



HAL
open science

Social and spatial interaction models

Claude Grasland, Sven Banisch, Romain Leconte, Étienne Toureille

► **To cite this version:**

Claude Grasland, Sven Banisch, Romain Leconte, Étienne Toureille. Social and spatial interaction models. European Commission - DG Research. 2018. halshs-04500863

HAL Id: halshs-04500863

<https://shs.hal.science/halshs-04500863v1>

Submitted on 12 Mar 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Work package 2 - Deliverable 2.3 & Milestone 6

Social and spatial interaction models

Milestone regarding international conflict/social and spatial models

Claude GRASLAND (UPD)*; Sven BANISCH (MPG), Romain
LECONTE (UPD), Etienne TOUREILLE (UPD)

University Paris Diderot - FR 2007 CIST

December 30, 2018

Executive Summary

Space does matter for the analysis of opinion dynamics and cultural conflicts. The concept of "cultural distance" used in dynamic models should involve not only the differences of opinions on selected features but also the more general effects of social position or spatial location of individuals. The first aim of this paper is therefore to propose a framework for the evaluation of the joined effect of social and spatial distances on the probability of interaction between individuals and their evolution through scale and time. Space is also crucial for the analysis of the agenda of social and classical media. The second aim of the paper is to demonstrate that the coverage of world news by daily newspaper remains clearly very unequal and subject to effects of size, social and spatial distance, preference for elite countries and time autocorrelation. Briefly said, newspapers are not global but provincial, which means that conflicts or topics of interest for public opinion in one place can be simply ignored in another one. The final section of the document describes how the methods used for the modelisation of international news flow could be further applied on other types of media sources used in the case studies of the Odyceus project and finally implemented as specific module in the Penelope platform.

* claude.grasland@parisgeo.cnrs.fr

Contents

1 Introduction	2
1.1 Motivation	3
1.2 Role in the project	7
2 A place for space in the modelization of opinion dynamics: a cross-disciplinary perspective on models in Odyceus	9
2.1 Cultural distance and geographical distance	10
2.2 A framework for the joint analysis of social and spatial positions	13
2.3 Analogy between Euro coins mixing process and opinion dynamics models	17
2.4 A place for (different kinds of) spaces in opinion dynamics	20
3 Work done	23
3.1 Linking media studies and spatial analysis	23
3.2 The case of international news flow of 31 daily newspapers in 2015	27
3.3 Main conclusions and interest for opinion dynamics and cultural conflicts .	30
3.4 Delivery of data sets and R program	35
4 Impact in the project	36
4.1 Introducing a debate about conceptual dimensions of opinion dynamics . .	36
4.2 Developing spatial dimension in case studies	37
5 Appendix	44

1 Introduction

This deliverable 2.3 expected at M24 (December 2018) recovers two objectives of the work plan of the ODYCCEUS project. Firstly, the achievement of the task 2.4 entitled “Social and spatial interaction models” which should design a set of models explaining the information flows between origins and destinations, by size effects, marginal constraints, spatial and social proximity, political and linguistic barriers, in order to research the spatial and social segmentation of public opinion and area of debate. Secondly, the validation of the milestone 6 entitled “Milestone regarding international conflict/social and spatial models” that is related to the establishment of links between concepts (WP1), models (WP2) and methods (WP3).

The first objective has been achieved by UPD through a publication accepted by the *International Communication Gazette* that proposes important innovations in the domain of International News Flow Theory i.e. the prediction of the amount of news published by a newspaper from country A about events happening in other countries B, C, D, E ... The publication is associated to a database of news published by 31 daily newspapers during the year 2015 and a set of R programs precisely documented for replication and further development of the innovations proposed in the paper.

The second objective was conducted by UPD in partnership with other teams (in particular MPG, but also other partners) and can be briefly summarized as a theoretical and empirical discussion about the concept of *distance* used in the modelization of conflicts and opinion dynamics. Different forms of distance (social, spatial, cultural, political, ...) are indeed used by ODYCCEUS partners with variable definitions and variable forms of modelization. We have tried in the present deliverable to identify - and possibly- bridge the gap between different options through the use of the multidimensional framework called 5W+H or 5W+2H.

1.1 Motivation

*“I keep six honest serving-men
(They taught me all I knew);
Their names are What and Why and When
And How and Where and Who.”*
Rudyard Kipling, *The Elephant’s Child*

As nicely explained Kipling, six questions are usually used for the understanding of a problem : Who ? What ? Where ? When ? Why ? and How? This six questions are also used in the school of journalism in order to define what should be immediately included in a news outlet in order to provide a full and complete description of an event and are called in abbreviated form **the 5W+H framework** (Fig. 1). Wikipedia (English) indicates that *Even though the classical origin of these questions as situated in ethics had long been lost, they have been a standard way of formulating or analyzing rhetorical questions since antiquity.* But the framework 5W+H remains still accurate in the age of digital humanities and big data. A nice example of application is provided by a paper published in 2015 entitled *The five w’s of “bullying” on twitter: who, what, why, where, and when* [3]. The authors demonstrate the possibility to extract information for each of the five dimension from twitter data and to produce large-scale empirical observations on the target phenomenon. The paper is also interesting because the authors that belong to different disciplines has successfully combined methods from computational scientists with questions formulated by experimental psychologists.

The interest of the 5W+H framework for ODYCCEUS project is based on the fact that an opinion is typically a combination of the dimensions Who and What (who says what ?) associated to a dynamic described by the dimension When (who says what when ?). But other dimensions can be introduced in the analysis, in particular the dimension Where which add a spatial perspective. We can illustrate how these different dimensions combines together with the example of the polarization of political debate around climate change (Cf.deliverables 1.2, 2.1, 2.2, and task 5.5).



Figure 1: Six (or seven) honest serving-men for Penelope ?

Who says What ?

In his State of the Union Address on 20 January 2015, US President Barack Obama said that climate change is the greatest threat to future generations, but this declaration was not accepted by all inhabitants of the US. The Global Attitude survey realized by the Pew research center in 2015 on a representative sample of the US population revealed a clear divide of opinion about climate change, correlated with the political support to Republicans or Democrats (Fig. 2).

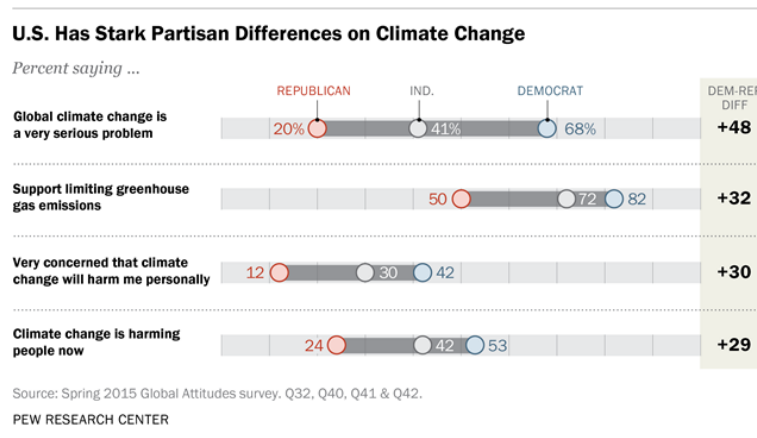


Figure 2: Americans' views about climate issues divide sharply along partisan lines (Pew research center, 2015)

But does it means that the political orientation was responsible from the opinion

expressed on climate change ? Many other social characteristic of individuals were also correlated to the answer to the same question like age, gender, religion or income. And it is not obvious, to determine easily what are the causal relations between opinion on climate change, political orientation and variables of social position (Fig. 3).

In U.S., the Lower Income, Women and Young Are More Concerned about Climate Change

Americans saying ...

	Global climate change is a very serious problem	Global climate change is harming people now	Very concerned global climate change will harm me personally
	%	%	%
TOTAL	45	41	30
Men	39	36	23
Women	51	45	36
18-29	52	49	34
30-49	49	42	37
50+	38	36	21
Below \$50,000	49	42	37
\$50,000 or above	41	40	21
Protestant	34	33	26
Catholic	50	45	39
Unaffiliated	56	49	27

Source: Spring 2015 Global Attitudes survey, Q32, Q41 & Q42.

PEW RESEARCH CENTER

Figure 3: Americans' views about climate issues depends from social positions (Pew research center, 2015)

Who-Where says What ?

Thanks to the surveys realized by the Pew research center, it is possible to compare the results observed in the US in 2015 to the answers of representative sample of inhabitants of 39 other countries located in different parts of the world (Fig. 4). The Where dimension reveals very strong international variation of the degree of concern about climate changes, somehow associated to the location in different world regions.

(Who x Where) says What ?

Crossing the two dimensions Who and Where reveals a general positive correlation between the right to left political orientation and the level of concern with climate change. But they can be exception like in the case of Poland where people who declared left-wing orientations appeared to be more skeptical than right-wings (Fig. 5).

Who-(Where x When) says What ?

Opinion dynamics implies the introduction of a time dimension that can be crossed either with Who or Where. As an example, crossing When and Where, the Figure 6) reveals contradictory tendencies with growing awareness about climate change in some countries (US, France, ...) but declining awareness in other ones (Russia, Turkey, Japan, ...).

Latin America, Africa Most Concerned about Climate Change

Percent saying global climate change is a very serious problem

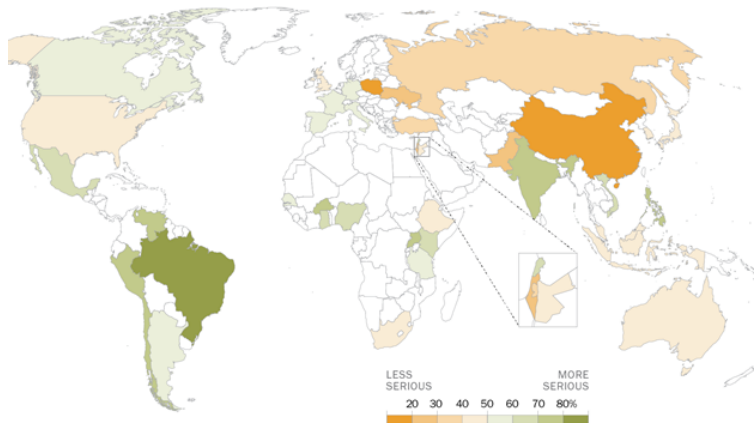


Figure 4: Latin America and Africa more concerned about climate change compare to other regions (Pew research center, 2015)

In Europe and U.S., Deep Ideological Divides on Concern about Climate Change

	Global climate change is a very serious problem				Global climate change is harming people now			
	Left	Mod	Right	Right-Left Diff	Left	Mod	Right	Right-Left Diff
	%	%	%		%	%	%	
Italy	69	59	42	-27	74	62	64	-10
France	70	55	49	-21	71	61	50	-21
UK	53	41	34	-19	59	50	44	-15
Spain	60	52	46	-14	69	63	51	-18
Germany	58	52	57	-1	73	63	59	-14
Poland	16	25	18	+2	25	23	36	+11
	Lib	Mod	Conserv	Conserv-Lib Diff	Lib	Mod	Conserv	Conserv-Lib Diff
	%	%	%		%	%	%	
U.S.	68	45	30	-38	59	37	32	-27

Note: Statistically significant differences in bold.

Source: Spring 2015 Global Attitudes survey, Q32 & Q41.

PEW RESEARCH CENTER

Figure 5: The effect of political orientation and geographical location on the opinions about climate change (Pew research center, 2015)

Some Publics Are Less Intensely Concerned than Five Years Ago

Global climate change is a very serious problem

	2010	2015	Change
	%	%	
Turkey	74	37	-37
China	41	18	-23
South Korea	68	48	-20
Japan	58	45	-13
Poland	31	19	-12
Russia	43	33	-10
Argentina	66	59	-7
Indonesia	47	41	-6
Pakistan	22	29	+7
U.S.	37	45	+8
France	46	56	+10
Nigeria	43	61	+18

Note: Only statistically significant differences are shown.

Source: Spring 2015 Global Attitudes survey, Q32.

PEW RESEARCH CENTER

Figure 6: The effect of political orientation and geographical location on the opinions about climate change (Pew research center, 2015)

1.2 Role in the project

If the 5W+H framework appears to be relevant for the analysis of opinion dynamics and cultural conflict, then the role of geographers and spatial scientists is clearly to contribute to the collective work through a specific expertise on the “When” dimension. This contribution can take three different forms that are explored in the next sections of the deliverable.

1. **Conceptualization.** The geographers and sociologist can offer an empirical and critical perspective concerning the use of the concept of “cultural distance” in the models developed by computational scientists. They can propose alternative concepts of spatial and social position likely to enrich the hypothesis used in dynamic models of polarization and conflict. This is the subject of section 2.
2. **Modelization.** Spatial and social interaction models are particularly efficient

for the prediction of international flows like trade, migration or tourism. But we demonstrate that the same models can be successfully applied to the prediction of foreign news. This is the subject of section 3.

3. **Impact.** The spatial dimension offers a specific added value to the analysis of cultural conflicts and opinion dynamics described in the case studies (WP5). Therefore, it deserves the creation of specific components in the Penelope platform. This is the subject of the final section 4.

2 A place for space in the modelization of opinion dynamics: a cross-disciplinary perspective on models in Odyceus

The aim of this section is to clarify the possible contribution of geography to the analysis and modeling of opinion dynamics and to relate the geographic approach described in this deliverable to other activities in WP2. To do so, it is important to address the question of the gap that can sometimes exist between computational explanatory approaches and the descriptive geographic ones when they try to address questions related to news circulation and opinion dynamics. Basically we can identify two important debates that can introduce a difficulty of communication between the two communities:

1. The debates of vocabulary and metaphors. At first glance the contribution of specialist from geography and more generally spatial science [21] should be a major one, considering the number of references to concepts like "distance", "mapping", "region", "zones", "barriers", "segregation" or "borders" in the literature produced by other disciplines working on models of opinion polarization or network visualization. In the majority of cases, however, the use of spatial concept is a metaphoric one with very few relation to concrete territories where social interactions take place. It is not a problem to use such metaphors when the purpose is to abstract a concept. But in other cases there is a real ambiguity when the same word is used in both abstract and geographical sense.

2. The debates of Occam's razor, the law of parsimony and explanatory versus descriptive approaches. In the majority of case, computational models are build in a deductive way with a minimum number of hypothesis. It is only when it comes to empirical implementation of models that supplementary hypothesis are added, following the famous quotation of Paul Valery: *Everything simple is false. Everything complex is unusable..* Many researchers in social sciences proceed in a more inductive way and start from empirical observation of dynamics before to formulate explanation, examine the residuals, and add new explanatory variables until the best level of explanation is reached. As noticed by L. Sanders [54] *"modeling spatial dynamics can take on several different meanings: it can consist of describing changes as clearly as possible, or of finding causality underlying the type and speed of the observed evolution. These two approaches, the former used to describe and the latter to explain, should logically complement each other and be conducted one after the other. In practice, however, the line between the two is not always clear [...]."*

To illustrate both debates, it is worth to consider firstly the case of two seminal papers using agent-based modeling. Namely, Thomas Schelling's model of spatial segregation [55, 56] from the 70ties and the model of Robert Axelrod on *The Dissemination of Culture* from 1997. They provide an illustrative example for the use of vocabulary in articles on computational models that may sometimes be confusing to the geographer. And it is also a good area for the debate around the law of parsimony, and the role of explanation and description.

