



ARTICLE



<https://doi.org/10.1057/s41599-024-03829-1>

OPEN

# Analysing inter-state communication dynamics and roles in the networks of the International Institute of Intellectual Cooperation

Rubén Rodríguez-Casañ <sup>1</sup>, Elisabet Carbó-Catalan <sup>1,2</sup>, Albert Solé-Ribalta <sup>1</sup>, Diana Roig-Sanz <sup>1,3✉</sup>,  
Javier Borge-Holthoefer <sup>1✉</sup> & Alessio Cardillo <sup>1,4,5✉</sup>

The International Institute of Intellectual Cooperation (IIIC) was an international organisation established post-World War I, aimed to foster intellectual relations for global peace. As this institution becomes centenary, the digitisation of archival records has democratised access, sparking renewed scholar interest and eventually enabling new research avenues. Here, we examine two letter collections from IIIC's digitised funds, focusing on administrative and artistic/literary matters. By analysing recognisable sender-receiver pairs and their geographical origins, we construct networks revealing intricate international relationships. Notably, the community structures and roles differ between administrative and literary exchanges, suggesting distinct communication dynamics. Administrative matters depict a more egalitarian distribution. In contrast, relevant literary correspondents include Western European countries exclusively, reflecting the prominence of certain geocultural areas as well as potential geopolitical influence attempts, challenging the established historical narratives on centres and peripheries, inviting a reevaluation of the IIIC's geographical organisation and intellectual cooperation during the interwar period.

<sup>1</sup>Internet Interdisciplinary Institute (IN3), Universitat Oberta de Catalunya, Barcelona, Spain. <sup>2</sup>Faculty of Arts, KU Leuven, Leuven, Belgium. <sup>3</sup>ICREA—Catalan Institution for Research and Advanced Studies, Barcelona, Spain. <sup>4</sup>GOTHAM Lab—Institute for Biocomputation and Physics of Complex Systems (BIFI), University of Zaragoza, Zaragoza, Spain. <sup>5</sup>Pyrenean Institute of Ecology (IPE-CSIC), Zaragoza, Spain. ✉email: [dsanzr@uoc.edu](mailto:dsanzr@uoc.edu); [jborgeh@uoc.edu](mailto:jborgeh@uoc.edu); [acardillo@uoc.edu](mailto:acardillo@uoc.edu)

## Introduction

The International Institute of Intellectual Cooperation (IIIC) was an international organisation created under the auspices of the League of Nations (LoN) after the First World War to promote intellectual relations in the interest of world peace. Based in Paris and active between 1925 and 1946, with a period of inactivity during the Second World War, the IIIC is considered UNESCO's direct forerunner (Renoliet, 1999). The IIIC was part of a group of bodies constituting the Intellectual Cooperation Organisation (ICO), which shared the goal to promote the circulation of ideas and the institutionalisation of a global intellectual space (Sapiro, 2009). With the IIIC fulfilling executive functions, the ICO also included a deliberative body—the International Committee on Intellectual Cooperation (ICIC), located in Geneva and active between 1922 and 1939—and several National Committees of Intellectual Cooperation (NCIC) spread across more than 40 countries. National Committees articulated and coordinated the relationships between each national field and the Paris and Geneva headquarters. Altogether, they constituted an innovative organisation combining an inter-governmental composition and transnational working methods (Grandjean and van Leeuwen, 2019; Laqua, 2011), bringing together state representatives, intellectuals, and international public servants.

In the last few years, the global turn in the humanities and the social sciences, and the centenaries of the LoN, the ICIC, and the IIIC (respectively, in 2020, 2022, and 2025–2026) have encouraged a renewed interest in the latter and a moment of critical assessment. The digitalisation of a large part of their archival records (e.g. available through the UN Archives Geneva (United Nations, 1919), and UNESCO's archives (United Nations Educational, Scientific and Cultural Organizations (UNESCO), 2023)) has further favoured scholarly attention (Institute for European Global Studies, University of Basel, 2017), while also contributing to democratise access conditions and opening up new research possibilities through the application of quantitative methods.

Intellectual cooperation has been mostly studied through qualitative methods, although relevant contributions have been conducted regarding the quantitative analysis of the ICIC's funds (Grandjean, 2018). Indeed, the IIIC has not yet been explored within a data-driven approach and a network science perspective. However, this is now possible given the recent digitalisation of IIIC's funds, today hosted at the UNESCO headquarters in Paris, in the framework of the 'Digitising Our Shared UNESCO History' project. The latter has digitised more than 770,000 pages so far, and we anticipate that data-driven approaches can offer a fruitful contribution to existing efforts to rewrite the history of intellectual cooperation within a less Eurocentric perspective, an interest that is visible in recent scholarship. In geographic terms, this can mean overcoming excessively Western and Eurocentric approaches and reasserting the roles of peripheral actors within the organisation (Dumont, 2018; Herrera and Wehrli, 2019; Joyeux-Prunel, 2019a; Roig-Sanz and Subirana, 2020). This can also be broadened to a more nuanced view of the specific role of very well-known figures, such as Albert Einstein and Marie Skłodowska-Curie, or introducing a still lacking gender perspective in the history of the organisation. In terms of the topics under discussion, this can be translated into abandoning an exclusive focus on power politics and reasserting the ICO's functions in the intellectual field including education, translation, or cinema (Carbó-Catalan and Meylaerts, 2022; Löhr, 2010).

In this scenario, we argue that current qualitative knowledge provides a solid starting point to deepen in quantitative approaches. Critically exploring archival material with quantitative methods can contribute to nuance established historical narratives, shedding light on the multiplicity of actors involved, their

communities, networks and forms of interaction, and pointing toward structural dynamics that cannot be detected when exploring large amounts of archival material only with close reading (Champenois and Joyeux-Prunel, 2023; Joyeux-Prunel, 2019b). In this respect, we propose to combine both methodologies (distant and close reading) in order to get a relational and more complete picture of intellectual cooperation. As digitised archives correspond to those of the ICO's central institutions, located in Paris and Geneva, there exist the risk of reproducing and/or reinforcing traditional Eurocentric narratives in the methodological and historiographical domain, especially if we consider that most archives of National Committees are sparse or non-existent. We argue that these risks can be mitigated if the same material is approached combining a qualitative analysis with network theory (Newman, 2018). Complexity science has been already framed in relation to biological and technological systems. Also, it has been applied to the social sciences in relation to the study of digital platforms and the dynamics therein (Foucault Welles and González-Bailón, 2020). However, despite some sparse attempts (Champenois and Joyeux-Prunel, 2023; Grandjean, 2018; Schich et al., 2014), it is still a promising research avenue when applied to objects related to the humanities, as we propose in this paper. This twofold methodology allows us to identifying multiple entanglements and interaction patterns, as well as reassessing the roles and functions of both central and peripheral actors. With a view to fill this gap, we examine here the IIIC as a complex dynamic system, and we aim at uncovering the underlying flow of communication and emerging structure—beyond that of its main broadcasters—generated as a consequence of its activities.

