Nobody Puts Redditor in a Binary: Digital Demography, Collective Identities, and Gender in a Subreddit Network

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Prior work on transgender technology users in CSCW has primarily focused on how they interact with algorithms and communication technology, empirically identifying specific use cases and profiles, and speaking largely to the designers and developers of these platforms. This work has emphasized how trans people are excluded, harmed, and misrepresented in existing platforms, algorithms, and research methods. While these critiques are important, this paper explores what trans-inclusive quantitative methods could be by applying a participant- or user-driven approach. While the problem of trans-inclusive, -affirming, or -empowering research methods is not specifically a CSCW problem—as we directly confront by comparing and contrasting the perspectives of CSCW and conventional demography—we argue that a CSCW lens may be uniquely suited to addressing it. To this end, this paper makes several contributions: conceptually, we identify points of increasing convergence between conventional demographic research methods (and criticisms thereof) and CSCW, focusing on shared limitations surrounding how identity is handled in research; methodologically, we present a sketch of how these limitations might be addressed by using social network analysis to "triangulate" social identities while considering them relative and situated; empirically, we implement these methods in a case study of gender within the broader social context of Reddit and discuss the results.

CCS Concepts: • **Information systems → Social networking sites**; **Social networks**; *Web and social media search*; • **Networks → Social media networks**; **Online social networks**; • **Human-centered computing → Social media**; • **Social and professional topics → Gender**.

Additional Key Words and Phrases: Reddit, social network analysis, LGBTQ+, transgender, identity, red pill, manosphere, feminism, digital demography

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1 INTRODUCTION

In tandem with the increasing visibility of transgender (trans) people and issues in mainstream culture, a growing body of work in CSCW, CHI, and adjacent fields has explored the relationship between trans people and technology. In particular, much of this work has demonstrated that—as trans people are underrepresented in academia and industry, and generally underserved by technology and tech research—inclusive technology requires designers and researchers to consider the distinct use cases of trans users. In particular, this work has used empirical studies of general technology use [82], social media and online communities e.g. [36–39, 41, 46, 79], and more recently,

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facial recognition algorithms [49, 83] to surface these needs and use cases, and highlight the current shortcomings of technology in serving trans people.

Building from social constructionist understandings of gender that have been adopted across a variety of disciplines—e.g. [8, 19, 35, 74]—this work has increasingly confronted reduction via categorization as a key point of tension between the inclusion and individual autonomy of trans users [46, 78, 83]. Such work surfaces the methodological question of, given a set of participants (with whom the researcher may interact directly or indirectly via intermediate data, such as via an image dataset), how to obtain a set of accurate and meaningful gender labels corresponding to each participant. This involves two points of concern: (1) which gender labels are available, and (2) the criteria for each label. The structure of this gender ontology or *index* is the core topic of this paper. Such gender indices may take many forms: the facial recognition algorithms discussed by Scheuerman et al. and Keyes use training data with fixed male/female labels and machine learning algorithms to generate probability-based criteria for each label. Alternatively, survey methods often provide a fixed set of labels (again determined by the researchers ahead of time) but allow participants to self-select the label or labels that best match them (and some provide a custom text entry box). Interviews and other qualitative methods have fewer constraints on the labels and label criteria, as individual observations need not have interoperable gender indices, but sacrifice the ability to make broader observations in doing so. Thus each of these methodological tools presents a different configuration of participant input and autonomy.

Recent CSCW work has examined the tensions between transgender research participants and quantitative methods. For example, Scheuerman et al. analyzed several facial recognition algorithms that assign gender labels to images of people, observing that algorithms have significantly higher rates of classification error when applied to images of trans and non-binary people [83]. Importantly, the authors note that a supervised gender classification algorithm can never assign a label that it doesn't know or can't recognize (e.g. non-binary) and can miss important contextual information (such as image captions or the words "not cis" on a T-shirt in a photo), and thus will by definition project a subjective and likely incomplete set of gender categories and their criteria onto its input data. The authors make several recommendations for the design of image datasets, including allowing for gender labels to overlap, labeling signifiers (such a beard, a dress, or make up) rather than attempting to infer gender, and allowing individuals to self-identify their gender rather than relying on automated systems. Similarly, Keyes points out that determining gender labels a priori denies trans people autonomy, and recommends that researchers instead use methods that involve self-disclosure of gender [49]. One such method may be using trace data, such as profile information [49].

Other CSCW work has explored the potential of survey methods in granting more autonomy to research participants. Jaroszewski et al. argue that presenting participants with both pre-defined options (e.g. "male" and "female") along with an open-ended text box allows researchers to collect data at scale while being mindful of non-binary gender identities. However, they observe that, for the open-ended text box to be used in the desired way, researchers must use language that is attuned to the community of interest and proactively design their survey to prevent trolling [46]. More recently, Ruberg and Ruelos have examined the notion of demographics itself, noting that survey conventions surrounding identity are often restrictive and incompatible with queer identities [78]. The authors argue that participants should be able to select multiple gender labels at once, surveys should allows identity labels to change over time, and surveys of marginalized communities should involve members of those communities in their creation [78].

In other words, there is a significant methodological gap between social theory that considers gender to be socially constructed, fluid, and contextual, and the available tools for probing and analyzing gender empirically. This paper addresses this theoretical-methodological gap by (1)

further clarifying the nature of the gap and (2) presenting a methodological sketch to explore how gender might be empirically studied within a social constructionist theoretical framing. To this end, we use a case study of Reddit to present empirical results from examining a network of subreddits. These results provide insight into a gender index in which identities are fluid, contextual, and defined by the community of study. The next two sections will further clarify the research gap and contribution of this paper, and then provide background relevant to our case study.

2 MOTIVATION, CONTRIBUTION, AND RESEARCH QUESTIONS

Demography—the discipline of collecting, analyzing, and producing demographic data—and the field of CSCW each produce work that informs real-world interventions, one primarily through policy and the other primarily through technology design. Albeit from very distinct histories and perspectives, both fields involve documenting, characterizing, and quantifying humans and human behaviors. However, as CSCW has increasingly explored the depth and complexity of social behaviors on digital platforms, such work has necessitated a more nuanced and flexible understanding of social identity, including collective markers like race, class, and gender. CSCW work thus often diverges from the conventional demographic paradigm by adopting a social constructionist perspective, meaning that the definitions of identities like "female" or "white" vary depending on the subject, the observer, and the context. This understanding of identities as contextual aligns well with CSCW's canonization of user or participant expertise. However, departing from the outmoded conventions of identity in demographic data reveals new challenges, as demonstrated by studies of gender recognition algorithms [49, 83].

More broadly, ruptures between automated or discretized models of gender and the trans people who become their data subjects are well documented. In their recent work, Ruberg and Ruelos point to the limits of demographic data conventions in representing queer lives [78]. In doing so, the authors identify key tensions within demographic norms surrounding collective identities. Along with Scheuerman et al. [83], Jaroszewski et al. [46], and Keyes [49], Ruberg and Ruelos [78] surface and challenge the norms of identity representation and prompt researchers to adopt methods that are inclusive, affirming, and empowering to trans research participants. To understand how such methods might take shape, this section outlines critiques of conventional representations of gender identity and motivates the empirical work presented in this study. We begin by presenting an overview of the demographic lens, and then, following Ruberg and Ruelos [78], we discuss the tensions between demographic data conventions and social theories of identity.

2.1 The Demographic Lens

Preston et al. define demographic work as the analysis of populations [73]. Efforts towards counting populations have existed since antiquity: Deng refers to periodic local censuses beginning in 2 C.E. in Qin-era China [23], and Missiakoulis argues that the first recorded population census is that of King Cecrops of Athens in 16th century B.C.E. [64][1]. However, the statistical tools used in current demography began to emerge in the 19th century. During this time, early statisticians aimed to extend the successes of the natural sciences to human social behavior, with the goal of informing public policy. [24]. In combination with population-level data—such as the data collected through national censuses, vital registration systems, and initiatives by the United Nations (UN) and World Health Organization (WHO)—basic statistics (e.g. life expectancy at birth and mortality rate) underpin our understanding of the social world, including public health analysis [67], allocation and distribution of foreign aid [66, 69], and as a foundation for advocacy [76, 77] [66].

[1]Both authors note that the historical counts do not directly map to our current understanding of population counts—for example, the Cecrops' census only counted male citizens [64].

While a mortality rate is interesting in isolation, its utility is largely in relation to other data points; for example to compare infant mortality rates across countries. Applications and extensions of demographic statistics map out a terrain in which social outcomes, such as health and well-being, may be quantified, compared, and predicted, as well as correlated with other factors (e.g. healthcare options). From here, policy makers (and the general public) may consider interventions: allocating research funding to the study of cancer rather than polio based on the relative prevalence of each disease, rezoning a neighborhood to adjust for population growth, or diagnosing the cause of a relatively high maternal mortality rate among black women.

This kind of comparative analysis of groups necessarily relies on drawing a strict boundary between them: to argue that an aging population in the rural U.S. will require changes in healthcare infrastructure, for example, first requires subdividing the U.S. population by labeling each person as rural (or not) and approaching old age (or not) [11]. We will refer to this set of labels used to organize a population and locate individuals within it as a *social index*. In the data gathered during the 2010 U.S. Census, for example, the gender index consists of the categories 'male' and 'female', while the age index consists of roughly five-year brackets from 'Under 5 years' to '85 years and over'. Beyond the traditional focus of formal demography on the most basic and conventional definitions of life, death, and movement, the study of "demographics" appears much more broadly, such as in advertising, media, politics, and the social sciences. The demographic lens and its associated social indices have arguably become an infrastructural—familiar, habitual, and rarely noticed—mechanism for representing life in social science and the public sphere: we routinely represent ourselves through demographic profiles when filling out census questionnaires, registering for a driver's license, participating in a study, or visiting a new doctor's office, and collective levels of health and wellbeing are often communicated through mortality rates and life expectancies.

Critical perspectives on demography are concerned less with its mathematical inner workings (how we put the puzzle pieces together), but rather with the foundation underneath these calculations (the shape of each piece), i.e. the problem of defining a population and component parts. Generally, these criticisms problematize the lack of justification for conventional demographic labels and the assumption that a population can be cleanly partitioned into groups given enough labels and and qualifiers. Demography applies social indices without justifying their existence or the ability of an external observer to accurately interpret them. At the same time, pursuing demographic questions puts significant weight on social indices, assuming that labels like race, gender, and class are so fundamental, obvious, and durable that they can support our collective knowledge of life, death, and movement; it assumes collective consensus on social indices. We refer to this approach as the *(direct) realist* lens to highlight the perspective that social labels are both (1) grounded in an external objective reality that is obvious to the researcher and (2) likely to capture some deterministic relationship [24].

