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How inquisitive was medieval inquisition? A network-analytical approach to information flow in the trials for Brandenburg-Pomeranian Waldensians (late 14th c.)

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Abstract

In this study, we analyse a medieval inquisitorial campaign by conceptualizing it as an information process. We investigate how investigative decision-making was structured by testimony-driven data gathering. Our case study is Peter Zwicker's well-documented 1393–4 anti-Waldensian inquisition in Stettin. We explore the reconstruction of the inquisitor's strategy by examining the sequencing of interrogations and subsequent actions based on suspects' names appearing in previous testimonies. We assess the extent to which the process was adaptive, with suspects summoned dynamically based on new testimonies versus being guided by pre-existing knowledge. We apply network analysis and temporal visualization to incriminations operationalized as network data and use statistical methods to map the feedback between information retrieval and decision-making. Our analysis follows sequences of interrogations where deponents incriminated others on specific dates. This allows us to identify inquisitorial responses to accumulated data, distinguishing between planned strategies and reactive decisions based on new testimony. The challenge of missing data adds complexity and theoretical engagement. A substantial portion of the depositions is lost, yet we can estimate the original volume, enabling an assessment of the impact of data loss. We employ data imputation simulations to test how missing records might obscure evidence of follow-up strategies. The results indicate that network visualization must be complemented by statistical analysis. Comparisons between deponents' testimony types reveal an interplay between structured pre-planning and selective incorporation of new intelligence. By conceptualizing inquisitorial work as a dynamic information process, this study proposes a novel methodological framework for analysing historical trial documents.

Keywords: feedback loop; Waldensians; premodern trials; incrimination; medieval inquisition; dissent; information flow; network analysis; heresy.

1. Introduction

Records of medieval heresy trials are highly pertinent sources for the study of information collection and processing in premodern conditions. Thanks to some of their typical features, such as the noting of specific names and dates, inquisition records allow us to trace how information flowed through the process of investigation. By examining the temporal and relational patterns in the testimonies, we can explore how inquisitors gathered information, put it into connections, and utilized it.

The procedure of *inquisitio*, adopted as part of the legal transformations of the twelfth and thirteenth centuries, aimed at suppressing dissident religious practices and beliefs. The legal, social, and religious phenomenon commonly known as the inquisition of heresy built upon the re-adoption of theories of truth and evidence from the Roman law for investigating criminal cases, which left a strong mark on the development of European legal procedures more generally, including those outside the religious sphere (cf. Vallerani 2012). Despite the common misconception, the process of *inquisitio*, in which a judge took the initiative in prosecuting a crime *ex officio* rather than acting upon a formal accusation, was first conceived to investigate not heresy but clerical misconduct (Trusen 1988: 188–9), and its application to heresy trials required, in fact, several procedural exceptions (Kelly 1989, 2001).

The relatively coherent trial documentation of heresy inquisitions provides excellent data for quantitative

studies of different aspects of the legal process: for example, the impact of the secrecy of witnesses (Darwin 1940, 1941; Shannon 1955); the careful keeping of written records and their efficient use for social control (Given 1997; Kras 2020); the institution of corrective detention (Given 1997); and, last but not least, the gathering of new evidence from witnesses, which could determine the direction of subsequent investigation.

The last element mentioned, the gathering of evidence and its use as leads for further inquiry, embodies a very modern 'empirical' or 'inquisitive' approach to investigation. This approach has received considerable attention in the context of using medieval inquisition records as sources for understanding the cultures and behaviours of suspects (Merlo 1979; Patschovsky 1991; Del Col 1994; Arnold 1998, 2001; Biller 2001; Bruschi 2009; Zbíral and Shaw 2022; Pihko 2024). While it is generally acknowledged that inquisition records are often formulaic and serve primarily the well-defined purposes of the trial for heresy (Kelly 1989; Patschovsky 1991), scholars began to emphasize, from the 1960s onwards, the role of experience and feedback based on information gathered through investigation, which sometimes led inquisitors to depart from their usual frame of interpretation regarding heresy and its investigation derived from pastoral work or inquisitors' manuals. Some historians extended this notion into ascribing an 'ethnographic' value to some of the extant inquisitorial records. This perspective was pioneered by Carlo Ginzburg (1966, 1976, 1992) and Emmanuel Le Roy Ladurie (1975), who both, in spite of abundant criticism necessarily accompanying any paradigmatic work (Boyle 1981; Rosaldo 1986; Del Col 1996; Arnold 1998, 2001, 2003), helped to constitute what is still a major strand in the study of inquisition records. This perspective on inquisition records, and premodern trial records more broadly (Davis 1995, 2002), has even proved formative for anthropological approaches to history, allowing scholars to refocus on the culture of the non-elite, illiterate, and thus generally less visible strata of premodern European societies.

The collection and active use of information within trials for heresy can be understood as a generative principle behind entangled information flows, reflecting the inner workings of the inquisitorial procedure (Nieto-Isabel 2018; Pihko 2024). The present article proposes a formal approach for looking into some salient features of the process of the acquisition and use of information in one extensive inquisition register: the records of the investigation of more than 450 people by the inquisitor Peter Zwicker organized in the Pomeranian city of Stettin (modern Szczecin in Poland) in 1393–4. Our objective was to study information flow by looking at a specific type of information crucial for the investigation, the deponents' recorded mentions of other suspects, and follow the extent to which these nominations create observable patterns in the subsequent process which betray a feedback loop. We thus explore the inquisition of heresy as an information processing system, using the concepts of information flows and feedback loops between information retrieval and decision-making, which could help us uncover important mechanisms of its internal operation.

2. Peter Zwicker's campaign and records

The records of the heresy trials conducted by Peter Zwicker at the end of the fourteenth century offer a great example of methodical investigation and recording, allowing us to examine such information flows. In our analysis we use a recent redating of Zwicker's inquisition (Välimäki 2025) that revises the previously accepted dating by D. Kurze (1975). Zwicker arrived in the Hanseatic city of Stettin in late 1393, commissioned as an inquisitor of heresy by the bishops of Cammin, Brandenburg, and Lebus and the Archbishop of Prague. Supported by his assistant, Nicholas of Wartenberg, a fellow Celestine monk, and at least two lay servants, Zwicker started his inquiry that would last till 25 March 1394 and cover over 450 persons accused of belonging to the 'sect' of the Waldensians. The accused were members of the urban and rural low and middle classes: farmers, servants, craftsmen, and manual labourers. Some lived in cities and towns such as Stettin, Prenzlau, or Bärwalde (Mieszkowice), among the Catholic population. Others resided in small villages, such as Klein- and Gross-Wubiser, where most residents were more or less involved in the local Waldensian community (Wattenbach 1886; Kurze 1968; Kieckhefer 1979: 53–73; Cameron 2000: 124–44; Biller 2022; Välimäki and Zbíral 2024; Välimäki 2025).

The origin of the Waldensians can be traced to the conversion of Valdes of Lyon in the 1170s and his—and his early followers'—appeal to imitate the apostolic way of life that they shared with a broad array of other twelfth- and thirteenth-century movements. Condemned by the papal bull *Ad abolendam* in 1184, Waldensians became a comparatively widespread and persistent dissident movement of the High and Late Middle Ages. They condemned Purgatory and the cult of saints, refused to take oath, criticized the Church's property and what they considered the worldly lifestyle of its priests, and stressed biblical morals, repentance in this life, and confession to their own lay confessors and preachers, commonly known as Waldensian Brethren in modern research (Cameron 2000; Benedetti and Cameron 2022; Tasca 2024). In late medieval Germany, the Brethren visited their followers maybe only once a year or every two years.