Keeping in mind that the IIIC was an international organisation with its own dynamic and interests, but also a diplomatic lever used by governments to exert cultural and political influence among countries, in this work we focus on the geographical aspects of the countries' interactions. To do so, we exploit a subset of the 146,561 digitised pages/sheets containing over 81,343 documents. Among them, we analyse two subsets of letters: one belonging to administrative issues (e.g. correspondence with governments, intellectual organisations, and national committees), and another related to literary and artistic affairs. For both subsets, we retain letters for which a sender and a receiver are digitally recognisable. More specifically, we draw our attention on the geographical origin and destination of these subset of documents and letters. These correspondence items are the basic ingredient to define pairwise interactions—and thus a network whose nodes are countries—and we interpret the quantity of letters exchanged between two countries as the intensity of their interaction.

With both networks at hand, we have found that pruning out the two main broadcasters, namely France and Switzerland, unveils a rich and non-trivial web of relationships. More interestingly, the pattern emerging from those relationships, in terms of community structure (Fortunato and Hric, 2016) and the functional role (Guimerà and Amaral, 2005) (i.e. the position they occupy in the web of relationships existing between countries) that single countries play is different for both subsets, pointing at two distinct communication dynamics among countries. Amidst the countries playing a prominent role in the literary correspondence exchange we have found Belgium, United Kingdom, Italy, and Spain; which historians classify either among the relevant countries on the interwar's geopolitical chequerboard, or as countries trying to gain influence on it.

Correspondence on issues involving (among others) governments, intellectual organisations, and national committees, instead, yield a much more egalitarian picture, with a relatively

large number of key players from North and Latin America, or from Eastern Europe, many of which seldom appear in the mainstream historical narratives of the interwar period. Such a discrepancy opens the door to a re-interpretation of the IIIC’s geographical organisation and, more in general, of the intellectual relations between countries during the interwar period.

**Methods**

In the following, we provide details about the various processes involved in the networks construction and analysis. Unless stated otherwise, all computational aspects have been implemented in Python using several of its libraries. Specifically, numerical analysis has been carried out using the NumPy and NetworkX packages (Hagberg et al., 2008; Oliphant, 2006; van der Walt et al., 2011), while graphics have been prepared using the Matplotlib (Hunter, 2007) package.

**Data.** To generate the networks of communication’s occurring between countries involved in the IIIC’s activities, we have processed the information stored in the UNESCO’s Archives database named *Access to Memory* (AtoM) (United Nations Educational, Scientific and Cultural Organization (UNESCO), 2022). First, we reached an agreement with UNESCO to share with us all the scanned correspondence from IIIC archives. The raw archive consists of multiple series, but we concentrated on its *correspondence files* dated between 1923 and 1946 which, in turn, are organised into eleven subseries. We focused on two subseries (henceforth folders) due to their historiographic relevance in artistic and literary issues. On the one hand, Folder A (611 PDF files) contains administrative correspondence with governments, national organisations, National Committees, and state delegates, as well as records on the general affairs of the IIIC’s management. On the other hand, Folder F (226 PDF files) contains the correspondence relating to artistic and literary matters.

Each of the PDF files consists of several scanned sheets corresponding to distinct handwritten and typewritten documents. After isolating each document, we automatically sorted it into hand- or type- written, and as letters or attached documents. Then, we have used multiple digital tools to analyse these files and extract salient information like: the sender, the recipient, the date of creation, the language(s) used, geographical places, and the people appearing within each document (see Supplementary Note S1 of the SM for the details). As the focus of our investigation is the geographical distribution of IIIC’s activities, we used only the geographical information appearing in the head and tail of typewritten letters. Nonetheless, we believe that our extraction pipeline has a more general utility as it can serve as a stepping stone for the analysis of other aspects of IIIC’s correspondence.

**Generation of correspondence networks**

**Document selection.** After pre-processing the documents contained in folders A and F, we selected only those classified as typewritten letters. This means that over the 62,192 documents isolated in folders A and F, we consider only 12,230 of them in Folder A and 5906 in Folder F, respectively. In addition, we consider only those letters with a geographical information available in their head and tail (see the SM for the details) corresponding to the sender’s and recipient’s locations. Such a criterion leaves us with 4248 and 1596 documents corresponding to 35% of the whole corpus of letters for Folder A, and 27% for Folder F, respectively.

**Node extraction.** The Named Entity Recognition algorithm used extracts locations such as names of cities, regions, or countries (written not only in English). We decided to aggregate this

**Table 1 Structural characteristics of the correspondence networks.**

	Folder A	Folder A*	Folder F	Folder F*
<i>N</i>	66	64	53	51
<i>E</i>	285	185	214	143
$\rho$	0.13	0.09	0.16	0.11
$\langle k \rangle$	8.64	5.78	8.08	5.61
$\langle C \rangle$	0.52	0.12	0.50	0.22
$\langle l \rangle$	2.18	3.13	2.05	2.67
<i>N<sub>cc</sub></i>	1	4	2	8
<i>S</i>	1.00	0.95	0.98	0.86
<i>N<sub>sl</sub></i>	53	51	45	43

For each network, we report its number of nodes (*N*), of edges (*E*), the edges’ density ( $\rho$ ), the average values of the degree ( $\langle k \rangle$ ), clustering coefficient ( $\langle C \rangle$ ), and path length ( $\langle l \rangle$ ), the number of connected components (*N<sub>cc</sub>*), the size of the giant component (*S*), and of nodes with self-loops (*N<sub>sl</sub>*). Networks denoted with \* in their name correspond to those without France and Switzerland.

information at the national (country) level, keeping in mind also the historical organisation of nations during the interwar period. This means, for instance, that entities (e.g. a city) located in countries like Croatia, Ukraine, or Israel have been mapped as Yugoslavia, USSR, and Palestine, respectively (see Supplementary Note S1 of the SM for the details).

**Edge generation.** The countries identified in the head and tail of typewritten letters represent the nodes of a graph (network), and a letter exchanged between countries *i* and *j* corresponds to an edge connecting those countries. As we are more interested in the existence of communication between countries, rather than its direction, we consider undirected edges. Letters exchanged between institutions located within the same country correspond to the so-called *self loops* edges (i.e. edges leaving and arriving on the same node). Finally, the number of letters exchanged between two countries *i* and *j* is encoded as the edge’s weight,  $w_{ij} \in \mathbb{N}$ . This leaves us with two undirected weighted networks with self loops (Latora et al., 2017), whose main standard structural features are summarised in Table 1.