The goal of this paper is not to to argue against the realist lens; this has already been done at length, e.g. [8, 24, 31], and this perspective is the implicit origin in the move towards more participatory and inclusive research of trans people [46, 49, 78, 83]. Instead, to examine how we might move beyond the realist lens in quantitative studies of social behaviors, we turn to CSCW work for its generally social constructionist, empirically-grounded, and user-centered lens. The next section further explains these critical perspectives, motivating our research questions and connecting them to CSCW work.

2.2 Critiques of Demographic Identity Categories and Research Questions

We discuss two types of criticisms of formal demography: those of *implementation* and those of *intent*. The first category focuses on the counting and categorizing mechanisms applied by demographers. The second category locates demographic work within a broader social and informational context,

and surfaces questions of power and vulnerability. Each of these expand on the considerations of accuracy and autonomy raised by Scheuerman et al. [83], Ruberg and Ruelos [78], Jaroszewski et al. [46], and Keyes [49]. Building from the criticisms of implementation, we articulate the specific research questions to be addressed in the empirical case study portion of this work.

2.2.1 Criticisms of Implementation. Both Murphy and Voida et al. observe that the framing of a problem and structuring of data define the path to a solution [66, 90]. This can have disastrous effects: for example, in the context of a cholera epidemic in Bangladesh, Murphy details how fixation on death rates lead to short-term fixes rather than long-term changes to sanitation infrastructure; cholera patients were prevented from dying but not from getting sick, and their quality of life did not increase [66]. Voida et al. provide insight into how participatory research can mitigate this myopia, arguing that designing a data system should consider which measurements and corresponding political actions are enabled by a data design along with alternative designs that might enable different outcomes [90]. In their example of a foodbank on a university campus, Voida et al. note that the foodbank could track its impact by counting food items, calories per food item, or student ID cards scanned by the pantry logs, each presenting different a different framing of food distribution [90].

Building on the work of Murphy and Voida et al., we focus on the data design problem of social indices, specifically gender indices—how gender identity data collection can and should be structured. In our empirical case study of Reddit, we use trace data and a multi-layer social network to explore how gender identities are understood in practice by technology users. In particular, we aim to apply a user- or participant-driven lens to the trace data in our dataset by understanding how Reddit users create their own collective identities. This motivates our first research question:

RQ1 *How do Reddit users self-organize around gender themes?*

Designing social indices—in a broad sense, defining which kinds of people exist—is a uniquely complicated data design problem. The social, political, and historical complexities of implementing social indices are particularly topical now, as the U.S. Census Bureau completes the 2020 census. While census data have supported many areas of policy and research, activists and theorists have drawn attention to its imprecise and historically discriminatory definitions of social race, gender, sexuality [48, 84]. It may be argued that the social indices used by the U.S. Census work for the vast majority of people (most people in the U.S. do identify as male or female, for example). However, given the importance of census data in shaping interventions through public policy and research, it must also be noted that the error of an imperfect social index is not randomly distributed across the population; instead the burden of misrepresentation further disenfranchises already-marginalized communities by systematically removing them from the social and political frames. This paper addresses this methodological issue by exploring how network analysis can replace a priori definition of categories to capture both high-level patterns of social identity while retaining micro-level nuance. In other words, we seek to characterize the "glue" that draws together individual observations into macro-level generalizations by understanding meso-level dynamics. We define our second research question to pursue this challenge:

RQ2 *What patterns are visible at the meso level in each layer of the network?*

Finally, critical work highlights the contextual and often provisional nature of collective identity categories, particularly in the census [8, 24, 26]. This work highlights the importance of understanding social indices as a tool for enacting policy—a tool that is particularly important for the advocacy efforts of non-dominant groups. In other words, both the individual categories as well as the social index should be considered as social artifacts rather than neutral or objective representations of reality. Attempts to reshape a social index are often spurred by political events, and the resulting

categories are often the product of negotiations between multiple stakeholders [26, 87]. To examine how we might understand social indices as social and historical artifacts, we define our last question as follows:

RQ3 *To what extent do genealogical and algorithmic relationships align with crowd-assembled social indices?*

2.2.2 Criticisms of Intent. Considering only problems of implementation would suggest that the only challenges to demography exist at the seam between enactment and encoding of social experiences. However this would discount the teleological context of demography, which is itself the subject of significant criticism. While we limit our research questions to addressing challenges in implementation as a first step, we believe it important to briefly discuss criticisms of intent to illustrate both the broader context motivating this work, as well as potential for bringing a participatory research perspective to demography.

Perhaps most famously, Foucault identifies demography as a key mechanism in eroding the boundary between individuals and state-level objectives by attaching individual trajectories (e.g. who has children and when) to population-level statistics of life, death, and movement (e.g. fertility and mortality rates) [31]. The growing availability of personal data has raised significant concerns regarding the power of authorities to surveil the public and enact social controls. While allowing the state this kind of unidirectional access to its citizens can have undeniably positive outcomes (e.g. in the context of the current pandemic, authorities can quickly react to curb the spread of COVID-19), it also subjects the private lives of the population to datafication and surveillance, where population data is then used to frame and evaluate the success of political interventions [3, 31, 66].

As suggested by Voida et al. [90], framing data as a design problem allows us to consider these questions of intent more explicitly. CSCW has methodological and ethical expertise that may be useful in designing data systems that deliberately consider and respond to power and representation. While these design problems merit more attention, we leave this to future work and focus this paper on the questions of implementation raised in Section 2.2.1. Section 2.3 will return to questions of implementation and discuss demographic indices as a CSCW problem.

2.3 Social Indices as a CSCW Problem

As our lives become increasingly entwined with online spaces, CSCW work overlaps with questions of demographics and demography. Much CSCW and adjacent work on online communities considers questions of life [27, 40, 60, 65, 72], death [10, 32] and movement [55, 75, 86], with respect to digital identities, communities, or platforms. Recent work in adjacent fields has made an explicit connection between online spaces and formal demography, observing that not only can digital data be used for demographic research, but that these data can also provide insight into social behaviors not captured by traditional demographic methods [15, 63, 85, 92]. This work suggests that social media has great potential for methodological triangulation in demography by combining traditional data sources with social media data [15, 85].

However, CSCW work departs from demography in a key way, in that it is not tied to a behaviorist paradigm of crowd behavior. Instead, CSCW's roots in collaborative work have necessitated attention to human perception and cognition. While both demographers and CSCW researchers work between descriptive and prescriptive spaces, CSCW's direct connection to technology design and implementation has sparked conversations about the agency, experiences, and ethical treatment of research participants and subjects [8, 9, 89, 90].

With this work, CSCW researchers have constructed a novel understanding of crowd behavior, online communities, and technological mediation, along with a distinct ethical orientation towards

valuing non-academic expertise. In comparison to the realist lens presented in Section 2.1, the lens of cooperative work provides a new perspective on identity production that does not force the assumption of consensus. As discussed in Section 2.2.1, existing work has argued that design of data and scientific tools are CSCW problems: Voida et al. argue that the unit of analysis in quantitative work has political ramifications, and is thus a design problem [90], and Jackson et al. suggest that understanding of collaborative work can help strengthen the field of science policy [45]. The importance and timeliness of demographic research design and its convergence with CSCW domains is only underscored by the announcement that the 2020 U.S. Census would primarily rely on digital tools, including an iPhone application for collecting survey responses. Within this context, we contribute to emerging work by exploring how CSCW expertise on networked platforms can inform quantitative social science. Specifically, we pursue alternatives to the traditional "top-down", researcher-defined constraints imposed on social indices by exploring the potential of networked, bottom-up social computing systems.

This section differentiated the conventional demographic paradigm from the CSCW paradigm with respect to identity and, in doing so, discussed the potential of empirically grounded understandings of identity. We next use a case study of gender communities on Reddit to explore the methodological and empirical side of this argument. Before turning to the specifics of the case study discussed in Section 4, Section 3 provides background on gender on Reddit.

3 RELATED WORK

A core argument underlying this study is that—if we hope to reform the conventions surrounding representations of gender in demographic data to equitably serve trans people—we must better understand the failures of the conventional realist lens discussed in Section 2.1. A key observation is that trans communities are not the only communities (on Reddit and otherwise) who organize around perceived limitations in the way that gender norms shape their lived experience. While our work is motivated by an interest in representing trans people accurately and ethically in data, we speak to this interest through a broader analysis of multiple communities on Reddit. We do so for two reasons: (1) broadening our lens in this way allows for the possibility that these communities interact in important ways, and (2) while we firmly object to the principles of red pill and manosphere ideologies, these groups nonetheless provide an example of crowd-driven construction of gender indices. By synthesizing these multiple vantage points, we present an analysis of how gender indices are constructed on Reddit at meso and macro scales.

This study focuses on Reddit in its empirical component because of Reddit's relevance to movements and discourses regarding gender. An additional point of interest is Reddit's subreddit structure, which allows us to better understand the salience of different concepts and ideas on Reddit (i.e., if a group of Reddit users actively maintain a subreddit, we can assume that the subreddit's core organizing concepts are important to that group of users). This section summarizes existing work on gender identity-based communities on Reddit; this work is important not only as starting point for positioning this work, but also to illustrate the current operating paradigm in CSCW. First, we identify five discursive themes from the literature that are central to our analysis. We then characterize Reddit as a social platform, focusing on the ways that relationships can manifest within and across individual subreddits.

3.1 Gender Themes on Reddit

Digital spaces have facilitated both extensions and permutations of conventional notions of gender. This paper identifies five framings of gender on Reddit from prior work and examines them as five interacting case studies—the manosphere, the red pill, misandry, feminism, and minority gender identities. We use these themes as entry points to the space, considering each individually but also

the relational structure between them to understand "bottom-up" constructs. We present these five themes here:

3.1.1 The Manosphere. While men's liberation discourse has existed long before Reddit, its online presence is notable both for its proliferation and its tendency towards the extreme [34, 58]. Massanari observes how geek culture, masculinity, and a sense of marginalization have historically converged in online spaces centered around geek culture, including USENET, 4chan, and Reddit [59, 80]. Feelings of victimization often center around tropes of romantic rejection by women [59].

