Erschienen in: Journal Of Historical Network Research ; 1 (2017), 1. - S. 52-70
https://dx.doi.org/10.25517/jhnr.v1i1.6

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Hypergraph Representations: A Study of Carib Attacks on Colonial Forces (1509-1700)

Journal of Historical Network Research 1 (2017) 52-70.

Keywords

network analysis, directed hypergraph, centrality, colonization, Caribbean ethnohistory

Abstract

Network data consisting of recorded historical events can be represented as hypergraphs where the ties or events can connect any number of nodes or event related attributes. In this paper, we perform a centrality analysis of a directed hypergraph representing attacks by indigenous peoples from the Lesser Antilles on European colonial settlements, 1509-1700. The results of central attacks with respect to attacked colonial force, member of attack alliances, and year and location of attack are discussed and compared to a qualitative analysis of the data. This comparison points to the importance of a mixed methods approach to enhance the analysis and to obtain a complementary understanding of a historical network study.

LUXEMBOURG CENTRE FOR CONTEMPORARY AND DIGITAL HISTORY

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1 Introduction*

The study of networks commonly involves a set of actors or nodes, where ties are defined on the so called dyadic domain consisting of all possible pairs of nodes. These networks are represented by undirected or directed graphs, depending on whether the ties have a direction or not. There are however situations where supra-dyadic relations involving more than just two nodes need to be represented. For example, in the study of a collaboration network, the cooperation between actors may comprise of more than pairs. Analyzing this network as a simple graph would require the transformation of ties into two-way collaborations, thus losing information on the joint effort by multiple actors. Networks defined on the supra-dyadic domain can instead be represented as a hypergraph, which generalizes the notion of graphs. In a hypergraph, the ties, or the so called hyperedges, comprise of more than just two nodes that are potentially of different kinds. Put differently, a tie in a simple graph connects pairs of nodes, whereas a hyperedge connects a non-empty subset of nodes. Following the example on collaborations, a hyperedge can connect more than two nodes as part of a team. Other examples of applications include co-authorship networks (Han et al. 2009) and food webs represented as competition hypergraphs (Sonntag and Teichert 2004).

Historical data with complex event structures can be represented as hypergraphs in order to construct a narrative based on correct sequencing of events (Bearman, Moody and Faris 2002; Bearman 2015). In this paper, we use a hypergraph representation to analyze post-colonial attack data from the Caribbean interpreted by Holdren in the 1990s. Studying the history of the indigenous Caribbean from a network perspective has previously been emplyed in Hofman and Hoogland (2012); Mol and Mans (2013); Mol (2013); Hofman et al. (2014); Mol, Hoogland and Hofman (2015). The use of hypergraphs in this context is less established with the exception of the work by Bonacich, Holdren and Johnston (2004) where a notion of centrality for undirected hypergraphs is introduced and applied to attack data on colonial settlements Holdren (1998). Bonacich, Holdren and Johnston (2004) refer to their data as doubly supra-dyadic since more than two islands can be involved in an attack and each attack involved a year. With respect to these attributes, they aim to find the most central attacks. In this paper, we extend this analysis and use directed hypergraphs in order to distinguish between attack source

* **Acknowledgments**: This research is part of the project NEXUS1492, which has received funding from the European Research Council under the European Union's Seventh Framework Programme (FP7/2007-2013)/ERC grant agreement n° 319209.
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(alliances) and target (colonial settlement) given year and location of attack. We further explore the meaningfulness of the centrality results to shed light on the intense colonization period in the Lesser Antilles.

The organization of this paper is as follows. In Section 2 we present some historical background on the region of study and the data acquisition. Hypergraph representation of the data is introduced and shown in Section 3 followed by a centrality analysis in Section 4. The centrality results are compared to a more qualitative analysis of the data in Section 5 and in the final section we discuss limitations and extensions of the presented approach.

2 Data on Carib Attacks

The *Carib*[1], alleged migrants from the South American mainland, inhabited many islands of the Lesser Antilles when Europeans first navigated to the New World. The Spanish conquest of the Greater Antilles started an over 400 year period of colonization in the Caribbean with effects that still remain apparent today (Hofman and Hoogland 2012). This conquest had a more devastating impact on the economic, social and political organization of the indigenous societies there than what followed in the Lesser Antilles. The factors underlying this difference in repelling European colonists included strategic military responses taking place over a longer period of time in the Lesser Antilles and are further discussed and compared in Wilson (1993; 1997) and Beckles (2008).