**Community detection.** One of network science’s main research topics is the extraction of mesoscopic structures made of groups of nodes densely connected with each other (i.e. communities), identified via a quality function called modularity (Fortunato and Hric, 2016). To identify the communities of the networks, we used a modified version of the *Louvain method* (Blondel et al., 2008) called *Leiden algorithm* (Traag et al., 2019) which is a heuristic greedy multiscale method that attempts to maximises the modularity function. Given a network with *N* nodes distributed among *N<sub>com</sub>* communities, the modularity, *Q*, reads

$$Q = \frac{1}{2E} \sum_{i,j=1}^N \left[ a_{ij} - \frac{k_i k_j}{2E} \right] \delta(g(i), g(j)), \tag{1}$$

where *E* is the total number of edges in the network,  $a_{ij}$  is the element of the network’s adjacency matrix  $\mathcal{A}$ , *g*(*i*) is the community to which the *i*-th node belongs ( $1 \leq g(i) \leq N_{com}$ ), and  $\delta(g(i), g(j))$  is the Kronecker delta (Latora et al., 2017; Newman, 2006). A value of *Q* ≈ 0 corresponds to random assignment of nodes to communities, whereas we get *Q* ≈ 1 when the network is made of perfectly disjoint communities. Hence, a large value of *Q* implies a good partitioning. The Leiden method seeks the partitioning that maximises the modularity, producing partitions in which all the communities are also internally connected. As we consider weighted networks, we compute the weighted version of the modularity function (Fortunato and Hric, 2016). We account

for self-loops when we extract the community structure, as they play a role in the multiscale structure of communities (Arenas et al., 2008). We have also validated the statistical significance of our networks' modularities by comparing them with values obtained on a randomised version of our networks (Guimerà et al., 2004) (see Supplementary Note S2 of the SM). Finally, we have compared our communities with those identified using a different heuristic obtained via the RADATOOLS library, finding a high level of overlap between the two in both networks (see Supplementary Note S2 of the SM for the details).

**Nodes' functional role.** The assignment of a node to a small number of possible roles is performed according to the distribution of its connections across a network partition (González-Bailón et al., 2014; Guimerà and Amaral, 2005; Klimm et al., 2014). That is, given a partition  $\mathcal{P}$  of the network into  $N_{\text{com}}$  non-overlapping groups  $\mathcal{P} \equiv \{c_j | j = 1, \dots, N_{\text{com}}\}$ , for each node  $i$  we compute two indicators: i) the  $z$ -score of its *within group degree*,  $z_i$ , and ii) its *participation coefficient*,  $p_i \in [0, 1]$ . These quantities are computed as:

$$z_i = \frac{\kappa_i - \langle \kappa_{c_i} \rangle}{\sigma_{\kappa_{c_i}}} \quad i \in \{1, \dots, N\}, \quad (2)$$

where  $\kappa_i = \sum_j a_{ij} \delta_{c_i, c_j}$  is the within group degree, i.e. the degree of a node within the group it belongs to (Latora et al., 2017). Quantity,  $z_i$ , estimates how many connections node  $i$  has with respect to the average of the other members of the same group (i.e. its within group *hubness*). A value of  $z_i < 0$  denotes that  $i$  has less within group connections than the average of the other members of the group, whereas  $z_i > 0$  indicates the opposite condition. The participation coefficient of node  $i$ ,  $p_i$ , is defined as:

$$p_i = 1 - \sum_j \left( \frac{\kappa_i(c_j)}{k_i} \right)^2, \quad (3)$$

where  $\kappa_i(c_j)$  is the within group degree of nodes belonging to group  $c_j$ . Eq. (3) quantifies how the connections of a node  $i$  split across distinct groups. In particular,  $p_i = 0$  if  $i$ 's neighbours belong all to the same group, and  $p_i = 1$  if  $i$ 's neighbours belong to different groups.

After computing  $p$  and  $z$  for each node in the network, we divide the  $(p, z)$  plane into six regions,  $\mathcal{R} \equiv \{R1, \dots, R6\}$ , each corresponding to a distinct role. In particular, we divide the  $p$ -axis into the *peripheral*, *connector*, and *kinless* intervals, and split the  $z$ -axis into the *non-hubs* and *hubs* intervals. The position of the point  $(p_i, z_i)$  within the tessellation  $\mathcal{R}$  determines node  $i$ 's role (Guimerà and Amaral, 2005). The criteria used to delimit the roles' regions are available in Supplementary Note S3 of the SM.

## Results

With Folder A and Folder F networks at hand, we analyse their structure to understand the IIIC's geographical organisation. Table 1 summarises some basic descriptors of these networks. Worth highlighting, both networks display a high amount of closed triangles  $\langle C \rangle$  (i.e. triples of nodes connected with each other), and a low average shortest path length  $\langle l \rangle$  between nodes. The joint presence of both properties is the hallmark of small-world networks (Watts and Strogatz, 1998). Additionally, and despite their sparsity (low  $\rho$ ), we notice that in both networks the largest connected component,  $S$ , comprises the vast majority of the system. Finally, more than 80% of the nodes in both networks have a self-loop. These features highlight the compact and well connected nature of the web of bi- and multi-lateral relationships between countries, as well as the presence of a significant amount of 'self-communication'.

