Social Boundaries and Networks in the Diffusion of Innovations: a Short Introduction

Valentine Roux¹ · Gianluca Manzo²

Published online: 13 September 2018

© Springer Science+Business Media, LLC, part of Springer Nature 2018

Abstract

This short introduction briefly recalls how sociological theories and formal methods for social networks can help to interpret diffusion processes of ancient cultural traits. It also provides a presentation of the selected papers. These papers focus not on the ways archaeological data can be represented in a relational format, but on the potential of specific sociological network-related models to gain insights into the underlying mechanisms of diffusion processes. The necessity to develop more fine-grained information to reconstruct ancient local social networks is underlined while three aspects of the diffusion process are explored: (a) situations in which cultural practices are not borrowed in spite of contact between groups; (b) situations in which cultural practices are adopted; and (c) situations in which cultural practices in one group are copied by people from another group. All of them take inspiration from sociological studies of diffusion processes through networks, although to different extents.

Keywords Diffusion of ancient cultural traits · Sociological theories · Formal methods · Social networks · Data models

The papers in this special issue illustrate how sociological theories and formal methods for social networks can help to interpret diffusion processes of ancient cultural traits. In contrast to the special issue on networks in archaeology published by JAMT in 2015 (see Collar *et al.* 2015), the focus of our selection of papers is not on the ways archaeological data can be represented in a relational format, but on the potential of specific sociological network-related models to gain insights into the underlying mechanisms of diffusion processes, thus ultimately leading to the production of

✉ Valentine Roux
valentine.roux@cnrs.fr

Gianluca Manzo
gianluca.manzo@cnrs.fr

¹ CNRS, PreTech, Nanterre, France

² CNRS, GEMASS, Paris, France

contextualized regularities. By this, we mean mechanisms (*i.e.*, recurrent combination of social constraints, actions, and interactions) that explain why macroscopic regularities obtain only in certain social network contexts (*e.g.*, why diffusion through strong or weak ties¹ occurs only in certain relational structure contexts). Once explained and if ancient social networks are comparable, these regularities can be used by archaeologists to interpret diffusion processes.

To explain how contextualized regularities can help archaeological inquiry, let us first recall that interpretation of archaeological data entails reasoning by analogy in order to give meanings to otherwise undecipherable patterns (Gardin 1980; Wylie 1985; Wylie 2002; Gallay 2011). The analysis of dynamic processes such as diffusion is not an exception to this difficulty. Indeed, while archaeological data may allow us to describe processes of change in terms of transmission (*i.e.*, ethnogenesis versus phylogenesis) (*e.g.*, Collard and Tehrani 2005; O'Brien and Lyman 2000), they usually do not enable us empirically to trace the conditions required for the diffusion of cultural traits. For this, one would need empirical information at different levels of analysis, including at the actor level, which cannot be obtained for the distant past. That is why the study of the conditions required for the diffusion of cultural traits and new social practices are best understood by examining present-day diffusion processes.

This is a field of investigation of special interest for sociologists. A longstanding research tradition has indeed focused on the impact of relational structures of societies, namely, social networks, on how information is transmitted and diffused (for an overview, see Valente 1999). Over the years, sociologists have progressively moved from describing empirical network structures—with the aim to identify network-level properties correlating with fast diffusion (Granovetter 1973, 1983)—to modeling diffusion processes within artificial populations through computer simulations. The aim is to identify how network features, individual behaviors, and the content of what is being transmitted create more or less favorable conditions for the diffusion of cultural traits or new social practices (*e.g.*, Flache and Macy 2011; Centola 2015).

This is part of a more general analytical turn in sociological inquiry (for an overview, see Manzo 2010) in which more and more sociologists now design formal models relating individual actions (micro-level), the social network structure (meso-level), and the sociological regularities (macro-social generalizations) emerging from this dynamic interplay between actions and interactions (see Manzo 2007). Within some variants of analytical sociology, a specific class of formal models, namely, agent-based computational models, are regarded as an especially powerful way to design such multi-scalar, dynamic artificial societies (see Manzo 2014). The aim of this method is to recreate macroscopic regularities from the bottom-up, drawing attention to the fact that the relation between individual actions and large-scale dynamics is likely to be non-linear. The type of interactions in which individual actions are embedded may contain potentially mediating mechanisms that in fact explain how some individual actions generate certain macro-social regularities. Agent-based computer simulations allow the researcher to control and manipulate the supposedly explanatory mechanisms, thus

¹ Ties can be strong or weak. In analytical sociology, “strong ties describe frequently activated relationships (such as family/kin ties) whereas weak ties are used to describe infrequently accessed connections (acquaintances)” (Collar *et al.* 2015, p. 23).

helping to explain why certain social structures are favorable contexts for diffusion or non-diffusion of certain traits. In this sense, this method has the potential to highlight contextualized regularities that can be exploited in archaeology to understand diffusion processes (for a review of the use of agent-based model results in archaeology, see Cegielski and Rogers 2016).

