



Making sense of information in noisy networks: Human communication, gossip, and distortion

Mark E. Laidre^{a,b,*}, Alex Lamb^c, Susanne Shultz^{d,f}, Megan Olsen^e

^a Department of Integrative Biology, University of California, Berkeley, CA 94720-3140, USA

^b Department of Ecology and Evolutionary Biology, Princeton University, Princeton, NJ 08544, USA

^c The Institute, 2133 Derby Street, Berkeley, CA 94720-3140, USA

^d Institute of Cognitive and Evolutionary Anthropology, University of Oxford, Oxford, UK

^e Department of Computer Science, Loyola University Maryland, Baltimore, MD 21210, USA

^f Faculty of life Sciences, University of Manchester, M13 9PT, UK

HIGHLIGHTS

- We model how to make sense of information in networks with noise.
- We find simple decision rules can be highly effective at sorting through distortion.
- These rules compared and contrasted information from multiple sources.
- Fitness increased with more independent sources of information.
- Fitness remained high even if the population was composed entirely of distorters.

ARTICLE INFO

Article history:

Received 11 February 2012

Received in revised form

15 June 2012

Accepted 11 September 2012

Available online 19 September 2012

Keywords:

Communication networks

Information transmission

Gossip signaling

Evolution

Decision making

ABSTRACT

Information from others can be unreliable. Humans nevertheless act on such information, including gossip, to make various social calculations, thus raising the question of whether individuals can sort through social information to identify what is, in fact, true. Inspired by empirical literature on people's decision-making when considering gossip, we built an agent-based simulation model to examine how well simple decision rules could make sense of information as it propagated through a network. Our simulations revealed that a minimalistic decision-rule 'Bit-wise mode' – which compared information from multiple sources and then sought a consensus majority for each component bit within the message – was consistently the most successful at converging upon the truth. This decision rule attained high relative fitness even in maximally noisy networks, composed entirely of nodes that distorted the message. The rule was also superior to other decision rules regardless of its frequency in the population. Simulations carried out with variable agent memory constraints, different numbers of observers who initiated information propagation, and a variety of network types suggested that the single most important factor in making sense of information was the number of independent sources that agents could consult. Broadly, our model suggests that despite the distortion information is subject to in the real world, it is nevertheless possible to make sense of it based on simple Darwinian computations that integrate multiple sources.

© 2012 Elsevier Ltd. All rights reserved.

1. Introduction

Information provided by others through communication can be a valuable currency, enabling organisms to adaptively cope with an uncertain and ever-changing world (Donaldson-Matasci et al., 2010). While many species have evolved the capacity to

* Corresponding author at: Department of Integrative Biology, University of California, Berkeley 1005 Valley Life Sciences Bldg no. 3140, Berkeley, CA 94720-3140, USA. Fax: +1 510 643 6264.

E-mail address: mlaidre@berkeley.edu (M.E. Laidre).

communicate information about features of their external physical and social world (Cheney and Seyfarth, 1990; Searcy and Nowicki, 2005; Janik et al., 2006; Bradbury and Vehrencamp, 2011), the human species, in particular, outstrips all others in the scope and magnitude of its communication, embodied by language (Deacon, 1997; Radick, 2007; Fitch, 2010). Humans, moreover, both in traditional hunter-gather societies (Apicella et al., 2012) and in modern industrialized societies (Jackson, 2010), form complex networks (Goyal, 2009) in which vast quantities of information are exchanged among highly connected communicators (Easley and Kleinberg, 2010). Notably, such

networks can be noisy (Blume, 2003), with individual nodes altering and distorting information within the network as they send it onwards to other nodes, resulting in the propagation of misinformation. This raises an important question about the consequences of information distortion. Answers to this question hinge, ultimately, on the function of our species' communication.

Several overarching functions of human communication have been posited, especially in network contexts, including cultural learning (Baumeister et al., 2004; De Backer and Gurven, 2006), social bonding (Dunbar, 1996, 2004), and the enforcement of norms (Wilson et al., 2000; Kniffin and Wilson, 2005). Perhaps most fundamentally though, our species' communication can provide recipients with information about the surrounding state-of-the-world, especially information about other members of the network who listeners may interact with sometime in the future (Craik, 2009). For instance, a speaker *A* can convey to a listener *B* information about the behavior of a third-party *C* behind *C*'s back, effectively gossiping (Sommerfeld et al., 2007). Such information can then strongly influence how listeners perceive others (Anderson et al., 2011) and ultimately how they behave toward the gossiped-about third party. In experimental cooperation games, for example, individuals were significantly more likely to cooperate with those who had been talked about in positive ways, and significantly less likely to cooperate with those who had been talked about in negative ways (Sommerfeld et al., 2007). An important ultimate function of human communication therefore seems to be enabling cooperators to more readily identify and pair with other cooperators, and for defectors to be more effectively discriminated against (Enquist and Leimar, 1993; Nakamaru and Kawata, 2004). As such, information provided through communication likely played a key role in facilitating the high levels of cooperation among non-kin that characterize human societies (Axelrod, 1984; Nowak, 2006a,b; Sommerfeld et al., 2008; Tomasello, 2009).