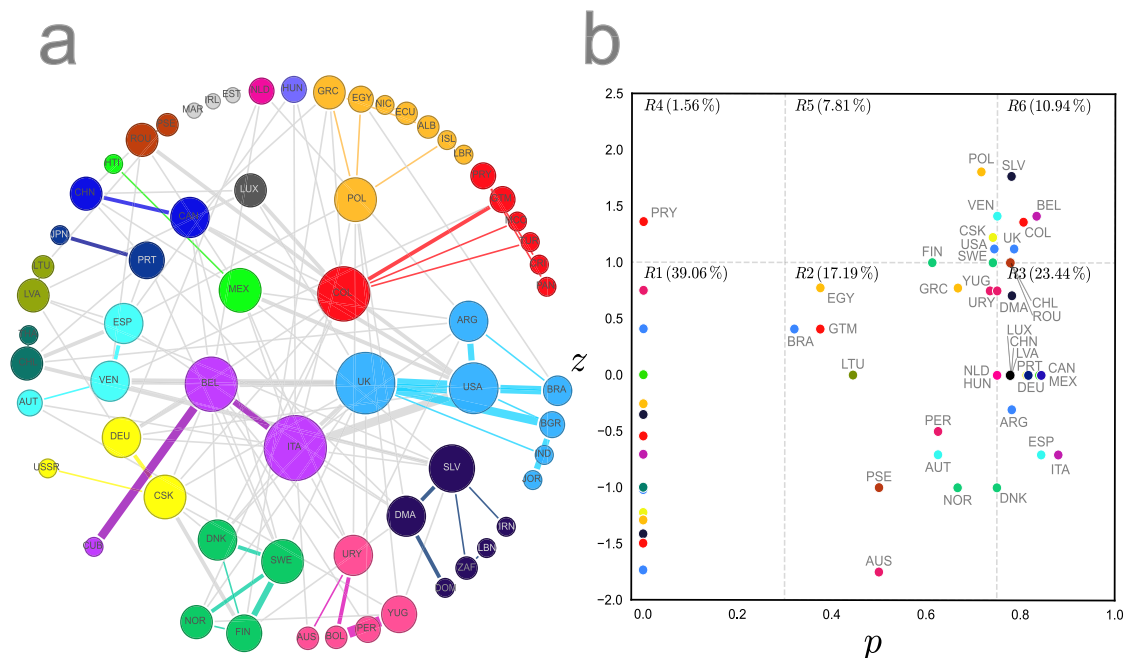
Going beyond these *macro* structural features, we are particularly interested in their networks' community structure. That is, the (possible) existence of modules within the networks emerging from the interaction patterns (Fortunato and Hric, 2016)—as opposed to some predefined partition that results from historical or cultural previous knowledge. With the term 'community' (or module) one usually refers to groups of nodes (i.e. countries) more tightly knit with each other than with the rest of the system. In our case, communities could arise from the existence of a shared history (e.g. Scandinavian countries) or from multilateral alliances.

One indicator to quantify how well defined is a network's community structure is the so-called *modularity*,  $Q \in [0, 1]$ , see Eq. (1) (Newman, 2006) in the Methods section. A large value of modularity ( $Q \gg 0$ ) implies the existence of well-defined communities, whereas  $Q \approx 0$  indicates their absence. Further, once a block partition has been identified from the networks, we focus on the *functional role* (Guimerà and Amaral, 2005) that each country plays in that community structure (see Methods). The following subsections explore these features.

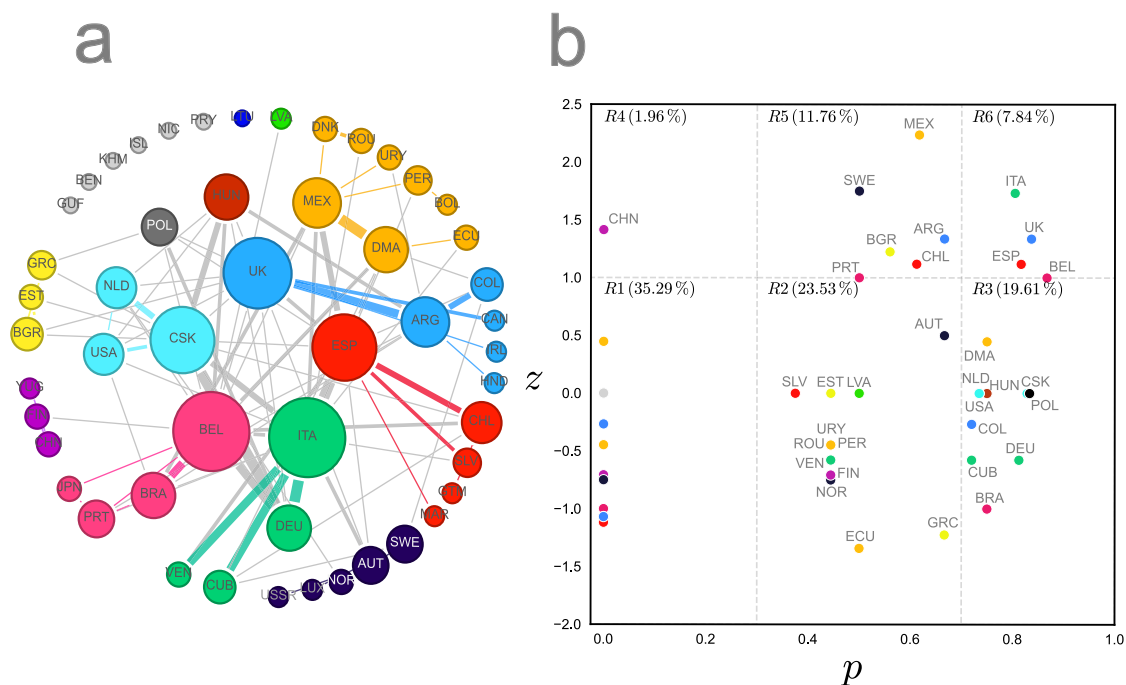
**The hierarchical organisation of the IIIC.** We extracted the community structure of our networks using a modularity maximisation algorithm (Traag et al., 2019) (see Methods). The community detection algorithm identified  $N_{\text{com}} = 14$  communities for Folder A and  $N_{\text{com}} = 17$  for Folder F, translating into a modularity of  $Q = 0.242$  for Folder A and  $Q = 0.303$  for Folder F, respectively. These values of modularity suggest that our networks do not possess a clear modular structure. However, the visual inspection of the *contact matrix plot* (i.e. the plots displaying the amount of letters exchanged between countries) displayed in Fig. S6 highlights the existence of a community structure, thus disproving our initial intuition. The disagreement between the low modularity values and observed community structure lays its roots in the presence of two countries, namely France and Switzerland, connected with a significant fraction of other countries.

These countries are, in fact, linked to a vast portion of the system: from the Paris-based IIIC's archive, France appears to exchange its correspondence with 85% of the countries in both folders, whereas Switzerland is connected to either 68% (Folder A) or 51% (Folder F) of them (see Table S9 of the SM for the details), corresponding to 83% (Folder A) and 73% (Folder F) of the available letters. These figures imply, in practice, that France and Switzerland behave like *broadcasters* in the system. Historically, this observation makes sense if we consider the role of Paris and Geneva as headquarters of IIIC and the ICIC, as well as the fact that both bodies benefited from Paris and Geneva's international character to cherry-pick their collaborators. Further, a deeper analysis of the history of IIIC tells us that Paris and Geneva exerted a strong cultural and political influence over the IIIC's structure, and had an internal dispute over its ruling as well as on the role of intellectual centres (Grandjean, 2022; Renoliet, 1999), going past the mere duplication of communication between these institutions. Structurally, the presence of France and Switzerland connected with a large portion of the other nodes induces a reduction in the values of  $Q$ , as the large amount of cross-community links dim the possible underlying modular organisation. In other words, our data analysis so far reflects the widely accepted consensus that Paris and Geneva acted as two competing centres (Grandjean, 2022).