The interpretative reasoning based on analogy is the following: if the social network structures of ancient societies and properties of the traits are comparable to those analyzed by present-day sociological studies, then it is possible to use the sociological regularities to interpret archaeological data and propose explanations to ancient diffusion processes. In this way, one can advance understanding of why a trait has not diffused between groups close spatially, or why a trait has diffused between remote groups, or why a trait has diffused more rapidly in one case than in another, or, put differently, why certain social network structures have favored (or not favored) social influence and has led (or not led) to assimilative influence (adoption of new traits). Needless to say, this type of analogical reasoning implies a first level of interpretation concerning ancient social network structures. Until now, archaeologists have tried to capture social connections between sites at the inter-regional level (Knappett 2013). To go further, however, it is necessary to develop more fine-grained information on strong and weak ties at multiple scales, that is, to say among distant as well as spatially close sites.

Among our selected papers, Knappett addresses this challenge by considering the Bronze Age Aegean as a case study. He emphasizes that incorporating the local scale in archaeology is necessary to better understand how diffusion unfolds. The question of the proxies to measure social ties at different scales and identify both communities of practice and regional networks is discussed in light of the distinction between “data” and “theory” models. Knappett argues that more progress is still needed in order to characterize network topology. He proposes to combine “theory models with data models that employ similarity measures derived from material culture patterns.” The strength of Knappett’s paper lies in showing that theoretical models are not sufficient for understanding complex phenomena such as globalization; data-derived models are necessary for a multi-scale approach, in particular for drawing the different links between both spatially close and distant sites.

With Knappett’s methodological statement as a background, the other papers explore three aspects of the diffusion process: (a) situations in which cultural practices are not borrowed in spite of contact between groups (Flache’s paper); (b) situations in which cultural practices are adopted (Roux *et al.*’s, and Mills’s papers); and (c) situations in which cultural practices in one group are copied by people from another group (Vander Linden’s and Manzo *et al.*’s papers). All of them take inspiration from sociological studies of diffusion processes through networks, although to different extents. Some rely on formal “theory models” (like Flache and Vander Linden), others being closer to “data models” (like Roux *et al.*, and Mills), and one trying to combine the two type of models (see Manzo *et al.*).

As to *non-borrowing*, the focus is on understanding both cultural diversity and boundaries and, more precisely, how polarization may arise creating situations in which traits are not borrowed between groups. This aspect of diffusion is explored by Flache who reviews and systematizes a large class of models on social influence dynamics in social networks. The aim is to understand the conditions and processes of the

emergence of monoculture versus cultural diversity. The paper highlights the microscopic mechanisms that, in the framework of assimilative influence, can lead to the coexistence of different cultures. In particular, Flache reviews models combining homophily (a regularity according to which people more likely interact and communicate with similar others) and assimilative social influence, and models combining assimilation and differentiation. He stresses that these models demonstrate how the dynamics of cultural influence depends on social structural conditions (like spatial clustering of social networks). The analysis of these conditions through agent-based computational simulations shows that permanent assimilative social influence (micro-level) may result in cultural clustering or even polarization (macro-level), patterns that echo the emergence of technological boundaries regularly observed in archaeology and anthropology (Lemonnier 1993; Roux *et al.* 2017; Stark 1998). At the end of his paper, Flache raises the question of the tools that can generate empirically testable explanations of archaeological data. As described above, explanations of processes leading to persistent cultural diversity cannot be directly tested in archaeology because of lack of data to trace micro-macro dynamics and the possible underlying individual-level mechanisms. However, archaeologists do have data describing the long-term evolution of material culture as well as social network structures. Thus, by analogy, results from agent-based computational models reviewed by Flache can be extended to ancient social settings having formal properties similar to those represented in the “theory model” at hand.

As to *adopting*, the focus is on the conditions for triggering the initial adoption of new cultural traits, with the understanding that, as shown by several formal models reviewed by Flache, to borrow a new trait entailing benefits, it is not enough to simply be exposed to it. Initial adoption is the starting stage of a diffusion process. It involves individuals who are likely to play a major role in the way the diffusion process will unfold (on this aspect, see also Manzo *et al.* paper). Thus, although these early adopters can rarely be identified in archaeology because of the coarseness of archaeological data, it is important to understand the type of people they are and under which conditions they initially adopt. These conditions relate to both the social connections between borrowers and previous adopters (short- or long-range ties, weak or strong ties), and the qualities (skills, status) of the early adopters.