2.1 Cultural distance and geographical distance

Axelrod's model is indeed based on the idea that the interactions between individuals is determined - from a probabilistic point of view - by **cultural distance**, culture being nicely defined as "attributes that social influence can influence". This cultural distance is based on a variable set of cultural features with a variable number of modalities. The probability of interaction depends on the number of common features divided by the total number of features. While the solution of the model would be trivial if every individual could interact with all others individuals as the entire system would converge to a single homogeneous culture, locating agents (or cultural units) within a geographic space leads to more interesting dynamics. The Axelrod model thus introduces a second **geographical distance** based on the spatial position of individuals on a regular grid of square cells. Interaction is possible only between contiguous cells and the central idea of the model is the fact that cultural distance (CULTDIST) and geographical distance (GEOGDIST) belongs to two independent realities:

$$prob(INTERACTION_{i,j}) = f(GEOGDIST_{i,j}).g(CULTDIST_{i,j}) \quad (1)$$

if INTERACTION is true, then modify cultural position and therefore cultural distance. But never modify geographical position.

What is subject of debate from a geographer's point of view is not the abstract form of the model nor the use of grid cells. From this point of view, Axelrod's model is very similar to the first model of spatial diffusion of innovations proposed in the early 1950's by the geographer T. Hägerstrand [27, 28, 29]. Hägerstrand proposed - without the help of any computers ... - a Monte Carlo simulation of the diffusion of innovation in farms of the county of Ashby (1929-1932) where he used a grid map of the area and combined a decreasing function of distance corresponding to an "information field" with various forms of barrier effects, related to the existence of lake or mountains reducing the opportunities of contacts between farmers. The difference between Hägerstrand's and Axelrod's model is not related to the mathematical form but rather to the role played by cultural and geographical distance. In Hägerstrand's model, the probability of interaction depends only from distance and is not modified by the adoption of innovation. In Axelrod's model, the spread of opinion create absolute barriers between zones, whatever the geographical distance between individuals.

He supports therefore the hypothesis of an "end of geography" [47], a "flat world" [19] where "distance is dead" [13] and replaced by the belonging of individuals to homogeneous cultural area. And it is certainly not by chance that Axelrod's mention Samuel Huntington's hypothesis about the so-called "Clash of Civilization" as a potential application of its model at the end of the paper [33]. In a very recent paper about *Media Attention and Public Attention Among 193 Countries*, Kwak & al. [37] has also attempt to validate Huntington's hypothesis because they used a network approach of similarity between public information in different countries where the structural effects of distance or common language was not controlled. The cluster of countries that they obtained

through a partition of the similarity network was indeed more or less similar to historical and religious divisions (fig. 7). But in our opinions, these clusters could be more simply explained by the unequal distribution of settlement associated with universal laws of spatial interaction ¹

Another point of debate for geographers is related to the fact that when interaction is successful in Axelrod's model, only cultural positions (and therefore cultural distance) are modified by the interaction but not the geographical position (and therefore the geographical distance). Individuals are assigned to a location where they can eventually change their opinion but they can never change their location. Accordingly, Axelrod's model is the exact opposite of Schelling's model [55, 56] where individuals are assigned to a permanent social position ("black" or "white", "rich" or "poor", etc.) but are likely to move to another spatial location if they are not satisfied by the social distance with their geographical neighbors. The equation behind Schelling's model is the same than with Axelrod's model, except on one point: the interaction is not bilateral with single neighbor but multilateral with all neighbors located below the threshold distance.

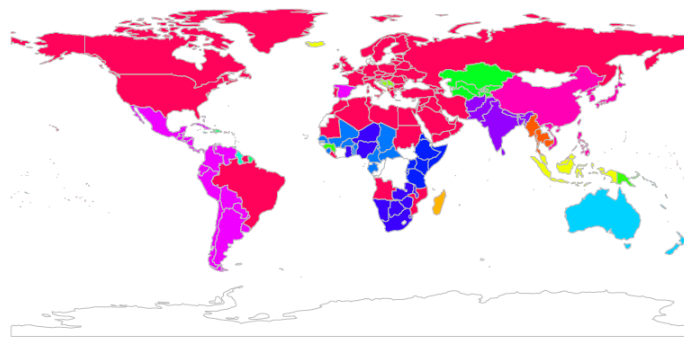
$$prob(SATISFACTION_i) = \sum_{k=1}^n f(GEOGDIST_{i,k}).g(SOCIALDIST_{i,k}) \quad (2)$$

if SATISFACTION is false, then modify geographical position and therefore geographical distance. But never modify cultural position.

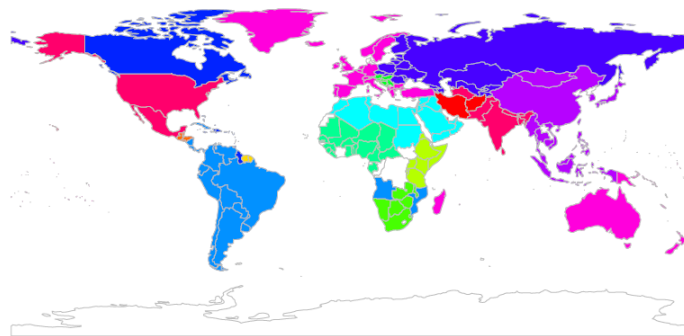
Thus, the common point of these two classical models used in the modelization of opinion dynamics is the fact that they introduce a clear separation between a cultural/social distance and the one hand, a geographical distance on the other hand. Another common point is that the effect of spatial concentration of human settlement is clearly ignored and the fact that people are living in large or small cities, central, periurban or rural areas is not at stake. By limiting the spatial process of diffusion to local proximity they exclude the scale effects that have been proven so important in the analysis of news flows. They also exclude mechanism of hierarchical diffusion of innovations through urban networks [53].

These considerations nicely illustrate how certain lines of research conducted within a certain scientific tradition may contribute to a conceptual distinction that is not easily accepted in another discipline. The quest for simple explanatory models – emphasizing certain aspects while neglecting many others – may put forth an analytical distinction that does not fit well with empirical research in Geography. On the other hand, the gravity-like models of news flow described throughout this text also work on the basis

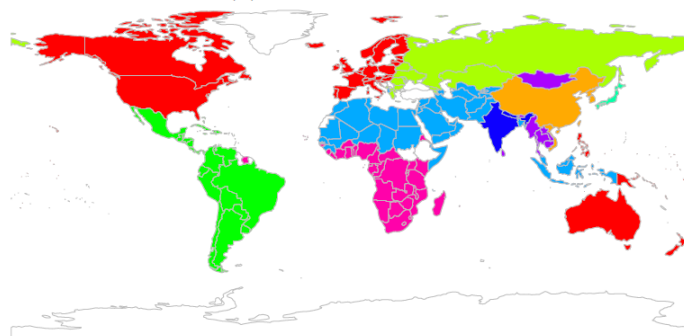
¹To demonstrate this point, it is sufficient to simulate a matrix of flows based on a gravity model and to apply the algorithm of clustering used by the authors. Because of the distribution of land, mountain, seas and desert we will observe without any doubt the emergence of significant clusters of relation in Northern America, Southern America, Northern Africa, etc. These clusters will "look like" civilizations. But, according to the law of parsimony, they can be more simply explained by population size and distance effects rather than by language, history, religion or dubious racial theories !



(a) Media Attention



(b) Public Attention



(c) Civilizations proposed by Huntington [15]

Figure 7: Community structure of international public and media attention (Kwak & al., 2018)

of such a distinction when taking cultural features such as language and spatial features such as geographic distance as independent factors in the model of estimation. In fact, they may in this form inform models of opinion or cultural dynamics about the relation of cultural versus geographic effects on the probabilities of influence.

In any case, the scale effects found in news flows indicate that topologies of interaction used in opinion dynamics models might profit from a more careful consideration of

geographic realities. Flow of information or news is certainly an important marker for potential influences on opinions and cultural practices and a model more closely tuned to specific empirical circumstances could be obtained on this empirical basis. On the other hand, especially the physics-inspired literature on opinion dynamics has seen many articles that concentrate on the effect of networks of different kind on the process of opinion exchange. Certain aspects related to concentration such as networks with skewed degree distributions have been intensively studied. It still remains an open issue to relate these network models more closely to the Geographers perspective on spatial-cultural spaces.

2.2 A framework for the joint analysis of social and spatial positions

Grasland [23] has proposed a framework for the joint analysis of social and spatial interaction that offers to some extent a solution to the issues mentioned in previous section. This framework is based on Waldo Tobler's first law of geography ("everything is related to everything but near things are more related than distant things") [72, 71] combined with Peter Blau's fundamental distinction between quantitative and qualitative parameters of social position. Blau's structural perspective [5, 6] is an extension of Durkheim's work on social integration and social morphology [17, 16] but introduces also Simmel's ideas on crosscutting circle [65, 4, 7]. Although Blau does not explicitly envisage the role of the geographical proximity of individuals as a factor of social integration, given some readjustments his theory and its central concepts are sufficiently broad to be applicable not only to the study of the impact of sociological positions but also to the study of geographical positions.

Blau's structural analysis begins by defining a multidimensional space by way of describing the social position of individuals according to a range of properties known as structural parameters. According to Blau, structural parameters belong to either one of two elementary kinds that may combine to form more complex combinations.

(1) Nominal parameters pertain to the qualitative attributes of individuals and define social categories such as ethnic group, religious affiliation, professional activity, etc. The degree of differentiation of nominal positions is a reflection of the heterogeneity defined by Blau in the simplest sense of the term as the probability that two members of a given population belong to different groups.

(2) Graduate parameters refer to quantitative attributes, i.e. continuous distributions of differences of resources and statuses such as income, education, etc. that serve to define social strata. The degree of differentiation of graduate parameters reflects inequality, defined at its most basic as the coefficient of variation (or Gini index) of differences between levels.

Applied to the study of geographical positions, Blau's distinction overlaps with the distinction made by Grasland [23] between territorial parameters and spatial parameters of location.

(3) Territorial parameters pertain to qualitative variables of the location of individuals such as their affiliation with different territorial grids, which operate an exhaustive partition of space and society. Every individual belongs to one or several territorial grid; the status of these parameters is formally equivalent to the status of the nominal

parameters defined by Blau.

(4) **Spatial parameters** refer to quantitative variables of location such as a system of coordinates including latitude (X) and longitude (Y). This two-dimensional space may be characterized by a metrics with the usual properties of mathematical distance (identity, symmetry, triangular inequality). It is similar to Blau's graduate parameter of social position because it can be used to extract a continuous measure of distance between individuals.

		MATHEMATICAL PROPERTIES		
		NOMINAL / QUALITATIVE (-> Heterogeneity)	Area of uncertainty	GRADUATE / QUANTITATIVE (-> Inequality)
SOCIETAL PROPERTIES	SOCIOLOGICAL POSITIONS (-> Social distances)	Social category <i>(ex. religion)</i>	<i>(ex. Cast, social class or professional category)</i>	Social level <i>(ex. income)</i>
	Area of uncertainty	<i>(ex. nationality)</i>	<i>(ex. ethnic Group)</i>	<i>(ex. distance from a center)</i>
	GEOGRAPHICAL POSITIONS (-> Geographical distances)	Territorial location <i>(ex. administrative units)</i>	<i>(ex. position in urban network)</i>	Spatial location <i>(ex. latitude, longitude)</i>

Figure 8: Four types of individual position in space and society (Grasland, 2009)

The fundamental hypothesis of Blau's structural theory is that positions constitute structures that have a weak determining effect on the relations forged by individuals. This weak determinism implies that the structure in question may not necessarily exert a direct pressure on individual choices (by ruling out certain relations or making others compulsory), but exerts rather an indirect pressure based on the restriction of opportunities for relations resulting from differences of position and the correlative increase of sociological or geographical 'distances' between individuals. We recognize here the same hypothesis than in Axelrod's or Schelling's model, but in a wider framework of analysis where social and geographical distances are not considered as separated part of the reality and where both qualitative, ordinal or quantitative continuous variables can be introduced.

This multidimensional space of position can then be transformed into distances between individual and opportunities of interaction derived from these distances and from the capacity of individuals to overcome distance effects that can be different according to various resources (age, income, gender, ...). Once interactions are realized between individual they are likely to modify all parameters of individual position and not only the spatial position (as in Schelling's model) or the social/cultural position (as in Axelrod's model). Agents may learn to associate themselves to certain social categories or territorial locations and differentiate into regional and cultural identities with their own

rules of interaction.

A nice example of these feed backs between political opinion and spatial or social location can be illustrated by the case of the neighborhood of Connewitz in Leipzig that ODYCEEUS members visited during the scientific conference of 2018. In the context of strong polarization between alt-right and alt-left, the neighborhood of Connewitz illustrate the process of territorialization of individuals sharing a common political opinion with the building through graffiti of a symbolic border protecting an "antifa area" against "fascists" and "cops" (fig. 9).



