

# Fifty Shapes of Reddit: Do Prolife Activists Have the Same Interaction Patterns of Gun Fanatics?

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**Abstract.** Online social networks represent a large share of our daily interactions. Conversations on these platforms are a rich source of data that may be used to better understand human behavior and the dynamics of user relationships, which can lead to or originate from particular participation patterns. These online social relations are often characterized by group-wise interactions, making hypergraphs, rather than traditional graphs, the ideal representation for complex, multi-actor interactions. This work aims to explore such high-order dynamics in online social media communities. Specifically, it focuses on subreddits—topic-specific communities on Reddit— and uncovers their underlying similarities and differences from a structural perspective.

**Keywords:** Reddit · Hypergraphs · Social media platforms · Network motifs · Conversational data

## 1 Introduction

Online Social Networks (OSNs) have revolutionized our lives, greatly impacting how we interact with other people. Not only our lives, but these platforms have reshaped the web, changing protocols and utilities to support a completely different consumer pervaded by the online world [18, 19]. The rapid advancement of technology has transformed our interactions from face-to-face to screen-based communication. However, this modern form of dialogue may not carry the same significance. Messages exchanged on screens are prone to various interpretations, making it challenging to discern the intended tone, whether it is a joke, sarcasm, or a straightforward remark. As a consequence, analyzing these conversations is challenging and requires the selection of appropriate tools to represent and examine such data.

OSNs are usually composed of interactions between multiple people (e.g., friends within the same group) who discuss a specific topic. In literature, graphs are the most used representation of these interactions. For example, an OSN can be modeled as a graph  $G = (V, E)$ , where  $V$  denotes a set of users and  $E$  represents the connections between two users. This link can easily define a real-world friendship or, for instance, the typical follow-follow relation [13]. However, representing these interactions with pairwise links between nodes could be a limitation when modeling many-to-many relationships [5]. In many real-world

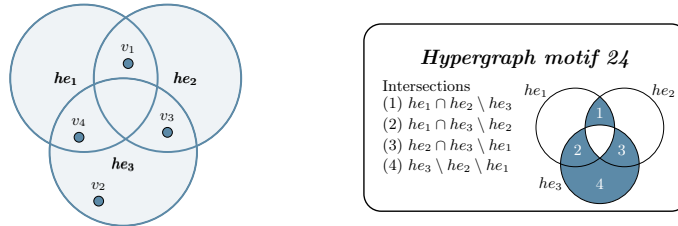


Fig. 1: Example of a hypergraph with three hyperedges and 4 nodes (on the left). From this configuration, it is possible to extract an instance of h-motif (on the right), given by the intersections: (1)  $he_1 \cap he_2 \setminus he_3$ ; (2)  $he_1 \cap he_3 \setminus he_2$ ; (3)  $he_2 \cap he_3 \setminus he_1$ ; (4)  $he_3 \cap he_2 \setminus he_1$ .

systems, relations are non-dyadic and often involve more than two nodes. Social networks are a clear example of this phenomenon, as social groups are based on relationships among multiple users who interact simultaneously (e.g., a group of users commenting on the same post), leading to the emergence of high-order behaviors that are poorly encoded in the topology of a traditional graph [3]. In recent years, alternatives like hypergraphs have gained popularity for representing these higher-order interactions [2]. Hypergraphs generalize the concept of graphs, allowing a hyperedge to connect an arbitrary number of nodes [4]. As motifs for graphs, h-motifs have been proven to be critical in identifying unique local structural patterns in different domains [14, 15]. Hence, enhancing our understanding of their formation and evolution can be used to identify meaningful connections to, for instance, stop misinformation spreading [9]. Figure 1 shows on the left a simple example of this mathematical structure and on the right an example of h-motif.