European encounters in the Greater Antilles commenced with Columbus arrival in 1492 where the main focus was on Hispaniola, which was deemed as spawning more gold, followed by other islands including Puerto Rico. When Puerto Rico was conquered in the first decade of the 16^{th} century, Carib encounters with the Spanish became more frequent in the Lesser Antilles. These encounters included reciprocal raids between Puerto Rico and Carib from the northern Lesser Antillean islands, and two unsuccessful attempts by the Spanish to colonize Guadeloupe. The following century reflected a strong Carib resistance against Spanish attacks and it was not until the first decades of the 1600 that more persistent and direct pressure came from the English, French, and Dutch initiating their colonies. These colonies were different than those of the Spanish in the Greater Antilles, the Europeans were now better supplied, less dependent on the indigenous people and more interested in

1 The term Carib connects to the terminology used in the historical sources. Note however that we are aware of the complexity and the historical bias of the term used; the descendants of whom currently refer to themselves with the autonym Kalinago in Dominica and as either Kalinago or Garifuna on St Vincent (see Hulme and Whitehead, 1992,)

forcing the locals off their land to use it for crops (Wilson 1997). For example, the English established settlements on St Kitts (1623), Barbados (1627) and Antigua, Nevis and Montserrat (by 1635), while the French occupied part of St Kitts (1625), Dominica (1632), Martinique and Guadeloupe (1635). By mid 1700, the relations held between the English and the French with the indigenous populations were however very different. While the French integrated with the Carib society and achieved a closer relationship with the Caribs, the interest of the English was merely to exploit the lands for sugarcane plantations (Fraser 2014).

As the European colonization of the islands in the Lesser Antilles progressed, the indigenous peoples joined in alliances to resist the colonizing forces and to regain their independence. These alliances were also tainted by European rivalry and at times European factions allied with the indigenous population for strategic purposes. Holdren (1998) uses network analysis to model social exchange in Carib alliance networks after the European colonization. For this reason, she focused explicitly on Carib attacks on the European colonists, and therefore not including attacks the European colonists made on the indigenous inhabitants for which the latter in most cases simply retaliated. Her analysis shows that alliances between the Eastern Caribbean islands became more centralized as the European colonization progressed.

Bonacich, Holdren and Johnston (2004) developed a special network approach and applied it to data recorded in Holdren (1998) to assess centrality of attacks made by aggressive alliances, where alliances are defined as at least two islands or Amerindian groups joining against Europeans or other Amerindians. These two references are the core of the analysis in this paper. The 56 attacks recorded in Holdren (1998) and used in Bonacich, Holdren and Johnston (2004) are for our purposes further augmented and made less ambiguous. Augmentation is done by including more data points from Holdren (1998) listed as attacks on European colonists (that is, we do not only consider the aggressive alliance data) and by including attacks on Tobago as mentioned in Boomert (2002; 2016). The ambiguity is reduced by checking the source reference from where the data was originally recorded. For instance, in some situations the attack location is not given or the general term *Caribs* is used as part of an alliance but without indicating the island they are from. When going through source references, we clarified these kinds of question marks concerning the data. This clarification was done with the aim to have all observations comparable. Thus, we only included them in our data set if the following attributes of the attacks (of which we know the specific islands) are given: attacker, attacked colonial force, location of attack, and year of attack. These source references include de Rochefort (1666); Southey (1827); Barome (1966); Whitehead (1988), see Holdren (1998) for the complete list.

The augmented data resulted in 95 observations on attacks on five European settlement groups (French, English, Spanish, Dutch, and Courish) between 1509-1700. We do however note that the attacks that happened in the 16^{th} century are underrepresented in the present data (see e.g. Murga Sanz 1971; Alegría 1981; Moreau 1992; Sued Badillo 1995; Huerga 2006). The region of study is depicted in Figure 1 where islands part of an attack coalition or location are labeled, and can thus be used as a visual reference for the forthcoming narrative in Section 5. The members of alliances are shown in a network in Figure 2. A tie is present if two islands were part of the same alliance and the strength of ties represent the number of co-occurrences. As seen from Figure 2, Dominica and St Vincent appeared most often in a coalition together. We return to this observation for our analysis in Section 4 and 5.

Figure 1. A map over the Lesser Antilles where the labeled islands are part of the data.