Figure 9: Connewitz graffiti in Leipzig: an example of symbolic spatial border (source : <https://www.instagram.com/myconnewitz/>)

But the decision for individuals to locate in Connewitz is not only related to their political options. It is also related to spatial considerations (accessibility to city center) as well as social parameters (incomes, age, occupation, ..) in a context of rapid change due to renovation and gentrification. Similar examples could be found in France with the movement of the ZAD (area to defend) illustrated by the famous case of the airport of Notre-Dame-des-Landes which produced interaction and exchange between activists engaged in a great number of political conflicts, from anti-capitalism to struggle against climate change [32]. Both examples demonstrate that social networks are not reducing the need for face to face contacts but rather contributed to reinforce them through hybrid forms of accessibility [34]

The external structure of social or spatial systems also needs to be taken into account theoretically in order to understand its dynamics. And contrary to Axelrod's or Schelling's models, it is not necessary to limit the analysis to the individual level and, more generally, to a single level of social and spatial aggregation. The interactions observed between elements correspond to a precise moment (T) and a specific level of organization (L) of spatial or social reality. Yet the reality that is amenable to observation at this level and at this given time is not independent of entrances and exits from other

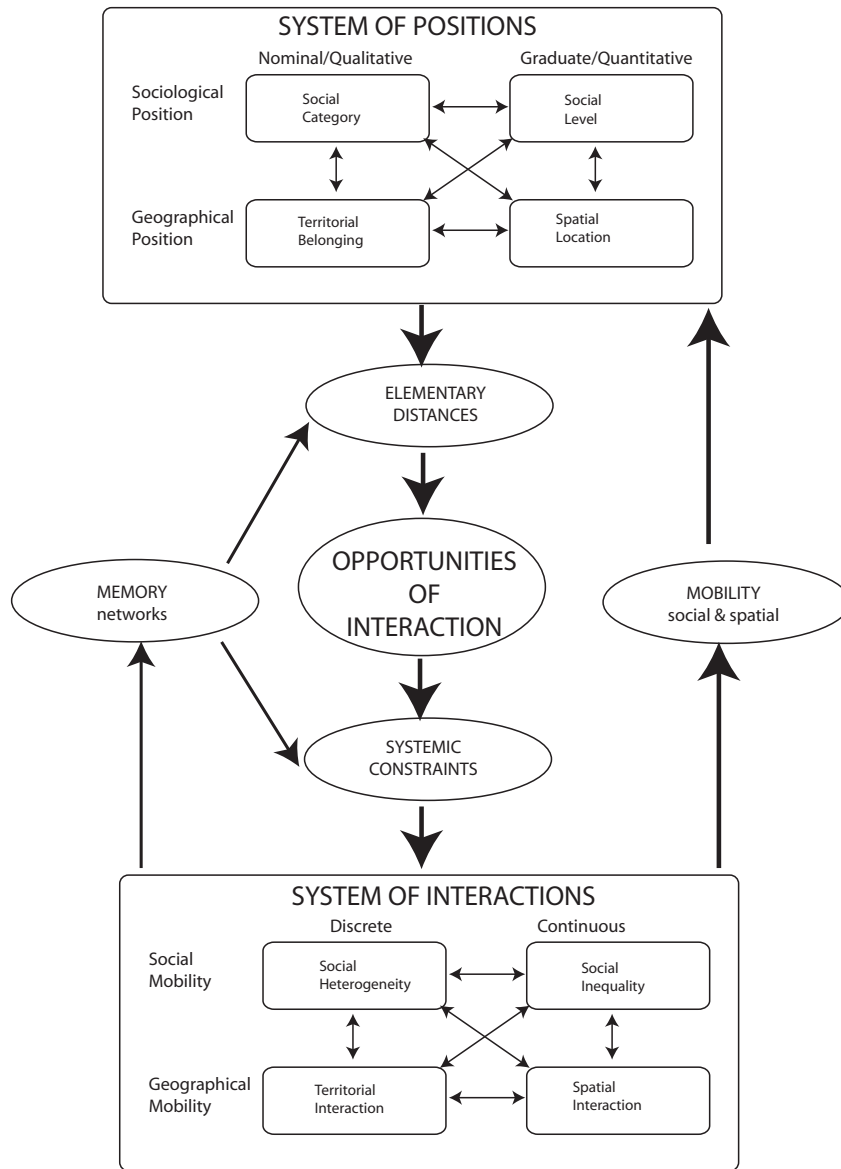


Figure 10: A multidimensional approach of social and spatial interactions (Grasland, 2009)

systems occupying different positions in time and within the hierarchy of organizational levels of aggregation [54].

By remaining confined to relations of immediate proximity, the state of the system

(L, T) obviously depends first of all on its previous state (L, T-1), which has generated a number of legacies. But it also depends on its future state (L, T+1) to the extent that agents' decisions take account of a range of anticipations pertaining to the future evolution of the system. These anticipatory effects are rarely addressed in current models of opinion dynamics. However, the social feedback model introduced within WP 2 (deliverable 2.1) is with its basis in reinforcement learning capable of taking into account future expected outcomes. Similarly for organizational levels, the state of the system (L, T) is the emerging effect of interactions forged between elements at a lower level (L-1, T), but it is also subject to a range of constraints and determinations related to the impact of systems of interaction at a higher level (L+1, T). However, the successive analysis of different organizational levels is not the only possible approach. Increasingly, studies in the field seek to apprehend simultaneously several levels with new statistical instruments of information, especially in the context of multilevel models.

2.3 Analogy between Euro coins mixing process and opinion dynamics models

The example of euro coins mixing process is a nice illustration of the interest of the approach described below as it was very similar to the model of creation of cultural zones described by Axelrod but could be empirically observed by many authors through various surveys.[74, 68, 69, 24, 39].

Starting from an initial situation at first January 2002 where all euro coins had been located in their country of origin, we could empirically observe what was the mixing process of coins through an analysis of the diversity of "national faces" printed in the coins of the moneybag of individual. Each coin present in the moneybag is equivalent to a feature and we can expect that, after a very long period of time, the convergence process will be achieved and all citizens of the euro zone will have the same distribution of coins printed in the different country (with of course more German coins than Luxembourg coins, as the number of coins printed depended from the population). The scientific challenge for researcher interested by the topic was to evaluate the time of convergence of the mix of euro coins.

Some authors adopted Markov models [74] where each country is considered as an homogeneous container where coins are automatically mixed over all the national territory. As a consequence, they predicted a very quick time of convergence that was not verified in practice because many coins are crossing the border at very short distance but are likely to return to their country of origin. Other authors used Brownian models [61] or Levy flight models [12, 11] which provided better results but failed to explain many regional differences revealed by empirical survey because they was based on the assumption of circulation of isotropic space in isotropic time. Finally, the best results was obtained by authors using spatial interaction models taking into account the heterogeneity of settlement and introducing explicitly a combination of hierarchical diffusion through urban network and diffusion by contiguity along the borders [39, 40].

But euro coins mixing was not only a spatial process but also a social one. On the basis or regular survey on a representative sample of french population between 2002 and 2011,

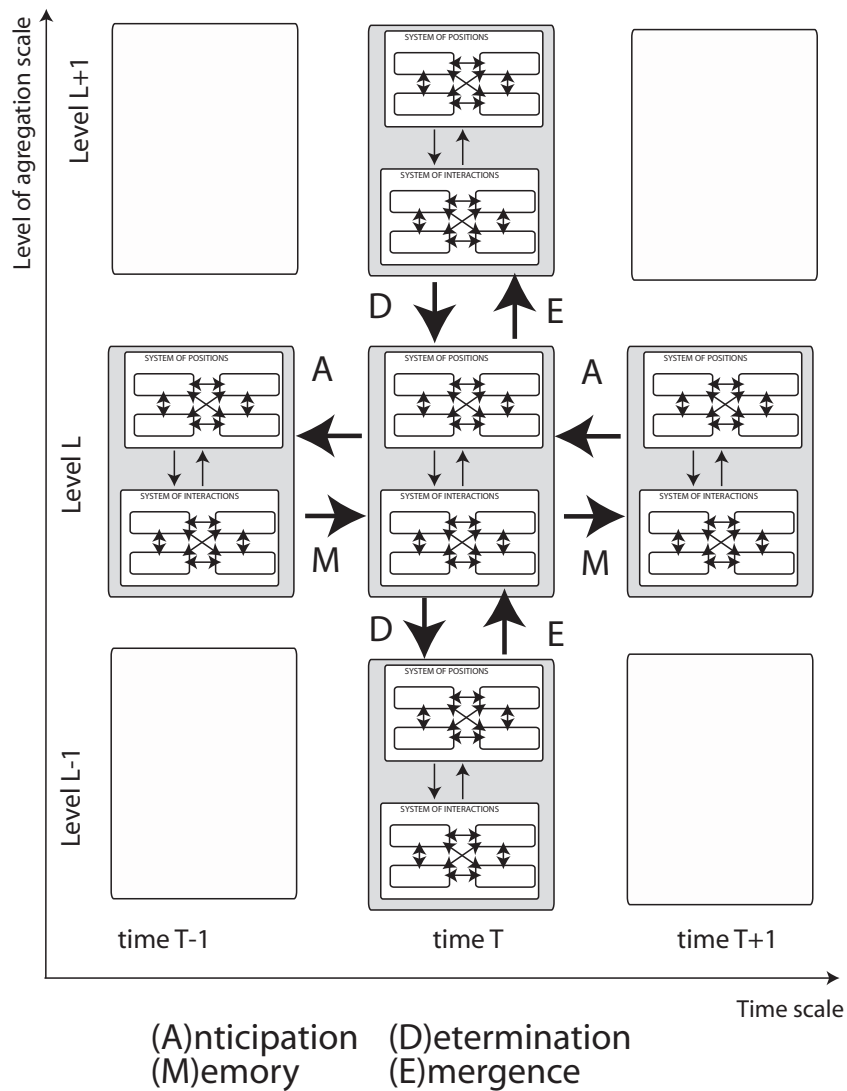


Figure 11: A multilevel approach of interaction dynamics (Grasland, 2009)

it was possible to demonstrate that the coins present in the moneybag of individuals could also be different according to social status, all things being equal with spatial location. At the beginning of the diffusion process, foreign coins were more frequent in the moneybag of blue collars than white collar, due to the cross-border exchanges with

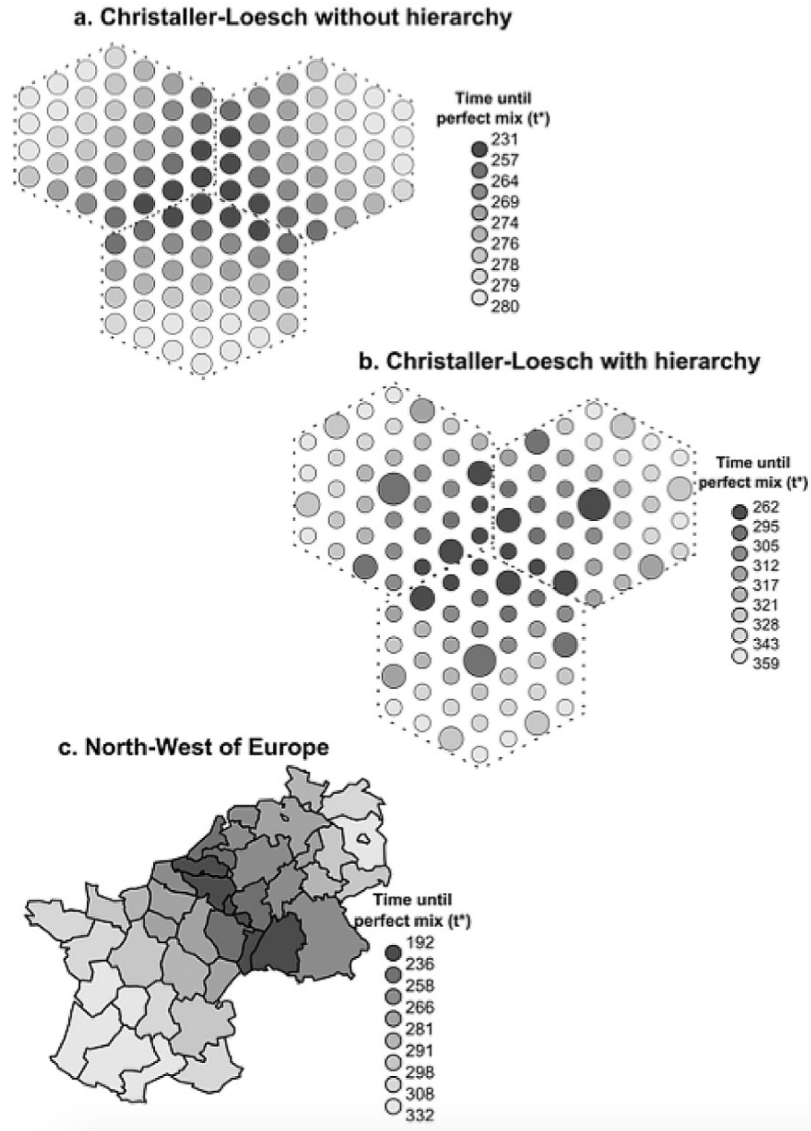


Figure 12: Spatial distribution of regional convergence time to perfect mix within different spatial systems. (Le Texier & Caruso, 2017)

Germany or Luxembourg. But the reverse was true in the metropolitan area where long distance travel was the privilege of individuals with higher social status [25]. This effect disappeared in following years, due to the process of local mixing. But it was possible to observe permanent social differentiation in the level of internationalization of moneybags during the whole period 2002-2007 in relation with age, gender, activity, standing or diploma [23].

Parameter			Parameter estimate		Significativity		
name	category	DF	value	effect	Standard error	Khi2	Pr > Khi 2
Intercept		1	4,811		0,073	4391,17	<.0001 ***
Nbcoins		1	0,936		0,017	2911,97	<.0001 ***
time	2002_03	1	-1,999	-86,5%	0,117	289,86	<.0001 ***
time	2002_06	1	-1,715	-82,0%	0,075	527,39	<.0001 ***
time	2002_09	1	-1,095	-66,5%	0,059	339,07	<.0001 ***
time	2003_01	1	-1,155	-68,5%	0,062	343,02	<.0001 ***
time	2003_06	1	-1,155	-68,5%	0,062	345,29	<.0001 ***
time	2003_09	1	-0,776	-54,0%	0,055	201,91	<.0001 ***
time	2003_12	1	-0,723	-51,5%	0,051	200,80	<.0001 ***
time	2004_06	1	-0,539	-41,7%	0,050	115,46	<.0001 ***
time	2004_09	1	-0,310	-26,7%	0,047	43,85	<.0001 ***
time	2004_12	1	-0,369	-30,9%	0,045	66,40	<.0001 ***
time	2005_06	1	-0,273	-23,9%	0,047	34,38	<.0001 ***
time	2005_12	1	-0,130	-12,2%	0,044	8,86	0.0029 ***
time	2006_06	1	-0,074	-7,1%	0,045	2,63	0.1046 -
time	2007_01	0	0,000	-	0,000	-	.
Age structure	W15-24	1	0,042	4,3%	0,058	0,53	0.4678 -
Age structure	W25-34	1	0,025	2,6%	0,051	0,24	0.6215 -
Age structure	W35-44	1	-0,026	-2,6%	0,052	0,25	0.6145 -
Age structure	W45-54	1	-0,117	-11,0%	0,055	4,46	0.0346 *
Age structure	W55-64	1	0,049	5,0%	0,053	0,84	0.3582 -
Age structure	W65 +	1	-0,031	-3,1%	0,050	0,38	0.5356 -
Age structure	M15-24	1	0,271	31,2%	0,060	20,64	<.0001 ***
Age structure	M25-34	1	0,116	12,3%	0,059	3,95	0.0470 *
Age structure	M35-44	1	0,076	7,9%	0,059	1,67	0.1964 -
Age structure	M45-54	1	0,089	9,3%	0,058	2,41	0.1208 -
Age structure	M55-64	1	0,117	12,4%	0,056	4,37	0.0366 *
Age structure	M65 +	0	0,000	-	0,000	-	.
Standing	Low	1	-0,066	-6,3%	0,029	5,02	0.0251 *
Standing	Medium	1	0,011	1,1%	0,026	0,16	0.6882
Standing	High	0	0,000	-	0,000	-	.
Diplom	Low	1	-0,062	-6,0%	0,031	4,17	0.0411 *
Diplom	Medium	1	0,011	1,1%	0,036	0,09	0.7659
Diplom	High	0	0,000	-	0,000	-	.
Activity	White collars	1	0,037	3,8%	0,028	1,75	0.1863
Activity	Blue collars	1	-0,152	-14,1%	0,043	12,58	0.0004 ***
Activity	Inactive	0	0,000	-	0,000	-	.
Scale parameter		0	41,087		0,000		

Source of data: Euro Spatial Diffusion Observatory – <http://www.esdo.prd.fr>

Figure 13: Spatial distribution of regional convergence time to perfect mix within different spatial systems. (Grasland, 2009)

2.4 A place for (different kinds of) spaces in opinion dynamics

The social feedback model meanwhile published in *The Journal of Mathematical Sociology* [2] may serve as an example from opinion dynamic modeling of how to translate quantitative and nominal features as those mentioned in Section 2.2 into networks of interaction. Two different network models that have been used in the analysis: first, spatial random graphs and second a simple version of a stochastic block model also referred to as island model.