Most of the time, the Waldensians in Brandenburg and Pomerania lived a double life, participating in Catholic services, confessing to their parish priests, and hiding their dissident allegiance (Kurze 1968: 77–87; Cameron 2000: 125–39; Välimäki 2021; Biller 2022: 170–5).

Zwicker's campaign against the Northern German Waldensians was part of a much larger persecution of German Waldensians that had started in the 1380s, culminating in the 1390s and in the early years of the fifteenth century, and continuing till the 1410s. Zwicker, together with his co-inquisitor Martin of Amberg/Prague, was a pivotal figure in this persecution from 1391 till at least 1404, leading inquisitions from the Baltic Sea to Austria and Hungary (Kieckhefer 1979: 53–73; Kolpacoff 2000: 247–61; Modestin 2007: 1–12; Välimäki 2019: 30–7). For reasons unknown, several Waldensian Brethren converted to Catholicism in 1390 or 1391. Two lists of converts, one containing eleven and the other twenty names, were compiled after the conversion. Twelve of the seventeen Brethren named in Stettin depositions as recent confessors of the local Waldensians are identifiable in one or other of these lists. Scholars agree that the conversion of what must have been the majority of German Brethren active at the time dealt a decisive blow to the Waldensian communities, depriving them of their respected religious figures and providing the inquisitors with followers' names and residences (Kurze 1968: 70–1, 79–81; Kieckhefer 1979: 57–8; Utz Tremp 1999: 166; Cameron 2000: 140; Modestin 2007: 2; Välimäki 2019: 116–7; Smelyansky 2022: 398).

This contextual knowledge allows us to assume that, even before the start of the process, Zwicker had enough evidence to convict at least some of the deponents. However, there are no lists of suspects or other similar written documentation preserved with the Stettin depositions, and so we have no way of knowing how detailed Zwicker's previous knowledge was when he arrived in Stettin. It is certainly not realistic to presume that the converted Brethren would have been able to list all of the over 450 deponents interrogated in Stettin. Most of the deponents had had only a few fleeting encounters with the Brethren (Välimäki and Zbíral 2024: 243; Välimäki and Zbíral 2025: 245–6), and there is no reason to assume that the Brethren could single out all or even most of the members of their dissident community. Consequently, information gathering either before the actual process or during the interrogations must have played a significant role in the inquisitor's efforts to root out heresy, and the best way to analyse it is through patterns of incrimination and summons to the court.

While we do not possess Zwicker's manual on how to conduct the inquisition of heresy in the form used in Stettin, we can reconstruct his approach reasonably well from the preserved versions which originate from his campaigns in Austria and Hungary in the late 1390s and early 1400s, and from his question lists and formularies transmitted in different inquisitors' manuals and compilations. The question lists in these manuscripts bear a strong resemblance to the Stettin inquisition records, and without doubt Zwicker used a very similar questionnaire in Stettin (Kurze 1968: 76, 1975: 17–8; Välimäki 2019: 104–70). Furthermore, some important aspects of the procedure and the information flow it built upon will necessarily remain unverbalized in inquisitors' manuals, but can still be reverse-engineered from the extant trial records.

Zwicker most likely opened his inquiry with a public sermon warning against the dangers of heresy and exhorting everyone with knowledge about heretics to testify. He then summoned suspects of heresy to court using public summonses or citations, read aloud in parish churches during mass on Sundays and festive days (when churches were most crowded) ordering those who were or had been involved in Waldensian heresy to appear before the inquisitor. Zwicker's formula for such citations in Upper Austria has been preserved in a St Florian manuscript (Välimäki 2019: 186–7). Finally, persons with a reputation (*fama*) of heresy were summoned personally, either by having their names read in their parish churches or by oral or written summons delivered directly to them. If needed, personal summonses were repeated, and the summoned were forced to come to the court under the threat of excommunication. Both oral and written summonses are recorded in Stettin depositions, as well as voluntary (i.e. unsummoned) arrivals (Wattenbach 1886: 24–6; Kurze 1968: 74; Välimäki 2019: 185–6).

Peter Zwicker has the reputation of being a flexible investigator, who adapted his questions to the deponents' level of understanding, formulated relatively neutral questions, and allowed answers that challenged his expectations (Kurze 1968: 76–7; Biller 2000: 255, 257; Modestin 2007: 124). His depositions are also extremely systematic and his apparatus of questions detailed and extensive (Utz Tremp 1999: 154, 160, 169, 177). Accordingly, his trial records contain no long diversions from the matter at hand—the deponents' involvement in heresy. In contrast to some other inquisition registers (Duvernoy 1965; Benedetti 1999), there is much more focus on the accused's own actions than on what he or she knew about others, and Zwicker was exceptionally interested in beliefs of the dissident laity (Biller 2005: 271–5; Välimäki 2019: 131).

The Stettin records are relatively short and concise in their expression, typically one handwritten and heavily abbreviated folio per deponent. All preserved records are the depositions of suspects of Waldensian heresy: in other words, there are no accounts where a witness would testify about other people without themselves being a defendant. Instead, the focus is always on the deponent. Nevertheless, when confessing their own involvement in heresy, they incriminated others and were specifically requested to denounce other Waldensians they knew. The preserved 195 depositions contain two cases (1 per cent) where suspects of heresy were exonerated. Both individuals had had only fleeting encounters with Waldensian ministers, they had not confessed their sins to them, and they did not hold any heretical beliefs (Kurze 1975: 153–4, 249–50). Thus, suspicion of heresy did not mean an automatic guilt even though acquittals were rare. On the other hand, the rest of the deponents seem to have been genuinely and knowingly involved in a dissident community and faith that challenged the Catholic Church.

3. Data and method

3.1 Data

Our dataset was manually compiled on the basis of Dietrich Kurze's (1975) edition of the Stettin inquisition depositions. Kurze's work is a selective edition of the 195 depositions that have survived from the original ca. 455, a count which was deduced by Kurze from the medieval deposition numbers (Kurze 1975: 18–9). While this edition, which omits many of the standard and formulaic answers, might present challenges for a study of Waldensian beliefs, it is characterized by a prosopographic emphasis, and minutely records all information relevant to the identification of individuals, including any references to locations. It was thus completely adequate for the purposes of the present study. From Kurze's edition, we manually collected relational data into several interconnected tables: a table of persons, a table of locations, a table of depositions, and a table of relations. In ambiguous cases, we cross-checked the edition with a digital reproduction of the original manuscripts.

The table of relations includes all interpersonal interactions and relations mentioned in Kurze's edition, alongside any spatial and temporal data. At the core of the data collection was dissident interaction, which was the dominant focus of the inquisitor's attention. The most typical form of incrimination was a description of the suspect's own dissident activity, often carried out together with another person, who was therefore also named. These relations were classified as 'Heretical interaction'. For example, when the widow Margaretha Cremer said that her last confession to a Waldensian minister had been 'at the home of her daughter in Mohrin' (Kurze 1975: 118), we created a 'Heretical interaction' link from the daughter (Margaretha Sibe) to the mother (Margaretha Cremer) with a second-level link type 'hosted confession' and location information Mohrin.

