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DOCTOR OF PHILOSOPHY

An Exploratory Study on the Identifiable, Classifiable,
and Predictive Nature of Extremist Content and
Communication

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To my wife, without whom I wouldn't be here.

Declaration

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Abstract

Counter-responses to the many phenomena of online extremism require the preliminary steps of identification, classification, and ultimately prediction of such behaviour. Despite the necessity of these building blocks, the field of study suffers from a lack of data-driven empirical research - particularly on individuals.

This thesis is an exploratory attempt to put forward a dimension-based extremist construct taxonomy (ECT) developed from known, but largely scattered, empirical insights into extremists, fundamentalists, Islamists, and jihadists (EFIJs) at the individual level of study, as a foundation upon which to build practical EFIJ research. A total of nine dimensions are proposed as delineations capable of identifying constructs in the written material produced by EFIJs, such as the content of communication exchanged by individuals on extremist online fora (EOF). Studies of a number of EOF showed that engagement with dimensions of the ECT over time was dominated by relatively few such dimensions. Specifically, this thesis finds that social relations and theological knowledge dominate the overall level of discussion influence in these communities. Further experimentation with the influence of the social relations dimension found that it could reliably predict both the ideological type of established EFIJ groups, and the behavioural role of EFIJ individuals in EOF communication networks, based on the manner in which they communicate relative to their peers, as tested against two large corpora of such material and communication.

The work contributes a detailed collation of studies, qualified by the inclusion of empirical individual level data and findings, a ground-level taxonomy of categorisation for the constructs found in EFIJ written content, two novel corpora collected and constructed directly from such content, and an application of advanced interdisciplinary algorithms and methods across three papers in pursuit of much-needed practical exploration of the EFIJ topic.

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List of Acronyms

AB	al-Badr	24
AE	Affective Experiences	10
AMB	al-Aqsa Martyrs Brigade	30
AM	al-Muhajiroun	21
ANF	al-Nusrah Front	23
ANOVA	Analysis of Variance	44
AQAP	al-Qa'ida in the Arabian Peninsula	27
AQC	al-Qa'ida Central	26
AQIM	al-Qa'ida in the Islamic Maghreb	22
AQIS	al-Qa'ida in the Indian Subcontinent	76
AQI	al-Qa'ida in Iraq	27
AQ	al-Qa'ida (Unspecified)	20
AS	al-Shabaab	19
ATB	Penn Arabic Treebank	64
BH	Boko Haram	60
BIC	Bayesian Information Criterion	45
BN	Binomial-Normal	44
CB	Conflict Behavior	10
CD	Collective Dynamics	10

CI	Confidence Interval	35
DFLP	Democratic Front for the Liberation of Palestine	21
DI	Darul Islam	22
ECP	Estimated Change Point(s)	43
ECT	EFIJ Construct Taxonomy	10
EFIJ	Extremist(s), Fundamentalist(s), Islamist(s), and Jihadist(s)	3
EGAC	Extremist Group Attribution Corpus	57
EIJ	Egyptian Islamic Jihad	19
EOF	Extremist Online Fora	3
ERAC	Extremist Role Attribution Corpus	57
EV	Existential Validation	10
FA	Fatah	21
FPI	Islamic Defender Front	24
FWER	Family-Wise Error Rate	71
GICM	Moroccan Islamic Combatant Group	27
GI	al-Jama'a al-Islamiyya	25
GLMM	Generalised Linear Mixed Model	44
GP	Geopolitical Perspectives	10
HA	Hamas	21
HB	Hizb-ul-Mujahideen	23
HE	Hizballah	21
HN	Hofstad Network	19
HTML	Hypertext Markup Language	10
HT	Hizb ut-Tahrir	23
HuM	Harkat-ul-Mujahideen	24

IAF Islamic Action Front	23
IAI Islamic Army in Iraq	59
IDQ Izz ad-Din al-Qassam Brigades	21
IJT Islami Jamiat-e-Talaba	23
IMU Islamic Movement of Uzbekistan	27
ISIS Islamic State of Iraq and Syria	19
JAL Jama'at al-Muslimin	24
JAS Jamaat Ansar al-Sunnah	27
JAT Jemaah Ansharut Tauhid	24
JeM Jaish-e-Mohammed	24
JIS Jam'iyyat Ul-Islam Is-Saheeh	23
JI Jemaah Islamiya	19
LeJ Lashkar-e-Jhangvi	27
LeT Lashkar-e-Tayyiba	23
LSA Latent semantic analysis	64
LTTE Liberation Tigers of Tamil Eelam	22
MB Muslim Brotherhood in Egypt	19
MCMC Markov Chain Monte Carlo	70
MIRA Movement for Islamic Reform in Arabia	60
MJC Muttahida Jihad Council	24
MKA Mujahedeen Kayamanya	22
MK Mujahedeen KOMPAK	19
MSA Modern Standard Arabic	39
MTR Mujahedeen Tanah Runtuh	22
NMI Normalised Mutual Information	46

NN	Normal-Normal	44
OE	Oppositional Evocations	10
OSINT	Open-Source Intelligence	49
PFLP	Popular Front for the Liberation of Palestine	21
PIJ	Islamic Jihad Movement in Palestine	21
PLF	Palestinian Liberation Front	22
PLO	Palestine Liberation Organisation	22
PP	Persuasion Processes	10
RBO	Rank-Biased Overlap	71
SR	Social Relations	10
SVC	Support Vector Classifier	41
SVD	Singular Value Decomposition	64
SVM	Support Vector Machine	41
TAL	Taliban	27
TAN	Tanzim	30
TeJ	Tehreek-e-Jihad	24
TF-IDF	Term Frequency Inverse Document Frequency	40
TK	Theological Knowledge	10
TNSM	Tehreek-e-Nafaz-e-Shariat-e-Mohammadi	24
TuM	Tehrik-ul-Mujahideen	24
UK	United Kingdom	19
US	United States	19

With the proliferation and mainstream use of social networks, fora, and blogs; online and text-based media have changed how individuals connect, communicate, and organise. The online communities formed using these media allow for information sharing of a scale and scope that is unprecedented in human history [2, 3]. The promise that the online medium of communication has for increasing human ingenuity and innovation is immense, however, online communication is not always used for good. Incivility online is extremely common [4], cyberbullying is a major concern, particularly for youth [5], and the Internet is used for a raft of crimes from fraud to drugs to terrorism [6, 7].

Accordingly, the societal and psychological consequences of online communication media are the subject of much academic research, with very mixed results. In a longitudinal study of families for the two years post introduction of the Internet into their households, Kraut et al. [8] found that members of the household communicated with each other less, reduced the size of their social circles and experienced increased depression and loneliness. Upon follow-up with many of these users, Kraut et al. [9] found that the negative effects were no longer present and, in their new sample, found positive effects on well-being and social participation associated with Internet use. However, it is important to note that positive effects were present for extraverts with high offline social support while negative effects were present for introverts with low social support, indicating that the effects of online interaction are influenced by individual level traits [9].

Individual motivation behind Internet usage also affects outcomes. Weiser [10] found that if individuals were seeking to acquire knowledge by using the Internet, they experienced increased psychological well-being; however, individuals seeking social and affective relations experienced diminished psychological well-being. Meta-analysis of the effects of the Internet on psychological well-being found a slight but significantly negative relationship, however, none of the individual moderators (participant age and gender) nor the type and quality of Internet usage served to explain this relationship [11]. Therefore, the effect of engagement with online communities on individuals' well-being and 'real life' social behaviour is not unidirectional, and appears to be affected by individual level factors such as personality, as well as the motivation for and nature of engagement. The interplay between the different factors and the extent of the effects remains unclear.

The nature and structure of communication in online communities have also been the subject of examination. As communication can readily occur between people who will, more

often than not, never meet and may not even set foot in one another's countries, the overall volume of communication occurring in online communities tends to be high. However, the fluid structure of online communities relative to traditional social and organisational forms means that individuals can freely and easily belong to multiple groups, enter and exit groups, and adjust the resources such as time and content that they contribute to any given community [12]. Consequently, although a great deal of communication often occurs, this volume is generated by a more distributed network of contributors relative to ordinary organisational forms [2]. This is attributable to the fluid structure which, relative to the offline world, inherently lends itself to a flatter hierarchy, whereby social role in a community is not assigned automatically by qualifications or employment position [13]. The differences in structure between online communities and traditional organisational or social groups - namely that an individual can come and go as they please, with minimal consequence, and can garner influence without a formal position or externally ascribed authority (for example, an educational qualification) - mean that the motivation of individuals participating in online communities and the functioning of said communities in terms of content and structure, will also differ.