In the former, agents are located at random positions in a unit square $(x, y) \in [0, 1]^2$ and linked if their distance is below a certain threshold. They hence mimic a spatial embedding of agents and allow interaction between agents if they are close enough. Noteworthy, the distribution of points (agents) in space can be modulated such that, for instance, center-periphery structures emerge if there is a larger concentration of agents in a certain region of that space. Some examples of this kind are shown in Fig. 2.4. This could be brought even closer to reality by generating a distribution of spatial positions that is taken from housing data.

The second graph model is more characteristic of being created in a space of nominal variables. Here two (or more) groups of agents are considered and a probability p

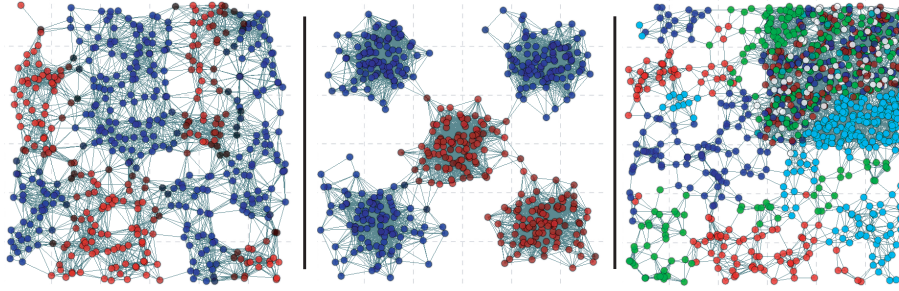


Figure 14: Three different types of spatial random graphs based on different spatial distributions of points in the unit square.

determines the ratio between in-group and out-group connections. In fact, there is a long tradition in studying the two-community topology in population genetics [77] and also theoretical work on opinion dynamics has relied on this as a stylized description of segregated communication structures [14, 1, 38]. One may think of it in spatial terms such as, for instance, as a set of villages with intensive interaction among people of the same village and some contact across, but it could also be related to homophily regarding to social classes, ethnicity, religious communities, etc. An example of such a network is shown in Fig. 15.

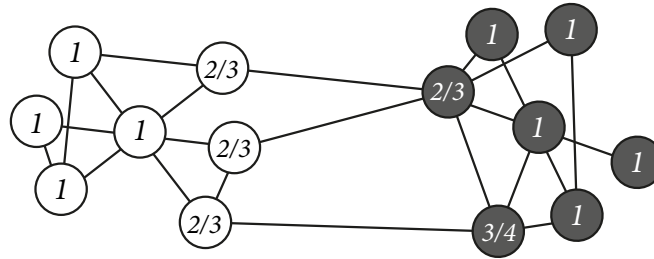


Figure 15: A small two-community graph with two densely connected components and a few »long-range« ties connecting them. The fractional numbers shown on the nodes correspond to the respective fraction of neighbors with the same opinion.

Noteworthy – but less explored – all kinds of combinations of these two graph models are possible. And a realization of the multidimensional approach of social and spatial interactions outlined in Section 2.2, in fact, corresponds to a certain combination of them. The network shown in the middle of Fig. 2.4 can be seen as one example where five different groups are within themselves connected by spatial proximity.

The most important result in [2], however, is the identification of a well-defined structural measure which networks or more generally interaction topologies have to satisfy to sustain polarization and plurality: namely, the existence of at least two cohesive subgroups. If two groups exist in which for each member the majority of connections is to

other members of that group (and not to the out-group) then polarization is a stable feature under the social feedback dynamics. This condition characterizes networks independent of the social and geographic basis on which they have been created. They just have to sustain cohesive sub-groups. This means that, in the context of these models, one important role of social Geography is to assess to what extent a certain social, cultural and territorial situation sustains cohesive subgroups and to identify the lines along which different groups may split. Also the empirical analysis and validation of the effects that the model would predict are a very important issue to assess the explanatory value of the model. For the models such an analysis will be of great relevance because it can provide new ways to think about reasons for empirical deviations from the idealized patterns observed in stylized networks.

3 Work done

In the previous section, we have tried to demonstrate the theoretical interest of the spatial dimension for the analysis of cultural conflicts and opinion dynamics. And we have demonstrated that spatial and social interaction models proved to be efficient for the modelization of the diffusion of a material innovation like foreign coins. But what about spiritual innovations like opinions ? Thanks to the diffusion of social networks and universal media like Google News or Wikipedia, one can imagine that the world has become flatter and that geographical distance and political borders does no more matter. For many gurus, language or religion can remain factors of cultural distance, but no more spatial proximity and we can announce the end of geography ...

The aim of this empirical study work done for the ODYCCEUS project has been to demonstrate that distance still does matter and plays a crucial role in the circulation of international news published by daily newspaper. To do so, we have firstly carefully explored the literature published in the field of media studies about the circulation of international news since the seminal work of Galtung & Ruge in 1965 [20]. But we have tried enrich and complete the models used by author from media studies with hypothesis elaborated by geographers and economists in the field of spatial interaction models derived from Tobler's first law of geography. And the major innovation of the paper accepted for publication in the *International Communication Gazette* has been to dis-aggregate the model by weeks and media in order to evaluate (1) the time variation of the rule governing the circulation of news and (2) the media variation of the international agenda. Therefore, we have not only validated the still active role of distance in the circulation of opinions, but also propose a method for the analysis of the variation of the rules governing media agenda through space and time.

3.1 Linking media studies and spatial analysis

The first part of the paper accepted by the *International Communication Gazette* address the theoretical question of the similarities and differences between the concepts used for the modelization of flows by specialists from media studies and specialists from geography, demography and economy.

The Laws of foreign news (Galtung & Ruge)

The joint publication of two papers in the same issue of the *Journal of Peace Research* in 1965 [20?] is considered as the birth date of the paradigm of international news flow theory (INFT). These two papers has indeed realized a synthesis of previous research through the elaboration of a bulk of hypothetical "factors" and "laws" that was supposed to govern the publication of foreign news. The verification of the laws proposed by the authors defined an exciting and ambitious research agenda, at the crossroad of many disciplines, with high potential political consequences : Fifty years later, we can acknowledge that the prediction was partly realized. A huge number of publication has indeed been realized by researchers in media studies, political science, international relation, sociology and even geography about the validation or criticism of what is commonly

designed as *Galtung's laws*. But we can suspect that only one part of the program has been really fulfilled. On the one hand, we can notice that the different laws proposed by Galtung & Ruge has not received the same attention. On the other hand, some original contributions of Östgaard has been to a large extent simplified ignored.

code	Law
F1	If the frequency of the signal is outside the dial it will not be recorded.
F2	The stronger the signal, the greater the amplitude, the more probable that it will be recorded as worth listening to
F3	The more clear and unambiguous the signal (the less noise there is), the more probable that it will be recorded as worth listening to
F4	The more meaningful the signal, the more probable that it will be recorded as worth listening to
F5	The more consonant the signal is with the mental image of what one expects to find, the more probable that it will be recorded as worth listening to
F6	The more unexpected the signal, the more probable that it will be recorded as worth listening to
F7	If one signal has been tuned in to the more likely it will continue to be tuned in to as worth listening to
F8	The more a signal has been tuned in to, the more probable that a very different kind of signal will be recorded as worth listening to next time
F9	The more the event concerns elite nations, the more probable that it will become a news item
F10	The more the event concerns elite people, the more probable that it will become a news item
F11	The more the event can be seen in personal terms, as due to the action of specific individuals, the more probable that it will become a news item
F12	The more negative the event in its consequences, the more probable that it will become a news item

Table 1: The 12 laws of Galtung & Ruge (1965)

The crucial point that Galtung & Ruge underline very is the fact that factors does not produce effects in an isolated way and have generally to be combined together. From this point of view, a crucial assumption of additivity is proposed concerning the cumulative effect of the different factors : *The higher the total score of an event, the higher the probability that it will become news, and even make headlines*. This hypothesis is crucial because it implies that one factor of newsworthiness can be balanced by another one. For example, a remote and poor country like Nepal has a low level of newsworthiness for media located in Europe or USA because it is a country remote (F4) and poor (F9). But this handicap can be balanced by events like the earthquake of 2015 which was especially intense (F1), unexpected (F6) and negative (F12). The followers of Galtung that has developed model of salience of countries has logically conclude from this rule of additivity that it is necessary to use multiple regression model combining the different factors of

newsworthiness.

But generally only some rules have been intensively tested with a particular focus on the effects of meaningfulness (F4), consonance (F5) elitism (F9, F10), personalization (F11) and negativity (F12). But only very few have tried to address the complete set of rules which means that they have ignored in particular the laws (F1) concerning the hypothesis of a minimum threshold and the law (F7) concerning the persistence of the signal. At our knowledge, the only empirical verification of the additivity hypothesis on the full set of laws (F1-F12) was realized by Peterson on the basis of a set of 5466 events from which only 15% was subject to publication of news in *The Times* of London. The results revealed indeed a positive correlation between the number of factors of newsworthiness verified by an event and the probability of publication (Peterson (1981)). One of the possible reasons for this difficulty to take into account the whole set of rules is the fact that it is not always obvious to decide in an objective way the status of news according to the rules proposed by Galtung & Ruge. Having tried to apply the rules on a sample of news with double check, some authors considered that: > “*A number of Galtung and Ruge’s factors appear to be problematic to identify while others may be identifiable but less in any intrinsic properties of a potential news story and more in the process of how a story has been constructed or written up.*”[31]. []

Competing news subject to systemic constraints (Östgaard)

Östgaard’s contribution should be rediscovered on at least one particular point which is not present in Galtung’s rule: the introduction of an implicit econometric model of competing news, taking the form of a quasi zero-sum game. According to Östgaard, the free flow of news is certainly hampered by political factors like censorship, propaganda or more subtle forms of ‘management of news’ by governments or international news agencies. But he considers that economic factors also play a major role, in particular through the feedback created by audience on media selection of news :

“We do maintain that for whatever reason the news is published, it will be intended to reach an audience. Whether the newsman is working for *The Times* or for *Tass* or for the *Daily Yell*, he will try to capture the attention of the reader, to interest him.” (Östgaard 1965)

The theoretical framework proposed by Östgaard implies therefore that the newsworthiness of an event should not necessarily be defined in absolute terms but rather in relative terms as a **choice model subject to constraints**. This idea of ‘choice’ is clearly present in the definition of the processing of news which is described as a kind of global stock exchange :

“Every minute of the day, thousands of men and women are at work, gathering, transmitting and presenting the news to the public. The decisions they make, when discarding most material available, when choosing what is to be presented, and when presenting in the way they consider best, will be called the processing of news.”(Östgaard 1965)

This competition between news could explain what he called the *news barriers* i.e. the existence of continuity or discontinuity in the coverage of event stories. At every moment, the event that occurred in different countries are engaged in a form of competition for publication and it is not only the newsworthiness of the event that does matter but also the existence of an international market of other competing events occurring at the same time. For example, it is very clear that the growing interest of media for the death of migrants crossing the Mediterranean between Libya and Italy at the end of April 2015 was strongly interrupted when the earthquake in Nepal occurred. Reversely, the earthquake of Mexico in Sept. 2017 failed to reach a peak of interest because of the pre-existing focus of media on the disaster induced by the hurricane Jose.

Event-oriented versus place-oriented approach (Wu & Segev)

A crucial dilemma for the followers of Galtung & Ruge and Östgaard has been to choose between event-oriented approach or country-oriented approach.

The event-oriented approach is based on a selection of foreign news related to a specific topic for which it is possible to define a finite and possibly objective list of events occurring in the 'real' world. One of the most interesting area of research from this point of view is the study of the mediatization of earthquake for which objective measure of magnitude or victims are regularly published. It is then possible to analyze the level of newsworthiness according to the different laws postulated by Galtung [36, 41]. The first problem with this approach is the fact that it is not possible to establish an objective list of events related to the topic (e.g. social movements). But the most important issue with the segmented approach is the fact that we can not assume that the different topics related in international events belongs to separated arena [75, 46].

The country-oriented propose a verification of Galtung's law through the aggregation of international news by country without interest for the topic of events responsible of unequal salience of world countries. Many authors has historically contributed to this field of research (see, review of work by Kim and Barnett [35] or Shoemaker [63] and empirical verification on large sample of data has been realized in particular by Denis Wu [79, 80, 81] and Elad Segev [57, 58, 60]. This research has confirmed that the global salience of countries is strongly determined by the size of countries, elite status and various factor of relatedness, including geographical, historical, economical or cultural distances. They have also introduce new factors not present in Galtung's law like the existence of flows between countries (trade, migration, tourism, . . .), the presence or lack of news agencies, etc. But they have generally used predictive models without systemic constraints which means that they have not taken into account Östgaard hypothesis about competing news [26]. One of the most important caveat revealed by the empirical studies is the difficulty to identify a so-called normal period where the salience of countries would not be biased by 'exceptional' events.

3.2 The case of international news flow of 31 daily newspapers in 2015

The originality of the empirical proposal of the paper accepted by the *International Communication Gazette* was to propose a theoretical model of circulation of international news where only structural factors are involved and where we deliberately ignore the explanatory variables related to a specific conjectural situation. Of course, we did not ignore that news from conflict ridden countries (such as Pakistan, Afghanistan, Libya, Iraq, Syria and so on) usually have prominence by virtue of regional and international political factors. But we wanted to evaluate precisely what could be explained by permanent factors (i.e. constant over a temporal period of minimum 20-years) and analyze precisely the residuals of this structural model for the identification of events that has attracted the attention of media.

The model that we propose is therefore voluntarily limited to the general parameters of size and distance classically used in spatial interaction models of the gravity type that are applied to the description of migratory flows and trade flows. These two factor families are typically the classical ingredients in spatial interaction models used by economists or geographers to model migratory flows or trade flows. They are inherited from a theoretical tradition known as the gravity model that was empirically formulated at the end of the nineteenth century by Ravenstein in a seminal work on the laws of migration [51, 70]. The first mathematical equation of the gravity model was derived from Newton's law and published by Zipf in the famous book titled *Human Behavior and the Principle of Least Effort* [83]. The gravity model was immediately applied by economists and geographers to migratory flows and trade flows. However, in Zipf's view, the model was more general. In addition, it is interesting to point to an earlier publication of Zipf in *The American Journal of Psychology* where he proposed an application of this model to the determinants of the circulation of information, with a specific focus on news published by *The Chicago Tribune* and *The New York Times* [82]. From Zipf's perspective, analyzing the circulation of information was crucial because he considered that movements of people or goods cannot occur without a previous circulation of information [30] and the location of intervening opportunities [67].