Where a deponent affirmed the heretical involvement of another suspect without specifying their own interaction with them, the relation was classified as 'Fama of heresy'. Many of these 'fama' links correspond to allegations the deponent made towards the end of his or her questioning. More specifically, after the deponent had confessed his or her own involvement in heresy, and before the inquisitor proceeded to the abjuration of heresy, the deponent was required to name his or her associates. A version of Zwicker's question list instructs the inquisitor to 'ask diligently about the accomplices' (Werner 1963: 274). In the deposition text these incriminations typically start with *Item nominavit* ('and she/he named'), followed by names of the denounced persons. For example, Margaretha Sibe, who had hosted her mother's last confession, named in her own deposition several persons stating 'that his husband Coppe Sybe is born in the sect, and she named [*nominavit*] her mother and another tenant Tele Tykyne, and her servant Peter Wrede of Gross-Wubiser, and two sisters, [first] Tele, who is the wife of Heyncze Wegener of Gross-Wubiser, and another Temel, the widow of Peter Reppyn, and also the daughter of her sister, named Trina, with whom [missing word] in Gossow, and her friends Trina and Geze, [and] Thyde Ermgart of Wubiser and Jacob Hildebrant of Gossow, their husbands' (Kurze 1975: 117). Margaretha Sibe's unusually detailed denunciation generated 'Fama of heresy' links between her and the named persons, in addition to kinship and social interaction links to define their relations to her and to each other. The main difference between 'Heretical interaction' and 'Fama of heresy' links is that in the former we know the exact form of interaction, often with temporal and location information, whereas the latter only signifies that these persons were members of the Waldensian community according to the deponent in question.

Beyond 'Heretical interaction' and 'Fama of heresy' relations, interpersonal 'Kinship' links were recorded on the basis of explicit mentions and logical inferences. For example, if two individuals shared a parent, they were classified as at least half-siblings, limiting the scope of inference vertically to three generations and horizontally only one level.

It was possible to collect a significant amount of locational data because Zwicker and his notaries were exceptionally systematic in recording the residence and

birthplace of the deponents. The location table records the name of the location, its type (village, city, etc.), its relation to other locations, and its geographic coordinates. Coordinates were coded manually on the basis of Kurze's disambiguation of the name variants with their modern German equivalents. As the region in question is situated at the border of modern Germany and Poland, many of the locations have Polish names, and we identified these with the help of local historical resources (Albert Heyde Stiftung 2023) as well as German and Polish Wikipedia. The coordinates were taken from Google Maps and GeoHack. When recording spatial information, we differentiated between explicit references—for example, 'in Bärwalde in Peter Beyer's house'—and inferred information. Inferred spatial references were made, for instance, where a deposition only recorded the owner of the house where a dissident interaction took place, omitting the settlement, which can nevertheless be inferred from other depositions.

The dataset derived from 195 surviving depositions out of ca. 455 covers:

- All individuals (529) out of a total of 1026 (mostly family members and personal relations) who were mentioned in relation to dissident activities in depositions.
- All relations between suspects mentioned, classified into the following categories: 'heretical interaction' (995 ties), 'fama of heresy' (592 ties), and 'kinship relations' (1,041 ties). Self-loops (self-incriminations) were excluded as irrelevant to this analysis, and multi-edges were simplified to only one edge.

The dataset is particularly rich in personal information, often capturing the age and origin of the individuals, their place of residence, and, in some cases, place of burial.

We projected this data on persons and their ties as a network of relations between persons, including only suspects participating in 'Heretical interactions' or 'Fama' incriminations. We were then able to analyse this projection within a clearly-defined relational framework. As depositions have a (partially inferred) date and deposition order, they form a temporal, sequential dataset. Building upon extant deposition dates and Kurze's (1975) reconstruction of the deposition order, based, in turn, on medieval document numbers, reliable dates can be ascribed to 187 out of 195 depositions (Välimäki 2025). Of the remaining eight depositions with uncertain dates, three can be placed exactly in the sequence of depositions through codicological evidence, and for the remaining five a probable order and approximate date can be inferred. The sequence of depositions is linked to data about persons, including the deponent and the persons incriminated by them. Personal data, in turn, include links to persons' residences.

3.2 Inquisition of heresy as an information processing system

Pihko's (2024) examination of inquisitorial records views them as texts shaped by processes of the selection and abstraction of information. In Pihko's perspective, medieval inquisitorial records were constructed through a complex flow of information (see also Nieto-Isabel 2018) shaped by the goals, interpretations, and constraints of inquisitors, deponents, and notaries alike. This flow of information was inherently entangled with social, political, and legal factors, as it emerged from interactions between historical agents who selectively contributed to and transformed information based on memory, social pressures, and procedural constraints (Pihko 2024). As Bruschi pointed out, both inquisitors and deponents had 'a will to drive the dialogue, to select the facts' (Bruschi 2009: 46).

While this entanglement emphasizes the multifaceted and sophisticated nature of inquisition records and suggests holistic and stratified approaches, we sought to further develop the information-theoretical path towards disentangling the flow of a specific type of information crucial to inquisition's operation, and explore the underlying mechanisms driving its process of investigation. We treated the inquisitorial process as an information-processing system that collects, evaluates, and documents information about individuals under suspicion. From this perspective, we could approach the records not only as legal documents but as a reflection of the inquisition's 'memory storage', or knowledge, containing abstracted data that reflect the underlying motivations and procedural decisions of the inquisitors (cf. Pihko 2024). We propose a means of studying some of the mechanisms behind the generation of the records which involved disentangling specific information flows and formally expressing the way the documented information was related to the organization of the process itself.

An observable element of the information flows is the follow-up mechanism using information gathered from previous deponents to make choices about summoning new deponents, as described by Nieto-Isabel and López-Arenillas (2021), who compare it to a snowballing process (also 2018: 87, 159, 226–9). The concept of snowballing, often used in social science research to describe one method of sampling, refers to an iterative process in which new research participants are added on the basis of their names being mentioned by previous participants. In the case of inquisitorial practices, snowballing implies a sequential uncovering

of suspects, where each interrogation potentially yields new names, which become objects of investigation, and decisions are made to collect evidence or assess the guilt of at least some of them. The proportion of such follow-up would be indicative of the degree of investigative decision-making (empirical 'inquisitiveness') within the process.

Such an investigative flow can be formally described as a feedback loop. In systems theory, a feedback loop is a process in which outputs (e.g. testimonies) are used to inform and adjust future inputs (e.g. decisions on whom to summon next). This concept, foundational to the work of theorists such as Wiener (2019) and von Bertalanffy (1969; also see Pouvreau and Drack 2007), has been crucial in various areas, among whom is the design of information retrieval systems that adapt based on user interactions (Spink 1997). In the context of inquisition, a feedback loop would naturally have formed between the information from testimonies and decisions to summon new deponents. It would have allowed inquisitors to refine their investigative focus on the basis of information from previous testimonies, embodying an iterative approach in which each piece of information could shift the course of the investigation. This feedback process, while a natural part of responsive investigation, would leave quantitatively analysable traces in the records, offering a pathway to explore the process's structure and strategic decision-making. A high degree of investigative feedback would signal a 'live' investigative approach, where new data actively shaped further interrogations. Conversely, an absent, weaker or less systematic feedback loop would suggest a process rooted in pre-existing knowledge, in which inquisitorial records served as legal documentation on deponents rather than as adaptive tools.

By analysing the sequence of depositions, we attempted to test to what extent prior testimonies influenced subsequent summons, revealing the system's level of responsiveness. We aimed to identify the connection between two key components in this feedback loop: (1) the systematic collection and organization of suspects' names and (2) the systematic organization of interrogations based on the sequential order in which deponents appeared. Together, these components indicate whether the inquisition's approach was more adaptive and 'empirical', or relied primarily on external, pre-existing information.