In this work, we explore the conversational patterns of online discussions on Reddit, a web platform that hosts various communities engaged in diverse topics [16]. Specifically, we model and examine the structural characteristics of the networks inferred from these conversations using hypergraphs and leverage the notion of h-motifs to describe the conversational patterns involving different topics. In particular, we aim to answer the following research question:

Within an OSN such as Reddit, where each subreddit functions as a distinct community, are there comparable patterns of interaction between these subreddits?

Results show that the conversational networks related to each Reddit community have their own structural characteristics, whose comparison within the same domain yielded unexpected results. In contrast to existing literature, our analysis revealed that conversations related to the same topic do not exhibit similar local interaction patterns. This suggests that high-order dynamics, such as groups of users interacting in the same conversation thread, cannot be overlooked when studying complex online human behavior.

## 2 Related Work

**The study of OSNs.** OSNs are probably the most visited and used websites on the Internet. Platforms such as Facebook, YouTube, and Reddit have facilitated how people create and maintain relationships, share information, and form communities. The study of OSNs has emerged as a dynamic and interdisciplinary field of research, involving experts from computer science [22], sociology [12] and many others [11]. The fast and easy access to these platforms has revolutionized the dissemination of information and coordination of activities. Social networks influence public opinion formation and can contribute to idea polarization. One example is the echo chamber effect, where individuals are exposed to homogeneous points of view, reinforcing existing beliefs and leading to increased polarization within society [7]. Analyzing these platforms has helped research to model and understand the behavior of people, diving into the shape of societal dynamics in the online world [6, 20].

**Hypergraphs.** Despite the prevalence of graphs, interactions in real-world systems often involve relationships between groups of entities. While graphs are ideal for representing pairwise relationships between them, the literature suggests that hypergraphs are better suited for capturing these more complex group interactions. Hypergraphs are, hence, the natural representation of a broad range of systems where group (or high-order) relationships exist among their interacting parts. Hypergraphs are a generalization of graphs where a (hyper)edge can group an arbitrary number of nodes. A hypergraph is formally defined as an ordered pair  $H = (V, E)$ , where  $V$  is the node set, and  $E$  is the hyperedge set [5]. Such structures can easily abstract social systems where individuals interact in groups of any size [15]; for instance, in the case of a co-authorship collaboration network, a hyperedge may represent an article and link together all authors (nodes) having collaborated on it [2]. Similar situations, characterized by high-order interactions, also exist in biology, ecology, and neuroscience [3]. In the social context, hypergraphs have been employed to model various scenarios, including the relationship between mobility and social connections [23], the formation of links between users using hypergraph neural networks [10, 17], the growth of social networks over time [21], and the impact of social influence on social networks [1, 24].

The concept of high-order motifs (h-motifs) has been recently introduced by Lee et al. [14] and describes the connectivity patterns of three or more connected hyperedges. As motifs for graphs, h-motifs have been proven to be critical in identifying unique local structural patterns in different domains [14, 15]. Each h-motif has a different shape, specified by the non-empty intersections between the hyperedges: (1)  $he_1 \setminus he_2 \setminus he_3$  (2)  $he_2 \setminus he_1 \setminus he_3$  (3)  $he_3 \setminus he_1 \setminus he_2$  (4)  $he_1 \cap he_2 \setminus he_3$  (5)  $he_1 \cap he_3 \setminus he_2$  (6)  $he_2 \cap he_3 \setminus he_1$  (7)  $he_1 \cap he_2 \cap he_3$ . An example of an h-motif is shown in Figure 1. It is important to note that an arbitrary number of hyperedges can be used to describe an h-motif, but the possible combinations increase drastically (e.g., 1,853 and 18,656,322 h-motifs for four and five connected hyperedges).

### 3 Results

In this section, we detail the experiments conducted to address the research question outlined in the Introduction. All code, images, and tools used in these experiments are available in a public GitHub repository<sup>1</sup>.