Further developments of Zipf's proposal have led to a strong improvement of the initial model, particularly not only with the introduction of discontinuities in the distance effect in the case of cross-border flows [43, 42, 10] but also with the addition of systemic constraints in the models, considering the competition effect of opportunities of relation [76, 15]. As a whole, the development of the gravity model realized in further decades [18, 62] offers a solid theoretical and methodological basis for the spatial analysis of social facts in general [23] and the circulation of news flows in particular.

Quantitative factors of salience (size effect)

We propose to define firstly the quantitative salience of countries S_p as a combination of three complementary factors of size that increase the probability of apparition of events of interest for media

- the **geographical size** is measured by the land area of the country (Source :

World bank), defines the first dimension of salience. We assume that the many events of interest for international news are related to the size of the territory. It is typically the case of the so-called natural events (earthquake, volcano, storms, ...) but remain true for economic or social phenomena.

- the **demographic size** is measured by the resident population of countries (Source : World bank). As it is correlated to geographical size, we introduce in the model the population density in order to evaluate the specific effect of population located on a territory. Combined with the previous effect, the two parameters described an utopic situation of equal coverage of mankind by media.
- the **economic size** is measured by Gross Domestic Product in parity purchased power (Source : World bank). It is introduced in the model as GDP per capita in order to evaluate the specific preference for most developed countries, all things being equal with the equal coverage of territories defined by the previous parameters.

$$S_p = (SUP_p)^{\alpha_1} \cdot \left(\frac{POP_p}{SUP_p}\right)^{\alpha_2} \cdot \left(\frac{GDP_p}{POP_p}\right)^{\alpha_3} \quad (3)$$

Qualitative factors of salience (elite status)

We assume that the three quantitative salience factors are not sufficient to cover the specific situation of some countries that are structurally more important than other in international news flows, even when no specific events take place inside their borders. It is therefore necessary to introduce some qualitative parameters defining the elite status of specific countries in the international system Q_p

- the **five permanent members of the security council (P5)** are firstly likely to be more involved than others in international news because they are associated to the majority of decisions in case of conflict, with the right of veto. The Syrian crisis or the agreement on nuclear in Iran are two examples of events where the P5 has benefit from a specific level of mediatization.
- the **Other members of the G20 (G14)** (i.e. 14 countries excluding the P5 members and the EU) has been introduced in the model in order to verify if they can also be considered as elite countries when we exclude the specific case of P5.
- the **Vatican effect** has been introduced as an ad hoc parameter considering the exceptional positive residual that appeared for this country in the first simulation of our model, especially in newspapers from Latin America.

$$Q_p = \beta_1^{P5_p} \cdot \beta_2^{G14_p} \cdot \beta_3^{VAT_p} \quad (4)$$

The relatedness factors (quantitative or qualitative)

The relatedness function described the factors likely to increase or reduce the probability for the international desk of a media (m) to select news about country (p), all things

being equal with the salience effect. After various test including other factors of proximity (common border, belonging to the same continent, former colonial relation) we have decided to limit the model to the two factors that are the more predictive and the less correlated.

- The *geographical proximity* is measured by the grand circle distance between the capital of the host and guest countries (Source : CEPII). We use inverse the transformation (1/Distance in km) in order to obtain a factor of proximity
- The *language proximity* is measured by the fact that the host and guest countries are sharing a common official language or a common language spoken in each country by 20% or population (Source : CEPII). This effect of common language can be explained by the facility of communication. But it can be also considered as a general proxy of various cultural and historical factors of proximity. ‘

$$R_{m,p} = (1/DIST_{m,p})^{\gamma_1} \cdot \gamma_2^{LANG_{m,p}} \quad (5)$$

The time dependence effect (permanence of signal & news barriers)

Last but not least, we introduce a parameter of time dependence measuring if the media has published a minimum number of news about the country of interest during the previous period of time. It is clearly a reference to the 7th rule of Galtung (“If one signal has been tuned in to the more likely it will continue to be tuned in to as worth listening to”) but also to the idea of news barriers formulated by Östgaard. We use here a dummy parameter with value 1 if the media m published at least one news about country p during the previous period of time $t-1$ and 0 in other case. We could also imagine more sophisticated functions of activity during the previous week and, more generally introduce a time auto correlation function based on ARIMA functions.

$$T_{m,p,t-1} = \delta^{(F_{m,p,t-1} > 0)} \quad (6)$$

General form of the model

The model take therefore the final form below, with an additional parameter describing the number of news sent by each media at each period of time :

$$F_{m,p,t} = F_{m,t} \cdot S_p \cdot Q_p \cdot R_{m,p} \cdot T_{m,p,t-1} \quad (7)$$

Exclusion of flow-based and event-based factors

In contrast to the majority of media studies specialists, we have voluntarily excluded two groups of explanatory variables.

- **the factor of relatedness based on flows:** Many studies produced by specialists in media flows introduce a contemporary interaction in models such as bilateral

trade flows, the number of foreigners present in host countries coming from guest countries or, conversely, the number of tourists from host countries visiting guest countries [78, 79, 59]. These factors are generally characterized by high explanatory power and are always very significant from a statistical perspective. However, is it logically consistent to introduce them into the model? Trade, tourism and migratory flows are themselves strongly related to size and distance factors, which means that a statistical bias will be introduced in the model. And what is the most important, migration, trade or tourism cannot be considered as independent factor explaining news flows because they are themselves depending from the information field linking countries [30]. As demonstrated by Snyder & Kick [66], the world system is organized by a multiple-network analysis of transnational interactions. And it is not possible to isolate one type of linkage for the explanation of another one without introducing very complex feed-back effects.

- **the factors of salience related to the number of ‘events’ occurring in a country during the period** As explained in the beginning of this section we have voluntarily excluded this factor because we want to build a model where only structural factors are involved and where events are analyzed through the residuals. But another important reason of exclusion of these event factors is the difficulty to find objective measure of the presence of war, natural disasters, economic crises in countries, especially when we try to dis-aggregate the model by short period of time as we do here on a weekly basis.

3.3 Main conclusions and interest for opinion dynamics and cultural conflicts

We try here to summarize the main conclusions of the paper published in *International Communication Gazette* but also to discuss the interest of the results for the modelization of opinion dynamics and cultural conflicts.

Structural factors explains more than half of the international agenda of newspapers

The main added value of the work has to be found in the attempt to propose an inductive approach of the discovery of international news event through a structural model where the gravity model proposed by Zipf [82] and further developed by other authors like Tobler [70] is used as a filtering procedure. This approach is in our opinion complementary to the deductive approach developed by the majority of the specialist of International News Flow Theory [35, 78, 79, 80, 81, 63, 57, 58, 59]. The model that we propose is certainly less efficient in terms of explanatory power (because of the exclusion of event-based and flow-related factors) but present the advantage to be possibly applied in real time for the detection of emerging events. Indeed, we have demonstrated that these exceptional events can introduce a temporary modification of the values and significance of the parameters of gravity model. However, it is always the case that more than half of the production of international news remains subject to the rules of “business as usual”.

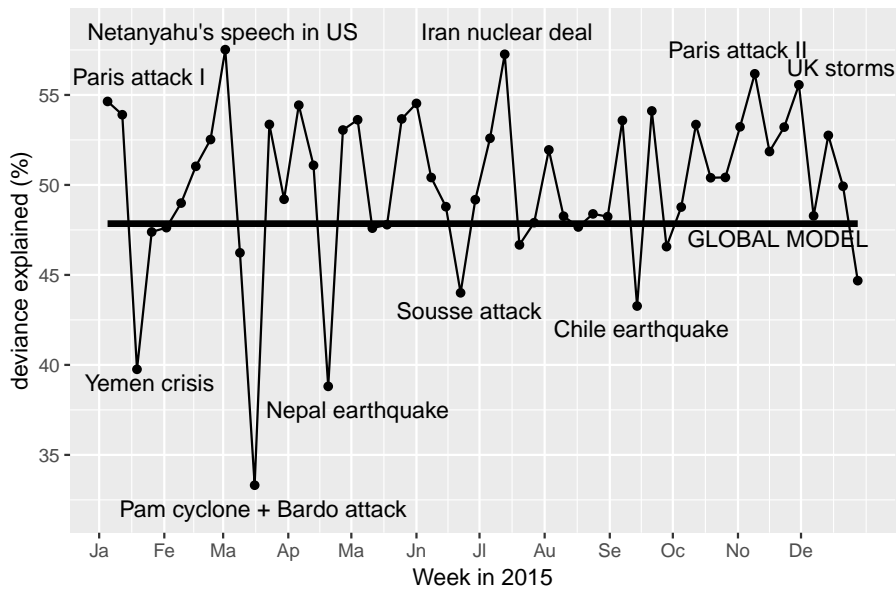


Figure 16: Deviance explained by a spatial interaction model applied to international RSS news flows of 31 daily newspaper in 2015 (Grasland, 2019)

Interest for ODYCCEUS: We can really ask if the importance of spatial proximity and common language has been observed for daily newspaper at global scale is also true for other media (tweeter, Facebook, ... and for other scales (national, regional, local, ...). When it is the case, a spatial and social dimensions should be explicitly introduced in the modelling of opinion dynamics.

It is possible to identify exceptional moments of perturbation of the rules governing news flow

The simultaneous dis-aggregation of the model parameters by week, countries and media appears as an important innovation for the analysis of competition between news at international level [26]. It offers promising solution to the answer of many questions raised by specialist of agenda setting theory and competition between news [48, 50, 64, 44, 45]. We have demonstrated that, despite the voluntary exclusion of classical explanatory variables (flows and conflicts), the classical rules of spatial interaction models used for modeling trade or migration can successfully be applied to the circulation of international news. To a large extent, it is possible to predict the salience of foreign countries in the international agenda of daily newspapers with a very simple sets of structural parameters consisting of the size (area, population, GDP), the remoteness (geographical distance, border, common language) and the elite status of countries (members of PM5, Holly See). Despite the perturbation induced by exceptional events such as the Paris attacks or the earthquake in Nepal, a large part of the international agenda of newspapers remains more likely to be predictable at the week level using the same parameters than during a

one-year period.

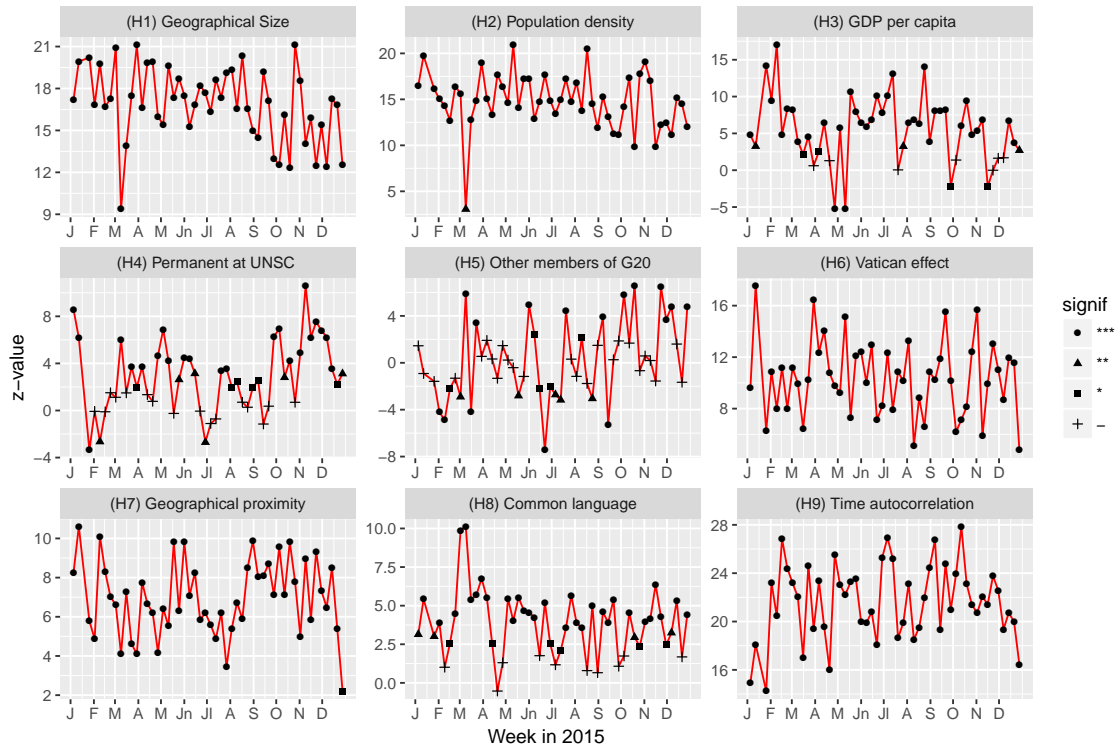


Figure 17: Significance of parameters of a spatial interaction model applied to international RSS news flows of 31 daily newspaper in 2015 (Grasland, 2019)

Interest for ODYCCEUS: The analysis of the time variation of structural factors governing news flow offers interesting perspective for the identification of exceptional events that are likely to produce discontinuities of bifurcations in opinion dynamics at macroscopic level.

The circulation of international news is regional rather than global

However, it is important to consider the dis-aggregation of the model not only by weeks but also by media. Indeed, we have demonstrated that the the rules governing media exhibit spatial non-stationarity. This does not mean that we should adopt an idiographic approach considering that all media are unique. But we have to consider the interest of a place-based approach where universal rules certainly exist but display variation in their parameters [21, 22]. Media located in elite countries – particularly in the USA – are relatively less influenced by geographical distance or a common language than are media located in poor countries. Elite media are therefore likely to produce a broader coverage of world news but with a higher level of conformism and reproduction than media located in more peripheral areas. Because of their focus on more local news, peripheral

newspapers can zoom in some parts of the world that are less covered by mainstream media. It is therefore of particular interest to carefully examine the residuals produced by each media outlet facing an event and to avoid a blind aggregation of news produced by different media. Finally, the most important interest of our approach is to offer a dis-aggregated vision of the variations of salience of countries by media and through time, making possible to reveal strong divergences in international agenda according to language and regional localization of newspapers.