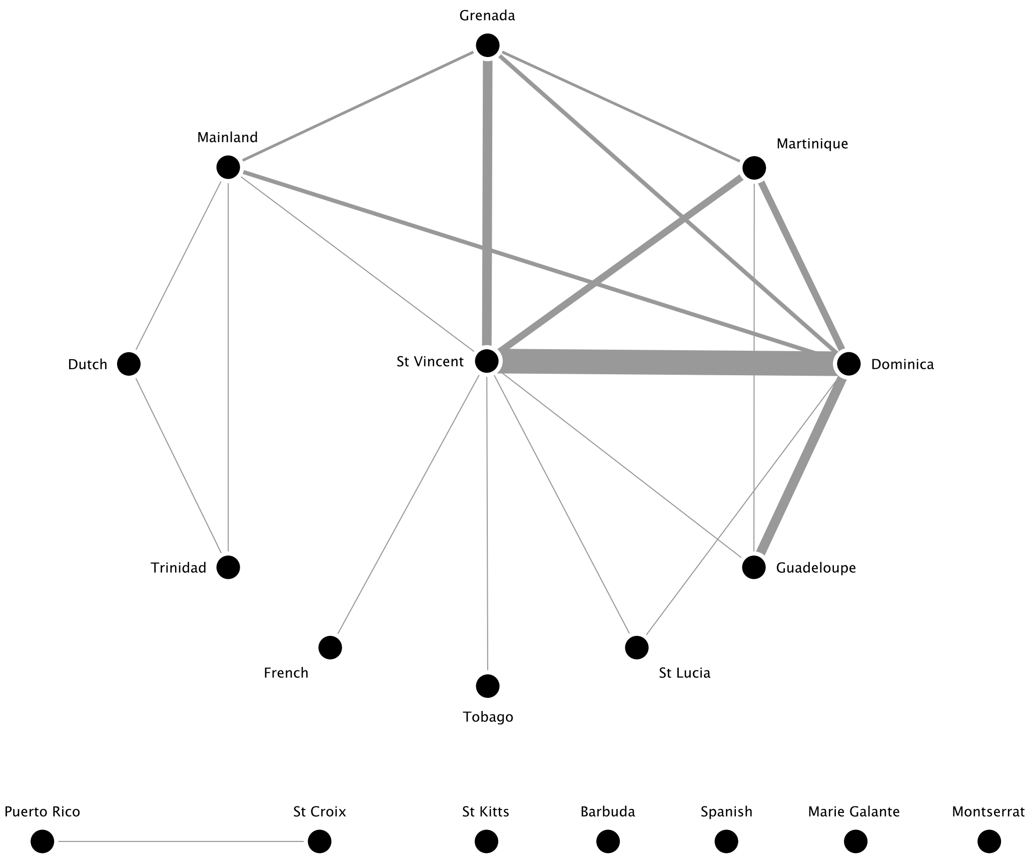

Figure 2. Alliance network where the strength of a tie indicates frequency of co-appearances in a coalition.

Following the approach of Bonacich, Holdren and Johnston (2004), we use the presented data to perform a centrality analysis of attacks on colonial settlements. This is done by using a directed hypergraph representation of the attack network data introduced.

3 Networks on Dyadic and Supra-Dyadic Domain

Networks are commonly represented by undirected or directed graphs consisting of a set of actors or nodes, with ties connecting pairs of nodes. These pairs of nodes are the dyads and the variables under study when analyzing network structural properties. Network data structures with a supra-dyadic property can instead be represented as a hypergraph where the ties, or hyperedges, represent an event under study. The hyperedges can connect any number of nodes, where each node corresponds to a situational attribute to the event. These attributes may for example be location and time for where and when the observed hyperedge took place, and important to consider for obtaining a richer descriptive picture regarding formulated research questions. These questions may for instance concern detecting the central events or central attributes of the event.

In Figure 3, two attacks from the data described in Section 2 are represented as an undirected and directed hypergraph. In the undirected representation, the two hyperedges include time of attack and the islands involved, where no distinction is made between the source and target island of attack. The directed hypergraph, however, does take this distinction into account. Here the directed hyperedges indicate who the attackers and attacked colonial forces are, while also considering coalition members together with location and year of attack.

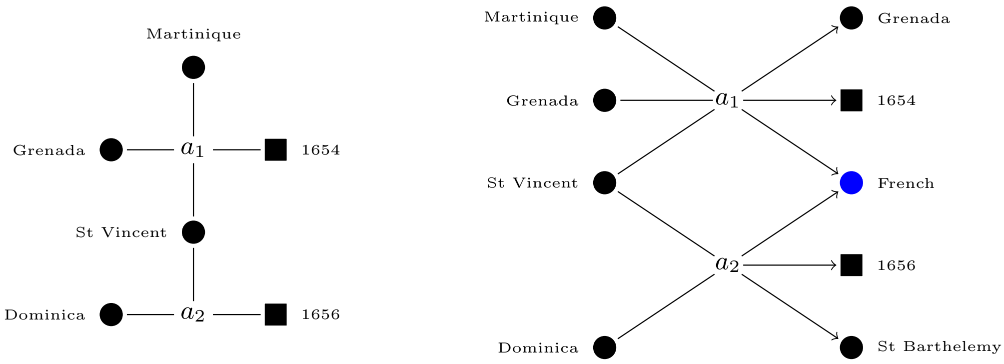

Figure 3. Two attacks (a_1 and a_2) from the Caribe data represented as undirected hyperedges considering attack location and year of attack (left), and as directed hyperedges considering source of attack (alliance), target of attack (the French), and location and year of when and where the attack took place.

For a dyadic binary network with n nodes and m ties, an $n \times n$ adjacency matrix is a common representation form, where two nodes are called adjacent if they are connected by a tie. An alternative way is to use an $m \times n$ incidence matrix, where two ties are called incident if they share a node. The rows of an incidence matrix for a dyadic network only has two non-zero entries since ties only have two nodes at each end. For an undirected network, these non-zero entries take on value 1 to indicate a tie, while for a directed network, these entries are either -1 or 1 to distinguish between the source and target of a tie.