Classical sociological studies argued that new traits are preferentially borrowed between groups that are related through weak ties (Granovetter 1973; Granovetter 1983). More recent scholarship challenges the strength-of-weak-tie thesis and suggest that the “weak tie condition” is necessary but not sufficient (Centola and Macy 2007). Roux *et al.* embark on a discussion of this issue on the basis of both (present-day) ethnographic and experimental data. The first type of data, collected in three different countries, shows that weak ties are favorable conditions to the borrowing of new pottery techniques, but only when combined with high-level of potters’ expertise. Experiments conducted in northern India confirm that the potters exposed to a new technique and who borrowed it, all were expert potters. Roux *et al.* explain that expertise is a determinant factor for potters to borrow a new technique because only expert artisans are able to understand the advantages of the properties of a new technique and are therefore in a position to select it. Thus, the authors argue that it is not enough for a technique to present benefits to be selected. These benefits must first be identified by actors, which requires craft expertise. This is an important social

mechanism that may explain, other things being equal, why diffusion of techniques can follow different rhythms depending on who is exposed to the new technique and under which social conditions.

Mills also studies the complex interplay between structural conditions and individual-level skills for the initial adoption of new techniques but within a different context, namely, the effect of intermarriage (outside the local group) on household production. In particular, Mills's aim is to understand how pots and potters' movements created regional bridges and participated in the sharing of many commonalities, that is, to say the large diffusion of cultural traits across the Pueblo communities. She relies on ethno-historic examples of Hopi pottery vessels to show how movements of populations directly contributed to the evolution of ceramic styles while certain traits related to the forming techniques and vessel proportions remained resistant to change. Mill's analysis shows, however, that intermarriage interacts with individuals' skills, with exceptional potters responsible for inventions and diffusion of styles across communities, or, conversely, that individuals who had never potted simply adopted the style of their in-laws. By using the reasoning by analogy that we have previously described, Mills builds on these results as reference models to interpret the variability and evolution of pottery practices in terms of intermarriages during the late preHispanic period.

As to *copying*, the last two papers focus on the study of the impact of social networks' features on the diffusion process of new cultural traits and practices, once the new practice has reached a given community. One paper (by Vander Linden) builds on simple theoretical models studied through agent-based simulations; the other (by Manzo *et al.*) combine the analysis of present-day network data with empirically calibrated agent-based simulations.

Vander Linden focuses on a specific, but widespread, characteristic of social networks, namely, homophily. He argues that, despite its empirical relevance, this is a "force" of social interactions that is largely neglected by archaeologists. To explore how consequential homophily could be for macroscopic patterns of diffusion, Vander Linden builds on a classical simulation model of the formation of cultural clusters, *i.e.*, Axelrod's model of cultural dissemination (see Axelrod 1997). In this model, homophily is represented as a higher probability for interactions between two agents sharing similar cultural features, and adoption amounts to copying one random feature from the interaction partner (with probability proportional to the cultural similarity between the two agents). Vander Linden's analysis consists in a systematic study of Axelrod's model when homophilious interactions are coupled with factors of special archaeological relevance, in particular different forms of spatial constraints (like "mountains" and "coastlines"), geographical directionality of social interactions, dynamic modifications of cultural features and traits, and demographic phenomena (like expanding population). Vander Linden shows that all these model variants generate macroscopic patterns and dynamics that can enrich the set of explanatory hypotheses archaeologists can employ to interpret specific archaeological situations as well as the "variability of the archaeological record."

In contrast to Vander Linden, Manzo *et al.* do not focus on specific features of social interactions but on their structure. They compare two population of potters (still active in northern India and central Kenya) and attempt to explain why, in both communities, the innovation at hand (a new firing technique and a new shape, respectively) spreads

faster and more completely in one of the two religious sub-groups present in the two regions. The analysis of empirical family ties within these religious sub-groups is surprising. While, among Indian potters, the diffusion of the innovation was faster in the sub-group where family ties are more reachable (*i.e.*, many brokers exist) and locally redundant (*i.e.*, potters' relatives are potters), among Kenyan potters, the innovation spread faster and more completely within the religious sub-group equipped with the less reachable and locally redundant kinship networks. Manzo *et al.* find evidence that this difference is the result of variation in the level of involvement of the most central potters in the circulation of information within the different religious sub-groups. To increase the generalizability of the proposed mechanism, Manzo *et al.* designed a set of agent-based simulations in which network features and micro-level adoption mechanisms are dynamically intertwined. Results show that network reachability and local redundancy are necessary to reproduce the by-group diffusion curves observed in India and Kenya but, most important that these network features can indeed lead to fast or slow diffusion depending on the quality of the signal (*i.e.*, the behavior of the central potter) circulating within the network.