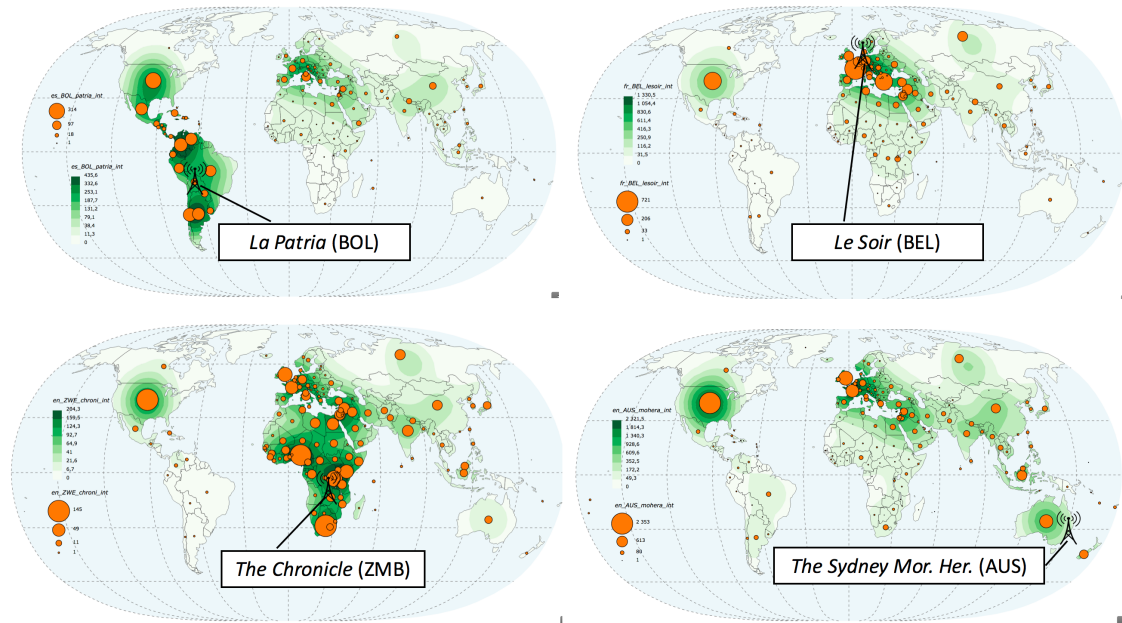


Figure 18: Example of newspapers characterized by strong effects of distance or language in 2015

Interest for ODYCCEUS: The analysis of opinion dynamics should not focus only on broadsheet newspaper in English language. As long as distance or language introduce strong variations in media coverage of events, it is of utmost importance to enlarge the panel of media used to have a better understanding of “one world with many voices”.

The use of space-time model as event filters

In a previous research project called GEOMEDIA, we have developed a tool called “event explorer” for the interactive application for the visualization of international event through space and time, presented at the final conference of the project and freely available on the web. Based on the same data than the present paper, this tool focus on the detection of events in the narrow sense of brutal increase of the interest of a media for a country as compared to previous time period. The tool was very useful for the identification of “new” event creating a sudden break in time series, as we can see with the example of the first week of January 2015 where all media reported the Charlie Hebdo

attack in Paris. But the tool was not able to identify structural anomalies associated to long term crisis over several months or years, like it was the case for Syria, Greece or Ukraine during the same period. The residuals of the model presented here proposes a solution to the problem because they are based on structural parameters that are stable through time. The model can therefore identify countries that are characterized by a permanent media coverage (like the US or the Australia in the majority of the media of our sample) or media that received a coverage more important than usual during several months (Yemen, Ukraine) or years (Syria, Greece) because a situation of long-term political crisis. But the model can also indicate what are the variation of the pattern of time coverage of countries from one media to another.

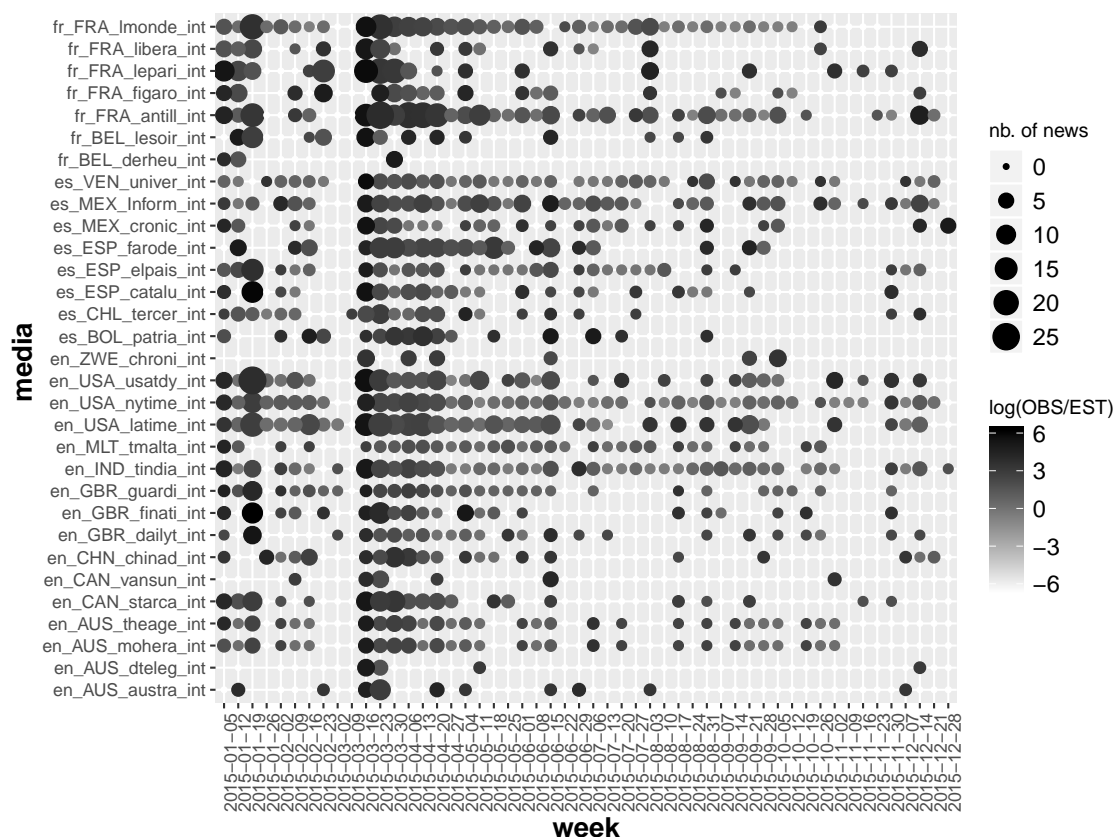


Figure 19: Example of residual analysis : the coverage of the Yemen in international RSS news flows of 31 daily newspaper in 2015 (Grasland, 2019)

Interest for ODYCCEUS: Spatial interaction models can be used as filters in order to eliminate the trivial part of the circulation of news and to focus on the residuals which are more likely to reveal unexpected events or innovative points of view. Models dis-aggregated by time period or media sources are the most interesting for this task.

3.4 Delivery of data sets and R program

The publication accepted by the International Communication Gazette (Annex A) is completed by an appendix that describes precisely the procedure of collection and aggregation of news published by daily newspapers (Annex B). We have also propose to add a folder containing all the data used by the spatial interaction model used in the paper with a logbook written in R markdown that describes all the steps of the program code and the alternative options not necessarily used in the final version of the paper (Annex C).

All these documents will be made available immediately on the ODYCCEUS website and further on the website on the journal in order to make possible reproduction and enrichment of the proposed model by other researchers.

4 Impact in the project

The impact of the current deliverable 2.3 on the project should not be limited to the Geographer's claim that "space does matter". What is really at stake here (and it is the reason why the deliverable is associated to a milestone) is the fact that tools and models produced by ODYCCEUS project have to combine different dimensions in order to produce rich description and sound explanations of opinion dynamics and cultural conflicts. Each of the researcher tend naturally to privilege some dimension and to neglect - or simply ignore - the other ones. It is the reason why the production of this deliverable was interesting because the debate between cultural distance and geographical distance discussed in section 2 was a very good opportunity to have a debate between geographers and mathematicians, paving the way for further development.

4.1 Introducing a debate about conceptual dimensions of opinion dynamics

This deliverable 2.3 has focused on the importance of the spatial and social interaction models for the analysis of opinion dynamics and cultural conflicts. But of course spatial location, even combine with social position, is only one of the possible dimensions of interest. The real challenge for ODYCCEUS project as a whole is to elaborate a conceptual and methodological framework able to integrate all the dimensions of the 5W+H framework described in the introduction of the document and to develop tools for the Penelope platform likely to be used by different case studies (cf. WP5) and different types of data (not limited to RSS flows of daily newspaper). The UPD team has therefore elaborated a proposal of representation of Penelope's pipeline and ODYCCEUS workflow which can be considered as a debate paper related to the achievement of Milestone 6.

We suggest that opinion dynamics implies necessary a time dimension (WHEN) related to the publication or replication of a message by individuals, media or group of interest (WHO) about a conflictual topic of debate (WHAT). We introduce the proposal that a spatial dimension (WHERE) should be generally introduced, concerning either the author of the message (WHO-WHERE) or the topic of the conflict (WHAT-WHERE) making possible to introduce spatial interaction models describing different effect of distances. The distance can associated to the location of the authors of the message (e.g. spatial location of individuals sharing common or opposite opinions, distance between author of a tweet and followers, etc.). It can be also associated to the distance between objects of the conflicts (e.g. border conflicts between two countries). And finally it can be associated to the distance between authors of the message and topic of the conflict (e.g. international agenda of media described in this document).

The content of the message is not only related to a topic (WHAT) but also to the formal of the message (HOW) that can involve the choice of specific words (e.g. "Migrants" versus "Refugees") and more generally the expression of different forms of framing that can be described by sentiment analysis or precision grammar (e.g. used of performative verbs). The analysis of the form of the content (HOW) should be distinguished from the emerging results of the aggregation of individual message (HOW MUCH) that is

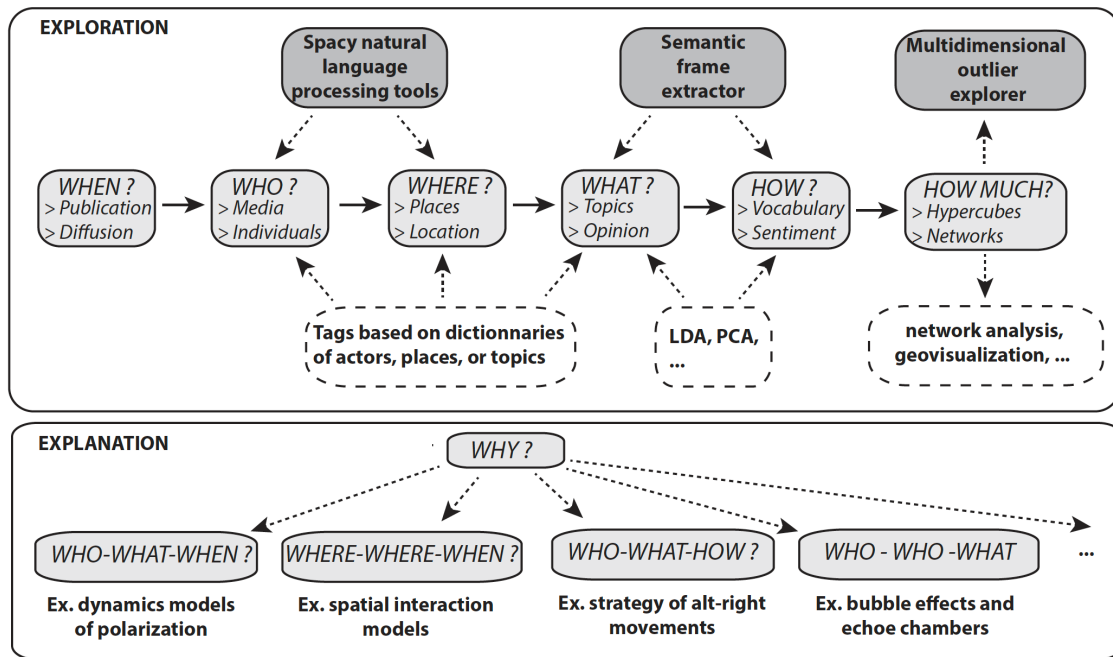


Figure 20: A draft vision of the place of spatial components in Penelope's pipeline

associated to a crucial modification of the nature of data. Among the different ways of aggregation, we can firstly mention the cube or hyper cube approach that has still been implemented in Penelope. But we can also use a network or multiplex network approach that offers very different perspective of modelization.

The six first dimensions (WHEN-WHO-WHAT-WHERE-HOW-HOW MUCH) defines the exploratory stage of the scientific work and can support typically an inductive research of explanation of the configurations observed. But it is of course only with the use of explanatory model that the final question WHY can be addressed. The important contribution of the H5+2W framework to the explanatory stage is to reveal which dimensions are used and which one are ignored in a model. It is certainly not possible to cover all dimensions at the same time but it is useful to have a clear vision of the choice made and their potential consequences in terms of interpretation. As discussed in section 2, the elimination of geographical distance in models will automatically reinforce the probability to interpret clusters of individual as based on cultural factors. And in the case of international relation, it will lead to a support of Huntington's thesis ...

4.2 Developing spatial dimension in case studies

Another impact of the deliverable 2.3 should be to precise the list of components of Penelope that should be developed by UPD in order to combine efficiently with the other dimensions. Until now, we have yet developed many procedures in R language for the extraction of list of places, visualization of network of places, production of animated

maps, ... But we need a coherent view of the expectations of other project partners, not limited to the case studies where UPD is engaged. It is the reason why we have tried to explore the content of case studies where space is taken into account and to propose some cooperation with other teams.

INSTAGRAM DATA : Integration and fragmentation in the mediatized city (UVA-S)

An important output concerning spatial dimension is a working document by John D. Boy and Justus Uitermark of the University of Amsterdam to be submitted to a special issue of *Social Media + Society* in January 2019. Building on their previous work [9, 8], their paper examines processes of integration and fragmentation at the interface of urban and online spaces. Using a large data set of geocoded Instagram posts from Amsterdam, they use a range of methods to test the hypothesis that people self-organize into online bubbles or urban enclaves. The authors notice that :

“When we look at the spatial footprint of the different clusters, as we do in Figure 1, we get a very different sense of how Instagram users are positioned within the city. What is remarkable is that the heat maps are so much alike: all clusters have their center of gravity in the center of the city. There are a couple of clusters that also show a lot of activity in Amsterdam South East because of the concert venues in that neighborhood but this is hardly distinctive. If there is one cluster that stands out, it is a cluster with Amsterdammers of Turkish descent that shows a lot of activity in the Western part of the city. However, this cluster, too, gravitates to the center of the city. While both classic writings on the city and contemporary writing on social media would lead us to expect stark differences, we do not at all find that groups sort into internally homogeneous “natural areas” [49].”

They conclude that, by and large, social media users in their database have much more inter-linkages than the literature on polarization would suggest. Boy and Uitermark argue that their findings urge us to consider how social media might contribute to integration and promote conformity.