In terms of how individuals engage with these online communities, multiple group membership, and the transient and fluctuating nature of membership leads to individuals being less tied to one set of social norms than is typically the case in one's physical community [3]. The looser social hierarchy, in combination with the anonymity often afforded in online communities, emboldens people to share their ideas as they have less fear of being judged based upon their social status and less fear of losing their social status [14]. It has even been posited that in the online context, individuals become 'disembodied', creating entirely alternate identities that share little to no similarity with their offline persona [3]. Therefore, the study of individuals and groups in the online context requires a different lens, as the ways in which online groups organise is very different, and the 'selves' that individuals embody online can depart completely from their offline self.

The influence of the content communicated in online communities on individuals' interactions with said communities has also been explored. Language in online communities is extremely powerful as, in the absence of clear roles or structures, language both facilitates the expression of individuals and forms the basis of the collective identity developed in the community [15]. In fact, Danescu-Niculescu-Mizil et al. [15] found that one's willingness to adopt the language and linguistic changes of a community reliably predicted retention in an online community such that faster adopters of linguistic changes remained in communities longer. Investigating language use and individuals' roles in an online community, Huffaker [16] found through analysis of user content that leaders in online communities influence other members through the diversity of their words, measured by the number of unique words communicated, and higher use of affective and assertive language [17].

To summarise, online communication and the communities that facilitate it have become very common in modern society. The effect of this medium on individual well-being and offline behaviour is variable and dependent on individual traits and the drivers of online engagement. The lack of physical or socially constructed barriers to communication mean that the networks of these online communities tend to be more distributed in terms of overall structure and the influence of individuals [18]. Individuals are also, relative to offline life, freer to move in and out of communities and are therefore less tied to a single set of social norms. Language in online communities is a powerful tool for developing the collective identity of the group, and is also a key determinant of the influence of individual actors in the network.

Much of this research is predicated on the notion that online communities centre on a purpose (such as discussing a hobby) and then develop an ideology and culture around that purpose [3]. This makes sense as this is the format and nature of the majority of online communities. However, it does leave the question of what happens when an ideology that is predefined in the offline world forms the purpose of the online community [19], such as in extremist online fora (EOF). Each online platform and each community within them will differ in the factors that drive social influence within them [20]. Therefore:

- How does content and structure develop in a community based around an external ideology?
- How do individuals obtain social influence?
- And how does the use of language affect both the structure of communication and individuals' ability to influence others within the community?

These are the broad questions that this thesis seeks to explore by analysing data from 27 online discussion fora identified as extremist(s), fundamentalist(s), Islamist(s), and jihadist(s) (EFIJ) spanning up to 14 years (2000–2014), and ranging from 392 to over 250,000 discussion threads per board. Given the importance of language in online communities in general, and the established ideology of these particular communities, the analysis focuses on the nature of the content (language) used, engagement with language over time, and the role of language in determining individuals' roles in the communication network.

First, a comprehensive review of literature that empirically examines EFIJ at the individual level of analysis is undertaken to derive a taxonomy of dimensions that is useful for identifying and categorising EFIJ constructs present in the language and communication of such individuals through analysis of the content they produce. The usefulness of the derived taxonomy is then tested on 13 of the EOF to ascertain whether the content does fall into these dimensions, refining the taxonomy through the identification of subdimensions,

and analysing whether user and community engagement with the constructs within these subdimensions changes over time. Finally, the role of the subdimensions in determining an individual's role in the communication network is explored.

1.1 Theoretical Background and Justification

While there remains debate about the efficacy of the Internet as a vehicle for the spread of extremist ideology and real-world violence [21], there is no doubt that the Internet is being used by EFIJ individuals and groups for a variety of reasons, including ideological diffusion, recruitment, planning and operations, legitimising and 'advertising' terror campaigns, and fundraising [22]. The Internet is an attractive medium for EFIJ groups as it is easy to access, minimally regulated, has a huge audience, and offers a degree of anonymity, the means to communicate with like-minded individuals, and the ability to influence mainstream media [23]. However, Aly et al. [24] argues that the real power of the Internet in transforming the extremism and terrorism landscape is its facilitation of two-way communication, allowing for the audience of extremist messages to participate, thus fostering a sense of virtual community.

A literature suggesting policy and policing responses has developed in light of the rise of the prominence of the Internet in extremism and terrorism. For instance, Dean [25] suggests that policing violent extremism requires navigation of the four 'Ps' - policing, public, policies, and politics. Policing is the authorities undertaking their sworn duties with consent of the public; these two elements (policing and the public) are inextricably linked. Policies act as the guide to police and, ideally, are aligned with the public's expectations. Finally, politics, both external and internal to the police organisation affect policing. In the context of online extremism, issues include respect of the public's privacy, the need of political leaders to be seen as tough on terrorism, and navigation of legislative requirements that are fundamental to democratic society during time-sensitive investigations [25]. In a similar vein, Neumann [26] puts forward that the government can combat online radicalisation by restricting freedom of speech (noted as an ineffective and undemocratic measure), the dissemination of counter-narratives and education of younger generations that may be susceptible to extremist messaging, and the exploitation of EFIJ online communication for actionable intelligence.

Though there is a substantial body of literature emphasising the need to research extremist groups' use of the Internet, and a body of literature examining policing and policy responses to this use of the Internet, there is comparatively little empirical literature on the content, structure, and specificity of communication between individuals participating in EOF. This can partially be attributed to the sheer volume of content generated on the Internet making traditional, human-led analysis near impossible [27], which has in turn led

to calls for greater collaboration between the terrorism and computer science fields [28]. The collaborations thus far have been fruitful, demonstrating the importance of the content exchanged online and significant potential to inform interventions. For example, Johansson et al. [27] built a machine learning model of linguistic markers [29] of violent extremism, derived from known warning behaviours that are detectable in text. These warning behaviours include leakage, the communication of intent to harm a third party, fixation, pathological preoccupation with a person or cause, and identification, the view of oneself as a pseudo-commando [27]. Ferrara et al. [30] put forward a machine learning framework for (1) detecting extremist users, (2) predicting regular users' adoption of extremist content, and (3) predicting reciprocation of contact that produced very promising reliability scores.

The majority of work focusing on EFIJ communication at the individual level of analysis has turned to contemporary social media for sampling. However, persistent large-scale disruption [31] and suspension [32] efforts targeted at individual accounts have created (and continuously sustain) a fast-growing resurgent effect of duplicate accounts that re-enter online extremist populations. Wright et al. [33] identified this phenomenon, which in turn, introduces a problematic bias of replicate error to studies that aim to explore extremism at the individual level in the online context. Whilst EOF also suffer from disruption, re-emergence does not require the recreation of individual accounts, as these data are protected by administrators and entire snapshots of the fora are restored after a takedown event, something which is not within the control of EFIJ individuals on other social media. Parekh et al. [34] went further and discovered that the inclusion of irrelevant accounts (i.e., non-EFIJ) is widespread in individual level studies that draw samples from contemporary social media, due to the manner in which graphs are constructed from the respective social networks. In excess of 70% of the studies examined made no clear attempt to describe the extent to which they actually did collect EFIJ accounts, which the authors argued is surprising and troubling, since it becomes impossible to attribute findings to online extremist activity.