3.3 Method

Network analysis has gained much momentum in historical research, offering new insights into the social interactions and other processes documented in premodern sources (Brughmans 2010; Fazioli 2023). In this study, we used network analysis to assess the feedback loop between collected information and decision-making, and thereby to understand a crucial aspect of the flow of information within the inquisition process. Our primary objective was to understand the logic governing the sequence of depositions. This holds a key to the strategy employed by Zwicker in governing his decision-making process. Zwicker summoned suspected heretics either through general or personal citations, and these calls can be seen as a result of his specific decisions. We have no direct information on how often those decisions were made and revised. The list of deponents could theoretically have been drawn up before the actual inquisition began, or alternatively, after every interrogation session, newly uncovered names could have triggered the summoning of new suspects.

This process aligns with an investigative feedback mechanism described in the previous section, where new suspects emerge from testimonies, while summoning individuals 'out of nowhere' suggests reliance on external information, like a pre-existing suspect list. In our case, such a list would have likely been a combination of incriminations by the converted Brethren (see above) and information gathering before the actual process (e.g. see Kras 2020: 206–8). Such external resources unavailable to us would nevertheless be indirectly documented in the patterns of the information acquisition process within the source.

For quantitative testing and exploration, we applied statistical methods to measure relationships between the succession of deponents and the flow of information captured in the source. The flow is structured by the deposition dates but we also relate it to various characteristics of the deponents and to the unfolding relations between them and others. The sequence of depositions serves as a critical component for understanding how the information on the names of suspects moved through the network and was documented. However, more than half of the original depositions are missing, meaning that the recorded sequence represents only a partial view of the inquisitorial process, a fact that needs to be carefully considered while interpreting the results.

To uncover the generative processes behind the deposition order, including the possible effect of the personal and network characteristics of deponents and the hypothesized presence of feedback dynamics, we used the following methods: (1) temporal network visualization of the inquisitorial 'interrogation schedule'; (2) statistical exploration of possible follow-up patterns; (3) simple synthetic data simulation; (4) correlation analysis of deposition order and individual properties of deponents; and (5) temporal-spatial clustering of deponents residences.

We developed a visual representation of the network (1), which simultaneously illustrates the sequential, day-by-day progression of the inquisitor's schedule and the accumulation of incrimination connections between deponents. Together, these two elements expose how evidence was collected and organized, highlighting both the procedural structure and the strategic use of information during the investigation. Through this lens, the deposition records become a storage system potentially influencing future decisions. This connection between information collection and decision-making can then be followed as it progressed in time, distinguishing for each deponent whether or not they had been incriminated by others before. The visualization adopts a 'retrospective' project management perspective, reconstructing how the inquisitorial office might have perceived the deposition process as it unfolded. This layout arranges deponents according to the chronological order of their interrogations, depicting how information flowed across the process.

In addition to visual analysis, we also conducted a statistical analysis (2) of when, in relation to the day of their own deposition, deponents were incriminated by other deponents, that is, how many days before or after. This way we intended to expose the patterns of potential follow-up of incriminations. As part of this analysis, we compared the distributions of two different kinds of tie types, accusations of 'Heretical interaction' and 'Fama of heresy'.

To distinguish purely random patterns from those shaped by inquisitorial strategy, we implemented a simple imputation simulation (3), in which we also addressed the fact that approximately half of the depositions are lost. We generated synthetic deponents and depositions that adhered to observed statistical patterns and the known number of missing depositions, but simulated a random process without any strategic decision-making or historical influences. The patterns we included in the simulation were the distribution of incriminations per deponent, and measures such as the distribution of mentions before and after deposition and the proportions of the two mention types. Some of the synthetic deponents represented people incriminated by documented deponents but not known to be deponents themselves, others were entirely newly created. By integrating the imputed data into the broader dataset, we were able to qualitatively compare the empirical and simulated scenarios, assessing both the robustness of our analysis to missing data and the distinct traces left by a strategy-less process.

Furthermore, we used correlation analysis (4) to examine the strength and direction of associations between an individual's deposition order and various other variables, including their topological position within the network and the geographical location of their residence.

Finally, to further explore the spatial organization of depositions, we applied spatial clustering (5) using the K-Means algorithm. This clustering was then visualized in a temporal dimension (Fig. 6), using a similar calendar plot as in (1), but without connections, and colouring individual deponents according to their spatial cluster.

4. Quantitative analysis and results

To uncover the investigative feedback mechanism and provide a temporal overview of the information flow, we used a calendar network plot. This visualization helps to trace potential sources of information that may have guided decisions to summon specific individuals to give testimony. We visualized references by deponents to other persons as ties in a graph. We only explored references to people who also had been or were to later become deponents, discarding non-deponent suspects. Probably most of the discarded non-deponent suspects were in reality interrogated, but their depositions have been lost, and with the existing data we cannot ascertain when and if they were summoned. Therefore, they are not relevant to our detection of a potential feedback loop mechanism. We included the two aforementioned types of incrimination ties recorded in our data: 'Heretical interaction' ($n = 995$) and 'Fama' ($n = 592$). We then expressed how many deponents were mentioned before, or only after their own deposition in the available data (Table 1).

In the visualizations (Figs 1 and 2), red lines indicate mentions made before the appearance in court of a given deponent, while blue lines show mentions made afterwards. Similarly, blue nodes are persons mentioned only later (or during the same day), while red ones are persons mentioned by another before their own deposition. As seen in Table 1, only ∼12 per cent of deponents were incriminated for 'Heretical interaction' before their depositions, while ∼32 per cent were associated with 'Fama of heresy' before being summoned. In total, ∼68 per cent of deponents were altogether mentioned by others in any context (incl. kinship). The statistical difference between depositions describing 'Heretical interaction' and 'fama' is significant (Table 1; $\chi^2 = 8.7$; P-value ∼.003), indicating that

Table 1. Incriminations by type and timing of depositions

	Mentioned before own deposition	Mentioned after own deposition
Heretical interaction	23 (12.37%)	42 (21.54%)
Fama of heresy	62 (32.63%)	34 (17.84%)