Cultures of online masculinity have evolved within and across digital platforms. Currently, their manifestations are often grouped into the *manosphere*, a collection of websites, blogs, and social media communities. Ging, exploring "Masculinities of the Manosphere", identifies five internal "hubs": *MRAs* (men's rights activists), *MGTOW* (men going their own way, sometimes written as "MGHOW"), *PUAs* (pick up artists), traditional Christian conservatives, and gamer/geek subculture [34]. Within the first discursive theme, the "Manosphere", we limit our empirical analysis to three manosphere hubs—MRAs, MGTOW, and PUAs—because of their distinct vocabulary, which allows for targeted data sampling. While the ideologies of the factions that comprise the manosphere often diverge, they generally are antifeminist and view women through a reductive frame of biological or sexual utility [34, 59, 88]. This uniting ideology of the manosphere is termed the "red pill" and is discussed next as our second discursive theme.

3.1.2 Red Pill Ideology. "Red pill" ideology professes that men can appeal to women by becoming "alpha males", who exemplify virility and traditional masculinity to increase their value in the "sexual marketplace" [88]. More simply stated, red pill ideology and its adherents view gender as a biological and sexual dynamic, where men should achieve peak masculinity and women are at worst targets for vitriol and at best reduced to a predicated biological purpose. As with manosphere subreddits, red pill subreddits have a significant presence on Reddit [34, 59], and as observed by Datta and Adar, can be prominent sites of inter-subreddit conflict [22].

3.1.3 Misandry. Marwick and Caplan identify the discursive thread, *misandry*, as emerging from manosphere platforms as early as the 1990's [58]. Manosphere adherents specifically use the term to signify their mistrust of women and the perceived virulence of feminists [58]. The manosphere, the red pill, and misandry are each closely related, yet distinct themes; while existing work has examined their discursive overlap, we contribute an empirical analysis that reveals their position and relationships within the networked infrastructure of Reddit. "Misandry" is our third discursive theme.

While we can expect overlap between manosphere communities, red pill adherents, and subreddits that organize around misandry, we separate these into three themes for several reasons. Firstly, these three themes have been well-studied, and researchers have identified the distinct mechanisms within each one. Manosphere dynamics, for example, are likely best analyzed as a coalition of online groups. The red pill, on the other hand, represents a unifying ideology among these groups, and is thus better understood through a lens of narrative or frame negotiation in a crowd—blue pill and black pill ideological groups have emerged as counterweights and permutations of the original red pill. If the goal of this paper were to present a representative portrait of gender-centric subreddits, it would make sense to combine these three themes into one overarching theme. However, treating each gender theme as a unique window into the Reddit ecosystem, our goal is to characterize and evaluate the perspective gained through each theme. In other words, as our primary contribution is methodological rather than empirical, we separate these into three distinct themes, and compare their structures in Sections 5 and 6.

3.1.4 Feminism. Feminist discourses, although perhaps not immediately associated with Reddit, are nonetheless embedded in the cultures of masculinity that shaped online culture. While prior work has explored several feminist subreddits as sites where conversations relevant to feminism occur (e.g. [25, 51, 57], Reddit's role as a platform that *supports* feminist discourse is doubtful, and largely overshadowed by the themes of misogyny and antifeminist rhetoric [34, 58, 88]. From the red pill perspective, for example, feminist rhetoric aims to manipulate men such that women can find the best mates [88].

It's also worth noting that feminism has existed in full force long before the internet and has seen multiple political evolutions and fractures (for example, regarding the place of trans women in feminist spaces [43]), suggesting that "feminist" discourse on Reddit might be channeled into more granular subcategories, such as radical feminism, intersectional feminism, and lesbian feminism. This is reinforced by the prevalence of subreddits dedicated to specific threads of feminist discourse, such as radical feminism or postmodernist feminism. Still, as noted by Massanari, the network of "ShitRedditSays" (SRS) subreddits can be considered as loosely pro-feminist contrast to red pill discourse [59].

Existing work therefore indicates that Reddit is a site for multiple discourses to define and negotiate feminism across multiple subreddits. This paper contributes an empirical study of the network of feminism-affiliated subreddits through the multiple lenses of conceptual, infrastructural, and moderation relationships. "Feminism" is our fourth discursive theme.

3.1.5 Minority Gender Identities. Digital spaces have often served as community building sites for traditionally marginalized identities. At the micro scale, these platforms can fill multiple social and informational needs: Jenzen describes social media as an imperfect "lifeline" and cultural platform for LGBTQ+ youth [47]. Haimson and Jaroszewski et al. note that social media can (albeit imperfectly) fill a uniquely transgender need, serving as "transition machinery" to document, disclose, and otherwise manage the process of identity transition [36, 46]. Subreddits can serve as both resources for concrete informational needs (e.g. medical [6]), as well as spaces for exploring and affirming gender minority identities and experiences [21]. Through the lens of public health, Saha et al. add that the r/lgbt subreddit provides a space for disclosures of "minority stress," further noting that the subreddit is a potential point of contact for otherwise hard-to-reach populations [79].

At meso levels, these systems become more complex. On Reddit, broader LGBTQ+ or queer subreddits can vary on their inclusion of gender minority identities, causing conflict within and across subreddits [25, 30]—acceptance of transgender women in feminist subreddits has been a particularly prominent point of controversy [30]. Foeken and Roberts note that lesbian (separatist) feminist and radical feminist communities strive for a collective identity that demands homogeneity, and thus particularly hostile towards transgender women, who are seen as men in disguise, and bisexual women, who are considered to be insufficiently committed to the separatist cause [30].

Even in a bottom-up system, interactions between algorithms and identity categories can further complicate the space: in a study of Tumblr, Dame notes an interesting dynamic between text tagging systems and gender classification, where the user ability to categorize gender through tags both broadens the available categories, but also introduces social pressures, historical prejudices, and semantic limitations [20]. Existing work thus provides a strong foundation through which to understand gender discourse and gender ontologies at the subreddit scale, e.g. [42]. While several authors have examined relationships between subreddits through the social lens of trolling and harassment, e.g. [54], little is known about how different, conflicting communities form a user-driven information ecosystem.

This existing work provides a strong foundation for understanding how online spaces can support marginalized gender communities through the lens of individual identity labels. However, little is known about how these communities interact with each other, and with broader discussions of gender on Reddit. One difficulty of studying the identity categories of trans, non-binary, and otherwise "gender variant" populations is that the categories themselves are rapidly changing. For our purposes, we thus select several (English-language) identity labels that have been most frequently used in discussing experiences in recent times, and which are supported by the work discussed in this section. Specifically, we examine subreddits tied to the labels *genderqueer* [21]; *non-binary* [21, 46]; and *trans*, *transsexual*, and *transgender* [20, 46]. To examine the interplay between these, we thus combine these labels into our fifth and final theme, "Gender Minorities." In contrast to the manosphere, red pill, and misandry themes, we are not aware of work that documents the history of each of these online communities' internal dynamics or relationships relative to each other, and we therefore combine them into a single theme. This lack of granularity is further discussed in Section 7.

3.2 The Networked Ecosystem of Reddit

Existing literature provides notable in-depth studies of Reddit communities outside of the mainstream. What stands out from this work is the potential for a subreddit to carve out space to contesting or circumventing mainstream narratives. Samory and Mitra observe that conspiracy theorists in /r/conspiracy engage in framing and interpretive negotiations surrounding breaking news events [81]. Similarly, in the context of /r/the_donald, a political trolling subreddit, Flores-Saviaga et al. categorize "call to action" posts, observing that these posts used a variety of rhetorical strategies to build collective identity, articulate a historical framing, and motivate action [29]. Tan's study of subreddit genealogy further suggests that the emergence of subreddits might be analogous to complex contagion [14, 86], where early members to new subreddits share dense connections from existing subreddit.

From here, it seems that not only do subreddits appear to afford a rich social and cultural fabric, existing community structure can shape the creation of new subreddits, and thus the informational infrastructure. Collective identities, frames, and ontologies that materialize in a subreddit appear to persist beyond the topical or fleeting information that travels through it. Subreddits appear tied to social and cultural relationships; however these ties can transcend the subreddit boundary. For the purposes of this paper, we consider subreddits to be loose social concentrations that accommodate varying levels of engagement, from core users to occasional visitors and lurkers.

3.2.1 Norms, Rules, and Moderation on Reddit. While Reddit establishes some sitewide rules, subreddits are given leeway to define additional rules and norms for content and interaction. Each subreddit has one or more moderators who regulate content published on the subreddit and can ban specific Reddit users from posting to the subreddit [44]. In addition to regulation by moderators, subreddit users can take an active role in content curation by upvoting or downvoting content [50]. The use of decentralized moderation allows for wide variation in subreddit norms, rules, and moderation styles [28, 50, 54, 62]. Moderators might see themselves as political figures (e.g. "dictators" or "defenders") or more neutral facilitators (such as "hosts" or "janitors") depending both on the subreddit community and its relationship to the rest of Reddit [54, 61]. Building on this, Chandrasekharan et al. observe that subreddits are not interchangeable sites of discourse; after Reddit adopted a new anti-harassment policy and banned two subreddits known for hate speech, their user base continued to participate in other subreddits, but lowered their participation in hate speech [17]. This indicates that the culture of a subreddit is not solely dependent on its user base, but its historical trajectory and its relationship to the rest of Reddit.

While it might seem that the regulatory systems of subreddits operate in isolation, the power to moderate content might be more centralized than it appears on the surface. Massanari describes how the dependence on volunteer community members as subreddit moderators and the resulting reliance on volunteers to moderate causes a power imbalance: users can entrench themselves in the moderation of any number of subreddits resulting in "mini-fiefdoms" where many subreddits are controlled by a small group of moderators. Furthermore, "it is incredibly difficult, too, for powerful moderators to be removed from their positions, however inefficient or problematic they become" [59].

As users become moderators either by creating the subreddit or being appointed by other moderators, a user must likely show some alignment with a subreddit community to be appointed to a moderator role. To maintain a functional subreddit community, we can also infer that the subreddit community must generally approve of the subreddit's moderators [18, 33, 50, 56]. While Matias' work illustrates the wide range of moderation behaviors, it also emphasizes that moderation roles are primarily characterized by strong, sustained relationships between moderators and the communities they moderate [61].