Inarguably, EOF represent rich sources of conversational data due to the authoritative position these fora occupied in the broader EFIJ consciousness after their expansion period in the timeline of online extremist activity [35, 36], which coincided with Abu Musab al-Suri's critique of the so-called 'elitist' top-down approach to the dissemination of jihadist material and the rise of Abu Musab al-Zarqawi [37]. Further, EOF content is produced primarily by self-professed EFIJ individuals due to the presence of strict internal moderation, a requirement of the self-hosted nature of these fora, which acts as a limit on the inclusion of irrelevant accounts. In their own words, Abu Sa'd al-Amili, a prominent jihadist online author, lamented as an error the reliance EFIJ individuals and groups have placed on popular social media because they were run by "enemies" who would, he argued, inevitably "shut their doors in our faces", and that such reliance endangered EOF as "protected strongholds"

which must continue to serve as the “base and foundation” of EFIJ online [38]. The high degrees of internal control and moderation exercised by EOF hierarchical structures in keeping these communities free from abuse and overt external influence, whilst maintaining a space for EFIJ individuals to converse freely, mean they are unique and particularly attractive archives for study.

In sum, there is growing concern in the literature and amongst counter-terrorism practitioners about the role of the Internet in radicalisation and violent extremism. While we know that the Internet is being used by extremist groups, we know very little about its efficacy and the mechanisms that underlie audience engagement [39]. As Conway [28] states, both what and why questions remain about Internet extremism due to a lack of analysis of individuals’ experiences online and the structures that facilitate and constrain said experiences. Neumann [26] summarised key mechanisms identified in the literature that extremist groups use to radicalise individuals online. These include mortality salience, prompted by exposure to death and martyrdom; a sense of moral outrage, sparked by shocking audiovisual imagery; normalisation of criminal and deviant behaviour; online disinhibition, leveraging the sense of anonymity felt online to promote hostility towards the outgroup; role playing; and linking to offline terrorist networks [26]. However, these tactics do not address the processes - how individuals respond to and create information online, nor how specific online communities form and change.

Therefore, this thesis answers the recent calls of researchers to examine extremism in the online context across ideologies, groups, and countries, leveraging tools from the computer science discipline to facilitate the analysis of large volumes of content that are typical to the medium [27, 28]. Further, by examining two-way communication, rather than one-way communication such as magazines, communiqués, and other elements of jihadist culture published by extremist groups, we can examine how communities form and change, how information is disseminated within them, and how the content shared by individuals affects their influence. This capacity for community building, as Aly et al. [24] says, is the important role of the Internet in transforming the extremism landscape.

1.2 Statement of the Problem

The online environment is an increasingly used space for the spread of extremist ideology that promotes acts of violence and terror. While we know that the Internet is being used for this purpose, we know little about how it works - how the audience responds, how content affects connection, and how content and connections change over time.

As it stands, a small proportion of the literature on extremism is undertaken at the individual level of analysis. Due to the difficulty accessing primary EFIJ data, the samples of

much of this research tend to be varied and, further, comparatively few empirical studies focus on individual level phenomena in the online context. Gill et al. [40] estimate only 6.5% of studies on radicalisation in the online context are data-driven and that primary data exists in roughly 2% of the literature. Those which do examine the online context typically analyse social media communication such as on Twitter [41], VKontakte [42], YouTube [43] or various media produced by extremist groups [44, 45, 46], which introduce their own specific methodological challenges unique to these data. This results in a limited understanding of the dynamics and mechanics of online extremism, which is problematic for both research and practice because the interactions of individuals who engage with extremist ideology and may commit or support terrorist acts vary greatly. As Dean [25] states, individuals committing terrorism can act alone or in tandem, and with tight or loose networks. Therefore, surely any efforts to understand and combat online extremism would benefit greatly from knowing how these dynamics - individual versus group, tight versus loose networks - affect the content and structure of online extremist communities.

This thesis begins to address these problems by examining communication on EOF, a known medium upon which EFIJ individuals communicate, but largely overlooked by modern interdisciplinary research. The fora examined span multiple ideological groups and known terrorist organisations, operating across many countries, beginning to answer the call of Conway [28]. The thesis focuses on the dynamics of the communities formed in these EOF - categorising the language used, examining the changes in language use over time, identifying the network structure of the communities, and analysing the influence of language on this structure. While terrorism is a broad concept which still struggles to find definitional consensus, key parts of the concept are those on- and offline communication processes by its perpetrators who seek the support of constituencies based on ties of ethnicity, religion, political affiliation, and the like [47]. This thesis does not attempt to suggest or discover predictors of offline terrorist acts that are identifiable in online behaviour. Rather, it seeks to shed light on the factors affecting online communication networks in EOF, based upon the understanding that these fora are a powerful mechanism for spreading extremist ideology and developing cultures of understanding of extremist ideology at its core. The practical importance of this approach should not be understated, however, as it is accepted that extremism may be a precursor to terrorism [23], thus identification of key players and their extremism as detectable in text, and the influence these key players and key language have on the overall communication network can inform policy and practice responses.

1.3 Significance of the Study

In light of the aforementioned gaps in the literature, the significance of the study can be categorised into four main contributions to the literature: further exploration of the dynam-

ics of online communication, examination of EFIJ communication at the individual level, the use of comparably objective data, and the utilisation and combination of complex linguistic, network, and statistical methods. In addition, the computer code used in the work is documented throughout for the benefit of future researchers (e.g., `Ckmeans.1d.dp`).

Online communication is becoming increasingly common, with many individuals leading very active online lives. However, knowledge about how people organise online such as how online communities form, the means and content of communication, the roles that individuals assume, and the acquisition and exercising of influence, remains relatively scarce. Given the extent to which individuals are now online, it is important to understand these dynamics as they differ markedly from offline communication and organisations. Take, for example, individuals in the organisation they work for: much like individuals engaging in an online community, they too enter the organisation on the premise of an interest (the industry and/or their career), and each organisation has its own culture which dictates norms and often nomenclature [48, 49]. However, in addition to typically having a hierarchical structure and more strictly defined roles for individuals, communication in offline organisations (regardless of the degree of formality) is very different. In an online community, any individual can communicate and receive the exact same level of exposure. While tenure and perceived authority and trustworthiness will differ between individuals and there may be differences in the level of attention an individual's communication receives, each individual can present their perspective in a manner that is visible to all community members. On the other hand, within a traditional organisation, organisational voice is often limited to a small number of individuals [50, 51, 52]. Even in informal organisations, voice is limited to literally who hears at the time or to who receives written correspondence. Therefore, online organisations are likely to differ to traditional organisations in terms of structure due to the lack of predefined roles and equal ability to express views, as well as the relatively limited 'offline' consequences.

In addition to the differences in organisational structure, individuals' engagement with an online community can differ significantly to their offline interactions. While the ideas expressed in online communities are undoubtedly affected by community members' offline experiences, the online context lends itself to the adoption of completely different ways of processing and communicating information. Many people engage in online communities as a means of escaping their 'real life' and, as such, engage a completely different identity that can be 'disembodied' from their offline personality. Consequently, examining and understanding the dynamics of online communities will contribute to our understanding of how humans organise and relate to each other. This is particularly important given the growth in the amount of time spent online.

There is a relatively small body of empirical research in the EFIJ context that is con-

ducted on the individual level. This can be attributed to difficulty accessing data at the individual level, difficulty analysing large volumes of data such as those found online, and a natural focus on the group level as attacks are usually coordinated and motivated by a particular collective. Due to the difficulties accessing data, most individual level studies are conducted with samples of varying quality and/or are one-sided, such as questionnaires, interviews, or analysis of social media data [53]. Therefore, while we have a reasonable understanding of EFIJ groups such as their locations of operation [54, 55], intricacies of their ideology [56, 57], their goals and motivations [58, 59, 60], and means of communicating and attacking [61, 62, 63], we empirically understand little about the micro-level. Gaining this understanding is imperative, as it is the dynamics at the individual level that build the organisations that have enacted so much violence in society and occupied so many government resources on policy and intervention.

In the research context, it is very difficult to obtain large-scale data that provides insight into the nature of EFIJ interaction. Consequently, as outlined above, studies at the individual level have largely used data from case studies, interviews, and questionnaires. While these studies are extremely valuable, they do not capture how the individual ‘naturally’ interacts with their peers. For instance, interviews ask the individual to recount their versions of events and reflect on their perspective, which is quite different than communicating in response to a topic of shared interest in an unobserved context. The introduction of an interviewer also increases the likelihood of social desirability bias affecting answers, which can either lead to the individual exaggerating or downplaying their experiences.