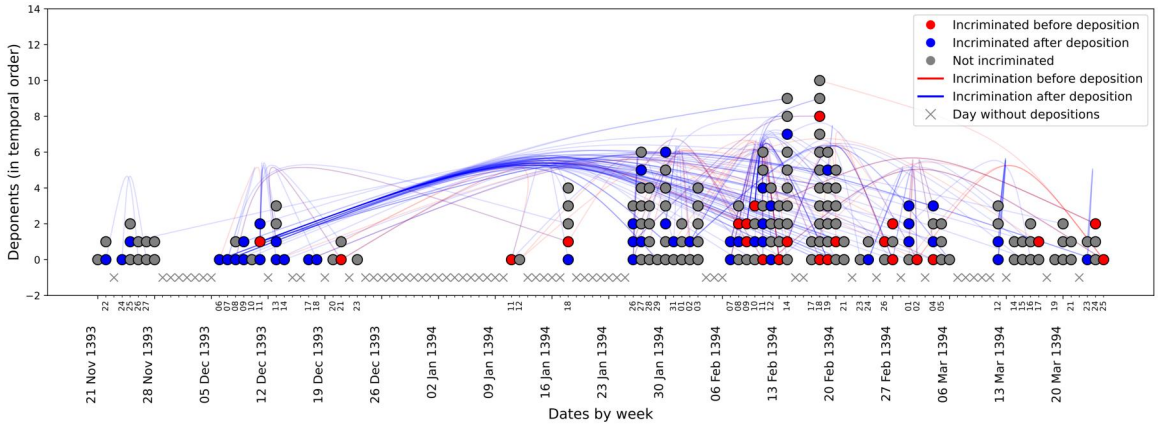

Figure 1. Deponents as interrogated by Zwicker and their incrimination status in 'Heretical interactions' by others. This visualization depicts in calendar format the sequence and connecting incriminations of type 'Heretical interactions' among deponents during the inquisitorial campaign. Each dot represents a deponent, arranged temporally according to their testimony along the horizontal axis (daily) and by textual order on the vertical axis. Dots are colour-coded to indicate whether individuals were incriminated before their testimony (red), after it (blue), or not incriminated (grey) by other deponents. Blue and red lines illustrate flows of incrimination before and after testimony. Days without recorded depositions are marked with 'X'. The image highlights the potential of the use of prior testimonies for evidence gathering in the interplay between investigative decisions and temporal progression.

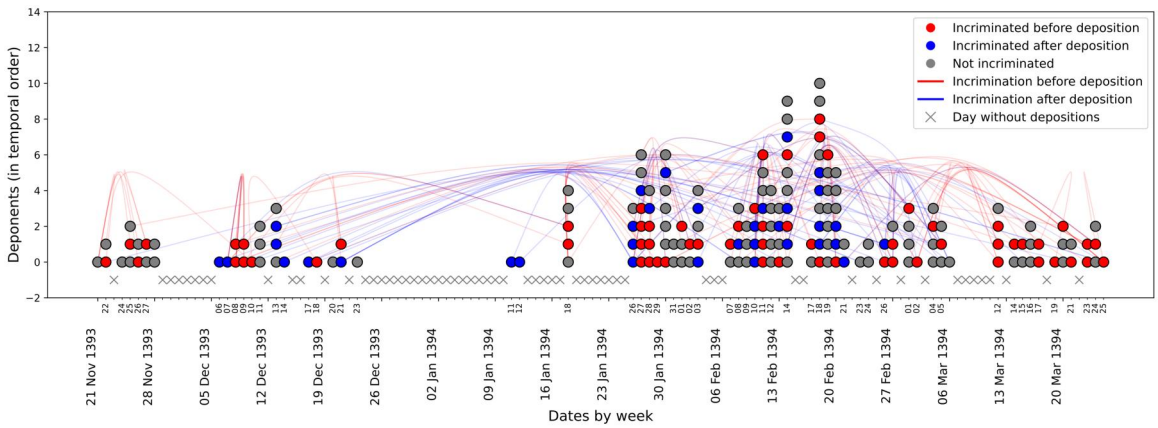

Figure 2. Deponents as interrogated by Zwicker and their incrimination status in 'Fama of heresy' by others. This visualization depicts the sequence and connecting incriminations of type 'Heretical interactions' among deponents during the inquisitorial campaign. The visualization follows the same logic as Fig. 1.

the difference among the distributions of these two mention categories is unlikely to be due to chance. This suggests distinct underlying processes of how each type of information shaped the progression of interrogations.

We know that a significant portion, more than a half, of depositions is lost. Therefore, we need to examine whether data on previous incriminations is robust to data loss. In the case of the Stettin protocols, we have the unique opportunity to address the significant gaps in the deposition records quite specifically, especially thanks to the medieval numbering of depositions as well as the known original total number of depositions. From the temporal point of view, we see continuous periods free of depositions, spanning multiple days (Figs 1 and 2). Although some of these might have been days without interrogations, most probably they illustrate the natural pattern of how a part of the original documentation went missing. Whole folios and even quires were lost when the original volume of the Stettin records was unbound and divided at some point in the Late Middle Ages or Early Modern Period (Kurze 1975: 18–31). A particularly large gap is between the medieval numbers 91 and

174. Five deposition fragments can be dated to this gap, but seventy-seven depositions most likely containing records of interrogations held in late January and early February 1394 have been completely lost.

We visualized the empirical distribution patterns of the two incrimination types, 'Heretical interaction' and 'Fama of heresy', for each deponent in temporal relation to their own deposition (Fig. 3). The visualization shows a clear difference between the dynamics of the two types. The red areas represent mentions made before the deposition, while blue areas correspond to mentions made after the deposition. The dashed line at day 0 marks the deposition day for each deponent, serving as the focal point for comparing pre- and post-deposition mentions.

From a follow-up perspective, the shape of the blue curve in both incrimination types primarily reflects a random process, meaning mentions after a deponent's interrogation arise from general network connectivity rather than a structured strategy. The distribution is also elevated by historical factors, such as the inquisitor deliberately asking about individuals who had recently been questioned. When the red peak—indicating pre-deposition mentions—is higher than the blue curve at a similar distance from the deposition day, it indicates a more deliberate process where the order of events was actively shaped by prior mentions leading to subsequent summons. This pattern, visible in 'Fama of heresy', indicates a follow-up strategy where mentions influenced who was called for interrogation.

For the 'Heretical interaction' incrimination type, mentions made before depositions were minimal, while those after showed distinct peaks. These peaks likely reflect group dynamics or specific events, as mentions often arose from deponents related by personal bonds incriminating one another on the same day. In contrast, 'Fama of heresy' displayed a pronounced pre-deposition peak, aligning with proactive decision-making by the inquisitor to summon individuals based on fama-based mentions. The difference indicates that 'Heretical interaction' was primarily used as legal evidence against the deponent him- or herself, whereas 'Fama of heresy' had the element of discovering new suspects.

Some deponents were incriminated in both categories before their depositions. However, for eight of the eleven deponents, mentions occurred within a short time span, not affecting the concerned patterns.

We simulated missing depositions using synthetic data to test the impact of lost records without assuming any inquisitorial strategy. This process, run as an

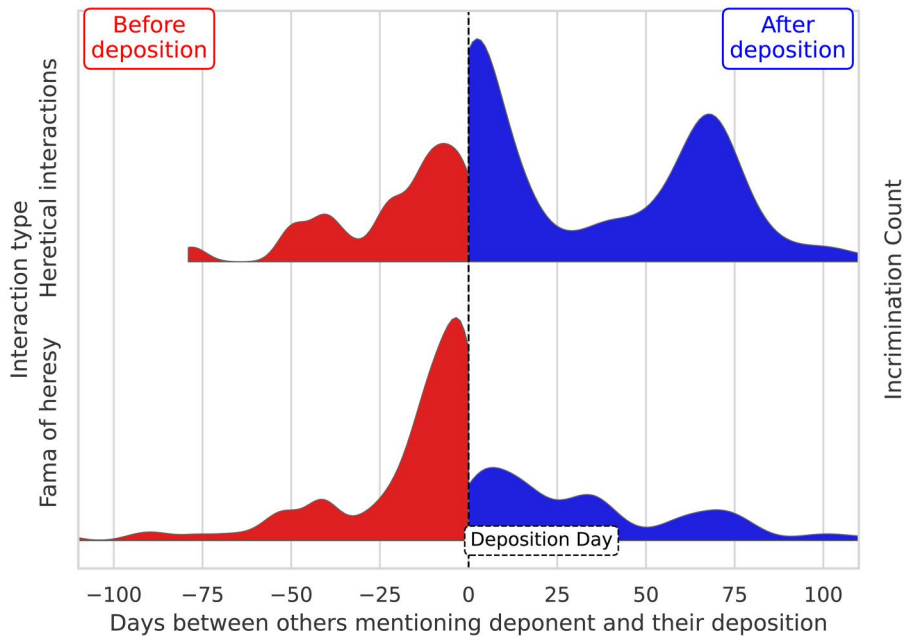

Figure 3. Temporal distribution of mentions of deponents relative to their deposition day. The plot shows the aggregated distribution of all deponents' mentions relative to their deposition day. The x-axis represents the number of days before or after their deposition that a deponent was mentioned by others, while the y-axis distinguishes between 'Heretical interactions' (top) and 'Fama of heresy' (bottom). Left-side (red) areas correspond to mentions before the deposition of a given deponent, and right-side (blue) areas to mentions after the deposition of a given deponent. In a random process, the distribution would resemble a symmetrical Gaussian curve. Deviations from this pattern, such as asymmetrical peaks, indicate strategies by inquisitors or external influences on the process.