3.2.2 The Subreddit Sidebar. While a subreddit's feed is designed to be dynamic, static information about the subreddit is shown in the title bar and sidebar. The sidebar is customizable and varies by subreddit, but often contains metadata such as a statement of the subreddit's purpose, the subreddit rules, and a list of the moderators. It is common for subreddits to mention other subreddits in their sidebar [25, 71]. These listings may serve a variety of purposes, such as routing visitors to related subreddits (these routing ties are sometimes hyperlinked, but not always) [71], differentiating the purpose of the subreddit from other related subreddits and thus bounding its user base, or explicitly forbidding certain actions or behaviors [25]. References to external subreddits are generally embedded within an annotation explaining the relationship between the two subreddits [25, 71].

3.2.3 Algorithms on Reddit. Reddit differs significantly from platforms like Facebook and Twitter in that its information flows do not directly map to a user's social ties. Instead, subreddits serve as social and informational centers, both collecting and rebroadcasting information and facilitating discussion. While a highly active feed might tend towards ephemerality due to the rapid flow of messages [4], subreddits are searchable and users can tag their posts with *flair*, allowing for aggregation or filtering. Similarly, a subreddit feed might focus the attention and conversation of subscribers or visitors to recent posts, while older posts can take on a different role, aging into historical artifacts, or expanding a repository of community knowledge. The organizing of information via subreddits can facilitate both in-the-moment convergence as well as long-term indexing and archiving of information by topic.

As Reddit is organized into subreddits with the intention that users will seek out the subreddits that interest them, it—like many other online platforms aiming to share informational content—suffers from the challenging problem of which content should be shown to new users. Showing content from subreddits with high subscriber counts can reinforce "toxic technocultures" that already have a strong foothold on Reddit, while showing content from smaller niche communities can open these subreddits up to trolling or harassment [59]. This work suggests that the difficulties of algorithmic content curation include both what is shown to users, but also what is not shown—what is missing from the results—at the risk of reifying existing power imbalances on Reddit. At the same time, these platforms often require algorithmically-aided search and discovery to prevent users, new and old, from being lost within a sea of overwhelming informational resources. More recently, scholarly work has focused specifically on the effects of algorithmic search on gender discourse (and other social ontologies such as race) [68, 70]. In this study, we focus on Reddit's

algorithmically-defined landscape of gender discourse as one layer of our analysis. We next turn to our empirical analysis in Section 4.

4 DATA AND METHODS

This section provides details on the study's data collection and analysis strategy by outlining three steps: (1) identifying seed subreddits through keyword search, (2) constructing search keyword, indexing, and genealogical relationships to build subreddit networks, and (3) examining each network layer as a set of sociotechnical organizing patterns defined through a relational lens. Examining these network layers will give us insight into the structure of social indices (RQ1), the nuance that might be lost in adopting a flat, macro-level system of categories (RQ2), and the extent to which the genealogical and algorithmic factors are related to social organizing mechanisms (RQ3).

4.1 Identifying Seed Subreddits

In Section 3.1, we introduced five themes of gender discourse. For each theme, we curated a list of search keywords, shown in Table 1, to capture related subreddits. These *seed subreddits* identified through search results served as access points into our digital fieldsite, with an approach similar to that of Balani and De Choudhury [1] and En et al. [25]. The goal was not to obtain a quantitatively representative view of the network space, but rather to identify subreddits in which the gender indexing behaviors of interest were undeniably present. The keywords shown in Table 1 and their interaction with Reddit's search algorithm thus constitute a strong mapping between the gender indices and the subreddit space.

Our set of search keywords was developed to be unambiguously relevant to the five themes of gender indices (i.e. excluding terms that are highly context dependent, such as widely used acronyms with multiple meanings), minimizing the chance of false positives. As with the higher-level gender index themes, the process of keyword selection was informed by the empirical findings of prior work discussed in Section 3.1[2]. To identify subreddits related to each search keyword, we used the native Reddit subreddit search[3]. We collected metadata for each subreddit using the PRAW API [7]. The results of the initial keyword search are summarized in Table 1.

We took two steps to refine the dataset. First, any subreddits that did not include a direct keyword match were removed from the collection[4]. This reduced the set of seeds from 730 to 281 subreddits. Of the initial 730 subreddits, 51 were private, suspended, or otherwise inaccessible; for these 51 subreddits, we used the subreddit name and public description fields for keyword matching, yielding 8 keyword matches.

Second, the 281 subreddits and keyword matches (465 subreddit/keyword pairs, where a pair refers to keyword k existing as a substring within the compiled metadata textual fields of a given

[2]To identify sites organized around the Red Pill, for example, a cursory search on the keyword "red" returns explicitly Red Pill subreddits, but these are buried within results for the Red Devils (sports team Manchester United), Red Dead Redemption (a video game), and even r/Red, with the description, "This subreddit is for anything red. All quality red content is accepted here", to name a few. Alternatively, searching "trp" [34] primarily returns Red Pill-affiliated subreddits (with the exception of r/TRP, which belongs to The Revolt Press, an apparently unaffiliated "anarchist printer and publisher from the Netherlands".

[3]As the external Pushshift API subreddit search was undergoing maintenance during our data collection period, we instead used the native Reddit API. To search each keyword, we used the *requests* library in Python and an API request of the format reddit.com/subreddits/search.json?q=[keyword]&include_over_18=on&limit=100&show=all&raw_json=1, along with the "after_id" parameter to paginate results.

[4]Reddit's documentation on this endpoint indicates that subreddit titles and descriptions fields are matched to the search keyword; however, this documentation appears to have been last updated in 2017, and the returned subreddits included many subreddits whose metadata did not directly contain the search term, but appeared topically related. As the selection criteria for "indirect" matches are not given, we excluded these from our seed subreddit selection.

subreddit) were qualitatively examined to identify incorrect keyword matches. As some subreddits matched multiple keywords, this step involved coding each subreddit/keyword pair as a "match", a "false positive", or "unsure". The coder considered the collected trace metadata and visited the subreddit, where necessary and possible. The coder evaluated all 465 subreddit/keyword pairs. A secondary coder coded a randomly selected set of 122 subreddit/keyword pairs. The percent agreement between coders was 94.3%. Subreddit/keyword pairs identified as false positives (13 pairs) or "unsure" (5 pairs) were removed[5]. 264 (5 private; the remaining 259 publicly accessible) subreddits from the 465 subreddit/keyword pairs were retained as the set of seed subreddits. Perhaps unsurprisingly, shorter acronyms tended to have higher yields with more ambiguity (calculated as percentage keyword matches coded as "false positive" or "unsure" during qualitative coding), while longer, more specific phrases yielded fewer search results with little or no ambiguity. After keyword matching and removing false positives through qualitative coding, search results for each keyword ranged between 0 ("mgtower") and 58 ("trans") subreddits, with a median size of 13, as shown in Table 1.

The initial keyword search was done on August 13, 2019, with the subsequent data collection running between August 13 and August 28, 2019. As this likely represents the most time-sensitive step in our data collection, we collected a replication dataset on September 15, 2019. Of the 435 positively-coded subreddit/keyword matches and 264 distinct seed subreddits, 427 (98%) subreddit/keyword pairs and 258 (97%) subreddits were present in the replication dataset. The six missing subreddits were still publicly accessible and active as of replication data collection. This fluctuation indicates susceptibility to false negatives, and thus presents a limitation of our findings though its quantitative impact is likely minor.

This process of seed subreddit selection identified sites of explicit connection between the gender index themes and the subreddit space. Our next step was to delve further into the subreddit ecosystem by reconstructing context around the seed subreddits in order to expand to parts of the space that we might not identify a priori.

4.2 Reconstructing Context by Building a Four-Layer Network

By design, the 264 seed subreddits limited our initial perspective to subreddits explicitly tied to curated search terms. However, given the widely varying norms and cultures on Reddit, surface-level text-based metrics are not sufficient to discern behavioral patterns [16]. Instead, to pursue the questions of how these subreddits behave and interact within a network, we reconstructed a relational context. To do so, we collected trace data for three types of social connections between subreddits: (1) undirected shared keyword ties, (2) directed indexing relationships, and (3) undirected genealogical relationships. The following section details the process of data collection for each type of network tie.

4.2.1 First Layer: Shared Keyword Ties. The first layer of ties, shared keyword ties, are defined as ties connecting two subreddits that match (or are assigned, as will be further explained) the same keyword, in other words, the projection of a bipartite keyword-subreddit network. The ties are *undirected*, meaning that the source and target of a tie are interchangeable, and thus the relationship does not carry an implied direction. These ties allow us to examine the structure of search results, i.e. whether search results appear to form an algorithmically-reinforced bubble, or to connect to a broader ecosystem (RQ2). From here we can understand the relationships between keywords as access points to Reddit's information space, and as a map of algorithmically-defined groups, against which to compare crowd-constructed social indices (RQ3).

[5]E.g. the search term "trp" matched both results for "The Red Pill" (true positive) and "Titan Role Play" (false positive)

4.2.2 Second and Third Layers: Link Tracing Indexing Ties. Of the study's 259 seed subreddits that were publicly accessible, 167 (64.5%) referenced another subreddit in their sidebar fields. We used these references to create our second and third network layers. In contrast to the shared keyword ties described above, these sidebar ties are *directed* relationships, meaning that the source and target are not interchangeable. These explicit sidebar relationships between subreddits represent subjective indexing of other identity-focused locales and serve as a lens into how subreddits "position" themselves within a cultural context. In other words, these ties serve to construct and explicate the social index from the perspective of a subreddit. We therefore refer to this set of ties as *indexing* ties.

As hyperlinks and unlinked references to other subreddits present the user with different options (one provides an easy pathway to the referenced subreddit and the other does not), and thus likely carry different meanings, we treat hyperlinks as a distinct subset of indexing ties. While a reference to another subreddit does not necessarily indicate overlap or even a positive relationship between user groups of the two subreddits, an annotated and hyperlinked listing facilitates movement between the subreddits. Both indicate a user-driven attempt to organize the subreddits into a networked information system. These network data therefore support inquiry into how concepts of gender map onto the digital space defined by Reddit users. To understand the connections between social indices and the user-shaped information space, we examine the structural characteristics defined by user behaviors (RQ1), the preservation of nuance (or lack thereof) in transitioning from micro to meso and macro perspectives (RQ2), and alignment between the indexing and genealogical structures defined by Reddit users and the shared keyword ties defined by Reddit's search algorithm.

