

Research Project

Epidemiology of Representations: An Empirical Approach

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1 Introduction

TODO: Faire attention à attacher aussi un peu dans le champ de l'anthropologie culturelle, pas que psycho-cog (pas du temps perdu car utile pour l'état de l'art de la thèse) si jamais les Gutachterinnen ont l'heur d'être SHS

Recent years have seen several attempts to bring cognitive science and social science together. “Social cognition”, “cognitive economy” and “cultural evolution” are examples of such fields having recently emerged, approached from multiple viewpoints and involving a variety of disciplines. The project we put forward focuses on a subject formalised by Dan Sperber in the mid-nineties: in a series of innovative articles gathered in Sperber (1996), the author suggests a research program called *cultural epidemiology*, which aims to provide the cognitive and social sciences with a common framework to address a long-standing anthropological question: how can societies be so diverse when the people that form them are all made of the same psychological substrate? The framework Sperber suggests starts from an ontology made only of “mental representations” (those from cognitive science) and their expressions in the outer world, “public representations”. The core principle is then to characterise societies by the distribution of public representations that circulate in them, and combine knowledge from cognitive science and anthropology to explain their evolution. As Sperber argues, this naturalistic approach builds on cognitive principles while at the same time allowing anthropological questions to be rephrased in terms of epidemiology of representations. For instance: what types of representations are only weakly transformed as they are interpreted and produced anew by successive people? Those representations, spreading wider than the others, become *cultural*. Are they attractors for the interpretation-reproduction process of representations? If so, which cognitive modules are involved in the stability of such representations?

This research program provides a framework to explore the interactions between evolution and culture (as exemplified in Baumann, André, & Sperber, 2013), and has recently seen several theoretical developments with genuine mathematical models (see for instance Claidière & Sperber, 2007). A number of other works also explore these questions with empirical approaches. Artificial transmission

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chains in the laboratory, for instance, have been used extensively to study iterated language evolution, as Tamariz & Kirby (2016) review. That paradigm has also been used to study the evolution of short audio loops (MacCallum, Mauch, Burt, & Leroi, 2012), of risk perception (Moussaïd, Brighton, & Gaissmaier, 2015), and of abstract visual patterns transmitted by apes (Claidière, Smith, Kirby, & Fagot, 2014). Another approach is the meta-analysis of a large number of anthropological or historical works on a given subject to rebuild the evolution of a representation as it happened. This technique has been used by Morin (2013) in his study of how painted portraits change over the centuries, and by Miton, Claidière, & Mercier (2015) in their examination of the practice of bloodletting. A third approach crawls online content and communities in order to study the spread and propagation of representations in human networks. While earlier works were based on atomic propagation and exposure models where simple entities such as URLs and innovations were the central object (see J.-P. Cointet & Roth, 2007 for a discussion), this stream of research is increasingly modelling representations as deep objects with complexity of their own, improving on simpler virus-like models. Several works have now studied large quantities of meaningful sentences, showing that their propagation depends heavily on social context (Bakshy, Karrer, & Adamic, 2009) and semantic content (Danescu-Niculescu-Mizil, Cheng, Kleinberg, & Lee, 2012), as well as on competition between items (Weng, Flammini, Vespignani, & Menczer, 2012).

The wide array of disciplines studying these complimentary questions, and the variety of techniques used in the process testify to a major obstacle: collecting relevant data in usable amounts to analyse cultural evolution is not easy. The works cited above develop several strategies to face the problem, yet invariably leave core aspects of the question aside: transmission chains operate on extremely simple representations; recompiling historical and anthropological works uncovers trends with many explanations competing for causality; models of online content propagation overlook cognitive levels of explanation by and large. It is possible, however, to combine the advantages of these techniques into new methods that significantly expand what empirical studies can tackle. By applying the tools of psycholinguistics to the study of online communities on one side, and enabling transmission chains to benefit from widespread computing power and internet infrastructure on the other side, we are able to collect massive amounts of usable data for the empirical and quantitative study of out-of-laboratory epidemiology of representations.

2 Scientific goals

TODO: tone down

This research project, which, with the support of the DAAD, I will be able to conclude within my PhD, develops empirical approaches for the study of cultural evolution with the following two broad goals:

1. Dramatically increase the amounts of data collected in order to improve experiments' resolving power, and
2. Diversify data sources to open the study of out-of-laboratory quantitative questions on cultural evolution.