**Dataset.** The dataset built for our analyses includes 22 different subreddits, spanning from January 4th, 2019, to July 31st, 2020, counting 1.173.347 messages and 5271 users. For each subreddit, we retrieved all conversations, storing information about authors and submissions. It is worth noting that we anonymized all sensitive information.

**Modeling conversational networks with hypergraphs.** In this work, we model each conversation with a Text Attributed Hypergraph (TAH). Formally, a TAH is defined as a tuple  $H = (V, E, T)$ , where each node  $v \in V$  is associated with at least one text  $t \in T$ , which contains all the messages in a Reddit conversation [8].

**Structural analysis.** In this study, we focused on analyzing the local interaction patterns of each conversational network by following the approach outlined by Lee et al. [14]. Specifically, we compared the local structural patterns of the various conversational hypergraphs by examining their Characteristic Profiles (CPs). CPs characterize a hypergraph by quantifying the significance of its h-motifs, which is achieved by normalizing and concatenating the significance of all h-motif instances. Figure 2 illustrates the CPs of the subreddits we analyzed. As illustrated in the plot, conversations in the subreddits can vary significantly

<sup>1</sup> <https://github.com/ddevin96/DevCommunities>

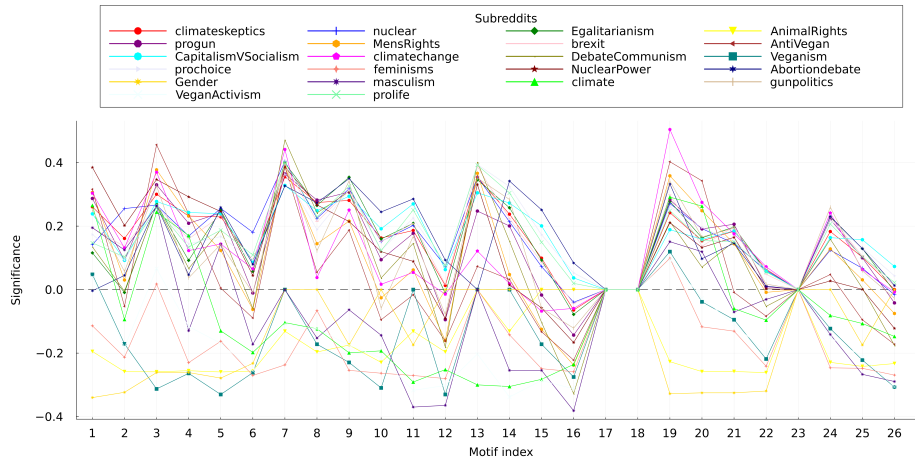


Fig. 2: CPs of the subreddits analyzed in this work.

in terms of local interaction patterns, suggesting that different network structures can emerge under similar conditions. To explore the common characteristics underlying similar conversational hypernetworks, we employed two grouping methods. The first method involves clustering the CP vectors, while the second measures cosine similarity between the CPs, providing a more nuanced categorization. Although both methods yield similar representations, they highlight different matches among subreddits. Figure 3 illustrates the outcomes of both methods.

To better understand the underlying motivations behind these two different categorizations, we selected three samples from each similarity matrix. Specifically, we chose the following triples of subreddits:

- *climateskeptics*, *progun*, *prolife*;
- *climateskeptics*, *nuclear*, *egalitarianism*;
- *climateskeptics*, *climate* and *climate change*.

Each group includes a conversation hypergraph of varying sizes and shapes, but all groups contain the *climateskeptics* subreddit for comparison. Figure 4 illustrates the curve trends for the CPs of the three distinct groups. The first two groups, which are clustered together in the matrix, show similar curve patterns. In contrast, subreddits from the third group, despite being from the same real-world domain (i.e., climate), display a different trend. These observations imply that local patterns can highlight diverse phenomena based on the composition of the groups.