Therefore, although online personas can be performative, that is, not authentic to one’s offline personality [3], it is the online persona that submits content and subsequently influences others in an online community. Consequently, given that this thesis seeks to understand how content affects the structure and nature of online extremist communication networks, the use of data that is uninfluenced by observation or intervention is a significant contribution. The nature of the data (EOF) and the scope of the analysis (including only conversational data between two or more persons) results in examination of an entire network of individuals, rather than relying on the memories and perspectives of a small group of individuals.

The fourth major contribution of this thesis is the use of complex methods. In order to derive meaningful results from such a large dataset, technical processing and analysis must be carefully combined with qualitative evaluation to ensure the richness of the data is maintained and leveraged to produce knowledge. Thus, a significant contribution of this thesis is its application and combination of manual, qualitative evaluation with a range of linguistic tools, such as semantic analysis and change point detection, statistical measures, such as time series analysis and meta-analysis, and network analysis tools, including modularity

and cluster analysis to the context of EOF. This provides new perspectives on how content (language) discussed on EOF affects the structure of EFIJ communication networks and the social influence of individual actors in these networks.

1.4 Paper Outlines

The first paper, *First-order Identifiable Dimensions of Extremist Content at the Individual Level* [64] (see section 2) undertakes a comprehensive review of the literature in order to derive a useful framework within which dimensions that are prominent in the study of EFIJ individuals can be organised. Given this goal, search parameters were based around the root words ‘extremist’, ‘radical’, or ‘terrorist’ and ‘Islam’, ‘jihad’, ‘Muslim’, ‘Salafi’, or ‘Wahhabi’. Criteria for inclusion in the review were the undertaking of primary research or inclusion of original data (i.e., not solely theoretical research), focused on the individual level. The rationale for these inclusion criteria is that the broader thesis seeks to examine the content of individuals participating in web-based fora that have been identified as extremist, therefore the framework developed to facilitate this examination will be more sound if it is based on extant empirical knowledge.

Analysis of the 219 articles that met the inclusion criteria reveals nine dimensions (themes) that appear prominently in studies of EFIJ individuals globally. These themes are geopolitical perspectives (GP), collective dynamics (CD), social relations (SR), theological knowledge (TK), conflict behavior (CB), oppositional evocations (OE), affective experiences (AE), persuasion processes (PP), and existential validation (EV). The paper details the nature of these dimensions and the ways in which they have emerged in different studies. The paper posits that these nine dimensions form an EFIJ construct taxonomy (ECT), within which most content produced by EFIJ individuals can be categorised. The overarching proposition of this paper is that the dimensions that emerge in the study of EFIJ individuals serve to connect these individuals and form the backbone of their communication.

To test this proposition, the second paper, *Taxonomic Classification and Analysis of Communication in Extremist Online Fora* [65] (see section 3) analyses 10,000 sentences between individuals across 13 EOF to determine whether the nine dimensions of the ECT effectively capture the content produced on these fora. The data were preprocessed, including the removal of single-post threads from the datasets as these did not constitute a conversation, the removal of Hypertext Markup Language (HTML), and the derivation of phrases, defined as tokens (words) that appear frequently together. The data were processed programmatically using a range of scripts and algorithms, detailed and cited thoroughly in the paper. The resulting sentences were then analysed to ascertain their sentiment using a classifier built from a balanced dataset of 32,000 positive and 32,000 negative statements. A

random sample of 10,000 words and phrases with high polarity were selected for manual coding.

The manual coding determines that the ECT is a useful framework for categorising the context of EOF, and identifies subdimensions within the nine dimensions that facilitate deeper understanding of the content of EFIJ individuals and allow for more fine-grained analysis. Statistical confirmation and subsequent final determination of influential ECT subdimensions was achieved through cluster detection algorithms. The other objectives of the second paper were to examine how usage of the words and phrases commonly communicated on EOF change over time, and how they relate to each other. To address the first objective, a novel change point detection algorithm is employed to identify statistically significant changes in the usage of a given phrase, as a measure of engagement with the phrase. A small proportion of words and phrases experience significant changes in the way in which individuals engaged in communication through them, and the majority of these related to the TK and SR dimensions. In addition, in terms of how words and phrases relate to one another, words and phrases in the TK and SR domains are also the most likely to appear together. The prominence of the TK dimension is not a surprising finding given the context of EOF, however, the emergence of the SR domain was unexpected.

As a result of the surprising importance of the SR dimension, the third paper, *Predicting Group and Role Attribution using a Relational Dimension of Extremism* [66] (see section 4), explores the effect that communication using words and phrases relating to SR has on ideological group membership and an individual's behavioural role in EOF communication networks. To establish a basis for ascertaining group membership from the content of communication, over 4,000 documents published by EFIJ groups were semantically analysed. This analysis resulted in the identification and classification of six known EFIJ groups based upon the nature of the content they produce. The purpose of identifying these groups was to investigate whether there are differences in the significance of the SR domain in the content produced by different groups. To this end, there was significant overlap in the SR subdimensions that were significant in determining group membership for three out of the six groups.

The second avenue of investigation of the third paper was the role of SR in determining the role individuals play in their respective communication networks. Network role is determined by an individual's position in the network relative to others and their behaviour, defined in this case as the nature of content contributed to the network by the individual. Based on their position in the network, individuals communicating across 27 different EOF were categorised into one of seven different network roles drawn from the network science literature. Analysis was then undertaken to determine whether use of content relating to SR subdimensions differed across roles. Individuals occupying hub roles in the network (i.e.,

highly connected [67]) differ in their use of a range of subdimensions relative to non-hubs, such that the factionist, fraternal/sororal, lesser-known person, and militant subdimensions were consistently more important to hub roles. Interestingly, the social relations subdimensions that predicted group attribution differed from those that predicted role attribution, indicating that content relating to social relations is used in different ways by groups and individuals.

The conclusion chapter then synthesises the findings of these papers and discusses their academic and practical implications, as well as their limitations.

First-order Identifiable Dimensions of Extremist Content at the Individual Level

2

2.1 Abstract

Background: The study of EFIJs¹ lacks a principled arrangement method required for empirical research on their written content. The present study conducted a systematic review of literature on EFIJ to collate evidence and determine whether these findings may assist in the development of a content identification system.

Methods: Qualifying empirical studies ($n = 219$) were identified from established and ad-hoc bibliographic databases, determined by the inclusion of original data and findings presented at the individual level. A large number of studies ($n = 5,866$) did not meet these review criteria. Samples were disaggregated by individual type ($n = 10$; e.g., lone-actor attacker, online extremist) and originated from a broad range of groups ($n = 51$) and ideological classifications ($n = 9$) within the EFIJ spectrum.

Results: Studies that produced evidence at the individual level of analysis provided support for nine EFIJ construct taxonomy dimensions that could be reasonably delineated on the basis of their potential for written content identification. The defined and proposed dimensions were: GP², CD³, SR⁴, TK⁵, CB⁶, OE⁷, AE⁸, PP⁹, and EV¹⁰.

Conclusions: The taxonomy dimensions outlined are a useful means to group evidence produced by empirical studies of EFIJ at the individual level and may prove viable to advance the study of these individuals as an auxiliary method in the systematic extraction (and analysis) of content from communities such as EOF.

2.2 Background

The study of content produced by Islamic religious extremist groups has attracted the attention of research for a number of years [68, 69, 70]. Despite this interest, the study of content written and interacted with at the individual level lacks exploration. Recent reviews

¹Extremists, fundamentalists, Islamists, and jihadists ²Geopolitical perspectives ³Collective dynamics
⁴Social relations ⁵Theological knowledge ⁶Conflict behaviour ⁷Oppositional evocations ⁸Affective experiences
⁹Persuasion processes ¹⁰Existential validation

of research in the broader fields of extremism, radicalisation, and terrorism that include the individual level of analysis do not specifically focus on a delineation of theoretical and empirical work on individuals [53, 71], and without a clear understanding of how factors that operate at this level may relate to content, the connection between the formal study of individuals and content cannot be reasonably made. Preliminary quantitative psycholinguistic work exists at the jihadist scholar [72], and more recently, suicide bomber level [73], and includes analysis of lengthy corpora but, like previous work remain egoistic, static, and monologue as opposed to dyadic, interactive, and dialogue in nature [74].

