on and less conventional messages omitted (e.g., Bangerter 2000; Bartlett 1932; Kashima 2000). Climate change is primarily perceived as an environmental issue (Leiserowitz 2005), and concerns about the health effects of air pollution (a central focus of our health statements) are common (Bickerstaff and Walker 2001). Thus, when people talk to each other about climate change, these may be the most accessible

[3] This is a common procedure used to stratify survey samples while holding sample sizes constant (Geraci et al. 2012).

and preferred topics. By contrast, messages about the impacts of climate change or potential benefits of its mitigation over societal competence, communality and development may not diffuse as widely due to their relative unconventionality.

This suggests that demonstrated advantages of less conventional climate messages among their initial recipients may be attenuated by a lower likelihood of such messages being shared through social networks. Here, we have demonstrated this in relation to society-focused messages, which Bain et al. (2012, 2015) found to be effective in producing pro-environmental attitudes. Yet this process may also operate in relation to other kinds of climate change communication, such as messages tailored towards system-justifying individuals (Feygina et al. 2010), messages highlighting local rather than global impacts of climate change (Scannell and Gifford 2013), or messages employing motivational rather than sacrifice framing (Gifford and Comeau 2011). Future research could examine the way in which each of these kinds of communication strategies is affected by conventionalization and other interpersonal communication processes.

Surprisingly, while initial recipients preferentially passed on gain-framed climate change communications, loss-framed messages were favored in later stages of reproduction. Past climate communication research has shown gain-framed messages produce relatively greater pro-environmental intentions than loss-framed messages (Spence and Pidgeon 2010; Bain et al. 2012). However, if gain-framed messages struggle to be re-shared beyond a single individual, this may limit their ability to diffuse widely throughout society, and thus reduce their advantage over loss-framed communication.

The interaction between chain position and message framing was not due to conventionality as measured by perceived public *agreement* with given statements. However, this effect may be explainable in terms of the general public's *shared knowledge*. Evidence suggests that people are exposed to more climate change information framed in terms of negative consequences than in terms of positive co-benefits (Hulme 2008). Therefore, while most people may have loss-framed climate change knowledge or 'schema' in their memory already, gain-framed information is relatively novel, and inconsistent with the schema. According to the 'Schema Pointer Plus Tag' model (Graesser, 1981), schema-inconsistent (SI) information is likely to be processed more deeply than schema-consistent (SC) information in order to facilitate understanding, encoding, and storing in memory. This results in a 'memory tag' being created for SI information, whereas the fact that SC information has been processed is coded as a 'pointer' to the schema. According to the model, a tag (SI information) is more easily accessed than a pointer (SC information), but more easily decays than the schema. Thus, participants who received gain-framed SI information in the first chain position may have been more likely to reproduce this information than those who received loss-framed SC information.

However, people may experience more difficulty expressing and putting into words SI information than SC information. This is because they are less likely to possess accessible phrases and ways of talking about SI than SC information. SI information is therefore more likely than SC information to be degraded when communicated. Recipients of the communication are likely to find the processing of SI information more difficult than SC information, and will be able to identify loss-framed information more easily in degraded communications. Thus, in both communication and cognition, SI information is lost at a greater rate than SC information. So even though gain-framed information may initially be reproduced more than loss-framed information, this may be reversed later in the communication chain. Kashima (2000) reported an analogous finding and explained it in similar terms. It would be useful to gain further insights into this process.

To our knowledge, this study was the first to use the serial reproduction methodology in simulated online interpersonal communication. Identifying conventionalization effects in this context adds to the evidence that interpersonal dynamics carry over from offline to online interactions (e.g., Postmes et al. 2001). However, we have barely scratched the surface of online interpersonal interactions, and our reliance on a simulated communication context is a definite limitation. With the increasing importance of social networking sites (e.g. Tang and Lee 2013), it will be important for future work to further explore how online and offline behaviors converge and diverge. Moreover, while the dynamics of simulated communication appear to mirror real-world interactions (Clark and Kashima, 2007; Kashima et al. 2013a), it will also be important to analyze genuine online social network interactions. For example, research could investigate patterns of information sharing on Facebook and Twitter in real time by tracking responses to public climate change messages, or tracking the frequency with which climate-related tweets are re-shared.

It should be noted that data for the first, second, and third chain positions were collected in discrete time periods; hence differences between chain positions may have been influenced by time-related factors. However, since there was no more than 13 days between each period of data collection, and timing was evenly distributed across conditions, we do not expect this would significantly impact

results.

In sum, the results suggest that interpersonal communication processes influence the diffusion of information about climate change via social networking websites like Facebook. Additionally, although past research has identified that less conventional society-focused and gain-framed climate change messages lead to greater pro-environmental intentions among individuals (Bain et al. 2012), these messages may struggle to diffuse through social networks relative to more conventional topics. For such messages to motivate climate change action across broader society, the mechanisms or conditions that facilitate the spread of nonconventional messages need to be identified in future research. In broad agreement with Bain et al. (2012, 2015), motivating public action on climate change can benefit by drawing on a broader range of messages, such as how addressing climate change has positive benefits for society. However, these positive effects may only be fully realized if there is a concerted effort from climate change communicators to emphasize and conventionalize these aspects of the issue.

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