However, it is possible to dig deeper into ICO's organisation, going beyond the well-known Franco-Swiss dominance. In particular, we are interested in surfacing the underlying flow of communication and emerging structure disregarding these



**Fig. 1 Network- and role-view of the countries in Folder A\*.** **a** Graph representing the pruned network Folder A\*. Community labels are represented by colour, and node size is proportional to its strength (sent-received correspondence). Some communities reflect historical or geographical affinities, but these alone do not explain the emergence of the structure. **b** Functional role of countries according to their position in the  $(p, z)$  plane for Folder A\*. Labels denote the countries' ISO 3166-1 alpha-3 codes. The colour of points is consistent with community membership in (a). Nodes in the structurally more relevant roles (R3, R5, R6) display a fair amount of diversity (North and Latin America, Western and Central Europe), but Africa and Asia are mostly relegated to peripheral roles (R1, R2).



**Fig. 2 Network- and role-view of the countries in Folder F\*.** **a** Graph representing the pruned network Folder F\*. Colour represents community membership, and node size is proportional to strength. As with Folder A\*, some communities reflect historical or geographical affinities (Table 2), but that is not the dominant pattern. **b** Functional role of countries according to their position in the  $(p, z)$  plane for Folder F\*. The colour of points is consistent with community membership in (a). Nodes in R6 are scarce and geographically homogeneous (in contrast with Folder A\*, Fig. 1b). Also in Folder F\*, Africa and Asia are mostly relegated to peripheral roles (R1, R2).

**Table 2 Organisation of countries into groups according to historical expertise.**

Group's name	Members
Western Europe and USA	France, United Kingdom, Switzerland, Germany, Italy, Belgium, The Netherlands, Spain, and United States of America
Central Europe countries	Austria, Czechoslovakia, Hungary, and Poland
Eastern Europe countries	Albania, Bulgaria, Greece, Yugoslavia, and Romania
Baltic countries	Estonia, Latvia, and Lithuania
Nordic countries	Denmark, Finland, Norway, Iceland, and Sweden
Ibero-American countries	Portugal, Argentina, Bolivia, Brazil, Colombia, Costa Rica, Cuba, Chile, Dominican Republic, Ecuador, Dominica, Guatemala, Honduras, Mexico, Nicaragua, Panama, Peru, Paraguay, El Salvador, Uruguay, and Venezuela
UK's Dominions	Australia, Canada, India, South Africa, and Ireland
Colonies	Egypt, Benin, French Guiana, Haiti, Turkey, Lebanon, Jordan, Morocco, and Palestine
East and South-east Asian countries	China, Japan, Cambodia, and Thailand
Middle East	Iran
Other countries	Luxembourg, Monaco, Liberia, and USSR

For each group, we provide its name and the list of its members. The countries listed are those available in either Folder A or Folder F.

countries' presence in the system. We do so by pruning France and Switzerland nodes (and their corresponding connections) off the network, and subsequently analysing the remaining graphs, which we denote as Folder A\* and Folder F\*. Table 1 highlights their main structural features.

#### A world beyond broadcasters: background flows in the IIIC.

Focusing on the structural indicators listed in Table 1 we notice that, despite the removal of the two main hubs, the networks are not dismantled, as the size of their largest connected component,  $S$ , decreases only slightly. In fact, 95% of the nodes in Folder A\*, and 86% of those in Folder F\*, belong to the largest connected component—that is, they remain attached to the bulk of the system.

The community analysis of Folder A\* and Folder F\* networks reveals—as hinted above—a sharp block organisation. The detachment of France and Switzerland has induced a significant increase in  $Q$ , with their values rising from 0.242 (Folder A) to 0.787 (Folder A\*), and from 0.303 (Folder F) to 0.676 (Folder F\*). These values are statistically validated against a null model, and exclude the possibility that the identified communities are the by-product of mere chance (Guimerà et al., 2004) (see Supplementary Note S2 of the SM). Figures 1a and 2a represent the resulting Folder A\* and Folder F\* pruned networks, respectively. In them, nodes are coloured according to their identified communities, and node size is proportional to its strength, i.e. the amount of communication that country is involved in. For visualisation purposes, nodes have been placed according to its across-modules communication.

To a certain extent, community membership can be easily explained by geographical proximity, cultural affinity, or geopolitical context: so happens with the bulk of Scandinavian countries in Folder A\*, gathered in a single community (Fig. 1a, in dim green); or the community dominated by Spain (ESP) and some Latin American countries, which were regrouped in some of the literary projects the IIIC stimulated, visible in Folder F\* (Fig. 2a, in red). Beyond these cases, the community structure in both folders (summarised in Tables S6 and S7 of the SM), reveals the existence of a non-trivial organisation. Indeed, most of the emerged blocks can only partially be explained through the canonical view on the relationships between countries during the interwar period: see for example Table 2, showing a possible grouping of countries according to historical expertise, and how it differs from the algorithmically inferred communities. Finally, it is important to remark that communities are quite different from Folder A\* to Folder F\*. Changes in community membership and/

or in position are the norm, rather than the exception. For example, United Kingdom (UK) and United States (USA) are unsurprisingly placed in the same module in Folder A\*, but remain quite apart in Folder F\*. Colombia (COL), on the other hand, is clearly a connector in Folder A\*, but remains quite peripheral in Folder F\*. Measuring the similarity between both partitions via the normalised mutual information (Ana and Jain, 2003) and the *element-centric* (EC) index of Gates et al., (2019) returns 0.64 and 0.29 (out of a maximum of 1), respectively, confirming the impression that communities in Folder A\* and Folder F\* differ.

These differences reflect a very interesting phenomenon: administrative and bureaucratic communication dynamics (Folder A, and its derived Folder A\*) yield a certain structure, which is very different from the one arising from artistic and literary matters (Folder F, and its derived Folder F\*). Such differences may be better grasped through functional roles in the context of the identified community structure. Indeed, sociologists have long characterised individual actors by the roles they play in social systems (Merton, 1957). 'Roles' here refer to patterns of behaviour associated to positions in a social structure. The network translation of this idea usually relies on the notion of structural equivalence and its looser version, structural similarity: actors playing similar roles will have similar patterns of connections with other actors in a network (Burt, 1976; Lorrain and White, 1971).