An incidence matrix can also be used to represent hypergraphs. For the undirected case, each row has at least two non-zero entries since multiple nodes can be assigned to a hyperedge. The incidence matrix for the undirected hypergraph in Figure 3 is denoted E and given by

$$E = \begin{bmatrix} \overbrace{\begin{matrix} 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 \\ \vdots & \vdots & \vdots & \vdots \end{matrix}}^{\text{islands}} & \begin{matrix} \\ \cdots \\ \\ \end{matrix} & \overbrace{\begin{matrix} 1 & 0 \\ 0 & 1 \\ \vdots & \vdots \end{matrix}}^{\text{years}} & \begin{matrix} \\ \cdots \\ \\ \end{matrix} \end{bmatrix}$$

where the rows correspond to attacks a_1 and a_2, the first group of columns indicates the islands involved in the attack, and the following group of columns refers to year of attack. The incidence matrix for the directed hypergraphs in Figure 3 is denoted E_d and given by

$$E_d = \begin{bmatrix} \overbrace{\begin{matrix} -1 & -1 & -1 & 0 \\ 0 & 0 & -1 & -1 \\ \vdots & \vdots & \vdots & \vdots \end{matrix}}^{\text{islands}} & \begin{matrix} \\ \cdots \\ \\ \end{matrix} & \overbrace{\begin{matrix} 1 & 0 \\ 0 & 1 \\ \vdots & \vdots \end{matrix}}^{\text{locations}} & \begin{matrix} \\ \cdots \\ \\ \end{matrix} & \overbrace{\begin{matrix} 1 & 0 \\ 0 & 1 \\ \vdots & \vdots \end{matrix}}^{\text{years}} & \begin{matrix} \\ \cdots \\ \\ \end{matrix} & \overbrace{\begin{matrix} 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots \end{matrix}}^{\text{attacked}} \end{bmatrix}$$

where the rows correspond to attacks a_1 and a_2, the first columns are members of alliances initiating the attack as indicated by entries -1, followed by columns representing the location where the attack took place (Grenada and St Barthelemy), followed by columns for year of attack (1654 and 1656), and finally, followed by columns for the colonial force under attack (French, English, Spanish, Dutch, and Courish). Note that the islands in the first set of columns may be repeated in the location columns to circumvent hyper-loops which occur when the same island involved in the attack also represents the attack location.

An incidence matrix can be converted into an adjacency matrix by multiplying the incidence matrix by its transpose, which is called a one-mode projection. This is commonly done for affiliation or two-mode networks in order to obtain one adjacency matrix for the actors, and one for the groups that the actors are affiliated with.

In the next section we present the centrality approach of Bonacich, Holdren and Johnston (2004) which is based on incidence matrix E shown above, and its corresponding adjacency matrices obtained via one-mode projections EE^T and E^TE. Further, we extend this approach for calculating centrality scores in directed hypergraph using incidence matrix E_d.

4 Centrality Analysis

Bonacich, Holdren and Johnston (2004) show how the concept of network centrality can be adapted to supra-dyadic networks using the incidence matrix E. In particular, they show how to conceptualize eigenvector centrality in hypergraphs. Eigenvector centrality of a node is defined as a linear combination of the centralities that the node is connected to. This recursive characterization can be solved by means of eigenvector decomposition of the symmetric square matrices EE^T and E^TE. Formally, this is given by

$$EE^T = X\Lambda X^T \qquad (1)$$
$$E^TE = Y\Lambda' Y^T \qquad (2)$$

where X and Y are matrices with columns representing eigenvectors, and Λ and Λ' are diagonal matrices with eigenvalues. In the application of Bonacich, Holdren and Johnston (2004), the first column of X corresponds to centrality scores for attacks, and the first column of Y corresponds to scores for islands and years. More technical details can be found in Bonacich (1991) and Bonacich, Holdren and Johnston (2004).

In the application to Caribe attacks, Bonacich, Holdren and Johnston (2004) consider 56 attacks on colonial settlements involving 22 islands and during 29 years between 1509 to 1700. Thus, the incidence matrix E has the form shown in the previous section. They obtain the centrality scores for attacks, islands involved and years by using the eigenvectors corresponding to the largest eigenvalues of EE^T and E^TE. Their results can be summarized as follows. The most central islands involved in attacks were Dominica and St Vincent, and the most central years of attack are around 1650. Regarding island centrality, the authors do however note that the most active islands were the ones colonized in the later time periods. For both cases the authors additionally note that centrality scores are positively correlated with the frequencies of islands involved in attacks, and the years that the attacks took place. For instance, Dominica was involved in 39 of the 56 attacks, thus being the most active island in the data set. Moreover, the greatest number of attacks took place between 1640 and 1652. These observations show that the need for a sophisticated centrality concept is not given in the present context since simple degree based measures would yield the same results.