Within Reddit, the prefixes "r/" or "/r/" indicate the name of a subreddit (e.g. r/TheRedPill). To collect directed indexing ties, we use a regular expression to match this syntax. Beginning with the outgoing ties from seed subreddits, ties are traced outwards one step to yield 660 new subreddits. Scraping metadata for new subreddits allows us to discover outgoing indexing ties for these new subreddits as well. Continuing to iteratively scrape metadata and trace indexing ties outwards until we reach a natural boundary where no new subreddits can be discovered via outgoing ties (16 steps), our dataset grows to a directed network of 44,167 subreddits and 264,334 indexing ties. Of these indexing ties, 14,815 (5.60%) are hyperlinked ties, while the remaining ties are unlinked references. We define the second and third network layers as (1) the small subset of indexing ties that represent hyperlinks and (2) the entire set of indexing ties respectively. We maintain the directed nature of indexing ties, as subreddit i may acknowledge subreddit j without the existence of the tie from j to i. Of the seed subreddits, 194 (73.5%) are weakly connected (connected by either an incoming or outgoing tie) in the indexing network.

4.2.3 Fourth Layer: Genealogical Ties. The fourth layer consists of shared moderator relationships. We define these ties to be instances in which a single Reddit user (or bot account) moderates two or more subreddits. Referencing Tan [86], we refer to these as *genealogical* ties which represent implicit community relationships. These ties are undirected by definition. The resulting genealogical network gives insight into structures of content regulation, pathways for potential information brokering and gatekeeping, and provides a heuristic for broader social ties across subreddits. Understanding the moderation structures within and across theme subgraphs allows us to examine how Reddit users self-organize by moving between subreddits at macro (RQ1) and micro (RQ2) levels, as well as the relationship between genealogical ties and user-defined social indices (RQ3). As we aim to ultimately understand the relationships in the indexing network relative to each other (rather than all of Reddit), we limit the analysis of genealogical ties to the those within the bounds of our link tracing sample (i.e. keeping the node set consistent across network layers).

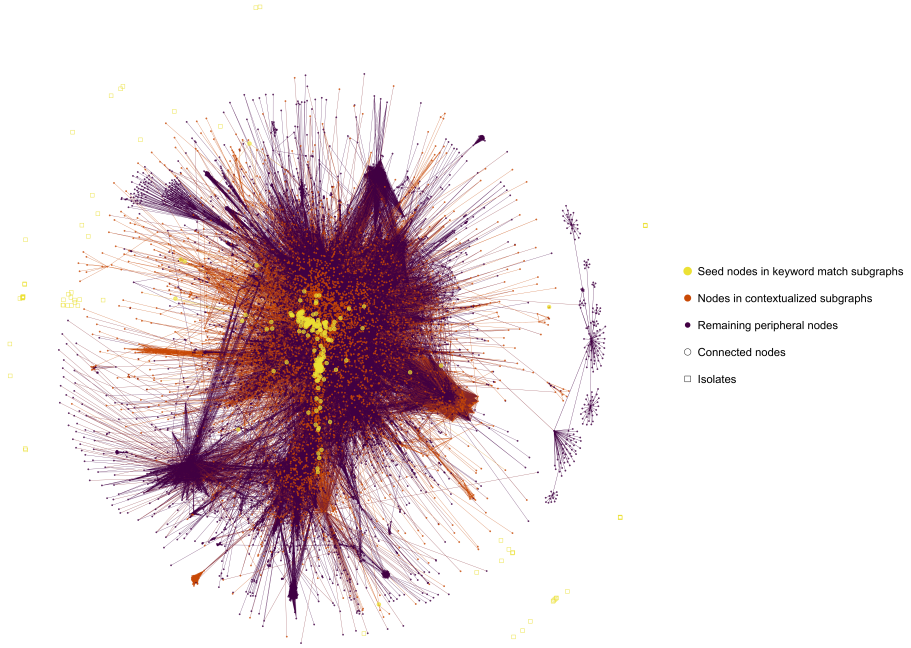

Fig. 1. Position of seed subreddits in the indexing network. Edges represent indexing ties and are colored by the two nodes they connect. Node positions were generated by the ForceAtlas2 layout algorithm.

To reconstruct these social relationships, we pulled the list of moderators for all publicly available subreddits in the indexing network with the PRAW API and connected all pairs of subreddits that shared at least one moderator. The weight of a tie between two subreddits is therefore the number of shared moderators. We note that this does not add any new subreddits to the dataset, but rather adds another layer of ties to the existing set. Of the subreddits whose metadata could be scraped, 67.23% shared a moderator with at least one other subreddit, resulting in 14,847 valued, undirected ties in total[6]. This network is shown in Figure 2. We next discuss our approach in examining these ties as indicators of information production, curation, and regulation.

4.3 Mapping a Networked Social Landscape

We consider the network of 44,167 subreddits as a population with varying positions relative to the explicitly gender-focused seed subreddits, either through an explicit indexing tie, or through an implicit genealogical relationship. This study population provides both a focused view of how specific subreddits orient themselves with respect to gender, but also places these narratives within a larger shared context. In a pluralistic fashion, it allows us to map connections and deviations between many differing social indices, and consider the relationship between these different forms of interaction and exchange.

[6]AutoModerator is a popular, customizable bot used to enforce content regulations in over eight thousand subreddits, including 3,418 subreddits in our sample. We exclude AutoModerator from our genealogical network because (1) it is a popular and highly customizable by subreddit, and thus tells us little about communities of moderation, and (2) because the $\binom{3,418}{2} * \frac{1}{2} = 2,919,826$ undirected edges generated would overwhelm exploration of more nuanced, non-automated relationships within the genealogical network

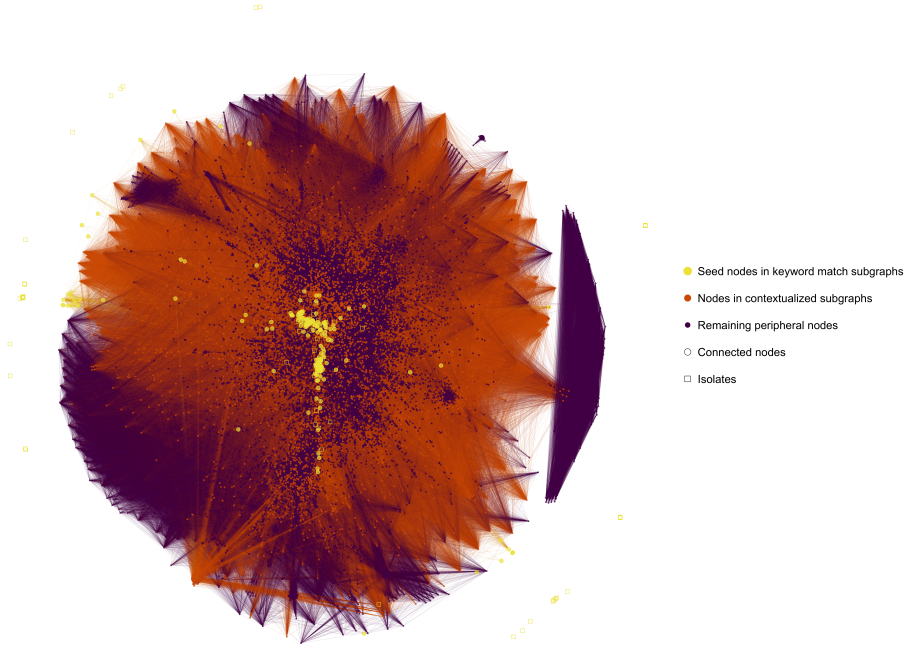

Fig. 2. Position of seed subreddits in the genealogical network. Edges represent shared moderator ties and are colored by the two nodes they connect. Node positions were generated by the ForceAtlas2 layout algorithm and are consistent with Figure 1

.

For each of the five gender index themes, we construct a theme-specific subgraph by drawing the subreddits that directly matched keyword search, as well as any subreddits one step away via a hyperlink or genealogical tie, with the goal of capturing subreddits that are proximate to conversations on gender, but that did not match the targeted keyword search. This strategy is akin to an egocentric network sample [91] of the keyword-matched subreddits, providing information about the local position, as well as the neighborhood in which these nodes are embedded. These five subgraphs are shown within the larger hyperlink network in Figure 2.

Of the 44,167 subreddits in the final (post link-tracing) dataset, expanding each subgraph to include adjacent subreddits in the indexing or genealogical network grew the total number of subreddits assigned to a keyword subgraph from 264 to 4,535. These final keyword subgraphs ranged in size from 0 (“mgtower”) to 2,220 (“trans”) subreddits, with a median final size of 467. Many subreddits belonged to two or more keywords, concept, or theme groups: at the keyword level, with the exception of “mghow” which consisted of one subreddit, percent overlap ranged from 29% (“manosphere”) to 100% (“non-binary”), with a median of 92%. At the theme level, this ranged from 49% (gender minority) to 96% (“misandry”). Overall, the overlap in search keyword results and the prevalence of keyword ambiguity highlights the instability of search keywords as classification tools, or more broadly, the interpretative flexibility of bottom-up, crowd-selected labels.

To summarize, we identify two lenses through which to examine the network layers described above:

- **Keyword Match Subgraphs:** This subset of nodes consists only of the 264 seed subreddits identified through keyword search, keyword matching, and qualitative coding. In other words, this subset represents search results with no additional social context. These subgraphs allow us to understand algorithmic grouping of keywords, concepts, and themes. We use these subgraphs to examine the *shared keyword* network layer.
- **Contextualized Subgraphs:** This subset consists of the 4,535 nodes in the "one-step" subgraphs described in the paragraph above, with theme and keyword groupings propagated along outgoing ties. These subgraphs address the limiting effects of keyword search by inferring context from acknowledgment and genealogical ties, allowing us to examine relationships explicitly based on user behaviors. We use these subgraphs to examine the *hyperlink/indexing* and *genealogical* layers.

The subsequent sections outline the analyses conducted to answer our research questions. These analyses employ network descriptive and exploratory methods to understand the structural features of the multi-layered Reddit networks described previously.

4.3.1 How do Reddit users self-organize around gender themes? To explore the organizing mechanisms of users, we focused on indexing ties and genealogical ties, as these are traces that directly map to user behaviors [25, 86]. To surface the distinct characteristics of indexing and moderation structures in the five different themes of gender indices studied here, we produce the following three metrics:

- Edgewise reciprocity, which is the fraction of ties that are reciprocated as a metric of hierarchy and stratification [91], to examine the extent to which relationships in each each theme-based subgraph are reciprocal (in the directed network of indexing ties).
- Network transitivity, which reveals triadic closure bias, is calculated as the fraction of length-three cycles to two-paths (i.e. the ratio of complete triangles to possible triangles), and is a metric for community cohesion [91].
- Krackhardt connectedness, which calculates the fraction of node pairs between which an undirected path (i.e. sequence of ties) exists in the network [53]. to characterize cohesion and potential for information flow (via a path of arbitrary length) at the macro-level.