imputation, maintained empirical statistical distributions and proportions of 'mentioned-before', 'mentioned-after', and 'not-mentioned' individuals but followed a random assignment of mentions. By adding 260 synthetic deponents and ca. 650 interactions, the simulation produced a significantly denser framework of incriminations. Since it did not assume any strategic follow-up mechanisms, it generally formed a flat Gaussian curve (with interruption in the centre due to the empty 0 day; Fig. 4), making the patterns in 'Heretical interactions' and 'Fama of heresy' indistinguishable. The distribution of such 'Fama' incriminations in data extended with simulated deponents and incriminations failed to reproduce their pattern in the empirical data alone, thus indicating that the pre-deposition peak in 'Fama'-type incriminations is actually due to specific decision-making processes. This pattern is not visible at all for incriminations based on specific evidence of the 'heretical interaction' type.

To explore further what dictated the sequence of depositions, we constructed a correlation matrix based on Pearson correlation between deposition order and several variables available in our data. Those included the deponents' residential locations, their demographic variables, and their positions within kinship and incrimination networks expressed through centrality measures. An illustrative selection of these measures is plotted out in Fig. 5.

The correlation analysis revealed a significant relationship between deposition order and spatial metrics, particularly the distance from the town of Stettin. This finding points to a spatially-informed logic underlying the inquisitorial strategy: individuals residing in proximity to Stettin were typically summoned for interrogation earlier than those dwelling farther away. The only other variable with meaningful effect was also of a spatial nature: spatial centrality. We found no evidence that the inquisitor prioritized suspects with the most links on the basis of prior incriminations, despite using pre-existing evidence in the inquisition which points to a non-hierarchical organization of the process.

To get a more detailed understanding of the significant and hitherto unrecognized spatial logic revealed by our analysis, we clustered the deponents by the locations of their residences. For clustering, we used the k-means algorithm to spatially cluster residences into eight separate regions, which is reasonably effective for the algorithm. In Fig. 6, nodes are coloured by the cluster they belong to. Nodes without spatial information are coloured grey. The plot shows that the interrogation process was indeed spatially ordered, even if without very clear-cut boundaries between different regions. In other words, people generally came approximately at the same time as people from the same region, even if they were not interrogated exactly during the same days. Deponents from some localities (e.g. Gross-Wubiser and surrounding areas, coloured brown) were continuously coming to depose, but still have a peak time period.

5. Discussion

Our analysis of information flow and feedback in the 1393–4 Stettin inquisition evidences the extent of investigative follow-up on newly-named suspects, the impact of lost depositions on our findings, differences in follow-up between specific illicit interactions and general 'Fama', and the influence of external factors such as geographic proximity on deposition order.

We assessed the extent to which the inquisition followed an 'empirical' approach, where suspects named in depositions were later summoned, this indicating investigative snowballing. If no leads were followed, mentions before and after depositions would be proportionally similar, with early deponents mentioned mostly after and later ones mostly before. Deviations from this baseline would suggest strategic decision-making or the influence of specific historical events.

Some follow-up is undeniable and well documented even through specific examples, such as the case of the

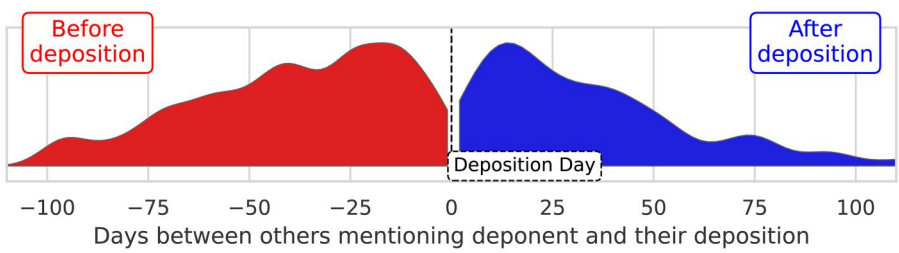

Figure 4. Temporal simulated distribution of mentions of deponents relative to their deposition day. The plot shows the imputation simulation by random scenario using the aggregated distribution of all deponents' mentions relative to their deposition day. The x-axis represents the number of days before or after their deposition that a deponent was mentioned by others. Left-side (red) areas correspond to mentions before depositions, and right-side (blue) areas to mentions after. Although it includes about half of empirical data, the distribution resembles a symmetrical Gaussian curve with minor additions from strategies by inquisitors or historical events.