Boy, John D. and Justus Uitermark (2016) How to study the city on Instagram, PLoS ONE 11(6): e0158161

ARCHIVE DATA: The diffusion of publication about Jews in France (UNIVE, UPD)

UPD and UNIVE has started for the exploitation of the spatial dimension of data contained in the corpus extracted for T.5.1 from Bibliothèque Nationale de France-Gallica digital archive in order to explore speech on Jews in 19th-20th century in France. Based on the Periodicals sub corpus from 1820 to 1914, the study of spatial dimension lays on the theory of spatial diffusion [28]. It examines places of publication through time and provides incentive results on the spatial spreading of ideologies (fig.21) :

1. The analysis of rank-size distribution at three different periods of time shows that the global growth of documents volume is synchronous with a spatial expansion. The

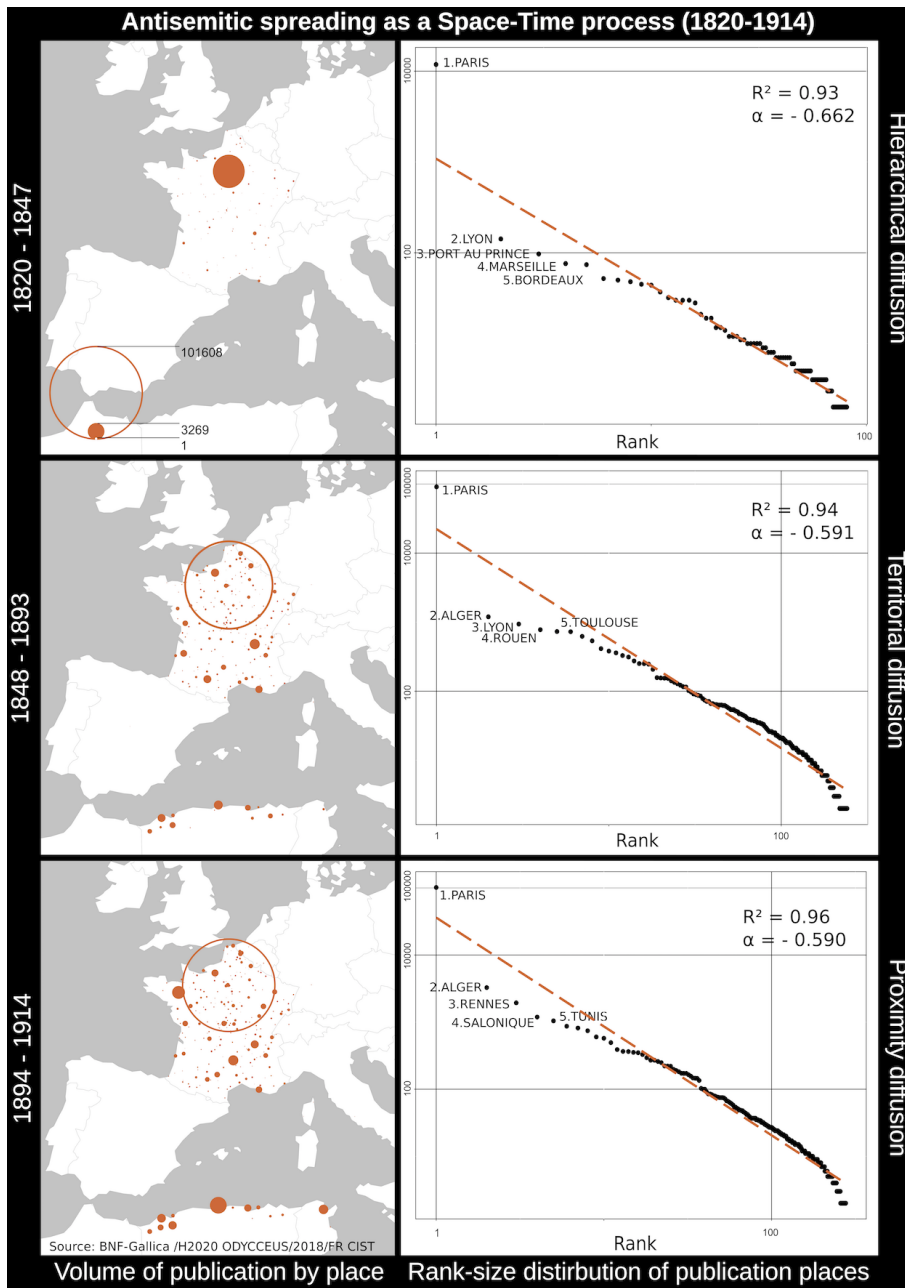


Figure 21: Antisemitic spreading as a space-time process (1820-1914)

Pareto parameter (alpha) of rank-size power regression is decreasing over time, demonstrating the decrease of hierarchy in spatial distribution.

2. The mapping of publication places over time shows three different channels of diffusion: there is first a hierarchical diffusion in largest cities (Paris, Lyon); a territorial

diffusion with the colonization of Northern Africa in the mid-19th that led to a re balancing of the spatial distribution with Alger at rank 2; then a proximity diffusion in medium and small cities as shown in the changes of cities top 5 order and by the growing filling of the map.

SURVEY DATA : Application to mental maps of Turkish students in 2013 (UPD)

Based on his previous work of PhD, Etienne Toureille proposes to transpose in ODYCEUS a method of topological analysis of list of places subject to positive or negative evaluation. This could be the base for a future Penelope component.

Topological analysis of words sequences leads to the observation of differentiated semantic universes (system of words). Applied to the analysis of sequences of answers to an opened question leading to the construction of list of countries according Turkish undergraduate students rated as where they want to live (attractive countries) or where they don't (repellent countries) we could observe the emergence of different geographical universes.

Figure 22 shows the result of a clustering analysis (top-down hierarchical classification of Reinert, a method used in French data analysis applied to text mining [52]). Each cluster is structured by a specific set of countries which are related to one another (co-occurrences). Cluster 3, for instance is organised around the mention of Iraq, which is one of the most often mentioned as repellent in the corpus [73]. According to the results, this country is significantly associated to other repellent countries: Syria, Iran, Afghanistan, Palestine and Saudi Arabia, which could be explained by the prominence of particular representations about these countries (political instability, humanitarian crisis, wars, authoritarian regimes sometime seen as conservative in comparison to the Turkish context). Students which mention this set of countries as repellent quote also other countries as attractive: France, Italy, United Kingdom, USA, Spain, Germany, Austria, countries which are always seen as attractive by the students. Thus giving interest to sequential analysis leads to the clue of identifiable ideologies (system of representations), like the fact to be attracted to Western developed countries while disliking Middle Eastern countries challenged by strong political and humanitarian difficulties. It is the case of Cluster 3 but also of two other, which could be seen as variants of this kind of Eastern/Western antagonism: Cluster 2 and 4, which could be gathered in a family of representations (Family 1). It is also possible to catch alternative ideologies, like for instance Cluster 8 / Family 4 which represent a geography which is antagonist to the Family 1 (Eastern Middle Eastern and Muslim countries as attractive vs Western developed countries as repulsive). This kind of systematic analysis leads also to the identification of the representations of "minority" which are hard to catch by considering the countries as isolated element (bag of words/aggregated analysis).

RSS DATA : Application to refugee crisis of 2015 (UPD)

Working on sequences of words could leads to control both the spatial and conceptual limits of a subject. For instance, the analysis of 14532 article of 26 newspapers located in 16

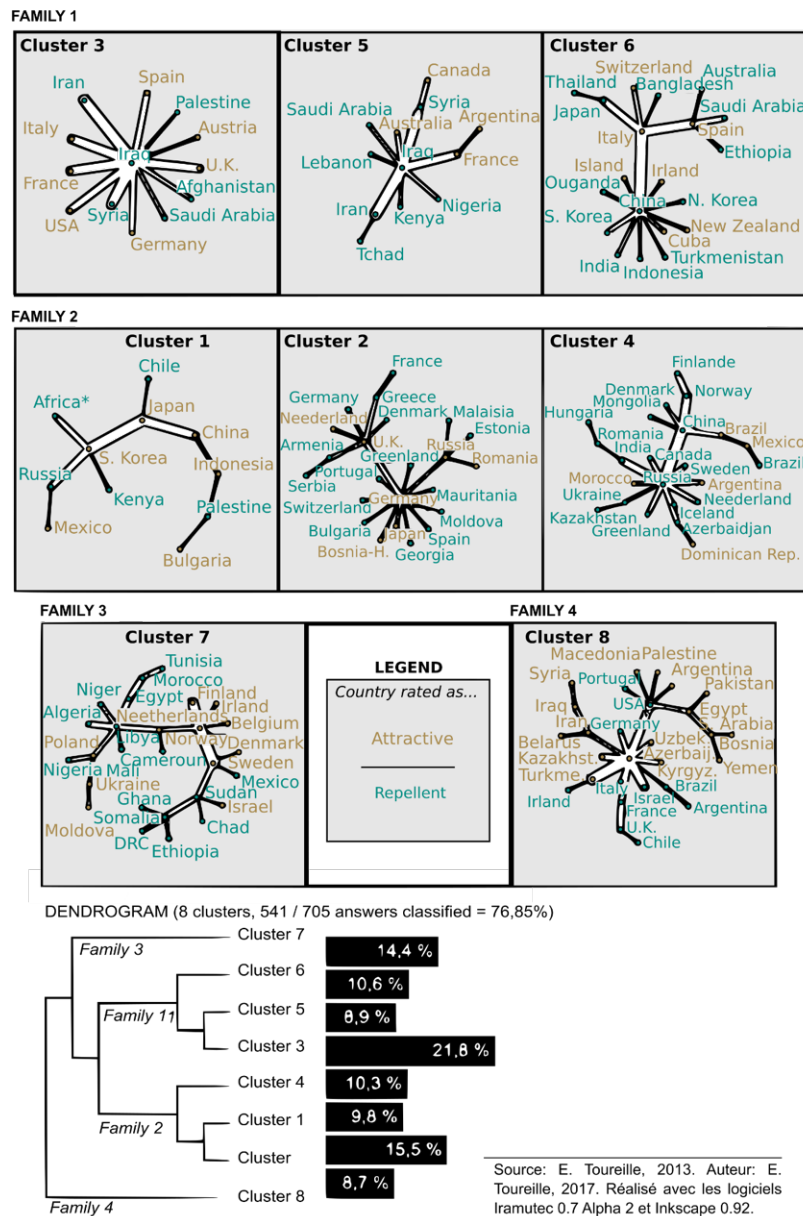
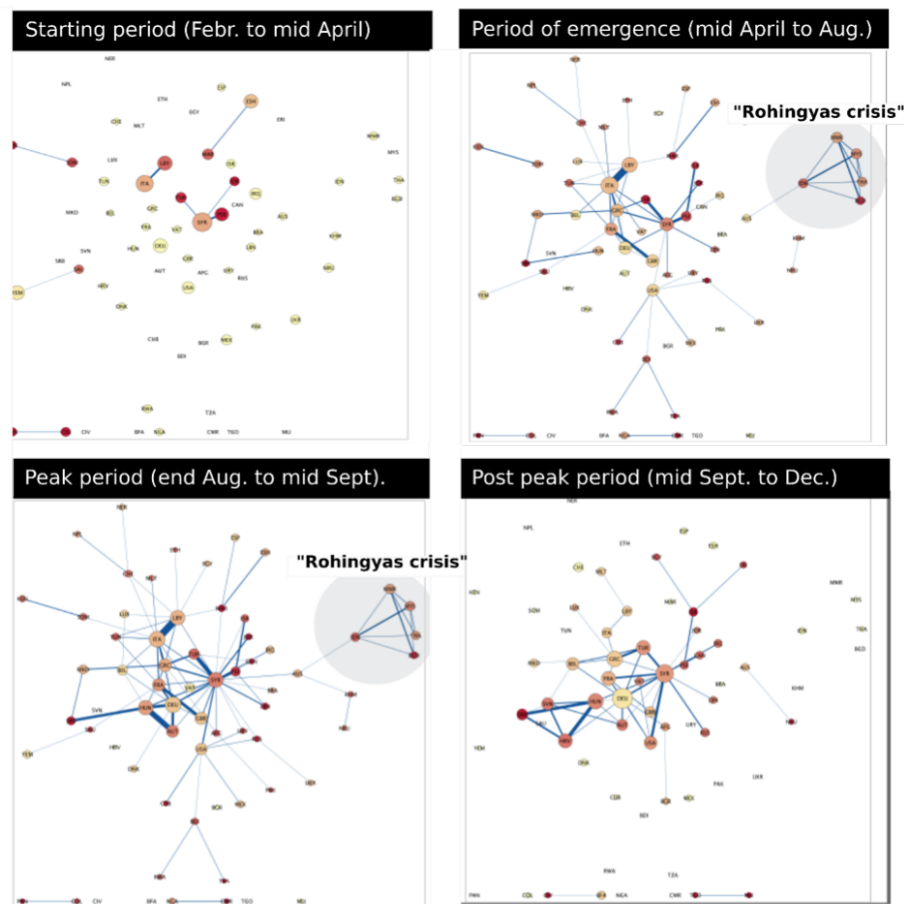


Figure 22: Differentiated system of representations (geographical universes) through co-occurrences (Source : Toureille, 2017)

countries related to the request: migrant* AND/OR refugee* (see case study: Contested European boundaries: migration and refugee crisis – T.5.3) leads to the identification of a geography associated to the migratory crisis (after automatic place recognition). In

many cases, places are not isolated in an article. A place, a country or an identifiable geographical and geographical actor (e.g. Angela Merkel, German chancellor) is more often associated with others places (e.g. expressions like: “Syrian refugee”, “French president François Hollande”, “Bruxelles”). These co-locations of places in the same text leads to study the co-occurrences of spatialized object. For instance, Fig.23 represent graph of co-occurrences of places, identified through the country of localisation (e.g. “Angela Merkel” = Germany).



Source: FR 2007 CIST - ANR GéoMédia 2015. Authors: FR 2007 CIST, Leconte, Toureille & Grasland, 2018

Figure 23: Identifying a parallel migratory crisis in Europe and Asia in 2015 (Source : UPD, task 5.3)

Thus it is possible to identify the geographies of the crisis regarding the evolution of the process (sliced in four exploratory time periods). As predictable, the Geography of the crisis is related to the spatial coverage of this phenomenon and its actors, for instance riparian countries directly involved in the management of EU boundaries: Libya, Turkey, Greece, Italy, for instance; and countries involved in these issues through their

implication in EU instances: Germany, France, Hungary, etc.). But, an interesting finding is related to the fact that some cluster of co-occurrences is not located in the Euro-Mediterranean area, but sometimes faraway: Indonesia, Myanmar, Thailand, for instance. These South-Eastern Asian countries are identifying another migratory crisis which was catches by international news flows during year 2015: the “Rohingyas crisis”. This example illustrates how the analysis of spatialized word networks could be a way to control the conceptual and spatial limits of a specific subject, and, if relevant to restrict the request to the single Mediterranean “migratory crisis”.

5 Appendix

The appendix is composed by the final version of the publication accepted in International Communication Gazette (A), the annex of this publication describing the methods of collect and aggregation of RSS flows (B) and the logbook of the program used for the computation of spatial interaction models (C). These documents are delivered in separated files.

A. Publication in International Communication Gazette

According to the rules of H2020 program, a green version of the publication is still available on an ArXiv website : <https://arxiv.org/abs/1810.04912>

B. Collection and aggregation of RSS flows

This document explains in detail the procedure of collection and aggregation of RSS flows, summarized by the Figure [24](#)

C. Commented R program for the modelization of news flows

This document is a folder containing the data and the program written in R markdown used for the realization of the publication. The program is clearly documented and options not adopted in the paper are mentioned, making possible to test alternative hypothesis and to reproduce all the results involved in the publication.

