Modeling Information Processing within Social Networks: Understanding the Persistence of Contrarian Health Beliefs

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This simulation study developed an agent-based model to examine the persistence of contrarian health beliefs that diverge from science-based positions, even when these science-based positions have been endorsed by "neutral" or authoritative sources such as governmental agencies and professional organizations. The model simulates an information environment in which identity group sources disseminate opinions that conflict with information disseminated by neutral sources. Whether an agent receives and accepts a message will depend on their trust in the source, which is a function of group identity, and the extent to which messages received from other, more trusted sources are in conflict (Zaller, 1992). The model was applied to consider the dissemination of information and beliefs about oral health care in low-income, Chinese American communities in New York City (NYC), in order to inform a pilot study offering community outreach services (Northridge et al., 2018). Major findings from this simulation study are described in a forthcoming chapter available upon request (Metcalf et al., in press).

Social networks play an intermediary role in the dissemination of information and thereby indirectly shape belief formation, since trust increases the likelihood that a person relies on a particular source (Huckfeldt and Sprague, 1987; Krueger et al., 2017). Trust is often grounded in group identity, where people are more likely to receive information and accept beliefs disseminated by sources aligned with their identity group(s) than from sources aligned with groups that are in conflict with their identity group(s). Group attachment essentially acts as an information filter such that the beliefs of group members are shaped by an "accepted" information environment that is biased toward the beliefs of sources aligned with the person's identity group(s). The impact of trust has been found to increase with the number and variety of identity groups, the average density and closeness of social links within identity groups, and the level of grievance between identity groups (Fearon and Laitin, 1996; Habyarimana et al., 2007).

Health care would seem to be a context in which people would value objective information, especially information that is validated scientifically, yet there are situations where health care beliefs that conflict with science-based knowledge persist over time. For example, anti-vaccination beliefs have not only persisted in the face of governmental efforts to counter them, but have reached the point where the World Health Organization recently included this movement on the list of the top 10 threats to global health. While anti-vaccination beliefs are not obviously associated with any demographic group, the

persistence of such beliefs raises questions about how the transmission of information shapes belief formation even when the consequences of inaccurate beliefs are potentially lethal.

We posit that subjective biases are more likely to emerge in health care contexts involving issues that are not immediately life-threatening, and where it is more difficult to objectively assess the relative effectiveness of alternative treatments. In our model, the value of truthfulness is inversely related to the impact of group identity on a person's likelihood of accepting information from a neutral source relative to that from a source aligned with their identity group. Experimenting with the importance of group identity in the model enables consideration of differences across contexts in terms of the relative value of information validated by a neutral source such as a scientific authority.

Should we expect group differences in health care information to persist over time? If different groups are simply provided with different information, we should expect this information asymmetry to dissipate over time, unless there are structural barriers. Hence, we should only expect group differences in information to persist if: 1) information search costs are high; 2) the value of the information is at least somewhat subjective; or 3) group membership influences the transmission of information. Any one of these conditions would be a disincentive for members of disadvantaged groups to obtain more valuable information.

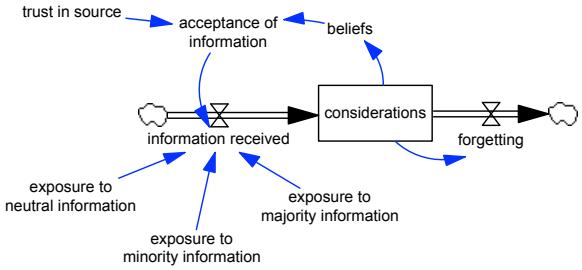
Members of certain immigrant and ethnic groups, such as Chinese Americans, may experience barriers to health care attributable to language difficulties and concerns over citizenship status. While neighborhood racial and ethnic composition accounts for a large portion of disparities in health care access (beyond insurance coverage and other institutional factors), many other differences among racial and ethnic groups remain unexplained (Kirby et al., 2006). Some of the unexplained group differences may be due to information asymmetries that arise due to subjective biases in how people process information and form beliefs about health care options. For example, Chinese Americans might hold shared beliefs about dental and medical care that influence their propensity to seek preventive care prior to experiencing acute oral pain or discomfort. These shared beliefs may stem in part from cultural influences that emphasize homeopathic and alternative medicines and treatments.

To the extent that ethnicity is a form of group identity that conditions a typical person's likelihood of accepting health care information, our model has the potential to provide insight into how information asymmetries can persist for members of ethnic minority groups. Therefore, it is informative to simulate the model for the urban context of NYC in which large populations of minority groups reside. Accounting for 7% of the overall NYC population, Chinese Americans constitute a substantial minority population in NYC. The highest concentrations of Chinese Americans are found in Queens (10%) and Brooklyn (8%), at levels that are higher than in Manhattan (7%), the borough where the historic Chinatown neighborhood is located.