First, we can observe that the size of the hypergraph does not influence the number of h-motifs. All the hypergraphs generated exhibit different shapes, and neither cluster differentiates based on a quantitative measure. Second, contrary to the assertions in [14], real-world hypergraphs within the same domain do not follow the same curve trend. This discrepancy is primarily due to two reasons.

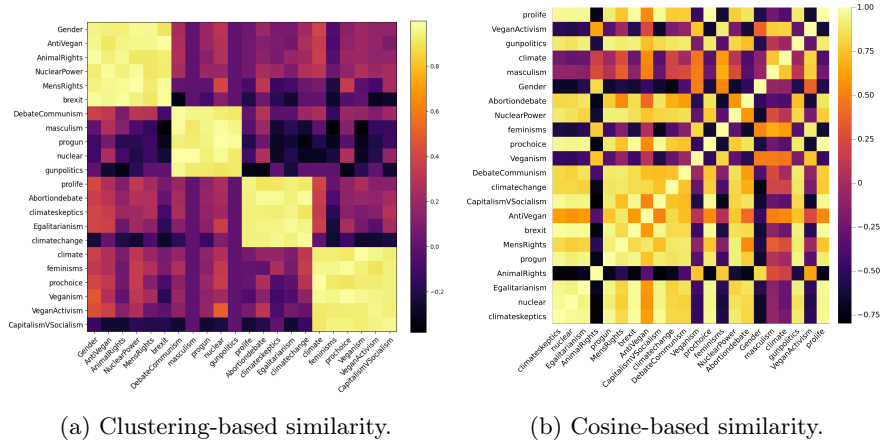


Fig. 3: Matrix of similarity for CPs.

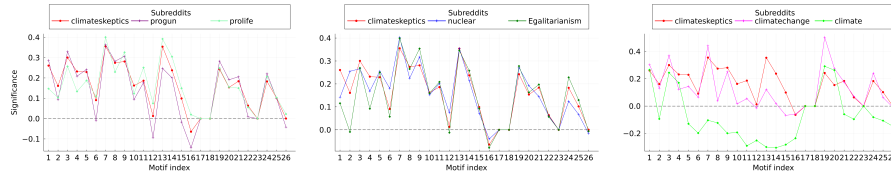


Fig. 4: a) Three subreddits that have similar CPs using clustering. b) Three subreddits that have similar CPs using cosine similarity. c) Three subreddits with similar domains.

Assuming these hypergraphs belong to the conversations or social network domain, Figure 2 clearly shows that multiple behaviors follow different curve trends. Therefore, this finding highlights that domain alone is not a sufficient feature to categorize different communities into the same group. Our results further suggest that the observed similarities are more closely related to the dynamic behavior of the Reddit platform rather than the specific topics considered. Conversely, if we consider these hypergraphs based on the domains suggested by their names (e.g., the progun subreddit not hosting discussions about vegan food), we find clear instances of hypergraphs from different semantic domains sharing similar patterns. This similarity is not observed in hypergraphs from the same domains.

In summary, while domain similarity offers a starting point for studying similar communities, users’ dynamic behavior and interactions play a more crucial role in defining their structural analogies.

Some limitations of this study relate to the data and their analysis. First, the temporal span and the selection of messages may limit the representation of how diverse users impact the observed communities. It is also important to acknowledge that the study considers a temporal slice of one and a half years in its entirety. Future research should explore both longer and shorter temporal slices to better understand the evolution of these communities.

## 4 Conclusion

This paper presented an analysis of Reddit conversational data through the lenses of hypergraphs. The results suggested that conversation interaction patterns are not entirely topic-dependent, indicating that subreddits from different discussion domains can exhibit similar local structural patterns. This outcome implies that the inherent user dynamics of the Reddit platform significantly influence conversation dynamics.

We are currently exploring the similarity of subreddits from a semantic perspective by analyzing language use. In future work, we plan to investigate the significance of h-motifs at the user level to better understand patterns of information diffusion and to determine whether certain structural patterns play a more prominent role in these dynamics.

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