As an extension to the work by Bonacich, Holdren and Johnston (2004), we illustrate how to calculate centrality scores for the augmented data described in Section 2. This data set includes more attribute variables connected to the attacks, while also accounting for the direction of hyper-edges to separate islands that are the source of attacks and the islands that are the target location of attacks. We perform a singular value decomposition (SVD) directly on the incidence matrix E_d which is typically much sparser than its one-mode projections. The centrality scores for attacks are given by the first left-singular vector and for attack attributes by the first right-singular vector, respectively. Put more formally,

$$E_d = UDV^T$$

where the columns of U are the left-singular vectors, V are the right-singular vectors, and D is a diagonal matrix of singular values. The singular vectors actually are the eigenvectors of the one-mode projections in Equation (1) and (2), that is

$$EE^T = X\Lambda X^T = UD^2U^T$$
$$E^TE = Y\Lambda' Y^T = VD^2V^T \ .$$

The calculated centrality scores for each of the four attack attributes are shown in Figure 4 and the following is noted. The most central colonial force under attack were the French, closely followed by the English. The two most central locations where attacks took place were Antigua and Grenada. The two most central islands who were members of a coalition were Dominica and St Vincent. Finally, the most central year of attack is 1654 which is shortly before 1660 when the English and French signed a treaty leaving the islands neutral and in control of the indigenous inhabitants (Honeychurch 2000). Both of these results are consistent with those of Bonacich, Holdren and Johnston (2004), but our analysis can distinguish between source (alliance members) and target (location and attacked colonial force) of attacks.

As already noted by Bonacich, Holdren and Johnston (2004) and mentioned above, centrality scores are positively correlated with observation frequencies. The greater the number of observations for an attack attribute, the higher its centrality will be. This phenomena is also apparent in our results. Figure 5 illustrates this correlation for the four different scores measured. As seen, a strong positive linear correlation is present in all cases. The smallest error terms are seen for the top right figure showing members of coalitions and indicating that centrality here is strongly determined by how active participants are in forming attack coalitions. If an island participates in many alliances, it will receive a high centrality score. On the contrary, the highest deviations from the fitted lines in Figure 5 is noted for the two bottom cases. This can also be interpreted as centrality having a stronger explanatory power for attack year and attack location since observational frequencies are not as influential in determining centrality here. In other words, there is more confidence in interpreting 1654 and Antigua as the most central attack year and attack location, than it is to interpret the French as the most central colonial force under attack and Dominica-St Vincent as the most central alliance.