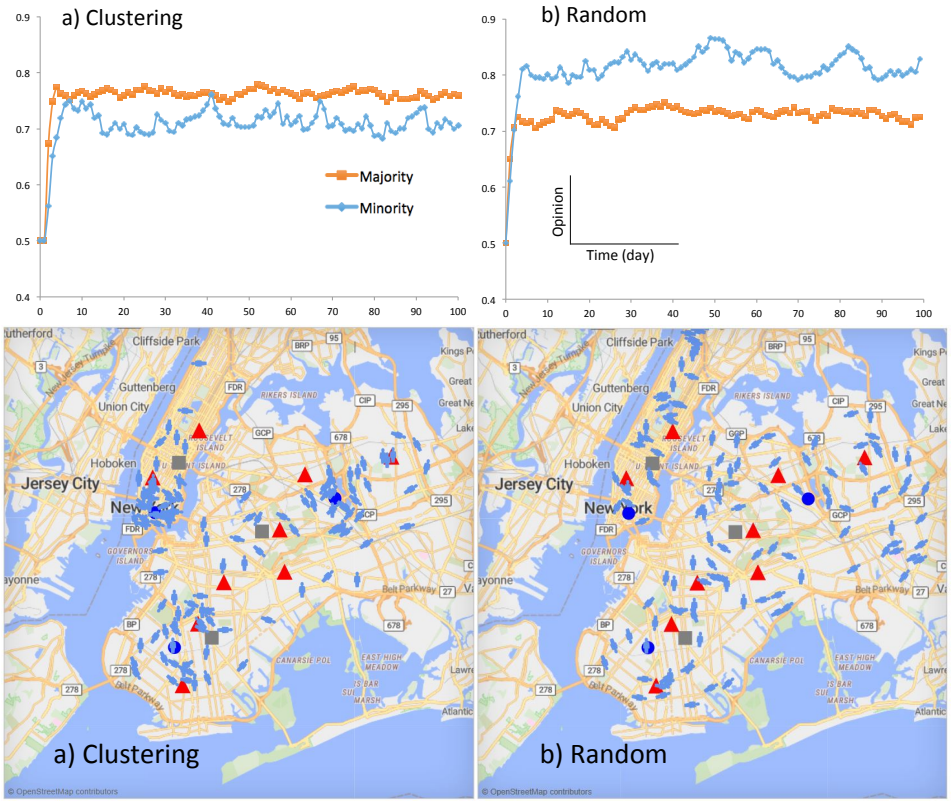
The model developed in this study focuses on the role of group identity as a mediating factor in belief formation. This model restricts the impact of group identity to influencing: 1) the likelihood that a person accepts information received from a source; and 2) the geographic distribution of households for the minority group. In the model, two types of agent classes were created: *Person* and *Source*. A Person agent is a community member who belongs to a minority or majority ethnic identity group. A Source agent is one of 3 types - *minority*, *majority*, or *neutral*. Each agent's health opinion, or belief, is represented as a value ranging from 0 to 1.

The opinion positions disseminated by Source agents are fixed in time (with 1 being the majority position, 0 being the minority position, and 0.8 being the neutral position), whereas Person agent beliefs change dynamically over time as they are exposed to opinions from different sources. In the model, the probability of a person's trust in a source is a weighted function of two components: 1) group attachment, i.e., the congruence (or lack thereof) between their group identity and that of the source; and 2) confirmation bias from their current belief. During the simulation, Source agents/locations are spatially fixed, representing community centers where health information could be disseminated. People agents traverse the urban information environment in a manner determined by a distance buffer and the nearest Source's location. Person agents accept a subset of considerations received from Source agents based on their level of trust (or distrust) in the source and the strength of their *a priori* beliefs (confirmation bias).

The stock-flow diagram below represents the conceptual framework for each agent's considerations in memory, which would need to be arrayed by type to separate considerations of the majority position, considerations of the minority position, and considerations of the neutral position.



Simulation experiments were devised that investigated the impacts of group identity, group size, and geographic constraints on information exposure. The experimental results point to particular parameter settings that facilitate the emergence of oscillatory minority opinion cycles and a sensitivity to the prevalence of the minority group in the broader population. Variations in the probability of acceptance of opinions from conflicting identity sources reveal both convergent and divergent outcomes for minority and majority groups across a range of scenarios. Highlighting findings from one of the acceptance scenarios, the figure below compares the behavior of average minority and majority opinion over time associated with clustering (panel a) versus random (panel b) placement of simulated minority group members (blue figures) relative to minority sources (blue circles) on an urban information landscape also comprised of majority sources (red triangles) and neutral sources (gray squares).



Interested readers should note that the model may be simulated online or explored directly using AnyLogic software to open the *.alp file in the Supplementary Material for this conference paper.

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