By computing network reciprocity, transitivity, and connectedness (and comparing them to baselines) we systematically characterize and compare the subgraphs. We focus specifically on these metrics as they capture structural features that align with information flow, group cohesion, and community ties [91]. From here, we examine relationships between the gender indices represented by our five themes, and the taxonomic and sociotechnical structures in the context of Reddit.

Network-level indices such as those used here (e.g. reciprocity) can be sensitive to network size and density; therefore we avoid comparison of raw scores across different subgraphs. We instead use conditional uniform graph (CUG) tests to determine the statistical significance of the observed connectedness, transitivity, and reciprocity values, comparing observed values with a baseline model capturing network size and average levels of activity (i.e. density) [12]. Krackhardt connectedness and transitivity tests were conditioned on the dyad census, while edgewise reciprocity tests were conditioned on density, as conditioning on dyad census would fix the edgewise reciprocity values.

In addition to these network-level indices, we examine the relationship between subreddit age and (in)degree centrality to understand if older subreddit's occupy a central and potentially influential position within the networked social landscape. Indegree centrality is defined as the number of incoming ties (indegree) in a directed network, or number of ties (Freeman degree) in an undirected network [91]. To understand centrality in terms of number of neighboring nodes, rather than strength of connections, we treat these ties as dichotomous, meaning that the number of moderators

shared by two subreddits does not affect the resulting statistic. We use Spearman's *rho* to calculate correlation between subreddit age (in years) and (in)degree (number of incoming ties). We use two-tailed permutation-based tests with 1,000 simulations to determine statistical significance. These tests compare the observed value to an expected ("chance") distribution generated by calculating the test statistic on randomly generated graphs with some structural features held constant.

4.3.2 What patterns are visible at the meso level in each layer of the network? Turning to RQ2, we seek to characterize the meso-level dynamics of each network layer. Answering this question grants us greater insight into the utility of the macro-level metrics presented in RQ1 and the networks lens more broadly. To answer RQ2, we used an interpretive, visual approach to examine meso-level structure for each network layer. Visual exploration was based on graphics constructed using the Force Atlas 2 layout in Gephi, a software for network visualization [2].

To improve the legibility of the meso-level network structure, we scale the edge weights of the indexing and genealogical networks. In the sidebar and hyperlink layers, we weighted each tie with $\frac{1}{w_s}$, where w_s is the number of outgoing ties from the tie's source node, to adjust for subreddits whose sidebars link to or acknowledge large numbers of subreddits. This approach highlights ties and likewise network substructures that represent stronger relationships and down-weights ties that may be weaker due to divided attention across many outgoing ties. In the genealogical network, we weighted each tie as $\frac{1}{w_m}$, where w_m is the number of subreddits in our dataset moderated by genealogical, to mitigate the effect of humans or bots who moderator hundreds or thousands of subreddits. For the 9% of moderators whose moderation roles were not available on their profile page, we approximated this weight using the number of subreddits who listed them as a moderator in our dataset.

Within Gephi, we iteratively filtered and visualized regions of each network layer, applying Louvain clustering [5], connected components, and k-cores analysis to visually identify structural patterns. Connected components and Louvain clustering (a community detection algorithm that maximizes ties within clusters and minimizes ties between clusters) highlighted rifts in the network. K-cores analysis, in which the k-core refers to the maximal subgraph of nodes with degree k, involves stripping away nodes with lower levels of connectedness to reveal denser core regions within the network. Iteratively applying these techniques and visualizing the results allowed us to move between micro and macro views of the network, and gain qualitative insight into the meso-level characteristics. The results of these findings allow us to answer RQ2 by contextualizing and evaluating the structural metrics discussed for RQ1.

4.3.3 To what extent do genealogical and algorithmic relationships align with crowd-assembled social indices? The previous analyses examined each layer of the network individually; we also wanted to explore the association between these ties. Specifically, we aim to understand how crowd-organizational ties between subreddits and social ties between subreddits align with (or deviate from) genealogical ties and the relevance ties defined by Reddit's search algorithm.

To approach this question, we calculated the network correlation between the indexing and genealogical (shared moderator) and shared keyword layers. If subreddit i shares a moderator with subreddit j, there may be overlap between the users of i and j, and thus the moderators of i may situate j within its social index to signal this relationship to users. Similarly, if subreddit i was identified through the same search keyword as subreddit j, the users of i may share interests and vocabulary with the users of j, and thus may define an indexing tie to denote this to users. These associations provide insight into the social, organizational, and predictive dynamics that shape Reddit's information space.

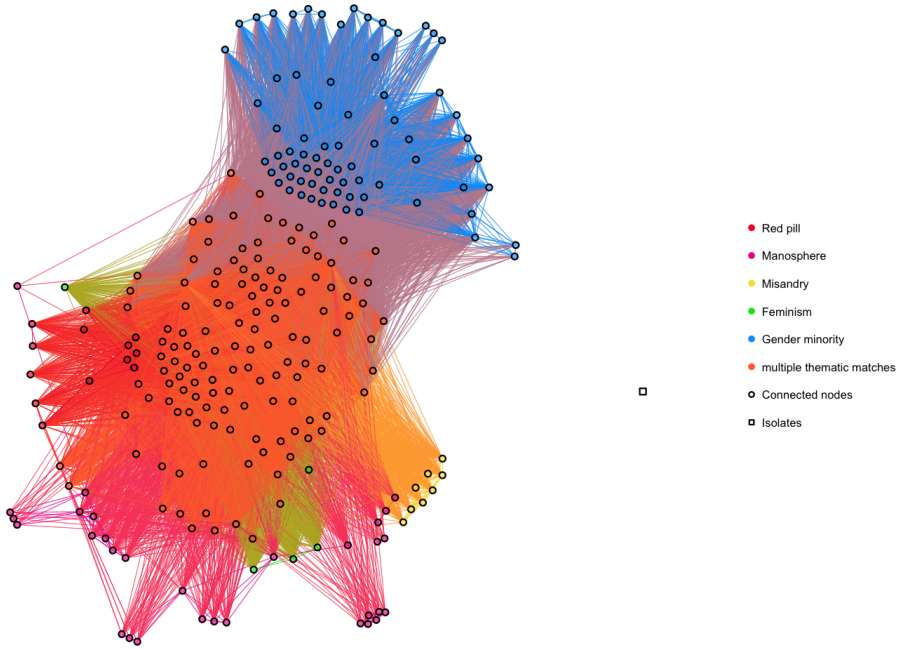

Fig. 3. Shared keyword ties between subreddits: undirected edges connect subreddits that matched the same search keyword. Node positions were generated by the ForceAtlas2 layout algorithm. The single isolate belongs to the Manosphere thematic group.

To evaluate the statistical significance of the observed network correlation, we used Hubert's quadratic assignment procedure (QAP), a non-parametric permutation-based test (or CUG test conditioned on all unlabeled properties of the network) run with 1000 simulations [52]. The QAP uses a matrix permutation in order to account for potential autocorrelation in network data. In addition, we consider the application of logistic regression models on the network adjacency matrix (i.e. the matrix whose i, j cell captures a directed tie from i to j). This simple model allows us to quantify the odds of observing a hyperlink tie between subreddits give the presence (compared to absence) of genealogical ties. To fit the logistic regression model, we used the *netlogit* function in the R software package *sna* [13].

5 FINDINGS

5.1 How do Reddit users self-organize around gender themes?

RQ1 aims to investigate social and organizational patterns as surfaced in trace data at an aggregate level. Therefore, to answer RQ1, we evaluate the network-level indices shown in Table 2 and the observed correlation between subreddit age and (in)degree centrality. This section will outline these findings for each network layer, beginning with the indexing ties.

We first focus on the subset of indexing ties that represent hyperlinks. Of the three layers we examined in this analysis, the hyperlink layer was by far the most sparse: the number of hyperlink ties in each thematic network ranged from 72 (misandry) to 489 (gender minority). For all thematic groups, edgewise reciprocity was significantly greater than might be expected in a random network

Theme	Conceptual Group	Keyword	Ambig.	True Positive Matches	Final Size	Overlap	Pct. Collected
Manosphere	Manosphere	manosphere	0.00%	8	643	29%	640 (99.53%)
	MRA	men's rights activists	0.00%	5	35	63%	35 (100%)
		men's rights movement	0.00%	11	256	98%	254 (99.22%)
		mra	22.22%	14	255	94%	254 (99.61%)
	MGTOW	men going their own way	10.00%	9	92	88%	91 (98.91%)
		mghow	0.00%	1	1	0%	1 (100%)
		mgtow	0.00%	13	198	82%	195 (98.48%)
		mgtower	–	0	–	–	–
	PUA	pick-up artist	0.00%	2	7	71%	7 (100%)
		pickup artist	0.00%	5	30	33%	30 (100%)
		pua	5.56%	17	527	74%	525 (99.62%)
Misandry	Misandry	misandry	0.00%	16	820	96%	818 (99.76%)
Red Pill	Red Pill	red pill	0.00%	13	483	92%	481 (99.59%)
		redpill	0.00%	25	583	95%	580 (99.49%)
		trp	34.78%	15	549	93%	547 (99.64%)
	Blue Pill	blue pill	14.29%	6	385	99%	383 (99.48%)
		bluepill	0.00%	12	451	97%	448 (99.33%)
Feminism	Feminism	feminism	2.86%	34	2074	74%	2067 (99.66%)
		feminist	3.03%	32	1434	75%	1423 (99.23%)
Gender Minority	Genderqueer	genderqueer	3.33%	29	854	99%	848 (99.3%)
	Trans	ftm	9.09%	20	628	99%	626 (99.68%)
		mtf	8.70%	21	422	97%	419 (99.29%)
		trans	7.94%	58	2220	80%	2207 (99.41%)
	Non-Binary	enby	0.00%	6	62	94%	62 (100%)
		non-binary	0.00%	11	636	100%	635 (99.84%)
		nonbinary	5.26%	18	490	97%	490 (100%)
	Transgender	transgender	3.33%	29	735	92%	727 (98.91%)
	Transsexual	transsexual	16.67%	5	289	35%	288 (99.65%)

Table 1. For each theme: the conceptual components, the search keywords used, and metadata for the resulting subreddits. "Ambig." refers to the percentage of keyword matches coded as "false positive" or "unsure" during qualitative coding for each keyword. "True Positive Matches" refers to the number of subreddits collected through keyword search, while "Final Size" refers to the subgraph size after following length-one paths. "Overlap" is the number of subreddits in the given subgraph that belonged to additional subgraphs. "Pct. Collected" is the number of subreddits for which complete metadata were publicly accessible.

with the same density, indicating that hyperlinks between subreddits tended to be reciprocated, and thus were not particularly hierarchical. Transitivity and Krackhardt connectedness were significantly greater than than expected given the baseline (conditioned on observed dyad census), indicating that thematic groups were relatively cohesive at both the micro-level of triads and broader, macro-level. We also note that correlation between age and indegree centrality was significantly greater than chance: $\rho = 0.35(p = 0)$, indicating that subreddit sidebars tended to direct users to older subreddits.