This work forms part of a larger study that investigates local level interactions, or direct communication, between individuals in online environments where large quantities of *religious extremist, fundamentalist, Islamist, and jihadist* or EFIJ content may be found in dialogue or conversational form. The empirical study of these interactions requires a principled arrangement method whereby constructs observed in the content of interactions between individuals can be grouped together on the basis of shared characteristics [75]. Such groups or dimensions become first-order identifiers of content as their aim is to capture the simplest or most fundamental level of organisation, experience, and analysis in the content written by EFIJ individuals in a number of communities, such as EOF. The contribution of a principled arrangement method of content is useful to the formal study of individuals in these environments, as recent work on how to progress research on the relationship between the Internet and EFIJ phenomena identified individual activity and experience in these spaces as significantly underserved areas of study [28].

2.2.1 Definitions

In the study of Islamic-based extremism, there remains a lack of definitional consensus in what makes an individual a religious extremist, fundamentalist, Islamist, or jihadist [76]. It is important to understand that extremism encompasses a broad range of ideologies, of which Islamic-based extremism is but a single strain [77]. Notably, Islamic-based extremism itself refers to ideological interpretations of Islamic principles and not to the religion of Islam [78]. While it is impossible to precisely determine the ideological orientation of individuals who engage with Islamic-based extremist content, a reasonable definitional assumption is that they fall somewhere within a spectrum of being susceptible to religious extremism at one end [79] and jihadism at the other [80], with varying degrees of non-violent and violent ideologies operating through individuals in-between these points [81].

Thus, for the purposes of containing the scope of this work's contribution to Islamic-based extremism, 'extremist' is used as an umbrella term to include individuals who fall within the conceptual delineations of this spectrum as defined by Wintrobe's religious extremist [79], Appleby and Marty's fundamentalist [82], Ayoob's Islamist [78], and Zaidi's

jihadist [80]. Being an Islamic-based religious extremist is therefore conceptualised as an ideological prerequisite to being a fundamentalist, Islamist and jihadist. Specifically, these individuals are defined as follows:

- A *religious extremist* holds views that go beyond the norm within a religion, adheres to his or her ideological perspective with an unparalleled degree of fervency, and he or she rejects notions of ‘balance’ in consideration and in living. He or she belongs to a group that deliberately segregates itself from society, rejects cultural norms, and looks disparagingly upon non-adherents to the detriment of ‘balance’ [79].
- The term *fundamentalist* shares a symbiotic relationship with religious extremism and refers to the individual that justifies the above behaviour by grounding it in the scripture through a purportedly ‘literal’ reading of the authoritative religious texts, that do not take context into account and justifies acts that are considered unjustifiable in the contemporary world [82].
- *Islamists* are religious extremists who deem themselves to be morally superior to others, reject many non-Islamic cultural norms, seek to impose a particular reading of religious law upon society and, in grounding their doctrine within the scripture and seeking to recreate the time in which it was revealed, they are fundamentalists [78].
- Where contemporary Islamists do not sanction political violence, *jihadists* utilise a violent expression of politics to impose the Islamist’s beliefs globally or locally, justified with a heavily manipulated and limited militant bibliography [80].

2.2.2 Objectives

In the absence of a developed construct taxonomy, the objectives of the present study are to:

1. Conduct a systematic collection and review of literature to outline what is known empirically through evidence about individuals who are attracted to or show support for EFIJ ideologies, are at risk of radicalisation or have been radicalised, or engage or have engaged in terrorism.
2. Use the current state of empirical findings to inform the outline of an ECT¹¹, by identifying dimensions at the individual level that may translate into groups of constructs that can be systematically identified in content written by such individuals.

¹¹EFIJ construct taxonomy

2.3 Methods

A systematic review of literature was conducted to identify individual level factors associated with susceptibility to and participation in radicalisation, terrorism, and violent extremism.

2.3.1 Data Sources

Data sources included the *ProQuest*, *Scopus*, and *Web of Science* bibliographic databases and documents were limited to scholarly journal articles, books, technical reports, and proceedings.

2.3.2 Search Parameters

The preliminary search was restricted to the following search terms: (extremi* OR radicali* OR terrori*) AND (islam* OR jihad* OR muslim* OR salafi* OR wahhabi*).

2.3.3 Review Criteria

After duplicates were filtered from the search results, a total of 6,085 documents were obtained for further evaluation. The full-text of each document was examined and the final set of literature was restricted to studies that presented findings at the individual level based on primary research and original data. Samples of individuals were limited to EFIJ.

2.4 Results

A total of 219 (3.6%) studies met these criteria and were included in the final review. The majority of studies either developed collections of individual cases from primary source, official, and court documents (43.38%), or used questionnaires as their primary research instrument (31.05%). The remaining studies conducted interviews (22.83%), and a small number relied on mixed methods research based on the aforementioned methods (2.74%). A total of 14 reported samples were reused by different studies, predominantly in research on online extremists (35.71%), which relied on a small number of core social media datasets. A total of 51 unique ideological, political, and military groups and organisations were identified in the data (see table 2.2). Individuals from these groups and organisations were included on the basis of whether their ideology formed part of the EFIJ spectrum defined in section 2.2.1. Identified ideologies broadly ranged from Salafi and Shia jihadism; Deobandi fundamentalism; pan-, vigilante, and political Islamism; Palestinian and Tamilian nationalism; and pro-Pakistan militancy. EFIJ ideological classification was determined through investigation of designated terrorist group lists and primary source documents produced by the groups and organisations.

Table 2.1: Individual type and instrument statistics of studies ($n = 219$)

Individual Type	Case	Instrument	
		Questionnaire	Interview
Extremist (online)	$n = 26$	–	$n = 2$
— n_μ, n_σ	2.17e4, 4.76e4	–	16.5, 1.5
Foreign fighter	$n = 8$	–	$n = 4$
— n_μ, n_σ	252.63, 423.92	–	22.75, 12.75
Group-actor terrorist	$n = 27$	$n = 9$	$n = 22$
— n_μ, n_σ	314.7, 507.06	192.5, 199.06	37, 29.83
Lone-actor attacker	$n = 6$	–	–
— n_μ, n_σ	122.75, 65.93	–	–
Suicide bomber	$n = 6$	–	$n = 1$
— n_μ, n_σ	748.67, 891.24	–	51, 0
Convict	$n = 7$	$n = 2$	$n = 8$
— n_μ, n_σ	128.17, 118.15	126, 101	49.14, 44.5
Population (general)	–	$n = 47$	$n = 8$
— n_μ, n_σ	–	3.51e3, 6.67e3	71, 79.06
Unspecified (at-risk)	–	–	$n = 10$
— n_μ, n_σ	–	–	21, 13.15
Unspecified (violent)	$n = 17$	–	–
— n_μ, n_σ	172.06, 199.99	–	–
Youth	–	$n = 14$	$n = 3$
— n_μ, n_σ	–	147.86, 116.47	121.67, 68.84

n = number of studies, μ = mean of n sample sizes, σ = standard deviation of n sample sizes

Individual types were disaggregated on the basis of information presented about the sample in each study. Disaggregated individual types ranged from comparatively rich data about individuals, such as group-actor terrorists, lone-actor attackers, suicide bombers, foreign fighters, and online extremists, to more general sample information, such as convicts, youth-, and population-based samples. Others included unspecified general violent individuals (e.g., Islamists, jihadists, and homegrown terrorists) and at-risk, or radicalised, individuals. The majority of studies that built custom collections of individual cases examined group-actor terrorists ($n = 27$) and online extremists ($n = 26$). Group-actor terrorists also formed the majority of samples for studies that conducted interviews ($n = 22$). Surprisingly, a large number of studies tested EFIJ-related questions on population-based samples ($n = 47$), which formed the majority of studies that used questionnaire instruments. Most studies were published between 2010–2019 (75.8%), while a smaller percentage were from 1980–2009 (24.2%). See table 2.1 for detailed statistics on the number of studies identified per individual type and the mean and standard deviation of sample sizes used in the studies.