We accomplish this by bringing data mining and psycholinguistics together through the possibilities of modern browsers and computing platforms. A first approach builds on the vast amounts of digital traces available online: by applying data mining techniques to filter and extract relevant information from large data sets, it becomes possible to ask quantitative cognitive-cultural questions to traces of activity from everyday lives. Our second approach connects fields the other way around: by using the potential and ubiquity of modern browsers, we lift a number of constraints on cognitive science and cultural evolution experiments in the laboratory. In particular, we develop transmission chain experiments as real-time web applications in the browser. This lets us work on ecological content with a much shorter transmission cycle and a diversified and easily scalable subject pool, while still

keeping full control over the complexity of cognitive tasks implemented. Alongside this empirical work, we review the main critiques of the *epidemiology of representations* program, both from social anthropology and non-classical streams of cognitive science, which frame the questions of cultural evolution differently and pinpoint debated assumptions in need of further work.

Upon completion, this project will have shown a path to analyse the evolution of real linguistic content, and the links it has with overall cultural change, with a set of workable constraints compared to previous techniques. By fruitfully combining social science, psycholinguistics, and large scale modelling, we hope to broaden the field of empirical possibilities, making it easier for the various disciplines involved to address new and debated questions on the links between cognition and cultural evolution.

3 Project breakdown

3.1 Transformations of quotations in blogspace

The first stage of this project focused on the analysis of *in vivo* interpretation-reproduction process by which representations evolve.

As alluded to in the introduction, several works have explored cultural evolution in other settings, starting with the *Dual Inheritance Theory* first introduced by Boyd & Richerson (1985) and Cavalli-Sforza & Feldman (1981). More recent models now include the notion of cultural attractor (see for instance Claidière & Sperber, 2007; and Claidière, Scott-Phillips, & Sperber, 2014). Empirical techniques include transmission chain experiments, the use of which is discussed by Mesoudi & Whiten (2008) and Tamariz & Kirby (2016) (for the case of linguistic evolution), and compilations of anthropological and historical works such as those made by Morin (2013) and Miton et al. (2015). To our knowledge however, the evolution of linguistic content out of the laboratory – which constitutes an important milestone in the empirical testing of epidemiology of representations – has not yet been studied.

We decided to study the following specific case in order to keep our analysis manageable: quotations on blogs and media websites. These short linguistic utterances additionally had a number of advantages:

- While quotations should normally not suffer any transformation when copied from website to website, actual observation shows that they do change regularly: they are sometimes cropped, but are also transformed by replacement, deletion, or insertion of words, or even by more substantial grammatical changes. This phenomenon is standard and well known in the oral case (Potter & Lombardi, 1990), and Simmons, Adamic, & Adar (2011) have shown that it is also common in blogspace (see Lauf, Valette, & Khouas, 2013 for a typology of the most frequently observed transformations).
- Quotations are usually quite short, and thus well suited to Natural Language Processing techniques, as opposed to more elaborate types of representations one could consider analysing.
- A reference data set, gathering a very large amount of online quotations from a million sources over nine months, has been made available by Leskovec, Backstrom, & Kleinberg (2009) – a unique situation compared, again, to other representations one could study.

Given that quotations in blogspace are gradually transformed, when copied from website to website, through exactly the kind of cognitive bias suggested by Sperber as a mechanism for epidemiology of representations, we investigated to what point the theory accounts for transformation patterns observed in the data collected by Leskovec et al. (2009). In particular, we tested if cultural attractors

appear in the dynamics of online quotations, and examined the role of cognitive biases in their emergence.

The research developed to answer these questions is presented in the article “The semantic drift of quotations in blogspace: a case study in short-term cultural evolution”, submitted to the journal *Cognitive Science*.¹ It consisted in applying psycholinguistic knowledge (in particular the effects of known word features on recall, for instance Yonelinas, 2002; and Zevin & Seidenberg, 2002) in a *data mining* approach as is commonly used in the study of online communities (for instance J. P. Cointet & Roth, 2009; Danescu-Niculescu-Mizil et al., 2012; and Gruhl, Guha, Liben-Nowell, & Tomkins, 2004), to analyse word substitutions in the MemeTracker data set collected by Leskovec et al. (2009). Using this technique we show that the way online authors replace words is heavily biased, consistent with known effects in psycholinguistics, and compatible with the existence of cultural attractors.