Examining the indexing network as a whole, we can immediately observe that each thematic network was much denser: the number of ties ranged from 1,454 (red pill) to 9,946 (feminism). As in the hyperlink layer, both edgewise reciprocity and transitivity were much greater than expected in the baseline, indicating that the subgraphs were cohesive at the dyadic and triadic scale. However, Krackhardt connectedness was significantly lower than chance, suggesting that the thematic subgraphs were fragmented at the macro scale. Subreddit age for this layer also correlates positively with indegree: $\rho = 0.35(p = 0)$. This indicates that older subreddits were influential in the network structure, serving as "anchor points" from which newer subreddits branched off, perhaps defining more nuances within the social index.

The genealogical subgraphs were again much denser than the indexing subgraphs, ranging from 39,490 (red pill) to 376,380 (manosphere) ties. As genealogical edges (along with shared keyword edges) were undirected, we did not calculate edgewise reciprocity for this layer. Turning to the other two metrics, both transitivity and Krackhardt connectedness were significantly greater than chance given the observed dyad census for all thematic groups. This suggests that this layer consisted of small clusters of subreddits that shared moderators, but was fragmented at the macro-level. As in the other layers, we observed a positive correlation between subreddit age and indegree centrality: $\rho = 0.10(p = 0)$.

5.2 What patterns are visible at the meso level in each layer of the network?

To answer RQ2, we present findings of our interpretive analysis of each network layer.

5.2.1 Shared Keyword Ties. We examined the shared keyword network, recalling that it consisted only of the 264 seed subreddits identified through keyword search. In this layer, we observed that themes were not evenly distributed, but instead that the groups of gender minority, red pill, and misandry subreddits appeared distinct from other groups; feminism, manosphere, some gender minority and red pill, and multi-theme subreddits appeared to form both a bridging core between other gender minority and red pill subreddits, and extended into a periphery. K-cores analysis indicated the densest region of the network was this core, along with large regions of the gender minority and red pill groups. We also noted a single isolate belonging to the manosphere group, representing a subreddit that matched the keyword *mghow*, which did not match any other subreddits. We characterized this layer of the network as dense and well-connected, with both regions of intermixing between themes, as well as regions of relative isolation.

5.2.2 Hyperlink Ties. Only 6,393 subreddits were connected in this layer; however, looking at the connected components, several patterns emerged. Despite the sparseness, the largest *strongly* connected component (i.e. taking into account the direction of hyperlink ties) consisted of 935 subreddits (15% of the connected subreddits). The remaining strongly connected components were much smaller. Visually examining these components revealed various smaller, denser clusters of interest, hobby, or locale-centric networks, loosely connected to each other by the intersections of their content: for example, 12 subreddits dedicated to different types of alcohol (such as r/cocktails, r/bourbon, r/whiskey, r/wine, and r/drunk) formed a tight, reciprocal cluster. r/wine then links to

r/fermentation, and r/homebrewing, which in turn linked to r/mead, r/homesteading, r/fromscratch, r/vinegar, r/canning, r/dehydrating, and r/kansascitybeer, which linked further to other clusters.

More general subreddits appeared to act as hubs for dense clusters, surrounded by more specific subreddits: r/newjersey is linked to by r/hoboken, r/newark, r/oceancounty (specific locales within the state of New Jersey), along with a subreddit for dating in New Jersey, and two subreddits related to New Jersey universities. Other clusters centered on sports teams, cars, musical genres, and parenthood, to name a few.

Within the five thematic groups, the most prominent clusters centered on mental health, LGBT+ identities and gender transition, sexual and erotic content, red pill content, and the manosphere. These clusters were not distinct from each other, but blended together. We also saw smaller clusters related to humor, digital culture and memes, parenting, and sustainability, and an isolated cluster of red pill subreddits specific to women. Broadly, we characterized this hyperlink layer as sparse ties, organized for flow between interest-based subreddits with related content.

5.2.3 Indexing Ties. The overall indexing network (consisting of all 44,167 subreddits identified through link tracing) was much denser and more connected than the subset of hyperlink ties, so we examined this layer by k-cores, iteratively stripping away nodes of lower connectedness to reveal dense clusters of nodes. Similar to the hyperlink network, we saw dense clusters of thematically-similar subreddits. The most prominent clusters were characterized by locale-based photos (e.g. r/thailandpics, r/spainpics, and r/italyphotos); a network of autofeeds from major news outlets (e.g. the Associated Press, Al Jazeera, and the New York Times); fantasy creatures and landscapes; the environment and sustainable living; discussing specific asteroids, planets, and other celestial bodies; locale-based political organizing; specific celebrities; music genres; medicine and epidemiology; and sexual/erotic content.

The 4,535 subreddits assigned to our five thematic groups appeared in these main clusters: many subreddits in the fantasy creatures and landscapes cluster were assigned as manosphere subreddits. A large cluster of feminism-assigned subreddits consisted of subreddits dedicated to adult film stars. The gender minority subgraph appeared as two densely-connected clusters, one centered on trans and LGBT identities and the other on sexual/erotic content, loosely connected by subreddits that bridge these two categories.

Many subreddits (1,765) in this network matched multiple thematic groups. Perhaps unsurprisingly given the sampling strategy, multi-theme subreddits tended to have higher indegree values. We can therefore characterize this subset of multi-theme subreddits as high-indegree hubs distributed across the broader network, and loosely connected to each other through other multi-theme pathways. Overall, the indexing layer of the network was denser than the hyperlink network, yet similarly organized for flow between subreddits related by common interests.

5.2.4 Genealogical Ties. Finally, we turned to the genealogical layer. Only 4,148 of the nodes from the indexing network shared a moderator; however among these nodes were 808,242 ties, each representing an instance of shared moderation between two subreddits. The edge weights discussed above became meaningful here: the median edge weight was 0.0036, suggesting that much of this density was due to accounts that moderate hundreds or thousands of subreddits. After filtering to edges with weights greater than the median, we again iteratively moved between k-cores, stripping away less-connected nodes to reveal denser clusters. This process revealed a large, central cluster, surrounded by smaller, peripheral clusters of nodes (visible in Figure 2).

Examining the smaller clusters, many clusters appeared to have relatively insular moderation structures and were interest-centric, as in the indexing network, e.g. locale-based offshoots of the infamous r/the_donald [29], subreddits dedicated to cryptocurrencies, and specific genres of erotic content. Beyond these small clusters, studying the large, central cluster surfaced few structural

patterns. Visual examination suggested that content similarity was influential in organizing shared moderation ties, although we also observed connections between apparently dissimilar subreddits.

Focusing on the positions of the five thematic groups within the genealogical network, 4,148 subreddits assigned to a thematic group (91.5%) were connected, i.e. shared at least one moderator with another subreddit. As in the indexing network, multi-theme subreddits appeared most prominent in the large, central cluster. We also observed several smaller, peripheral clusters specific to single themes: within the manosphere group, many of the subreddits dedicated to fantasy landscapes and creatures formed a dense moderation cluster, along with a mixture of subreddits centered on pickup artistry, hallucinogens, and anonymous web browsing, and several other smaller clusters; in the feminism and gender minority groups, smaller clusters centered primarily on adult film stars and erotic content. We also noted a red pill cluster of humor subreddits.

Interestingly, while the majority of the multi-theme subreddits appeared in the large, central cluster, there were also several multi-theme peripheral clusters—these clusters matched the keywords of multiple themes, but did not serve to join larger regions of the network. One of these clusters was composed of "gender critical" subreddits and subreddits focused on radical feminism. In addition, we observed a cluster of subreddits that organize around red pill keywords, yet matched multiple social index themes during our keyword search, indicating that they were nonetheless relevant to multiple gender indices on Reddit. Returning to the genealogical network as a whole, we can characterized this network layer as dense, and partially but not wholly structured by subreddit content. The position of multi-theme subreddits suggested that these central subreddits might serve as "crossroads" for different social indices, with the notable exception of "gender critical" subreddits.

5.3 To what extent do genealogical and algorithmic relationships align with crowd-assembled social indices?

To characterize the correlation between genealogical/shared keyword layers and indexing layers, we calculated the log odds of observing undirected tie Y given directed tie X between two subreddits, compared to observing Y *without* tie X. In all cases, the odds were significantly higher than chance. For all subgraphs, the log odds of shared keyword tie given a hyperlink or indexing tie ranged between 1.1 and 1.3. Genealogical ties showed a greater range: the log odds of a genealogical tie given a hyperlink tie ranged from 1.3 (misandry, feminism, and gender minority) to 14 (manosphere). The log odds of observing a genealogical tie given an indexing tie were much more extreme: these results ranged from 71 (misandry) to 8,200 (manosphere).

6 DISCUSSION

The goal of this empirical case study is to inform methodological practice with respect to collective identity categories, particularly in regard to representations of trans people in data. This paper thus contributes an analysis of how gender indices are co-constructed across gender counterculture communities on Reddit. To this end, we now situate our findings in relation to the critiques of implementation presented in Section 2.2.1. The discussion presented subsequently is organized by our three motivating research questions.