Among the operational definitions of roles (González-Bailón et al., 2014; Klimm et al., 2014), we present here the characterisation based on the work by Guimerà and Amaral (Guimerà and Amaral, 2005), assigning roles to nodes based on the analysis of their connections within and across groups/communities (see Methods). For each node  $i$ , we compute the *z*-score of its *within-module degree*,  $z_i$  (see Eq. (2), Methods), and its *participation coefficient*,  $p_i$  (see Eq. (3), Methods). The former quantifies how many connections one node has with respect to other nodes in the same community, whereas the latter measures to what extent a node's connections spread across communities. We divided the  $(p, z)$  plane into six regions (see Supplementary Note S3 of the SM for a detailed explanation of how we divided the  $(p, z)$  plane), each corresponding to a distinct role  $R$ . Specifically, nodes can be distinguished as *non-hubs* ( $R1, R2$ , and  $R3$ ) and *hubs* ( $R4, R5$ , and  $R6$ ), according to their value of  $z$ ; and as *peripheral* ( $R1$  and  $R4$ ), *connector* ( $R2$  and  $R5$ ), and *kinless* ( $R3$  and  $R6$ ), according to their value of  $p$  (Klimm et al., 2014). Worth highlighting, functional roles are specially suited to bridge all the descriptive levels in a network: they allow to spot a node's (microscale) position with

respect to communities (mesoscale) and the network as a whole (macroscale). In this sense, functional roles provide a richer interpretation than other descriptors, e.g. centrality measures (Wasserman and Faust, 1994) such as closeness or betweenness, which determine a node's importance in relation to the whole system—regardless of the presence or not of a community structure. Section Supplementary Note S4 in the Supplementary Material delves further in the differences and overlaps among these possible descriptors.

Figures 1 b and 2b show the position of countries (nodes) on the  $(p, z)$  plane. For consistency, points follow the same colour code as the graph visualisation on the left. Peripheral nodes in R1 (irrelevant in terms of connectivity and isolated with respect to modules other than their own) have not been labelled, to reduce the visual clutter (see Tables S11 and S12 in the SM for an exhaustive account). For the purpose of illustrating distinct communication dynamics in the folders, we will focus on roles R3, R5, and R6: those which truly glue the network together. In particular, nodes belonging to the R3 and R6 roles are also known as the *diverse club* (Bertolero et al., 2017). A shallow look to both folders'  $(p, z)$  plane already tells us that R6 in Folder A\* is quite populated, compared to Folder F\* (the same holds for R3). This means that the effort of maintaining the network connected is more homogeneously spread in administrative correspondence, while literary affairs depend on less (but stronger) actors, especially Italy (ITA), United Kingdom (UK), Spain (ESP), and Belgium (BEL)—the only ones in R6. Geographically, this difference in the connector countries points at a distributed (Folder A\*) versus exclusively Western-European (Folder F\*) functioning of the system: not only R6 in Folder A\* is shared by several countries, but these are more diverse—from Latin America, and East and West Europe and include peripheral actors within the organisation like Colombia and El Salvador. Note that also United States lies at the edge between R5 and R6.

At the other extreme, Figs. 1 and 2 highlight—within the two folders considered by our study,—the extremely peripheral role played by Asian and African countries. This fact can be attributed to unequal power relations in the political domain, which would be the case in colonial or imperial dynamics, as well as to uneven power relations in the intellectual domain. This is the case of most of Africa, the Middle East, and vast portions of Asia. India has only one connection (to United Kingdom) in Folder A\*, implying that UK mediated any participation of India in IIIC's governance. India does not even appear in Folder F\*'s network. Turning to China, we see it plays a bridging role as a kinless non-hub in Folder A\* (R3), and as a peripheral hub (R4) in Folder F\*. Japan, still lagging centuries of isolationism and upset with the outcome of the Treaty of Versailles, appears to be marginal in both folders' graphs.

Said findings do not coincide with Saikawa's conclusions on the role of China and Japan in the history of intellectual cooperation, a work written with a focus on the ICIC, rather than on the IIIC (Saikawa, 2014). This discrepancy points, in turn, to the need of further research, as well as the need to combine different archival records to fully decentring the history of intellectual cooperation.

## Discussion and conclusion

During the interwar period, the world witnessed unprecedented efforts to set a new style of international relations based on the cooperation of all of the countries of the world (Sapiro, 2009), albeit the reality of practice was much less universal and fair. The primary body of such new course was the LoN, founded in 1920, from which other organisations stemmed to transcend the mere political sphere. It was in this context that the IIIC appeared, amid a constellation of institutions promoting the internationalisation of the intellectual space. Despite their cultural

spirit, it is clear that the IIIC, and its related bodies, the ICIC and NCICs, were also a diplomatic lever and a space for the practice of soft power (Carbó-Catalan and Roig-Sanz, 2022)—such is the dominant narrative stemming from historians, and scholars from literature and arts (Grandjean, 2022; Renoliet, 1999).

As these institutions become centenarians, massive archival digitising initiatives pave the way to a better understanding of the influence dynamics occurring in those years at the international level (Institute for European Global Studies, University of Basel, 2017). International organisations are complex and multifaceted entities, where the actions of individual and collective agents converge. Among the latter ones, political, religious, professional, or gendered organisations are included, with each collectivity constituting one possible vantage point from which to examine the history of international organisations. In the case of the IIIC, we have selected countries as our vantage point. Rather than being the result of an unconscious reproduction of methodological nationalism, this choice is motivated by our interest in the political uses of intellectual and cultural activities (Carbó-Catalan and Roig-Sanz, 2022), as well as in the countries' role in complex scalar relations (Mansfield, 2005). However, it should be noted that the methodology presented here can be applied to characterise the actions of other collectivities and groupings.

The characterisation of the countries' roles within an international organisation demands the consideration of a multitude of factors, including the internal context of each country, the specifics of multilateral dynamics, and the distinctive levels of involvement of countries in different political areas, which are contingent upon their interests and traditions. In other words, the possible vantage points from which to reconstruct and characterise countries' involvement with international organisations are numerous. This, in turn, raises the question of how to construct a global history of international organisations (or of intellectual cooperation) that is sensitive to the existence of multiple perspectives, while at the same time enabling the generation of integrative narratives.

Taking up said challenge, in this article we have sketched a global characterisation of inter-country dynamics within the IIIC's work. To do so, we have adopted a data-based approach based on a portion of the correspondence preserved in the IIIC's archive, i.e. on two correspondence subsamples of those available in the IIIC's archive. By extracting the sender and receiver of the letters included therein, we have built a relational database with which we have reconstructed the network of correspondence flows at the country level: nodes are countries, and exchanged letters constitute the weighted connections among countries. The graph abstraction provides an intuitive—yet insightful—way to extract knowledge from relational data, especially when examined with network science methodologies (Schich et al., 2014), for instance, tools to detect the networks' communities and the latter's structure.