A problem lurks, however. The powerful sway that information such as gossip can exert in stabilizing cooperation can just as swiftly be unraveled. Information is susceptible to distortion, with speakers withholding, exaggerating, and, either through mistakes or lies, misrepresenting the state of the world or the behavior of the third parties they gossip about (McAndrew and Milenkovic, 2002; Hess and Hagen, 2006; Trivers, 2011). Indeed, the same linguistic mechanisms that support our species' capacity to communicate so exquisitely can also enable us to distort at a level that outstrips all other animal communication systems (Lachmann et al., 2001; Lachmann and Bergstrom, 2004; Ekman, 2009; Laidre, 2009; Trivers, 2011). How then can the problem of information distortion be countered, so that communication's positive functions (e.g., facilitating cooperation) remain intact?

Empirical studies have provided a partial answer to this question, revealing that humans use certain heuristics to sort true from untrue information, especially true vs. untrue gossip (Hess and Hagen, 2006; Sommerfeld et al., 2008; Collins et al., 2011). For instance, by comparing and contrasting information from multiple independent sources, listeners can potentially increase their confidence that specific statements are in fact valid. But while certain heuristics might appear intuitively more effective, it remains unclear how well different heuristics actually operate as decision-making rules for assessing information. It is also unclear to what extent cognitive constraints, like memory limitations for remembering information, might alter the effectiveness of decision rules. And, at a broader level, it is unclear whether any decision rules could remain optimal under the diverse range of social and ecological configurations that can characterize human social networks. Addressing these questions with a purely empirical approach would be prohibitively difficult given the large number of relevant variables, the wide range of

parameter space that would need exploring, and the difficulty of collecting data on a topic, like gossip, which can have potent personal significance.

In this paper, we therefore took a theoretical approach to the problem of information assessment. We employed agent-based simulation models to determine what factors enable individuals to make sense of information from others and ultimately converge upon the truth. Simulations have been useful in examining other aspects of human social information, such as how information from others impacts social-learning opportunities (De Backer and Gurven, 2006), how gossip and rumors spread (Nakamaru and Kawata, 2004; see also Zanette, 2002, for an analytic treatment), and how shared information strengthens vs. weakens relationships (Shaw et al., 2011). Here we use simulations of a network of information-propagating agents to examine the success of different decision rules for assessing the veracity of information. In particular, we focus on rules inspired by empirical studies of human gossip, which have suggested that individuals integrate information from multiple sources to distinguish true from false messages and thereby decide what to believe (Hess and Hagen, 2006; Sommerfeld et al., 2008; Collins et al., 2011). It has been argued that this way of making decisions is a hard-wired and potentially universal element of human cognition in the domain of information and gossip assessment (Hess and Hagen, 2006). Here, we investigate the fitness of such decision rules, comparing them to one another and also examining their performance in relation to different population-level variables and network configurations. By systematically varying several key parameters in our model we are able to isolate the conditions in which agents are able to make sense of information despite distortion and other limitations.

2. Methods

2.1. General framework of model

We built an agent-based simulation model to investigate the effectiveness of different decision rules for assessing information. Our model, written in the Java programming language, was designed to provide a computational framework for assessing information under a variety of conditions. The steps in the model involved constructing networks (Section 2.1.1), forming messages (Section 2.1.2), propagating these messages through the network (Section 2.1.3), allowing some agents to distort the messages (Section 2.1.4), letting agents choose which messages to believe based on different decision rules (Section 2.1.5), and then translating the agents' decisions into fitness (Section 2.1.6). Following a description of each of these model steps (see Table 1 for an overview of important terminology and definitions), we outline the key questions the model was designed to investigate. Exact algorithms for all components of the model as well as the entire source code are available upon request.

2.1.1. Network construction

The simulations involved 150 total agents—a population size approximating that in which human communication and information assessment is thought to have operated for most of our species' evolutionary history (Dunbar, 1996). The 150 agents were bonded together in a network, with nodes representing agents and the connections between nodes representing pathways over which information could travel (Fig. 1). Simulations were carried out on several types of networks (random, small-world, scale-free), each generated by established algorithms (Watts and Strogatz, 1998; May, 2006; Newman, 2010). At the start of any

Download English Version:

<https://daneshyari.com/en/article/6370911>

Download Persian Version:

<https://daneshyari.com/article/6370911>

[Daneshyari.com](https://daneshyari.com)