Overall, we believe that the selected papers support an important insight and a crucial methodological lesson. The insight is that diffusion processes arise from a complex interplay between actors' specific behaviors and the characteristics of the social networks constraining these behaviors. Social networks provide actors with opportunities, but the way these opportunities are translated into large-scale patterns depends on the concrete behaviors of actors with identifiable attributes (like social status and technical skills). As to methods, field observations of present-day specific case studies allow us to gain empirical insights concerning how this interplay works in a given social context. But formal models are necessary to abstract from this or that social setting and formulate explanatory mechanisms that can be used in a variety of times and places.

Acknowledgments The selected papers originate from a conference held in Paris on the 16th and 17th June 2016. This conference closed a research project granted by the French National Agency for Research in the context of a call on changing societies. The project lasted from 2013 to 2016. Its acronym was DIFFCERAM, standing from "Dynamics of spreading of ceramic techniques and style: actualist comparative data and agent-based modelling" (ANR-12-CULT-0001-01, Roux PI).

References

- Axelrod, R. (1997). The dissemination of culture: a model with local convergence and global polarization. *Journal of Conflict Resolution*, 41(2), 203–226.
- Cegielski, W. H., & Rogers, J. D. (2016). Rethinking the role of agent-based modeling in archaeology. *Journal of Anthropological Archaeology*, 41, 283–298.
- Centola, D. (2015). The social origins of networks and diffusion. *American Journal of Sociology*, 120(5), 1295–1338.
- Centola, D., & Macy, M. (2007). Complex contagions and the weakness of long ties. *American Journal of Sociology*, 113(3), 702–734.
- Collar, A., Coward, F., Brughmans, T., & Mills, B. J. (2015). Networks in archaeology: phenomena, abstraction, representation. *Journal of Archaeological Method and Theory*, 22(1), 1–32.
- Collard, M., & Tehrani, J. (2005). Phylogenesis versus ethnogenesis in Turkmen cultural evolution. In R. Mace, C. J. Holden, & S. J. Shennan (Eds.), *The evolution of cultural diversity: a phylogenetic approach* (p. 109–132). Walnut Creek: Left Coast Press.

- Flache, A., & Macy, M. W. (2011). Small worlds and cultural polarization. *Journal of Mathematical Sociology*, 35(1–3), 146–176.
- Gallay, A. (2011). *Pour une ethnoarchéologie théorique*. Paris: Editions Errance.
- Gardin, J.-C. (1980). *Archaeological constructs: an aspect of theoretical archaeology*. Cambridge: Cambridge University Press.
- Granovetter, M. (1983). The strength of weak ties: a network theory revisited. *Sociological Theory*, 1(1), 201–233.
- Granovetter, M. S. (1973). The strength of weak ties. *American Journal of Sociology*, 78(6), 1360–1380.
- Knappett, C. (2013). *Network analysis in archaeology: new approaches to regional interaction*. Oxford University Press.
- Lemonnier, P. (1993). *Technological choices: transformation in material cultures since the Neolithic*. London and New York: Routledge.
- Manzo, G. (2007). Variables, mechanisms, and simulations: can the three methods be synthesized? *Revue Française de Sociologie*, 48(5), 35–71 (Supplement: An Annual English Selection).
- Manzo, G. (2010). Analytical sociology and its critics. *European Journal of Sociology*, 51(1), 129–170.
- Manzo, G. (2014). Data, generative models, and mechanisms: more on the principles of analytical sociology. In G. Manzo (Ed.), *Analytical sociology: actions and networks* (p. 4–52). Chichester, UK: John Wiley & Sons.
- O'Brien, M. J., & Lyman, R. L. (2000). *Applying evolutionary archaeology: a systematic approach*. New York: Kluwer Academic/Plenum Publishers.
- Roux, V., Bril, B., Cauliez, J., Goujon, A. L., Lara, C., Saulieu de, G., & Zangato, E. (2017). Persisting technological boundaries: social interactions, cognitive correlations and polarization. *Journal of Anthropological Archaeology*, 48, 320–335.
- Stark, M. T. (Éd.). (1998). *The Archaeology of social boundaries*. Washington, WA ; London: Smithsonian Institution Press.
- Valente, T. (1999). *Network models of the diffusion of innovations* (2nd éd.). Cresskill, New Jersey: Hampton Press.
- Wylie, A. (1985). The reaction against analogy. *Advances in Archaeological Method and Theory*, 8, 63–111.
- Wylie, A. (2002). *Thinking from things: essays in the philosophy of archaeology*. Berkeley and Los Angeles, California: University of California Press.