The following section presents the studies' findings in the context of EFIJ factors identified in the individuals studied (objective 1). It will use these findings to propose plausible dimensions that may contain identifiable content at local level communication between EFIJ individuals, and these dimensions will form the outline of a construct taxonomy for further empirical work (objective 2). It is important to note that some overlap exists in the findings of these studies, and as a result, findings were restricted to unique factors that contributed to the overall schema of what is known. An effort was made to present the individual type, sample size, and other identifying information about individuals studied in each work.

2. FIRST-ORDER IDENTIFIABLE DIMENSIONS OF EXTREMIST CONTENT A/T INDIVIDUAL LEVEL

Table 2.2: Groups in local level studies, ideological classification, and sample statistics

Group	Code	Ideology	n_μ	n_σ	$A(n)$	Reference Study
Abu Nidal Organisation	ANO	PN	5	–	–	[83]
al-Aqsa Martyrs Brigade	AMB	PN	39	–	①	[84]
al-Badr	AB	PPM	54	–	–	[85, 86]
al-Jama'a al-Islamiyya	GI	SaJ	10	5	① ②	[87, 88, 89]
al-Muhajiroun	AM	SaJ	30	–	–	[90]
al-Nusrah Front	ANF	SaJ	190	–	②	[91, 92]
al-Qa'ida (unspecified)	AQ	SaJ	413.45	561.13	③ ④ ⑤ ⑥ ⑦	[84, 93, 94, 95, 96, 97, 98, 99, 100, 101]
al-Qa'ida in Iraq	AQI	SaJ	1,404	–	⑧	[101]
al-Qa'ida in the Arabian Peninsula	AQAP	SaJ	77	–	⑧	[101]
al-Qa'ida in the Islamic Maghreb	AQIM	SaJ	49.5	27.5	⑧ ④	[101, 95]
al-Shabaab	AS	SaJ	47.83	47.65	⑧	[101, 102, 103, 104, 105, 106]
Darul Islam	DI	IP	9	–	–	[107]
Democratic Front for the Liberation of Palestine	DFLP	PN	9.33	3.4	⑨	[83, 108]
Egyptian Islamic Jihad	EIJ	SaJ	10	5	① ②	[87, 88]
Fatah	FA	PN	21.75	25.3	⑨ ③	[95, 108, 109, 110]
Hamas	HA	PN	91.89	181.62	① ⑤ ③	[83, 84, 95, 96, 99, 108, 109, 110, 111]
Harkat-ul-Mujahideen	HuM	DF	18	–	–	[85, 86]
Hizb ut-Tahrir	HT	PI	3	–	–	[112]
Hizb-ul-Mujahideen	HB	PPM	367	340	–	[85, 86, 113]
Hizballah	HE	ShJ	227.8	217.35	⑥	[101, 99, 108, 114, 115]
Hofstad Network	HN	SaJ	40	–	–	[116, 117]
Islami Jamiat-e-Talaba	IJT	PI	40	–	–	[118]
Islamic Action Front	IAF	IP	654	–	–	[119]
Islamic Defender Front	FPI	IV	3	–	–	[120]
Islamic Jihad Movement in Palestine	PIJ	PN	12.83	12.64	①	[83, 84, 109, 110, 111]
Islamic Movement of Uzbekistan	IMU	PI	92.5	15.5	⑧	[101, 121]
Islamic State of Iraq and Syria	ISIS	SaJ	144.82	218.42	②	[91, 107, 122, 123, 124, 125, 126, 127, 128, 129, 130]
Izz ad-Din al-Qassam Brigades	IDQ	PN	43	22	③	[95, 108]
Jaish-e-Mohammed	JeM	DF	12.5	6.5	④	[85, 86, 131]
Jam'iyyat Ul-Islam Is-Saheeh	JIS	SaJ	30	–	–	[132]
Jama'at al-Muslimin	JAL	SaJ	34	–	–	[111, 133, 134]
Jamaat Ansar al-Sunnah	JAS	SaJ	1,404	–	⑤	[101]
Jemaah Ansharut Tauhid	JAT	SaJ	9	–	–	[120]
Jemaah Islamiya	JI	SaJ	65.2	81.03	⑥	[101, 107, 111, 135, 136, 137, 138, 139, 140, 141]
Lashkar-e-Jhangvi	LeJ	DF	181	–	⑥	[101]
Lashkar-e-Tayyiba	LeT	SaJ	196.4	360.91	④	[85, 86, 101, 107, 113, 142]
Liberation Tigers of Tamil Eelam	LTTE	TN	48.67	58.29	–	[84, 101, 95]
Moroccan Islamic Combatant Group	GICM	SaJ	77	–	⑧	[101]
Mujahedeen Kayamania	MKA	SaJ	2	–	–	[107]
Mujahedeen KOMPAK	MK	SaJ	23	16.63	–	[107, 139, 140, 141]
Mujahedeen Tanah Runtuh	MTR	SaJ	12	–	–	[107]
Muslim Brotherhood in Egypt	MB	IP	10	5	②	[87, 88]
Muttahida Jihad Council	MJC	PPM	2	–	–	[85, 86]
Palestine Liberation Organisation	PLO	PN	28.67	26.23	③	[83, 95]
Palestinian Liberation Front	PLF	PN	65	–	③	[95]
Popular Front for the Liberation of Palestine	PFLP	PN	28	21.74	⑨ ③	[83, 95, 108]
Taliban	TAL	DF	304	123	⑥ ⑦	[101]
Tanzim	TAN	PN	39	–	①	[84]
Tehreek-e-Jihad	TeJ	DF	1	–	–	[85, 86]
Tehreek-e-Nafaz-e-Shariat-e-Mohammadi	TNSM	DF	9	–	–	[85, 86]
Tehrik-ul-Mujahideen	TuM	PI	5	–	–	[85, 86]

DF = Deobandi fundamentalism, IP = Islamism (political), IV = Islamism (vigilante), PI = pan-Islamism, PN = Palestinian nationalism, PPM = pro-Pakistan militancy, SaJ = Salafi jihadism, ShJ = Shia jihadism, TN = Tamil nationalism
 $A(n)$: n_μ includes aggregated samples that lack clear demarcation of particular group affiliations (① = AMB HA PIJ TAN, ② = ANF ISIS, ③ = AQ AQAP AQIM AS GICM IMU JI, ④ = AQ AQIM, ⑤ = AQ HA HE, ⑥ = AQ LeJ TAL, ⑦ = AQ TAL, ⑧ = AQI JAS, ⑨ = DFLP FA PFLP, ⑩ = EIJ GI, ⑪ = EIJ GI MB, ⑫ = FA HA IDQ PFLP PLF PLO, ⑬ = JeM LeT)

2.4.1 Geopolitical Perspectives (GP)

Perceptions of relationships between countries, and subsequently belief systems, as well as grievances held by individuals and directed at foreign and domestic entities [143, 144], featured prominently in the studies examined. The perceived invasion of sovereign countries by the West, as a whole, was found in the reasoning of several militants interviewed about their involvement in Jemaah Islamiya (JI) ($n = 28$) and Mujahedeen KOMPAK (MK) ($n = 12$) [140], as well as in the study of recruitment cases from al-Shabaab (AS) ($n = 15$) [102]. Evidence for the perception of a schism between Islam and the West existed in the cases of homegrown terrorists in the United Kingdom (UK) and United States (US) ($n = 117$), among those who perpetrated an attack, attempted to do so, or illegally supported Islamic terrorism [145]. This perception extended to the notion of American domination of the Arab world, critique of Western life [146], and a view of an incompatibility between American and Arab cultures, as supported by representative questionnaire evidence of Sunni ($n = 179$), Shia ($n = 35$), and non-denominational ($n = 46$) Muslims in Lebanon and Syria [147]. Anti-American (and anti-Western) sentiment was found in the reasoning of militant relatives, such as in the case of JI ($n = 20$) [138], in case studies of the motivations of global jihadists ($n = 172$; $n = 500$) [148, 149], and in the content written by members of an EOF ($n = 15,345$) [150] and a pro-Islamic State of Iraq and Syria (ISIS) social media network ($n = 566$) [151, 152]. A large questionnaire-based study of individuals in Algeria ($n = 1,139$), Jordan ($n = 1,476$), Lebanon ($n = 1,484$), Morocco ($n = 1,144$), Palestine ($n = 1,154$), and Tunisia ($n = 1,150$) found that respondents who specifically used online fora for political expression were more likely to express support for ISIS than those who engaged in conventional political activity [153]. Unsurprisingly, observations of online extremists ($n = 50$) showed grievances were actively being used in attempts to motivate others to action [154].