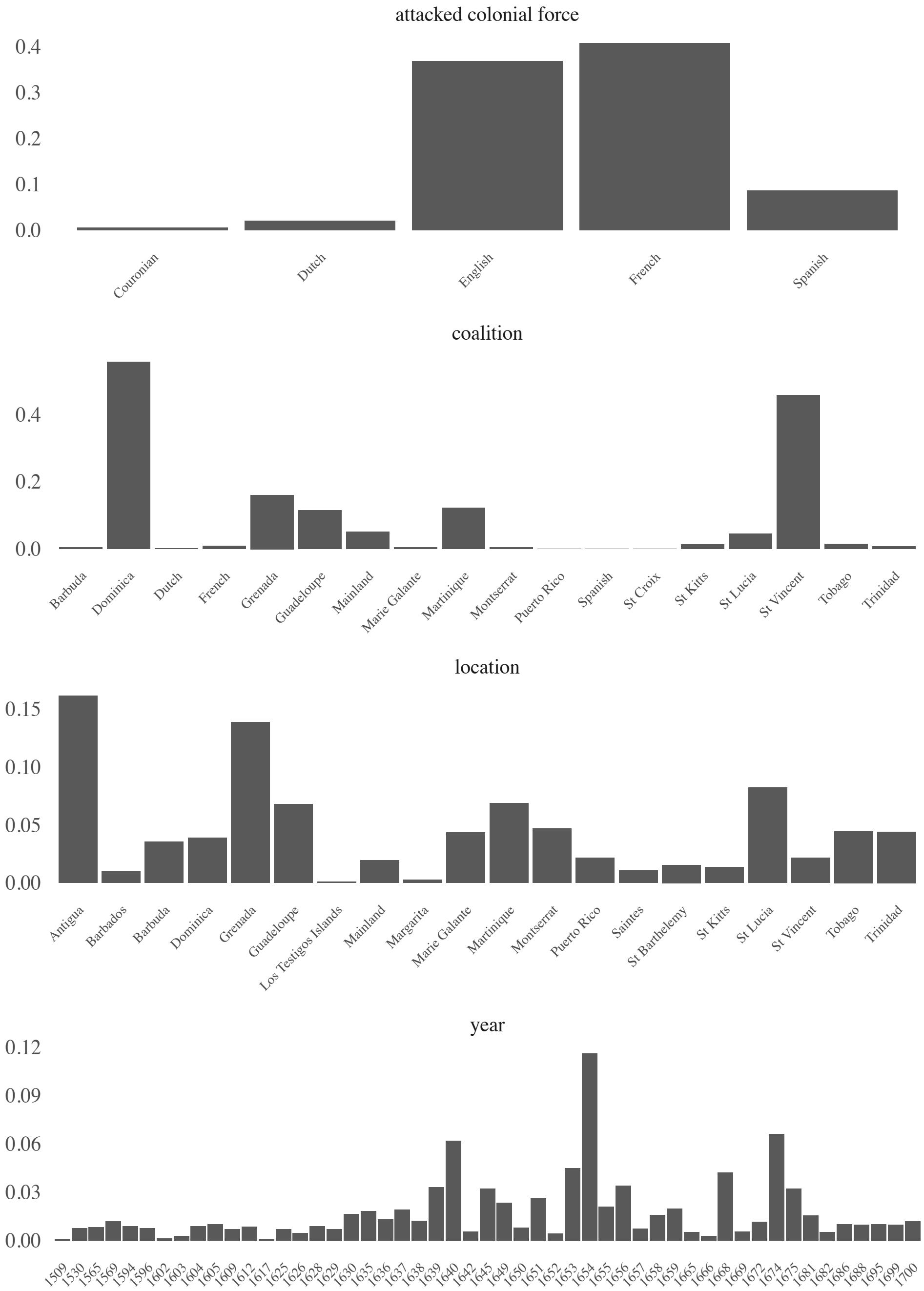

Figure 4. Centrality scores for attacked colonial settlements, attack alliance members, locations of attacks, and years of attacks.

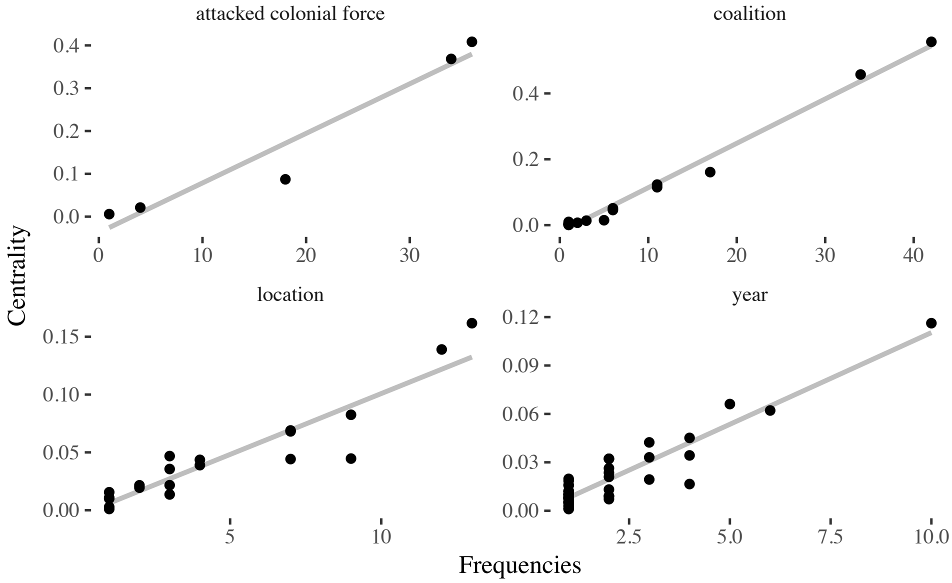

Figure 5. The linear correlation between centrality and frequencies of occurrences.

5 Further Exploration of the Data

In this section, we move away from the network perspective and treat attacks as individual events. The data is explored to find patterns that point to underlying processes which can explain the events.

Figure 6 shows the data in its entirety as an amalgamation of time lines split by source and target of an attack, and with marginal frequency plots. Dots on vertical time slices represent participation in attacks and the color of the dot indicates the attacked colonial force. Note that the islands are ordered top-down based on their geographical location north-south. Several trends consistent with historical facts are visible in Figure 6, some of which are mentioned in the following. As seen in Figure 6, we can roughly divide the time line into three periods 1500-1620, 1620-1660, and 1660-1700, with attacked colonial forces during these periods being the Spanish, the English and French, and the latter again in post-treaty context.