The methods and results presented in this work portray a partial, yet exciting, research avenue. First, our results confirm preexisting knowledge, but it also sheds light into invisible communities that have been overshadowed when scholarship has only adopted a qualitative approach. Our initial structural analysis at the macro- and meso-scale confirms the mainstream picture of a rampant dominance of IIIC activities exerted by France and Switzerland (Grandjean, 2022; Renoliet, 1999). As a matter of fact, such a dominance pervades the analysis to the extent that it blurs any closer inspection. For instance, the underlying community structure eludes the sensitivity of the available clustering tools. Then, our methods and results allow to extract new insights regarding the history of the IIIC. After removing France and Switzerland subtler channels of influence can be uncovered, pointing out the need to debunk an excessively Eurocentric (or at least Franco-Swiss-centric) approach

in the mainstream view about history of intellectual cooperation, and unearthing the emergent roles of supposedly peripheral actors within the organisation. Along this line, our results for administrative correspondence (Folder A/A\*) precisely reveal a distributed effort of countries spanning several continents to bridge different parts of the world geography. Instead, artistic and literary affairs (Folder F/F\*) are strongly mediated by a handful of Western European countries (Carbó-Catalan, 2024; Carbó-Catalan and Roig-Sanz, 2022; Grandjean, 2020; Roig-Sanz and Subirana, 2020). The disparate results observed in each thematic folder indicate the existence of dynamics specific to policy areas. The accrued country diversity in pivotal positions observed in Folder A/A\* suggests that, on a formal or diplomatic level, the IIIC was able to establish a relatively global network. However, the provincial character of the network of agents specialising in literary and artistic matters sheds light on the failure to develop truly global technical work, which in turn points to the existence of practical difficulties and implicit cultural biases and hierarchies.

Additionally, the networks' macro characteristics help us characterising the IIIC's global functioning. Such network presents a balance between local clustering (triadic relationships) and global connectivity (it is easily navigable from any node to any other in few steps), thus nicely falling in the 'small world' category. Further, its nodes and links are organised conforming a tight community structure. These features highlight the compact and well connected nature of the web of bi- and multi- lateral relationships between countries, as well as the presence of a significant amount of 'self-communication'.

Finally, our findings permit the formulation of several hypotheses for future research, particularly with regard to the community structure of both networks. Our findings have revealed the existence of modules within the networks that have emerged from the interaction patterns. These modules appear to reflect regional dynamics and multilateral alliances, which are worthy of further investigation from a qualitative perspective.

From a methodological standpoint, the reported new insights leave behind methodological questions which might be addressed tapping on a data-analysis approach firmly rooted in a historiographic research background. These questions might be: what happens if we study the information stored into each folder separately or all together using a layered network approach? (Cardillo et al., 2013). Also, we cannot overlook the fact that influence dynamics at the national level depend ultimately on the behaviour of individuals. From a complex network perspective, this implies modelling those dynamics at finer scales, e.g. considering cities, institutions, or individual agents rather than whole countries.

Finally, an expression of concern is necessary as well. Data are not neutral objects on which an aseptic analysis is performed. We should not neglect that, on top of a partial availability of the data—think for instance of countries and institutions which lack the resources for a comprehensive digitisation of their funds; archival dispersion; database incompleteness; or, unfortunately too often, plain irreversible documents loss—, current computational tools for handwritten text recognition, automatic transcription, named entity recognition are still far from perfect: human supervision and heavy fine-tuning are still needed. These pitfalls remind us that not all questions may be answered for the mere sake of digitisation, and that historical data can be a fertile ground if used both *for* and *in* the humanities.

### Data availability

The raw data used in this study are available in the CORA (Repositori de Dades de Recerca) public repository, available at: <https://doi.org/10.34810/data985>.

Received: 17 January 2024; Accepted: 19 September 2024;

Published online: 24 October 2024

### References

- Ana LNF, Jain AK (2003) Robust data clustering. In: Proceedings IEEE computer society conference on computer vision and pattern recognition, vol 2, p II-II
- Arenas A, Fernández A, Gómez S (2008) Analysis of the structure of complex networks at different resolution levels. *New J Phys* 10(5):053039
- Bertolero MA, Yeo BTT, D'Esposito M (2017) The diverse club. *Nat Commun* 8(1):1277
- Blondel VD, Guillaume J-L, Lambiotte R, Lefebvre E (2008) Fast unfolding of communities in large networks. *J Stat Mech: Theory Exp* 2008(10):P10008
- Burt RS (1976) Positions in networks. *Soc Forces* 55:93–122
- Carbó-Catalan, E (2024) Language and translation policies in the Intellectual Cooperation Organization (1922–1946). Promoting the internationalization of the intellectual field. PhD thesis, Universitat Oberta de Catalunya/KU Leuven
- Carbó-Catalan E, Meylaerts R (2022) Translation policies in the Longue Durée: from the International Institute of Intellectual Cooperation to UNESCO. In Roig-Sanz, D, Rotger, N, editors, *Global literary studies: key concepts*. De Gruyter, Berlin
- Carbó-Catalan E, Roig-Sanz D, editors (2022) *Culture as soft power—bridging cultural relations, intellectual cooperation, and cultural diplomacy*. De Gruyter, Berlin, Boston
- Cardillo A, Gómez-Gardeñes J, Zanin M, Romance M, Papo D, del Pozo F, Boccaletti S (2013) Emergence of network features from multiplexity. *Sci Rep* 3:1344
- Champanois R, Joyeux-Prunel B (2023) Visual Contagions: extraire et tracer la circulation d'images dans des imprimés illustrés. In *Humanistica 2023*, Circulations, Genève, Switzerland. Association Francophone des Humanités Numériques
- Dumont J (2018) *Diplomaties culturelles et fabrication des identités: Argentine, Brésil, Chili (1919–1946)*. Presses Universitaires de Rennes, Rennes
- Fortunato S, Hric D (2016) Community detection in networks: a user guide. *Phys Rep* 659:1–44
- Foucault Welles B, González-Bailón S (2020) *The Oxford handbook of networked communication*. Oxford University Press, USA
- Gates AJ, Wood IB, Hetrick WP, Ahn Y-Y (2019) Element-centric clustering comparison unifies overlaps and hierarchy. *Sci Rep* 9(1):8574
- González-Bailón S, Wang N, Borge-Holthoefer J (2014) The emergence of roles in large-scale networks of communication. *EPJ Data Sci* 3:1–16
- Grandjean M (2018) *Les réseaux de la coopération intellectuelle. La Société des Nations comme actrice des échanges scientifiques et culturels dans l'entre-deux-guerres*. PhD thesis, Université de Lausanne, Faculté des lettres
- Grandjean M (2020) Using network analysis to question the concepts of centrality and periphery in complex historical structures. In *Cultural organizations: between the local and the global (1880s–1960s)*, Barcelona, Spain
- Grandjean M (2022) The Paris/Geneva divide. In Carbó-Catalan E, Roig-Sanz D, editors, *Culture as soft power—bridging cultural relations, intellectual cooperation, and cultural diplomacy*. De Gruyter, Berlin, p 65–98
- Grandjean M, van Leeuwen MHD (2019) Mapping internationalism: congresses and organisations in the nineteenth and twentieth centuries. In *International organizations and global civil society: histories of the union of international associations*. Bloomsbury, p 225–242
- Guimerà R, Amaral LAN (2005) Functional cartography of complex metabolic networks. *Nature* 433:895–900
- Guimerà R, Sales-Pardo M, Amaral LAN (2004) Modularity from fluctuations in random graphs and complex networks. *Phys Rev E* 70:025101
- Hagberg AA, Schult DA, Swart PJ (2008) Exploring network structure, dynamics, and function using NetworkX. In Varoquaux G, Vaught T, and Millman J, editors, *Proceedings of the 7th Python in science conference*, Pasadena, CA USA, p 11–15
- Herrera HL, Wehrli Y (2019) América Latina y el internacionalismo ginebrino de entreguerras: implicaciones y resonancias. Secretaría de Relaciones Exteriores, Dirección General del Acervo Histórico
- Hunter JD (2007) Matplotlib: a 2D graphics environment. *Comput Sci Eng* 9:90–95
- Institute for European Global Studies, University of Basel (2017) League of Nations Search Engine. Available at: <http://lonsea.org/>. (Accessed on: 28 April 2023)
- Joyeux-Prunel B (2019a) Art history and the global: deconstructing the latest canonical narrative. *J Glob Hist* 14(3):413–435
- Joyeux-Prunel B (2019b) Peripheral circulations, transient centralities: the international geography of the Avant-Gardes in the Interwar Period (1918–1940). *Vis Resourc* 35(3–4):295–322
- Klimm F, Borge-Holthoefer J, Wessel N, Kurths J, Zamora-López G (2014) Individual node's contribution to the mesoscale of complex networks. *N J Phys* 16:125006