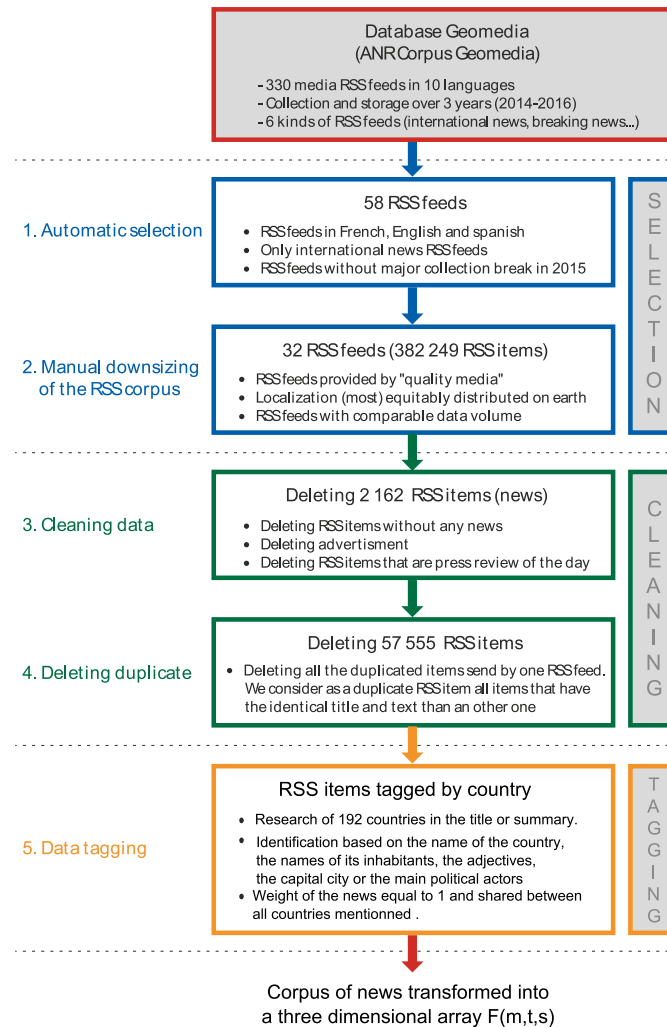


Figure 24: Extraction of geomediatric cube from RSS flows of daily newspaper

References

- [1] S. Banisch. From microscopic heterogeneity to macroscopic complexity in the contrarian voter model. *Advances in Complex Systems*, 17(05):1450025, 2014.

- [2] S. Banisch and E. Olbrich. Opinion polarization by learning from social feedback. *The Journal of Mathematical Sociology*, pages 1–28, 2018.
- [3] A. Bellmore, A. J. Calvin, J.-M. Xu, and X. Zhu. The five w’s of “bullying” on twitter: who, what, why, where, and when. *Computers in human behavior*, 44:305–314, 2015.
- [4] P. Blau. *Exchange and power in social life*. Routledge, 2017.
- [5] P. M. Blau. A macrosociological theory of social structure. *American journal of sociology*, 83(1):26–54, 1977.
- [6] P. M. Blau. *Structural contexts of opportunities*. University of Chicago Press, 1994.
- [7] P. M. Blau and J. E. Schwartz. *Crosscutting social circles: Testing a macrostructural theory of intergroup relations*. Routledge, 2018.
- [8] J. D. Boy and J. Uitermark. How to study the city on instagram. *PloS one*, 11(6):e0158161, 2016.
- [9] J. D. Boy and J. Uitermark. Reassembling the city through instagram. *Transactions of the Institute of British Geographers*, 42(4):612–624, 2017.
- [10] J. Bröcker and H. Rohweder. Barriers to international trade. *The Annals of Regional Science*, 24(4):289–305, 1990.
- [11] D. Brockmann. Following the money. *Physics World*, 23(02):31, 2010.
- [12] D. Brockmann and F. Theis. Money circulation, trackable items, and the emergence of universal human mobility patterns. *IEEE Pervasive Computing*, 7(4), 2008.
- [13] F. Cairncross. The death of distance: How the communications revolution will change our lives. 1997.
- [14] P. Dandekar, A. Goel, and D. T. Lee. Biased assimilation, homophily, and the dynamics of polarization. *Proceedings of the National Academy of Sciences*, 110(15):5791–5796, 2013.
- [15] G. Dorigo and W. Tobler. Push-pull migration laws. *Annals of the Association of American Geographers*, 73(1):1–17, 1983.
- [16] E. Durkheim. *Les règles de la méthode sociologique*. Flammarion, 2017.
- [17] E. Durkheim and S. Paugam. *De la division du travail social*. F. Alcan Paris, 1926.
- [18] A. Fotheringham and M. O’Kelly. *Spatial interaction models: formulations and applications*. Kluwer Academic Pub, 1989.
- [19] T. L. Friedman. *The world is flat: A brief history of the twenty-first century*. Macmillan, 2005.

- [20] J. Galtung and M. H. Ruge. The structure of foreign news: The presentation of the congo, cuba and cyprus crises in four norwegian newspapers. *Journal of peace research*, 2(1):64–90, 1965.
- [21] M. F. Goodchild and D. G. Janelle. *Spatially integrated social science*. Oxford University Press, 2004.
- [22] M. F. Goodchild and D. G. Janelle. Toward critical spatial thinking in the social sciences and humanities. *GeoJournal*, 75(1):3–13, 2010.
- [23] C. Grasland. Spatial analysis of social facts. *Handbook of Theoretical and Quantitative Geography*, University of Lausanne:117–71, 2009.
- [24] C. Grasland, F. Guérin-Pace, M. Le Texier, and B. Garnier. Diffusion of foreign euro coins in france, 2002-2012. *Population et sociétés*, (488), 2012.
- [25] C. Grasland, F. Guérin-Pace, and A. Tostain. The circulation of euros as a reflection of people’s mobility. *Population and Societies*, 384:2–4, 2002.
- [26] C. Grasland, R. Lamarche-Perrin, B. Loveluck, and H. Pecout. International agenda-setting, the media and geography: A multi-dimensional analysis of news flows. *L’Espace géographique*, 45(1):25–43, 2016.
- [27] T. Hagerstrand. The propagation of innovation waves. *Lund Studies in Geography*, B(4), 1952.
- [28] T. Hagerstrand. *Innovation diffusion as a spatial process*. University of Chicago Press - translation from swedish by A. Pred - 1967, 1953.
- [29] T. Hägerstrand. A monte carlo approach to diffusion. *European Journal of Sociology/Archives Européennes de Sociologie*, 6(1):43–67, 1965.
- [30] T. Hagerstrand. Aspects of the spatial structure of social communication and the diffusion of information. *Papers in Regional Science*, 16(1):27–42, 1966.
- [31] T. Harcup and D. O’neill. What is news? galtung and ruge revisited. *Journalism studies*, 2(2):261–280, 2001.
- [32] G. Hayes and S. Ollitrault. The french environmental movement in the era of climate change: The case of notre dame des landes. In *Green Politics section, Panel on The National Politics of Climate Change-ECPR General Conference*, 2011.
- [33] S. P. Huntington. *The clash of civilizations and the remaking of world order*. Penguin Books India, 1997.
- [34] D. G. Janelle and D. C. Hodge. *Information, place, and cyberspace: Issues in accessibility*. Springer Science & Business Media, 2013.
- [35] K. Kim and G. A. Barnett. The determinants of international news flow: A network analysis. *Communication Research*, 23(3):323–352, 1996.

- [36] R. Koopmans and R. Vliegenthart. Media attention as the outcome of a diffusion process—a theoretical framework and cross-national evidence on earthquake coverage. *European Sociological Review*, 27(5):636–653, 2010.
- [37] H. Kwak, J. An, J. Salminen, S.-G. Jung, and B. J. Jansen. What we read, what we search: Media attention and public attention among 193 countries. *arXiv preprint arXiv:1802.06437*, 2018.
- [38] R. Lamarche-Perrin, L. Tabourier, and F. Tarissan. Information-theoretic compression of weighted graphs. In *Poster session of the MSR-INRIA Join Center Workshop on Networks: Learning, Information and Complexity*, 2016.
- [39] M. Le Texier and G. Caruso. Assessing geographical effects in spatial diffusion processes: The case of euro coins. *Computers, Environment and Urban Systems*, 61:81–93, 2017.
- [40] M. Le Texier and G. Caruso. Aggregate and disaggregate dynamic spatial interaction approaches to modeling coin diffusion. In *Spatial Analysis and Location Modeling in Urban and Regional Systems*, pages 193–222. Springer, 2018.
- [41] M. Le Texier, M. H. Devès, C. Grasland, and J.-B. De Chabalier. Earthquakes media coverage in the digital age. *L’Espace géographique*, 45(1):5–24, 2016.
- [42] H. Linneman. A theoretical Foundation for the Gravity Equation. *American Economic Review*, 69(5):106–116, 1966.
- [43] J. Mackay. The interactance hypothesis and boundaries in Canada: a preliminary study. *Canadian Geographer/Le Géographe canadien*, 3(11):1–8, 1958.
- [44] M. McCombs. A look at agenda-setting: Past, present and future. *Journalism studies*, 6(4):543–557, 2005.
- [45] M. McCombs. *Setting the agenda: Mass media and public opinion*. John Wiley & Sons, 2018.
- [46] H. Nossek. Our news and their news: The role of national identity in the coverage of foreign news. *Journalism*, 5(3):343–368, 2004.
- [47] R. O’Brien. *Global financial integration: the end of geography*. Royal Institute of International Affairs, 1992.
- [48] E. Östgaard. Factors influencing the flow of news. *Journal of Peace Research*, 2(1):39–63, 1965.
- [49] R. E. Park. The city: Suggestions for the investigation of human behavior in the city environment. *American journal of sociology*, 20(5):577–612, 1915.
- [50] S. Peterson. International news selection by the elite press: A case study. *Public Opinion Quarterly*, 45(2):143–163, 1981.

- [51] E. G. Ravenstein. The laws of migration. *Journal of the statistical society of London*, 48(2):167–235, 1885.
- [52] M. Reinert. Une méthode de classification descendante hiérarchique: application à l’analyse lexicale par contexte. *Les cahiers de l’analyse des données*, 8(2):187–198, 1983.
- [53] T. Saint-Julien. *La diffusion spatiale des innovations*. Number 3. Reclus Mode d’Emploi, 1985.
- [54] L. Sanders. *Models in spatial analysis*. John Wiley & Sons, 2013.
- [55] T. C. Schelling. *The strategy of conflict*. Harvard university press, 1980.
- [56] T. C. Schelling. *Micromotives and macrobehavior*. WW Norton & Company, 2006.
- [57] E. Segev. Mapping the international: Global and local salience and news-links between countries in popular news sites worldwide. *International Journal of Internet Science*, 5(1):48–71, 2010.
- [58] E. Segev. Visible and invisible countries: News flow theory revised. *Journalism*, page 1464884914521579, 2014.
- [59] E. Segev. *International news flow online: Global views with local perspectives*. Peter Lang, 2016.
- [60] E. Segev. From where does the world look flatter? a comparative analysis of foreign coverage in world news. *Journalism*, page 1464884916688292, 2017.
- [61] F. Seitz, D. Stoyan, and K.-H. Tödter. Diskussionsbeitrag/discussion. paper coin: Migration and seigniorage within the euro area. *Jahrbücher für Nationalökonomie und Statistik*, 232(1):84–92, 2012.
- [62] A. Sen, T. Smith, and P. Nijkamp. *Gravity models of spatial interaction behavior*. Springer, 1995.
- [63] P. J. Shoemaker. News and newsworthiness: A commentary. *Communications*, 31(1):105–111, 2006.
- [64] P. J. Shoemaker and S. D. Reese. *Mediating the message in the 21st century: A media sociology perspective*. Routledge, 2013.
- [65] G. Simmel. *Soziologie*, volume 2. Duncker & Humblot, 1923.
- [66] D. Snyder and E. L. Kick. Structural position in the world system and economic growth, 1955-1970: A multiple-network analysis of transnational interactions. *American journal of Sociology*, 84(5):1096–1126, 1979.
- [67] S. A. Stouffer. Intervening opportunities: a theory relating mobility and distance. *American sociological review*, 5(6):845–867, 1940.

- [68] D. Stoyan. Statistical analyses of euro coin mixing. *Mathematical Spectrum*, 35(3):50–54, 2003.
- [69] D. Stoyan, H. Stoyan, and G. Döge. Statistical analyses and modelling of the mixing process of euro coins in germany and europe. *Australian & New Zealand Journal of Statistics*, 46(1):67–77, 2004.
- [70] W. Tobler. Migration: Ravenstein, thornthwaite, and beyond. *Urban Geography*, 16(4):327–343, 1995.
- [71] W. Tobler. On the first law of geography: A reply. *Annals of the Association of American Geographers*, 94(2):304–310, 2004.
- [72] W. R. Tobler. A computer movie simulating urban growth in the detroit region. *Economic geography*, 46(sup1):234–240, 1970.
- [73] E. Toureille. *La Turquie en Europe, la Turquie dans le Monde; analyse d'une catégorie macro-régionale au regard d'une géographie des représentations de l'Europe et du Monde turco-centrée*. Thèse de doctorat, Université Paris Diderot, 2017.
- [74] P. van Blokland, L. Booth, K. Hiremath, M. Hochstenbach, G. Koole, S. Pop, M. Quant, and D. Wirosoetisno. The euro diffusion project. 2002.
- [75] W. Wanta and Y.-W. Hu. The agenda-setting effects of international news coverage: An examination of differing news frames. *International Journal of Public Opinion Research*, 5(3):250–264, 1993.
- [76] A. Wilson. A statistical theory of spatial distribution models. *Transportation Research*, 1(3):253–269, 1967.
- [77] S. Wright. Isolation by distance. *Genetics*, 28(2):114, 1943.
- [78] H. D. Wu. Investigating the determinants of international news flow: A meta-analysis. *Gazette (Leiden, Netherlands)*, 60(6):493–512, 1998.
- [79] H. D. Wu. Systemic determinants of international news coverage: A comparison of 38 countries. *Journal of communication*, 50(2):110–130, 2000.
- [80] H. D. Wu. Homogeneity around the world? comparing the systemic determinants of international news flow between developed and developing countries. *Gazette (Leiden, Netherlands)*, 65(1):9–24, 2003.
- [81] H. D. Wu. A brave new world for international news? exploring the determinants of the coverage of foreign news on us websites. *International Communication Gazette*, 69(6):539–551, 2007.
- [82] G. K. Zipf. Some determinants of the circulation of information. *The American journal of psychology*, 59(3):401–421, 1946.
- [83] G. K. Zipf. *Human behavior and the principle of least effort: An introduction to human ecology*. Addison Wesley, Cambridge, Massachusetts, 1949.