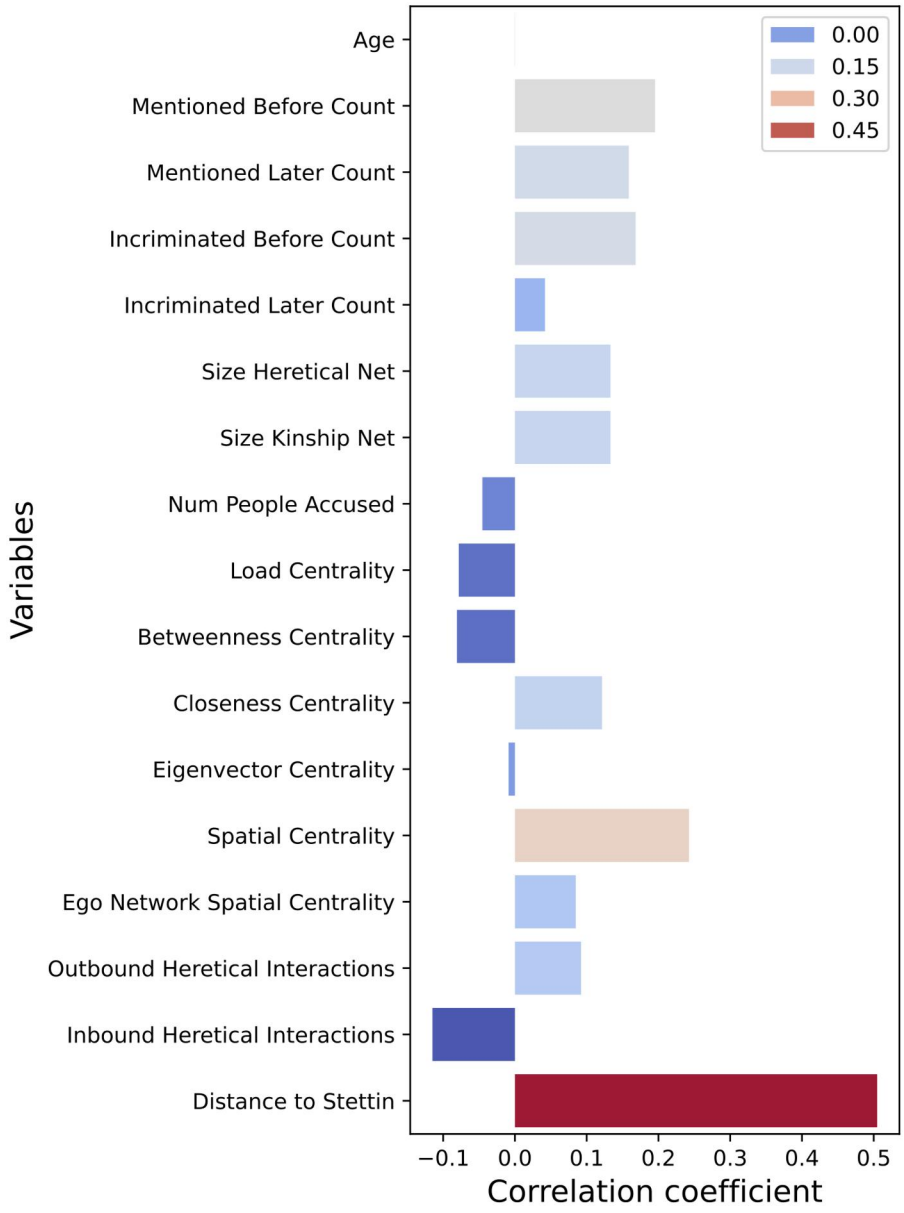

Figure 5. Correlation of deposition order with individual deponents' variables. This bar plot illustrates the correlation coefficients between deposition order and various deponent variables. Positive correlations indicate factors associated with deposing earlier if the factor grows, while negative correlations suggest a tendency for deposing later. The strongest correlation is observed with 'Distance to Stettin' (0.45), highlighting the spatial organization of the inquisition.

married couple Claus and Geze (or Gertrud) Walther from Gross-Wubiser. Claus was interrogated on 10 February 1394, and he denounced his wife. A little over a week later, on 18 February, Geze Walther appeared in court and was mentioned to have been summoned personally through a letter delivered by her parish priest. Such personal summons and interrogation within a week's time is best understood as the outcome of the inquisitor learning about Geze's involvement in heresy from her husband (Kurze 1975: 159, 236; for deposition dates, see Välimäki 2025, Appendix).

Globally, however, it turns out that in the extant depositions, a surprisingly small fraction of deponents were incriminated by others before their deposition—specifically ∼12 per cent (23 deponents) with the 'Heretical interaction' type of incrimination and ∼22 per cent (42 deponents) with the 'Fama of heresy'

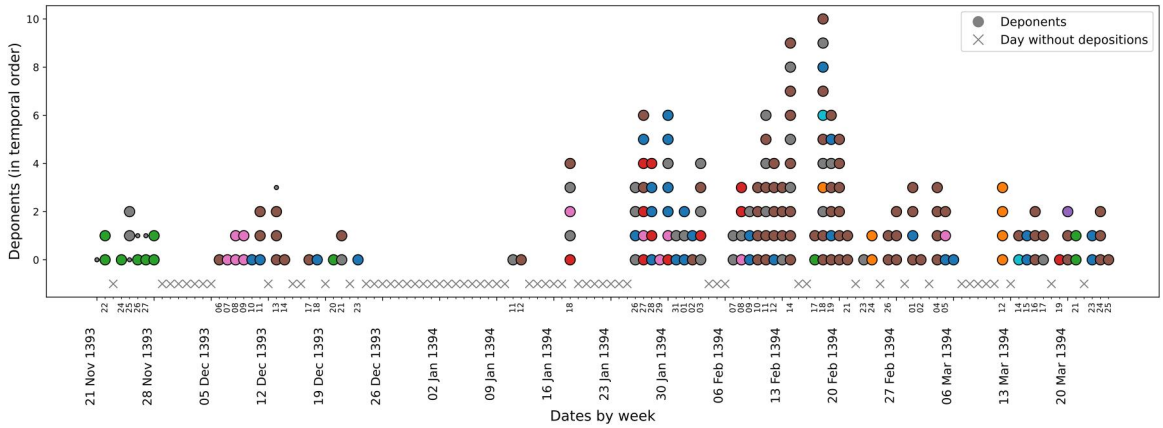

Figure 6. Spatial clustering of deponents in temporal progression. This visualization shows the spatial clustering of deponents based on their residences. Each dot represents a deponent, arranged temporally by their deposition date on the horizontal axis. Colours indicate different spatial clusters derived from the geographic locations of the deponents' residences. Grey dots represent deponents with unspecified clusters (unknown or ungeocoded location). The clustering reflects a tendency for deponents from the same or nearby locations to appear generally around the same time, suggesting spatially informed decision-making in the inquisition process.

incrimination. It is, moreover, important to underline that not all deponents who had previously been mentioned would have been called to appear due to genuine investigative follow-up: for instance, when investigating a closely connected local community, some deponents who were already bound to appear in court would inevitably have received preceding mentions. Our imputation simulation—which presumed no follow-up strategy, and, according to which, all of the simulation-generated mentions before one's deposition could thus be assumed coincidental to the later appearance of deponents—produced significant growth within this pool of previously mentioned deponents: about one-third of the whole. This illustrates that not all deponents mentioned before their deposition were summoned because of those mentions. A similar random process is shown by the continued appearance of post-deposition mentions, even after a deponent's case had been closed.

Therefore, as far as the preserved data go, the evidence of potential follow-up is limited, much more limited than we would expect from the 'empirical' and testimony-based approach to investigation that the medieval inquisition of heresy is usually thought to have impersonated. Due to the loss of over half of the original depositions, our data certainly may underrepresent the investigative feedback loop as illustrated by the random simulation. Nevertheless, we can assess the role of follow-ups using comparative statistical analysis of the incrimination types.

The analysis of incrimination patterns across the two types of incriminations allowed us to further understand the role of two different types of newly-acquired information for guiding decisions. The comparative distribution plot of the 'Heretical interaction' versus 'Fama' incrimination types (Fig. 3) illustrates the dynamics of mentions during the inquisitorial process, distinguishing between random processes and deliberate strategies. If mentions of names were entirely random, the statistical distribution would approximate a bell-shaped curve centred on the deposition day, reflecting a random Poisson process (see Fig. 4. for the illustration of such randomness dominating over a historical process). Deviations from this expected pattern, such as asymmetries or distinct peaks, suggest deliberate investigative strategies or external influences. From the perspective of follow-up, however, the distribution curve of mentions occurring after a deposition largely aligns with randomness, even though other effects—such as the inquisitor specifically asking about a previously interrogated person—could also contribute to its shape.

For 'Heretical interaction', comparison between the 'before' and 'after' curves (Fig. 3) reveals that mentions before depositions were even notably fewer than expected in a random process. This suggests that incriminations of this type rarely constituted a basis for summons. Conversely, mentions after depositions exhibit two distinct peaks. The first peak, immediately following the deposition day, reflects the tendency towards summoning groups from the same locality—who expectably incriminated one another—at around the same time. Another peak may correspond to deponents from the vicinity of Peter Gossaw's residence, incriminating both him and others closely associated with him. Gossaw, a central figure in the dissident network (Välimäki and Zbíral 2024: 239), exemplifies how the 'Heretical interaction' incrimination type was generally used as legal evidence against the deponents

themselves rather than to guide investigative follow-up.