We also demonstrate it is possible to study epidemiology of representations on complex linguistic content out of the laboratory, by doing the equivalent of a large scale psycholinguistics experiment on data from blogspace. Finally, the manuscript discusses the cost that such a study faces in dealing with the complexity of *in vivo* data, be it through the necessary filtering techniques to remove spam or the reconstitution of missing information in the data.

3.2 The contribution of empirical works to current debates

A second goal of the project is to examine the contributions of this empirical work in the context of the debate surrounding cultural evolution.

Indeed, a number of authors in anthropology and “4E” cognitive science² discuss the very notion of cognitive representation on which epidemiology of representations is built, and criticise the boundaries it defines between biological, psychological, and cultural (see Cuffari, Di Paolo, & De Jaegher, 2014, for a critique from enactive cognitive science; see Ingold, 1997, and 1998, for a critique from social anthropology). In line with prior works in social science (Bourdieu, 1980; Giddens, 1984; Mauss, 1936) and the ecological approach to psychology developed by Bateson (1972) and Gibson (2014), they argue that cognitive representations have no meaning *per se*, and therefore cannot be at the centre of a theory of cultural evolution. Fuentes (2006), among others, instead suggests that cultural evolution is best captured together with biological evolution in an extended framework for life evolution such as Developmental Systems Theory (Oyama, Griffiths, & Gray, 2001) which can account for multiple inheritance and sensitivity to context. As Ingold (2007, p. 16) explains:

(...) developmental thinking allows us to recognize that we are not dealing with separate but parallel systems, respectively biological and cultural, but rather that the biological process of development, of the living human organism in its environment, *is* precisely the process by which cultural knowledge and skills are inculcated and embodied.

Far from being a secondary issue for the empirical work we advocate, this debate is central in attempts to formalise the relationships between representation and context, which is where the meaning of a representation emerges. In spite of this, the question has remained in anthropological circles and, to our knowledge, is not yet explicitly addressed by cognitively inspired empirical work (Ingold, 2007). A second article, submitted to *Travaux de Linguistique*,³ discusses this issue and describes how it surfaces in experiments where the representations are short sentences, such as those described in the sections preceding and following this one. We believe that bringing together criticisms from the various disciplines interested in cultural evolution, on one side, and further developing empirical

¹The second version is currently under review (the editor requested a major revision to the version initially submitted).

²Embodied, Extended, Embedded, and Enactive cognitive science.

³The initial abstract proposal has been accepted for a special issue on “Les mêmes langagiers : Propagation, figement et déformation”, the full manuscript is currently under review.

approaches, on the other side, will enable the fields involved to test any hypotheses which have not yet been examined under consensual conditions.

Our goal to complete this stage, therefore, is twofold: first, thoroughly map the debate between cultural epidemiologists and supporters of extended approaches to life evolution; second, identify the precise controversial points which the new approaches developed here open to empirical scrutiny (indeed, a sub-goal of the next stage is precisely to show how this debate is unavoidable for transmission chain experiments). This is the current focus of work, to be completed by December 2016.

3.3 Semi-controlled transmission chains: Gistr experiment

Together with the first part of the project, it leads to the final stage: controlled transmission chains of linguistic content. Because of the constraints of the data set used in the previous study (notably missing information that had to be inferred), a number of questions were left unanswered and warranted further exploration.

The second part of this project therefore focuses on an *in vitro* experiment which

ADD:

- Elements of the Gistr Whitepaper (not limited to quotations),
- Details on the first launch

Planned work

ADD: Work remaining, which will be done during the grant.

- Anti spam
- Rationalisation des sources (cf. wiki)
- Transformations de courtes phrases à une seule composante
- Transformations de phrases transformables en enlevant des composants, on transformant des composants
- Modèle de marche aléatoire
- Contrastes minimaux entre deux tâches

as Kirby, Cornish, & Smith (2008, p. 10685) have observed for artificial vocabularies, “cultural transmission (...) gives rise to adaptive systems that respond to the pressures imposed by the transmission bottleneck that exists between the producer and learner of behavior”: we aim to show how the long-term evolution observed in linguistic transmission chains depends on the constraints of the transmission step (which is part of the context of representations during transmission).