Interviews with and examination of the cases of members of the Hofstad Network (HN) in the Netherlands found that geopolitical grievances were prime drivers for their participation in homegrown jihadism ($n = 40$) [117], where they sought to blame Western nations for geopolitical events and changes, which was also found in questionnaires of Muslim immigrants in Denmark ($n = 1,113$) [155], nationally representative samples from Algeria ($n = 1,282$) and Jordan ($n = 1,000$) [156], and a study of foreign fighter cases from 11 countries in East and North Africa, the Middle East, and South Asia ($n = 51$) [157]. Indeed, negative views of Western foreign policy were not only restricted to those who committed terrorism offences [112, 132, 158], and were often found to be a focal point in questionnaires that examined the perspectives of Muslim populations in Canada ($n = 430$) [159], Germany ($n = 1,201$) [160], the UK ($n = 1,149$) [161], and US ($n = 5,198$) [162]. A study of militant cases from Egyptian Islamic Jihad (EIJ), Muslim Brotherhood in Egypt (MB), and JI ($n = 15$) found that motivation for their activities stemmed from

responses to state aggression [88] or involved nationalistic goals [163], as was found in interviews conducted with incarcerated suicide terrorists, potential recruits, and close associates of successful bombers from six countries in Central Asia, Europe, the Middle East, and North Africa [164]. Geopolitical involvement by individuals was evidenced by studies on foreign fighting, such as cases of fighters from Belgium and France ($n = 13$) [165], or broader studies that found variation in conflict theatre choice across a large number of Western jihadists ($n = 1,346$) [166], as well as the origin of fighters killed and captured in Iraq ($n = 321$), who were from both developed and developing nations [167]. Given that information on specific countries and demonyms are likely to be included in the details of content that involve comparative perceptions of the West and Islam, such information acts as a reasonable first-order identifier for a range of geopolitics within this lens:

PROPOSITION 1 An EFIJ construct taxonomy should include a dimension to capture geopolitical perspectives that are defined by views of geographic or political factors that influence or characterise a country or region.

2.4.2 Collective Dynamics (CD)

Various behaviours and psychological processes were identified through inter- and intra-group dynamics at the individual level of examination. A number of questionnaire research studies investigated dynamics between and within groups of Muslim youth in Indonesia ($n = 139$), the Netherlands (of Moroccan and Turkish origin) ($n = 398$), and Spain ($n = 66$). These studies found a prevalence of shared ideology [168], perceptions of inter-group threat [169], and in-group superiority [170], where collective and social identity salience were present. These group dynamics were observed in experimental research in the form of antisemitism in the case of a Muslim youth sample in Pakistan ($n = 236$) [171], as well as differences between groups of Sunni and Shia Muslims in Lebanon [172], Pakistan [173], and eight European countries [174]. The studies investigated approvals of attacks ($n = 337$), and support for suicide bombing ($n = 215$) and terrorism ($n = 650$). Justification for suicide bombing was found to be more likely if respondents were highly disconnected and disordered, as was discovered by a questionnaire-based study of US Muslims ($n = 207$) [175]. A large questionnaire study of Muslims in Pakistan ($n = 16,279$) found positively associated ideological support for militancy if a formalised Islamic government implemented sharia by imposing hudud punishments and restricting women's public roles [176]. Evidence in poll data was also found for a sizeable undercurrent of ideological sympathy and support for specific groups, namely al-Qa'ida (unspecified) (AQ) and ISIS, in respondents from both Muslim-majority countries and Western Muslim diasporas [177]. A study of Western-born Muslims in Belgium ($n = 104$), Denmark ($n = 793$), and nine other Western countries ($n = 366$), found that compared to foreign-born Muslims,

Western-born Muslims were more vulnerable to the impact of perceived group-based relative deprivation and scored higher on extremism scales as a result [178]. Interviews conducted with foreign fighters ($n = 43$) who attempted to travel or were successful in their journey to Syria, found that the drive to help those who were perceived as mistreated by other groups was so strong in these individuals that it developed into a sense of obligation to act in defence of their in-group [179].

Perceived discrimination is common among diaspora Muslim populations and was found to be positively associated with support for anti-Western political violence in samples across four European countries ($n = 1,627$) and the US ($n = 1,050$) [180]. Support for this perception was observed in samples of at-risk Muslim youth [181], nationally representative Muslims [182, 183], jihadist converts [184], and ISIS-affiliated online extremists [185]. Studies that conducted interviews with religious leaders, representatives, and members of Muslim communities in the UK ($n = 73$) [186, 187], and citizens stopped and searched under terrorism acts ($n = 40$) [188], found a perception of institutional racism directed at Muslims. Interviews with members of al-Muhajiroun (AM) ($n = 30$) showed that experiences of perceived racism opened members to further seeking and intensified attraction to the message, frame, and reputation of AM's leadership [90]. A study that examined geo-referenced data on the behaviour of online extremists in the form of activists ($n = 854$) and followers ($n = 174,161$) in Belgium, France, Germany, and the UK, found that local level measures of anti-Muslim animosity correlated significantly and substantively with indicators of online radicalisation, including posting messages of support for ISIS [189]. Feelings of injustice and prejudice were echoed in samples of Muslim youth [168, 190], but also in studies that examined cases of lone-actor terrorism in Europe and the US ($n = 119$) [191], and in a wide range of interviews conducted with incarcerated Middle Eastern terrorists from Hamas (HA), Hizballah (HE), Islamic Jihad Movement in Palestine (PIJ), and Izz ad-Din al-Qassam Brigades (IDQ) ($n = 21$), as well as secular terrorists from Fatah (FA), the Democratic Front for the Liberation of Palestine (DFLP), and the Popular Front for the Liberation of Palestine (PFLP) ($n = 14$) [108]. The need for justice as a response to perceived injustice was identified as part of a radicalisation path in interviews with 36 Muslim youth in the Netherlands who were radicalised [192]. The collective prevalence of ideology, perceptions of prejudice, and subsequent drives toward justice speak to involved mechanisms of interplay between and within groups of individuals, which represents a first-order identifier of these mechanisms:

PROPOSITION 2 An EFIJ construct taxonomy should include a dimension to capture mechanisms that deal with any assemblage or collection of persons or parts that form a complex or unitary whole.

2.4.3 Social Relations (SR)

Individual agency as the basis of social structure formed the object of analysis for a number of studies and as a result, a number of recurring relations and interactions with others were identified. A study that examined individual cases of terrorists in AQ and al-Qa'ida in the Islamic Maghreb (AQIM) ($n = 22$), the Palestinian Liberation Front (PLF), the Palestine Liberation Organisation (PLO), FA, HA, IDQ, PFLP ($n = 65$), the Liberation Tigers of Tamil Eelam (LTTE) ($n = 11$), as well as terrorists in Chechnya and Iraq ($n = 12$) ($n = 51$), found that women played a near equivalent role in these groups and organisations, but exhibited distinct involvement mechanisms compared to their male counterparts [95]. Another study that examined Islamist women ($n = 116$) involved in political and revolutionary conflict identified unique roles women occupied, including active, caring, support, and ideological roles [193]. A study that explored support roles among extremist women in the online context ($n = 93$) found that pro-ISIS networks contained a number of discernible female roles [194], including baqiya members (accepted into the virtual 'family') [195], muhajirat (migration 'success' stories in propaganda) [196], and so-called fan girls (enthusiastic young females) [197, 198]. Indeed, a nationally representative survey of Muslims in Pakistan ($n = 16,279$) found that women are significantly more likely to support a sectarian group with a female outreach wing than one without such efforts [199]. Relatively high levels of marriage among jihadists, as was found in a study of European cases ($n = 242$), indicated that social relationships were important in these populations [200], which supports the presence of various gender-based social relationships observed in recruitment efforts [201, 202]. Interviews conducted with jihadists affiliated with JI and MK ($n = 50$) in Indonesia identified familial pressure as a persistent force in the lifespan of engagement with their ideologies [141]. Further work found that social bonds featured prominently in all major entry points to Darul Islam (DI) ($n = 9$), Mujahedeen Kaya-manya (MKA) ($n = 2$), Mujahedeen Tanah Runtuh (MTR) ($n = 12$), JI ($n = 12$), and MK ($n = 7$) [107]. Other studies that examined homicide and suicide bombings across 14 countries ($n = 950$) and on behalf of militant organisations ($n = 219$), produced evidence of pre-existing familial bonds and concentric circles that facilitated their recruitment process [203, 204]. The same phenomenon was observed in cases of jihadi converts ($n = 48$) with a confirmed role in the plotting and/or execution of terrorist attacks in ten European countries [184] and deceased Georgian foreign fighters ($n = 29$) [205]. Other studies stressed the importance of family, friend, and peer networks due to their consistent presence in cases of individuals who engaged in terrorist activity [200, 206, 207, 208].