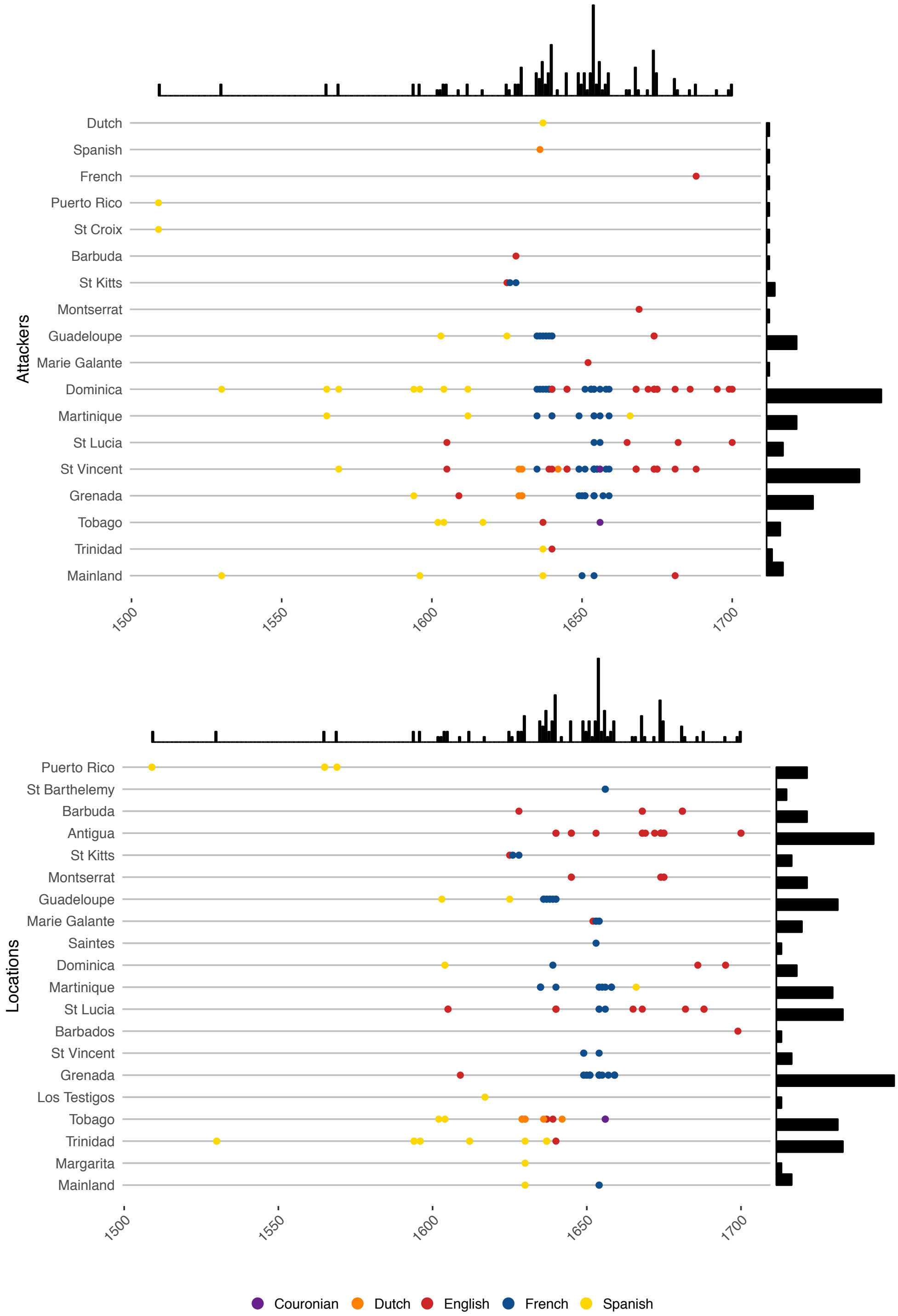

Figure 6. Time line of attacks by alliance members (top) and attack location (bottom) with marginal frequency distributions. Each dot represents an attack on a colonial force.

The first period reflects the presence of the Spanish as the sole main colonial force in the Lesser Antilles. Although they sporadically made efforts to gain ground in the east, the Spanish forces were more focused on the Greater Antilles; partly because they found the indigenous people there easier to subdue, and partly because they assumed the land to hold more gold and plantation prospects. Around the 1550s, the interest of French and English was increasing. English activity increased around 1580s with the goal of attacking the Spanish. They made landfalls in the Lesser Antilles with the main purpose of restocking and preparing for attacks in the Greater Antilles and the mainland coasts. Around 24 such landfalls are recorded between 1580-1600 (Wilson 1993; see also Moreau 1992). There were however unsuccessful attempts made by the English to establish permanent settlements in the Lesser Antilles, a few of which are visible in Figure 6. In 1605 the English attempted to colonize St Lucia but were swiftly repelled by Caribs living there and those arriving from St Vincent to counter attack. Similar resistance was met when the English aimed to colonize Grenada in 1609 (Wilson 1993). By 1610, the largest unconquered indigenous population inhabited also the largest of the Windward islands (Guadeloupe, Dominica, Martinique, St Lucia and St Vincent). They would participate in most of the resistance attacks to come in the following decades.

In the 1620s, the Dutch, French, and English became more successful in their colonizing missions and a battle intensive second period followed. As done against the Spanish in the 1500s, the indigenous population organized counter strategies to repel the Europeans. This organization included resettlement of Carib communities which the colonists took advantage of. The decreasing number of the indigenous population in parts of the Leeward islands, which already had experienced severe damage during the previous century, made them easy targets (Beckles 2008).

The more permanent English and French colonization began simultaneously on St Kitts where the two colonial forces split the island amongst themselves in 1625. The English part of St Kitts was used as a base for English colonization of the neighboring islands Antigua and Montserrat shortly after. In 1639, an English expedition to St Lucia was repelled and the year after the Caribs attacked English settlements in Antigua. The French part of St Kitts was used as a base to colonize the much larger Guadeloupe and Martinique in 1635, and St Martin and St Barthelemy in 1648. From Martinique the French colonized St Lucia in 1643 and Grenada in 1649, but failed to gain effective control in Marie Galante.