La deuxième consiste à reproduire le processus et ces effets dans une série d’expériences de chaînes de transmission pour en examiner les déterminants en situation contrôlée. Cette partie permet d’examiner les effets accumulés de la cognition sur l’évolution du contenu ainsi que les rétroactions que cette évolution génère sur le processus de transformation lui-même. Elle permet également de mettre en lumière le rôle de la tâche de reproduction dans le type d’évolution à long terme qu’on observe. Ce travail crée les conditions pour une modélisation réelle du processus dans des travaux futurs, intégrant les principes et rétroactions identifiés dans des simulations à comparer aux phénomènes réels, pour identifier ainsi le rôle des transformations dans l’évolution du paysage global.

4 Location and environment

TODO: Why CMB, with who

Bibliographie

- Bakshy, E., Karrer, B., & Adamic, L. A. (2009). Social Influence and the Diffusion of User-created Content. In *Proceedings of the 10th ACM Conference on Electronic Commerce* (pp. 325–334). New York, NY, USA: ACM. <http://doi.org/10.1145/1566374.1566421>
- Bateson, G. (1972). *Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology*. University of Chicago Press.
- Baumard, N., André, J.-B., & Sperber, D. (2013). A mutualistic approach to morality: The evolution of fairness by partner choice. *Behavioral and Brain Sciences*, 36(01), 59–78.
- Bourdieu, P. (1980). *Le sens pratique*. Paris: Editions de Minuit.
- Boyd, R., & Richerson, P. J. (1985). *Culture and the evolutionary process*. Chicago: University of Chicago Press.
- Cavalli-Sforza, L. L., & Feldman, M. W. (1981). *Cultural transmission and evolution: A quantitative approach*. Princeton, N.J.: Princeton University Press.
- Claidière, N., & Sperber, D. (2007). The role of attraction in cultural evolution. *Journal of Cognition and Culture*, 7(1), 89–111. <http://doi.org/10.1163/156853707X171829>
- Claidière, N., Scott-Phillips, T. C., & Sperber, D. (2014). How Darwinian is cultural evolution? *Philosophical Transactions of the Royal Society B: Biological Sciences*, 369(1642), 20130368. <http://doi.org/10.1098/rstb.2013.0368>
- Claidière, N., Smith, K., Kirby, S., & Fagot, J. (2014). Cultural evolution of systematically structured behaviour in a non-human primate. *Proceedings of the Royal Society of London B: Biological Sciences*, 281(1797), 20141541. <http://doi.org/10.1098/rspb.2014.1541>
- Cointet, J. P., & Roth, C. (2009). Socio-semantic Dynamics in a Blog Network. In *International Conference on Computational Science and Engineering, 2009. CSE '09* (Vol. 4, pp. 114–121). <http://doi.org/10.1109/CSE.2009.105>
- Cointet, J.-P., & Roth, C. (2007). How Realistic Should Knowledge Diffusion Models Be? *Journal of Artificial Societies and Social Simulation*, 10(3), 5. Retrieved from <http://jasss.soc.surrey.ac.uk/10/3/5.html>
- Cuffari, E. C., Di Paolo, E., & De Jaegher, H. (2014). From participatory sense-making to language: There and back again. <http://doi.org/10.1007/s11097-014-9404-9>
- Danescu-Niculescu-Mizil, C., Cheng, J., Kleinberg, J., & Lee, L. (2012). You had me at hello: How phrasing affects memorability. *ArXiv:1203.6360 [Physics]*. Retrieved from <http://arxiv.org/abs/1203.6360>
- Fuentes, A. (2006). Evolution is important but it is not simple: Defining cultural traits and incorporat-