- Laqua D (2011) Internationalisme ou affirmation de la nation? La coopération intellectuelle transnationale dans l'entre-deux-guerres. *Crit Int* (3):51–67
- Latora V, Nicosia V, Russo G (2017) *Complex networks*. Cambridge University Press, Cambridge, UK
- Löhr I (2010) Die Globalisierung geistiger Eigentumsrechte: Neue Strukturen internationaler Zusammenarbeit 1886–1952. Vandenhoeck & Ruprecht, Göttingen
- Lorrain F, White HC (1971) Structural equivalence of individuals in social networks. *J Math Sociol* 1(1):49–80
- Mansfield B (2005) Beyond rescaling: reintegrating the 'national' as a dimension of scalar relations. *Prog Hum Geogr* 29(4):458–473
- Merton R (1957) *Social structure and animie. Merton social theory and social structure*. Free Press, New York
- Newman MEJ (2006) Modularity and community structure in networks. *Proc Natl Acad Sci USA* 103(23):8577–82
- Newman MEJ (2018) *Networks*. Oxford University Press, Oxford
- Oliphant T (2006) *Guide to NumPy*. Trelgol Publishing
- Renoliet J-J (1999) *L'UNESCO oubliée: La Société des Nations et la coopération intellectuelle (1919–1946)*. Éditions de la Sorbonne, Paris, France
- Roig-Sanz D, Subirana J (2020) *Cultural organizations, networks and mediators in contemporary Ibero-America*. Routledge, New York
- Saikawa T (2014) From intellectual co-operation to international cultural exchange: Japan and China in the International Committee on Intellectual Co-Operation of the League of Nations, 1922–1939. Ph.D. thesis, Heidelberg Universität
- Sapiro G (2009) *L'espace intellectuel en Europe: De la formation des Etats-nations à la mondialisation, XIXe-XXIe siècle*. Editions La Découverte
- Schich M, Song C, Ahn Y-Y, Mirsky A, Martino M, Barabási A-L, Helbing D (2014) A network framework of cultural history. *Science* 345(6196):558–562
- Traag VA, Waltman L, van Eck NJ (2019) From Louvain to Leiden: guaranteeing well-connected communities. *Sci Rep* 9:5233
- United Nations (1919) UN Archives at Geneva. Available at: <https://archives.ungeneva.org/> (Accessed on: 28 April 2023)
- United Nations Educational, Scientific and Cultural Organization (UNESCO) (2022) Archives database Access to Memory. Available at: <https://atom.archives.unesco.org/iic> (Accessed: 1 Jan 2022)
- United Nations Educational, Scientific and Cultural Organizations (UNESCO) (2023) UNESCO Archives. Available at: <https://www.unesco.org/en/archives> (Accessed on: 28 April 2023)
- van der Walt S, Colbert SC, Varoquaux G (2011) The NumPy array: a structure for efficient numerical computation. *Comput Sci Eng* 13(2):22–30
- Wasserman S, Faust K (1994) *Social network analysis: methods and applications*. Cambridge University Press, Cambridge, UK
- Watts DJ, Strogatz SH (1998) Collective dynamics of 'small-world' networks. *Nature* 393(6684):440–442

## Acknowledgements

The authors are grateful to A. Pam and E. Sengsavang of UNESCO's archive in Paris for their help with the data. The authors thank also V. Traag, N. Masuda, and S. Kojaku for helpful discussions, and M. Moreno and V. Ikoff for their help during preliminary and ulterior stages of this research. DRS, ECC, AC and RRC acknowledge the support of the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (project *MapModern*, Grant agreement No. 803860, PI DRS). ASR and JBH acknowledge financial support from the Spanish Ministerio de Ciencia e

Innovación, through project No. PID2021-128966NB-I00. AC acknowledges financial support from the Spanish Ministerio de Ciencia e Innovación, through project No. PID2022-141558NB-I00. JBH acknowledges financial support from the Ramón y Cajal program through the grant RYC2020-030609-I. This research has been carried out within the Global Literary Studies Research Lab (GlobaLS, IN3-UOC) funded by the Catalan Government, AGAUR (SGR 2021 01202).

## Author contributions

DRS and JBH secured funding; DRS, AC, and JBH designed the study; RRC and ASR collected, curated, and integrated the raw data; ECC conducted qualitative investigation to guide the quantitative analysis; RRC and AC performed the quantitative analysis; All authors analysed the results; AC and JBH wrote the paper; RRC and AC prepared the graphics. All authors read, reviewed, and approved the final manuscript.

## Competing interests

The authors declare no competing interests.

## Ethical approval

This article does not contain any studies with human participants performed by any of the authors.

## Informed consent

This article does not contain any studies with human participants performed by any of the authors.

## Additional information

**Supplementary information** The online version contains supplementary material available at <https://doi.org/10.1057/s41599-024-03829-1>.

**Correspondence** and requests for materials should be addressed to Diana Roig-Sanz, Javier Borge-Holthoefer or Alessio Cardillo.

**Reprints and permission information** is available at <http://www.nature.com/reprints>

**Publisher's note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



**Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

© The Author(s) 2024