6.1 How do Reddit users self-organize around gender themes?

In both the hyperlink and indexing layers, we see a process of chronological branching, where newer subreddits situate themselves with respect to older subreddits. Rather than being flat or self-contained, this pattern suggests that not only are social indices defined relationally in practice—they grow and develop from older ideas, and may appear in response to gaps or fractures that exist in prior schema—but these relationships are dynamic and evolving over time. Emerging

Edge Type	Theme	Size	Edge Count	Density	Edgewise Rec.	Transitivity	Krackhardt Conn.
Shared Keyword	Manosphere	123	4,877	0.65	–	**0.87*****	*0.98****
	Red pill	94	4,240	0.97	–	**0.98*****	1.0
	Misandry	58	1,653	1.0	–	1.0	1.0
	Feminism	129	8,200	0.99	–	**0.99*****	1.0
	Gender Minority	150	9,483	0.84	–	**0.93*****	1.0
Hyperlink	Manosphere	1,472	262	0.00012	**0.14*****	**0.6*****	**0.0083*****
	Red Pill	6,42	77	0.00019	**0.23*****	**0.44*****	**0.002*****
	Misandry	820	72	0.00011	**0.28*****	**0.28****	**0.0021*****
	Feminism	2,233	400	0.00008	**0.14*****	**0.58*****	**0.0078*****
	Gender Minority	2,654	489	0.000069	**0.14*****	**0.33*****	**0.0082*****
All Indexing	Manosphere	1,472	4,054	0.0019	**0.44*****	**0.83*****	*0.43****
	Red Pill	642	1,454	0.0035	**0.44*****	**0.69*****	*0.46****
	Misandry	820	1,766	0.0026	**0.34*****	**0.39*****	*0.49****
	Feminism	2,233	9,946	0.002	**0.37*****	**0.83*****	*0.57****
	Gender Minority	2,654	8,582	0.0012	**0.32*****	**0.43*****	*0.62****
Genealogical	Manosphere	1,472	376,280	0.17	–	**0.97*****	*0.77****
	Red pill	642	39,490	0.10	–	**0.55*****	*0.82****
	Misandry	820	124,544	0.19	–	**0.85*****	*0.83****
	Feminism	2,233	303,212	0.06	–	**0.65*****	*0.79****
	Gender Minority	2,654	324,098	0.05	–	**0.7*****	*0.67****

Table 2. For each theme: network-level indices by each type of tie. Edgewise reciprocity is calculated on indexing ties, while Krackhardt connectedness and transitivity are calculated on both indexing and genealogical ties, and statistical significance for all three metrics was determined using a conditional uniform graph (CUG) test; transitivity and connectedness tests were conditioned on the dyad census, while edgewise reciprocity tests were conditioned on density. **Bolded** cells represent an observed value significantly higher than chance; *italicized* cells represent an observed value significantly lower than chance; "*", "**", and "***" represent p-values less than or equal to 0.05, 0.01, and 0 respectively.

gender categories are at least partially defined by their position relative to older categories, even though these older categories may or may not be actively used. Subreddits on the periphery of the network may represent emerging gender identities, while those at the center may be more entrenched in the gender culture of Reddit. A network perspective allows for reconfiguration of

X	Theme	Y	
		Hyperlink	All Indexing
Shared Keyword	Manosphere	**1.2*** **	**1.2*** **
	Red Pill	**1.2*** **	**1.2*** **
	Misandry	**1.2*** **	**1.1*** **
	Feminism	**1.3*** **	**1.2*** **
	Gender Minority	**1.3*** **	**1.3*** **
Genealogical	Manosphere	**14*** **	**8,200*** **
	Red Pill	**7.5*** **	**380*** **
	Misandry	**1.3*** **	**71*** **
	Feminism	**1.3*** **	**1,200*** **
	Gender Minority	**1.3*** **	**6,500*** *

Table 3. For each theme: Log odds of observing relationship Y given relationship X (vs. absence of relationship X). This was calculated by performing a logistic regression of the indexing network on the genealogical network [13]. **Bolded** cells represent an observed value significantly higher than chance; *italicized* cells represent an observed value significantly lower than chance; "*", "**", and "***" represent p-values less than or equal to 0.05, 0.01, and 0 respectively.

this relational structure; we can observe the aggregate of various positioning relationships across time. Past relationships may persist, or they may be changed to reflect new ideas and community participation. Though outside the scope of this study, one might also consider a dynamic or temporal network analysis to measure emergence and reconfiguration directly. This view of identities as constantly evolving demonstrates the utility of the social constructionist lens when combined with crowdwork, and the potential for new demographic paradigms.

It's also important to note that there is no requirement for consensus among (or within) gender-based communities on Reddit. Instead, the branching structure may indicate patterns of partial consensus—for example, feminist subreddits may loosely agree that patriarchal structures exist, but disagree on the finer points of how this manifests and how to respond. This interpretation is also supported by the high reciprocity and low connectedness compared to the baseline: there may be small communities or subnetworks with interoperable social indices, but this consensus is not enforced across the entire platform. The networks lens, and the reciprocity metric in particular, allow us to surface such patterns. Where flat indices force consensus by allowing only one configuration of identity categories, our findings suggest that networked approaches to social indices may reveal representations of how social categories are subjectively experienced. Elevating the social indices of Reddit users and other research subjects—i.e. seeking to understand how individuals situate themselves in the social world—may be well-served by social indices that allow for relational, nuanced, and evolving structures. In other words, our work aligns with that of Scheuerman et al. [83] and Keyes [49] in pointing to the dangers of supervised labeling algorithms and predetermined social indices, as well as the potential for using trace data to understand how those in the community of study label themselves. Future work may examine how this model of identity can be incorporated

into demographic metrics, i.e. demographic data might be restructured to allow for fluid identities and category systems [78].

6.2 What patterns are visible at the meso level in each layer of the network?

The results of our interpretive analysis indicate that the way hyperlink and indexing network layers are organized facilitates flow across subreddits with similar topics. In contrast, while the genealogical (shared moderator) layer did show a similar pattern of organization by topic at times, it also broke with this pattern. This may indicate that there are different understandings of moderator expertise across subreddit communities: some moderators may be subject area experts, and thus moderate several topically-similar subreddits. Other communities may have different approaches to selecting moderators that may not be directly tied to the subreddit's topic. Reddit may serve different roles for its users: some users may build their identity around a single topic, while others may build identities across multiple subreddits and topics. The social "glue" that holds subreddits together into communities may be highly contextual and evolving. In other words, both the individual identity labels and the social index that is comprised of them are in flux; however, some labels are likely more "stable" than others, and macro-scale patterns may arise despite fluctuations at the micro level.

Along with the branching nature of the hyperlink/indexing layers, these findings point support the need for greater nuance in conventional social indices. In practice, users may foreground different identities in different contexts or hold multiple identities simultaneously, as indicated by Ruberg and Ruelos [78]. In addition, a distinct separation between what is and isn't a gendered identity may not be possible—father, actress, enby, body builder, and feminist each have a unique relationship to gender—instead, social identities may be situated in varying degrees of proximity to explicit concepts of gender. Abstractions or aggregate representations of gender indices thus require further consideration of what gender means in a given context. Systematic data collection informed by this networked understanding of identity would represents a major shift from the conventional linear array of checkboxes, and would require new methods of collection, storage, and analysis. Given the increasing attention to how data can shape our understandings of identity, a network lens presents an exciting way forward, and beyond flat and rigid social indices. Future work may examine how collective identities are produced in other contexts, as well as how basic demographic metrics might be rewired to allow for dynamic and/or relational identity categories [78].

6.3 To what extent do genealogical and algorithmic relationships align with crowd-assembled social indices?

Finally, we turn to the relationship between crowd-assembled social indices and their social and technical context. This question allowed us to explore the situatedness of Reddit, defined by both a distinct social and cultural history as well as unique platform affordances and algorithms. Our findings indicated that genealogical ties are generally very likely given an indexing tie, meaning that if subreddit i situates subreddit j within its social index, it is very likely that there is some shared community between subreddits i and j. Again, the network lens allows for these multiple relationships to be captured and represented; it is also straightforward to explore their co-incidence.

This shared community is unsurprising; community norms likely correspond to shared cultural, worldview, and language. From the STS perspective, tools like categories and indices are produced by social behaviors and therefore reflect shared history. Without a causal direction, we might interpret this to mean that existing social groups build and organize subreddits, or that shared social indices (i.e. aligning worldviews or experiences) provide the necessary foundation for social ties to form. From a social constructionist perspective, we might look for collective rituals or everyday

interactions that reify the shared social index [35], such as posting and commenting on a subreddit's feed (and crossposting content from other subreddits). The strength of shared history and culture across the subreddit network (including many subreddits that do not appear to be gender-centric) also speaks to why quarantining or banning individual subreddits may not be successful in fully shutting down communities that organize around hate speech and harassment.

7 LIMITATIONS

There are several important limitations of this work. First, as discussed in Section 2, we focused on the problem of implementation rather than intent with respect to empirical studies of gender. The degree and nature that any research method may be considered participatory depends on many factors, and methods that are nominally participatory or trans-inclusive may still be mechanisms in larger systems that cause harm to trans people. We also note that this method is participatory in the sense that it examines how Reddit users define themselves; however, combining these methods with more in-depth ethnographic work will likely produce more nuanced understanding of what these gender labels mean to the Reddit users who define and negotiate them.

We also note that the opacity of Reddit's subreddit search algorithm and the small fluctuations in the subreddit search results suggest that there may be minor variation in the network nodeset and the algorithmic ties, and as moderators and sidebar content can change, the genealogical and indexing layers may vary as well. Future work may involve temporal analysis of these three layers to evaluate their stability. Finally, we note that the methods presented in our empirical study are particularly sensitive to the amount of existing knowledge about community. As the mechanisms of the manosphere, red pill, and misandry themes were already well-documented, we were able to separate these into distinct themes with high confidence, compared to the gender minorities theme. This again suggests that our keyword search method may be improved by conducting exploratory ethnographic work beforehand. This aligns with Keyes' recommendation of using methodological triangulation with respect to gender identity [49].

8 CONCLUSION

This paper explored a gap between theory and method with respect to quantitative analysis of gender categories. We explore alternatives to top-down, predefined gender labels using a multi-layer network and trace data, and viewing collective identities as a product of crowd work. Building on CSCW expertise on participatory methods and networked platforms, we present a method that surfaces user-defined gender categories as relational, situated, and evolving in the context of Reddit. This work supports existing literature that calls for more flexible and participant-driven approaches to demographic data and identity labels, and points to the utility of network analysis in moving beyond the current convention of "flat", linear categories. More broadly, our findings suggest that researchers can use online environments and trace data to understand how collective identity categories emerge from a confluence of social, cultural, historical, and technological factors.

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