- ing complex evolutionary theory. *Behavioral and Brain Sciences*, 29(04), 354–355.
- Gibson, J. J. (2014). *The Ecological Approach to Visual Perception: Classic Edition*. Psychology Press.
- Giddens, A. (1984). *The constitution of society: Outline of the theory of structuration*.
- Gruhl, D., Guha, R., Liben-Nowell, D., & Tomkins, A. (2004). Information Diffusion Through Blog-space. In *Proceedings of the 13th International Conference on World Wide Web* (pp. 491–501). New York, NY, USA: ACM. <http://doi.org/10.1145/988672.988739>
- Ingold, T. (1997, January). From the Transmission of Representations to the Education of Attention. Retrieved from <http://lhc.ucsd.edu/MCA/Paper/ingold/ingold1.htm>
- Ingold, T. (1998). From complementarity to obviation: On dissolving the boundaries between social and biological anthropology, archaeology and psychology. *Zeitschrift Für Ethnologie*, 123(1), 21–52. Retrieved from <http://www.jstor.org/stable/25842543>
- Ingold, T. (2007). The trouble with ‘evolutionary biology’. *Anthropology Today*, 23(2), 13–17. <http://doi.org/10.1111/j.1467-8322.2007.00497.x>
- Kirby, S., Cornish, H., & Smith, K. (2008). Cumulative cultural evolution in the laboratory: An experimental approach to the origins of structure in human language. *Proceedings of the National Academy of Sciences*, 105(31), 10681–10686. <http://doi.org/10.1073/pnas.0707835105>
- Lauf, A., Valette, M., & Khoulas, L. (2013). Analyzing Variation Patterns In Quotes Over Time. *Research in Computing Science*, 70, 223–232. Retrieved from http://www.micai.org/rscs/2013_70/Analyzing%20Variation%20Patterns%20In%20Quotes%20Over%20Time.html
- Leskovec, J., Backstrom, L., & Kleinberg, J. (2009). Meme-tracking and the Dynamics of the News Cycle. In *Proceedings of the 15th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining* (pp. 497–506). New York, NY, USA: ACM. <http://doi.org/10.1145/1557019.1557077>
- MacCallum, R. M., Mauch, M., Burt, A., & Leroi, A. M. (2012). Evolution of music by public choice. *Proceedings of the National Academy of Sciences*, 109(30), 12081–12086. <http://doi.org/10.1073/pnas.1203182109>
- Mauss, M. (1936). Les techniques du corps. *Journal de Psychologie*, 32(3-4). Retrieved from http://classiques.uqac.ca/classiques/mauss_marcel/socio_et_anthropo/6_Techniques_corps/Techniques_corps.html
- Mesoudi, A., & Whiten, A. (2008). The multiple roles of cultural transmission experiments in understanding human cultural evolution. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, 363(1509), 3489–3501. <http://doi.org/10.1098/rstb.2008.0129>
- Miton, H., Claidière, N., & Mercier, H. (2015). Universal cognitive mechanisms explain the cultural success of bloodletting. *Evolution and Human Behavior*, 36(4), 303–312. <http://doi.org/10.1016/j.evolhumbehav.2015.01.003>
- Morin, O. (2013). How portraits turned their eyes upon us: Visual preferences and demographic change in cultural evolution. *Evolution and Human Behavior*, 34(3), 222–229. <http://doi.org/10.1016/j.evolhumbehav.2013.01.004>
- Moussaïd, M., Brighton, H., & Gaissmaier, W. (2015). The amplification of risk in experimental diffusion chains. *Proceedings of the National Academy of Sciences*, 112(18), 5631–5636. <http://doi.org/10.1073/pnas.1421883112>
- Oyama, S., Griffiths, P., & Gray, R. D. (2001). *Cycles of contingency: Developmental systems and evolution*. Cambridge, Mass.: MIT Press.
- Potter, M. C., & Lombardi, L. (1990). Regeneration in the short-term recall of sentences. *Journal of*

- Memory and Language*, 29(6), 633–654. [http://doi.org/10.1016/0749-596X\(90\)90042-X](http://doi.org/10.1016/0749-596X(90)90042-X)
- Simmons, M. P., Adamic, L. A., & Adar, E. (2011). Memes Online: Extracted, Subtracted, Injected, and Recollected. In *Fifth International AAAI Conference on Weblogs and Social Media*. Retrieved from <http://www.aaai.org/ocs/index.php/ICWSM/ICWSM11/paper/view/2836>
- Sperber, D. (1996). *Explaining culture: A naturalistic approach*. Oxford, UK; Cambridge, Mass.: Blackwell.
- Tamariz, M., & Kirby, S. (2016). The cultural evolution of language. *Current Opinion in Psychology*, 8, 37–43. <http://doi.org/10.1016/j.copsyc.2015.09.003>
- Weng, L., Flammini, A., Vespignani, A., & Menczer, F. (2012). Competition among memes in a world with limited attention. *Scientific Reports*, 2. <http://doi.org/10.1038/srep00335>
- Yonelinas, A. P. (2002). The Nature of Recollection and Familiarity: A Review of 30 Years of Research. *Journal of Memory and Language*, 46(3), 441–517. <http://doi.org/10.1006/jmla.2002.2864>
- Zevin, J. D., & Seidenberg, M. S. (2002). Age of Acquisition Effects in Word Reading and Other Tasks. *Journal of Memory and Language*, 47(1), 1–29. <http://doi.org/10.1006/jmla.2001.2834>