The third period 1660-1700 starts shortly after the peak seen in the bar charts on top of each plot in Figure 6. This peak reflects the increased intensity of the English and French colonizations giving rise to the highest number of counter attacks by the Caribs in 1654. When Carib women in Dominica got molested by the French in 1653, and a year later a French trader in Saint Vincent misbehaved too, complete Carib outrage was reached. The latter event triggered a series of attacks in which the Vincentian Caribs went first in attacking the French on several islands, the counter attacks by the French adding oil to the fire. After the English in the 1640s had secured Antigua in the north, now predominantly the French started to close in on Carib territory by taking possession of the Carib islands of Marie-Galante, Saint Lucia, the Grenadines and Grenada, a strategic Carib location in movements towards the mainland. The French agression, their ways to the North and South being blocked, and their strongholds of Dominica and Saint Vincent now being under threat too, seem to be the main reasons for the many Carib attack events for this specific year (du Tertre 1667; Boucher 1992). This was already noted in the centrality analysis of previous section with 1654 being the most central year. A decline of number of attacks followed after the French and English signed a peace treaty to leave Dominica and St Vincent to the Caribs as neutral territory (Boucher 1992; Honeychurch 2000).

Although a decline of attacks towards the French is seen in Figure 6 after the signing of the treaty, the number of attacks towards the English continues with Antigua being the most frequent attack location. The French had a closer relationship with the indigenous people, living among them, trading with them and providing them with military training (Fraser 2014). The English on the other hand focused on black slavery and sugar cultivation. This antagonistic relationship continued far into the 18^{th} century.

As mentioned in Section 2 and also noted in Figure 2, European groups allied with the Caribs to prevent colonization attempts made by other nations. For example, in 1637 the Dutch allied with the Caribs on Trinidad to attack the Spanish, and in 1688 the French joined forces with the indigenous people to attack the English. This interaction did however come to end by the 18^{th} century when the Caribs were forced into reserves on St Vincent and Dominica (Wilson 1997).

From the order of the alliance members and locations, we also see that the first period mainly involved islands in the north and south, with the islands in the center are involved in attacks during the later two periods. This is a noticeable feature prevalent in the data and not captured by the centrality analysis of the previous section. This north-south division reflects the Windward and Leeward Islands based on the prevailing trade winds blowing east to west. The center and more rugged islands were initially left 'neutral' because the larger part of the indigenous population of the Lesser Antilles was living there (and fleeing to), but potentially also because the lands were deemed less suitable for agricultural plantations. Dominica, however, despite being 'neutral' and one of the latest to be colonized, was the main place for colonists to refresh after their transatlantic journeys because of favorable currents and winds bringing them there (Moreau 1992; Honeychurch 2000).

In summary and consistent with results from the centrality analysis, the most frequent members of alliances are Dominica and St Vincent, and the most frequent attack locations are Grenada and Antigua, as seen from the peaks in the frequency bar charts on the right of each plot. The nomadic nature of the Caribs resulted in St Vincent and Dominica being two of the more heavily populated islands. Since the European colonization mainly focused on the islands in the peripheral parts of Leeward and Windward, the surviving indigenous population moved towards the center. Moreover, from an organizational perspective and given the geographic location of these two islands, it is logical to hypothesize that Dominica and St Vincent worked as central hubs in the alliance network. However, in order to test this hypothesis, an approach needs to be taken in which centrality over time is not treated homogeneously. This and related topics are briefly discussed in the next section.

6 Discussion

We use a hypergraph representation to analyze Carib attacks on European colonialists, 1509-1700. The major advantage of this approach is to keep the data in its original shape, without transforming it to a more convenient form which may imply information loss. We extend the work of Bonacich, Holdren and Johnston (2004) to calculate centrality in directed hypergraphs and apply it on a more detailed data set of attacks. However, we show that for this data set, observational frequencies are positively correlated with centrality scores. This means that we do not get further insight by only relying on the centrality results and need to consider alternative methods for detecting apparent trends in the data. To that end, we compare the centrality results to a descriptive analysis of the attack data. For our particular data set, these descriptives give more insight to the underlying historical trends. For example, the different European forces become more evident and the pattern of the European conquests not only provides insight into the changing Carib reactions to European intrusion, but also makes patterns of the European conquests more visually pronounced.

This points to the importance of not only relying on network analytic methods, but to also consider non-relational analysis of the data in order to find the most suitable approach. Moreover, this comparison also indicates the relevance of a mixed methods approach for analyzing network data Domínguez and Hollstein 2014; Bellotti 2014). Combining quantitative and qualitative methods in empirical research can provide a more thorough understanding of the contexts where the networks are created, and emphasizes the social reality in which networks are placed.

The attack data considered in our study is more heterogeneous than what the applied quantitative method in Section 4 allows for. The diversity in the alliance data is mainly temporal, but there are also strategic and opportunistic factors in how alliances formed over time. A static reading of the network over the whole period considered is therefore inadequate and a qualitative approach identifying these dynamics is needed. In Section 5, three time periods were distinguished and a further direction of the analysis could be to investigate the alliance network and calculate centrality scores with respect to these periods. In order to adapt the quantitative analysis to the trends apparent from the holistic reading of the data, more attack attributes can be included that account for the opportunistic and strategic factors underlying the formation of alliances and may thus also reflect the cost and beenfit of an attack. Such factors could be represented by geographical distance between the islands, number of troops or ships, number of casualties and the structural balance of actors ("the enemy of my enemy is my friend"). This is but one suggestion for future research.

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