By contrast, the plot for 'Fama of heresy' exhibits a distinct peak of people being mentioned around five to fifteen days before their deposition, aligning with a plausible timeframe for the inquisitor to process testimonies, identify relevant individuals, and summon them for questioning. A considerably smaller peak in the 'Heretical interaction' plot underscores that 'Fama' was more systematically associated with actionable information and follow-up, highlighting a fundamental difference in how these two types of information were utilized within the inquisitorial process. The distribution of 'Fama' mentions in the empirical data significantly deviates from random simulation results (Fig. 4), confirming that these mentions were not incidental but indicate deliberate handling by the inquisitor. The inquisitor primarily used 'Heretical interactions' as legal evidence against the deponents themselves, whereas he routinely employed 'Fama' to identify and summon new suspects, effectively closing the investigative feedback loop. This preference for 'Fama' as a name generator is reasonably surprising, as this incrimination type lacked the circumstantial detail that 'Heretical interactions' typically provided, and thus generally constituted less solid evidence.

Surprisingly, correlation analysis indicated a lack of relations between network centrality measures and follow-up order, which suggests that central individuals were not summoned earlier. As seen from the temporal distribution analysis, information from 'Fama' incriminations was acted upon quickly, while longer-term pre-existing knowledge was organized in a different manner.

The same correlation analysis indicated that the strongest influence among the factors we examined was the spatial proximity of deponents' residences to Stettin (with the correlation coefficient for distance to Stettin being approximately 0.45), meaning that individuals living closer to the city tended to be called earlier than those from more distant settlements. This supports the idea of preplanning, likely based on spatial logic. Zwicker may have even used a suspect list organized by settlement, similar to lists known from some other inquisition registers (Davis 1948: 103–9; Palès-Gobilliard 2002: 98–174).

The spatial clustering visualization (Fig. 6) further illustrated that individuals from the same region often appeared in court within a restricted temporal window. However, the spatial order was not entirely rigid. Indeed, the Pearson correlation coefficient (∼0.45) expressing the association between the order of depositions and distance to Stettin reflects some mixing between geographical clusters, indicating that this tendency to proceed by settlement and start with those close to the seat of the investigation was not the only driver of decision making; it was complemented by the feedback process following up new information, and possibly also by the varied behaviours of deponents after they were summoned and other historically contingent factors.

Zwicker's responsiveness to events as they unfolded was required already because some dissidents' initiatives challenged his planning. For example, in the village of Klein-Wubiser, a group of Waldensians, led by a certain Sybert Curaw, resisted the inquisitor, imprisoned his messenger, prevented his summons to be read aloud, and went fugitive for a couple of months (Kurze 1968: 74; Kieckhefer 1979: 63–5; Cameron 2000: 141). Two of the fugitives, Heyne Smerwynkel and Sybert Curaw himself, only yielded at the very end of Zwicker's inquisition. They were the third last and last deponents of the whole process, having no doubt disturbed the inquisitor's intended course of interrogations. Another surprise came from the five Waldensians who arrived voluntarily to confess and abjure heresy from the neighbouring diocese of Poznań, in which Zwicker had no jurisdiction. Zwicker responded by immediately receiving their confessions, making them abjure, absolving them and sending them with letters directed to the bishop of Poznań expressing the hope that he would confirm the absolutions (Kurze 1975: 235–6). Such down-to-earth circumstances obscure the original planning process from a statistical standpoint, but at the same time bear witness to the complex historical reality, as well as to suspects' agency.

Our analysis supports the conclusion that the Stettin inquisition followed a partially predetermined, spatially organized strategy, with additional suspects summoned on the basis of new 'Fama' information, but with snowballing playing only a limited role. Visible patterns suggest that Zwicker had access to a substantial amount of information at the outset of the campaign, which he used for strategic planning and decision-making. Our results corroborate the historiographical claims that Zwicker began with a pre-existing partial list of suspects (Kurze 1968: 70–1, 79–81; Kieckhefer 1979: 57–8; Utz Tremp 1999: 166; Cameron 2000: 140; Modestin 2007: 2; Välimäki 2019: 116–7; Smelyansky 2022: 398), and extend them with indications that it was most likely organized by location, and that among these locations, Zwicker gave comparative temporal priority to those closer to Stettin.

We were able to corroborate the presence of a feedback mechanism, and thus claims in previous scholarship about Zwicker as a systematic (Utz Tremp 1999: 169) and flexible investigator, capable of incorporating empirical evidence, most famously by accepting the

Waldensians' denial of Lucifer-worship accusations in Stettin (Biller 2000: 255, 279, 2004: 455; Utz Tremp 2008: 307–10). Importantly, our conclusion draws from a different epistemic source than such previous claims, which were based on observations drawn from individual depositions or Zwicker's question lists. By contrast to previous studies, we illustrate the inquisitors strategy from a different angle—through a global analysis of the process of name acquisition and use during the entire process.

In spite of clear evidence of a feedback mechanism, it is far from being the dominant driving force of the investigation, and, interestingly, follow-up is less typical for detailed circumstantial evidence on 'Heretical interactions' than for the much more general and less substantiated 'Fama'-based incriminations; only these seem to have specifically served as a generator of new names.

6. Conclusion

In conclusion, the Stettin inquisitorial process emerges as a dynamic interplay between a pre-planned framework, the selective integration of new information, and the unpredictable realities of human behaviour and historical events. Thanks to a formal analysis of the process of name acquisition and use in the process, we were able not only to provide evidence of the interplay of these factors, but also to shed much more light on the relative importance with which they contributed to the Stettin records.

The analysis exposes how Zwicker's inquisitorial information collection relied on depositions serving two key functions: assessing a deponent's guilt for legal purposes and gathering intelligence on other suspects. Our results make it possible to further outline Zwicker's strategy as follows:

- To plan the deposition sequence based on a pre-existing, spatially ordered list of suspects.
- To selectively follow new information from 'Fama' incriminations in order to identify additional suspects.
- Heretical interaction confessions were primarily serving as legal evidence of a deponent's transgressions, but potentially were to a limited extent followed up for investigative purposes

These results illustrate the utility of computational methods and information-theoretical conceptualizations in illuminating the mechanics of medieval inquisitorial systems, offering a clearer perspective on how such investigations functioned as structured systems of information collection, retrieval, and legal adjudication. For although different medieval inquisitors compiled manuals on how to proceed against heretics (e.g. Dondaine 1947; Sackville 2013; Sackville 2019), the practical choices specific inquisitors made would hardly be fully described in them, perhaps not even fully consciously determined in all of their aspects. The Stettin protocols, while containing traces of this systematic design, nonetheless also reflect the inherent unpredictability of historical events and individual behaviours of suspects. These elements introduced randomness that partly obscured the systematic features of the process. Nevertheless, if turned into data and subjected to computational analysis, inquisitorial choices transpire quite clearly from extant trial documentation.

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Author contributions

Kaarel Sikk (Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing—original draft, Writing—review & editing), Reima Välimäki (Conceptualization, Data curation, Investigation, Validation, Writing—original draft, Writing—review & editing), and David Zbíral (Conceptualization, Investigation, Methodology, Resources, Validation, Writing—review & editing)

Supplementary data

Supplementary data are available at *DSH* online.

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Data availability

The data underlying this article are available in the article and in its online supplementary material.

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