Social mechanisms within these networks such as reciprocal peer influence and immersion were identified in a number of cases as driving forces in the radicalisation of homegrown terrorism offenders in the US that were inspired by AQ's ideology ($n = 68$) [97], and in criminal cases where extremists expressed Salafi-jihadist sympathies or explicitly facilitated

a sympathiser in the Netherlands ($n = 209$) [209, 210]. These roles of friendship and peer relations became increasingly concentrated inside the group or organisation for those who already enjoyed involvement, as was found in a study that conducted interviews with informants from Islami Jamiat-e-Talaba (IJT) in Pakistan ($n = 40$) [118].

A number of studies found that potential recruits were exposed to leaders with experience [112], knowledge [211], and charisma [132]. Such exposure occurred both on- and offline [97, 124, 212] and in a wide range of populations: those charged with or convicted of violent jihadist acts or conspiracies, Muslim youth who attempted to join ISIS ($n = 160$), members of Hizb ut-Tahrir (HT) in the UK ($n = 121$), and radicalised Muslims ($n = 83$), including members of Jam'iyyat Ul-Islam Is-Saheeh (JIS) in the US ($n = 30$). In the case of HN, it was found that members desired the social emulation of role models [116]. Both foreign and domestic Islamist fighters often experienced contact with a veteran [166]. A study that examined the relationship between leadership and militants observed that social connections existed between militants from 32 countries and prominent Islamist leaders [207], as was the case in those that targeted the UK ($n = 350$). Others also echoed this finding in the form of mentorship [145], and one study concluded that foreign fighters sought spiritual authority in individuals for inspiration and guidance [91], based on the examination of European and other Western recruits affiliated with al-Nusrah Front (ANF) and ISIS ($n = 190$). References to those who partake in the social structure around an individual represent first-order identifiers for a range of social relations denoted by roles, reciprocity, kinship, and leadership in EFIJ networks:

PROPOSITION 3 An EFIJ construct taxonomy should include a dimension to capture connections or associations that involve two or more persons who occupy different social roles.

2.4.4 Theological Knowledge (TK)

Individuals' understanding of cultural systems of behaviour and practices, sacred texts, holy places, and the societal organisation that relate them to their order of existence were inalienable features in studies of EFIJ individuals. Interviews conducted with jihadists in custody for terrorism offences in France found evidence that some of these individuals adhered to rigoristic religious beliefs ($n = 12$) [213]. In the online context, interviews with informants of a prominent EOF in Saudi Arabia showed that the majority of Islamic fundamentalists and extremists who used the forum did so as a means to establish credibility and defend their way of practising religion ($n = 15$) [214]. Others discovered that the leaders and militants of organisations such as Hizb-ul-Mujahideen (HB) ($n = 707$) and Lashkar-e-Tayyiba (LeT) ($n = 918$) were educated and focused on the production of a jihadi culture well-versed in Islamic moral principles [113]. A study that surveyed Jordan's Islamic Action

Front (IAF) ($n = 654$) found the group's active members were far more educated than other Jordanians [119]. Evidence for an interest in Islamic studies was found in a large number of cases of international jihadis from Jama'at al-Muslimin (JAL) ($n = 34$) [133, 134], HA ($n = 81$), JI ($n = 31$), PIJ ($n = 39$), and a number of individuals from other groups in Afghanistan, Egypt, Iraq, and Pakistan ($n = 39$), where the formal study of Islam represented a significant part of their tertiary educational background [111]. Indeed, a number of studies found that madrasa and religious seminary attendance were present in the life histories of militants from al-Badr (AB) ($n = 54$), Harkat-ul-Mujahideen (HuM) ($n = 18$), Jaish-e-Mohammed (JeM) ($n = 6$), Muttahida Jihad Council (MJC) ($n = 2$), Tehreek-e-Jihad (TeJ) ($n = 1$), Tehreek-e-Nafaz-e-Shariat-e-Mohammadi (TNSM) ($n = 6$), Tehrik-ul-Mujahideen (TuM) ($n = 5$), HB ($n = 27$), LeT ($n = 13$), and slain mujahadeen militants in Pakistan ($n = 141$), based on questionnaires of their families and households [85, 86, 131]. Studies of JI members ($n = 300$; $n = 75$) in Indonesia also provided support for this finding and observed a strong association between terrorist activity and radical madrasa exposure [136, 137]. A similar phenomenon was observed among those who engaged in terrorist attacks in Palestine ($n = 819$), where a larger percentage of suicide attackers were educated in religious schools and fundamentalist organisations, as compared to those who did not engage in suicide attacks [215].

A questionnaire of HE members ($n = 341$) found support for the view that violent actions were divinely ordained [115], or support for a belief in militant or violent jihad, as was found in interviews with members of Islamic Defender Front (FPI) ($n = 3$), Jemaah Ansharut Tauhid (JAT) ($n = 9$), and among a sample of Muslims in Indonesia ($n = 934$) [120] and Morocco ($n = 260$) [216]. The concept of a gratified afterlife was also identified as a prospect in the case of interviews with Palestinian prisoners who attempted suicide bombing in Israel ($n = 7$) [217]. Some studies identified theological understanding as a relatively strong factor in the radicalisation of individuals, including specific claims of a religious motivation by perpetrators for their acts [145], as well as the religious legitimacy argument for fighting put forward by information disseminators in jihadist networks [92, 218], which is based on a level of theological interpretation [91]. The level of interpretation is not always sophisticated and can be superficial, as was observed in interviews with convicted ISIS members in Malaysia ($n = 34$) [129]. A study of extremist views among black and minority ethnic UK men ($n = 1,413$) found that those at risk of depression experienced protection from a strong cultural or religious identity, but that antisocial behaviour increased with extremism, and that religion, although protective, determined targets of violence after radicalisation occurred [219]. Given the prominence of theological and related constructs in determining support for and engagement with religious extremism, these constructs represent clear first-order identifiers in the written content of EFIJ individuals:

PROPOSITION 4 An EFIJ construct taxonomy should include a dimension to capture awareness of religious faith, practice, and experience.

2.4.5 Conflict Behaviour (CB)

The often intertwined relationships EFIJ individuals share with conflict are well-established in the literature, both in the form of external friction and discord and internal struggle within their minds. Sympathy for violent protest and terrorism was found to be positively associated with depressive symptoms in a sample of Muslims in the UK ($n = 600$) [220, 221, 222]. Another questionnaire research study found that Muslim respondents with fundamentalist religious beliefs were more likely to be supportive of the use of violence to defend their faith in France, Germany, and the UK ($n = 1,200$) [223]. Support for terrorism was found in nationally representative samples of questionnaires in Pakistan ($n = 6,000$) [224], the UK ($n = 1,000$) [225], and in 14 countries in East and West Africa, Central and South Asia, and the Middle East ($n = 7,849$), where support was positively associated with the belief that Islam was under threat [226, 227]. One study found that when followers believed jihad supported the use of violence, a strong association existed with the view that terrorists had valid grievances, as was observed in a Muslim population in Australia ($n = 800$) [228].

Training for violence is common among a number of extremist populations, such as overseas training and combat among jihadists whose offending occurred after they took up residence in Canada ($n = 64$) [229], or firearms and bomb construction training in members of the global jihadist movement who were convicted of terrorist-related offences and operated on behalf of AQ, an affiliate, or were inspired by AQ's ideology ($n = 183$) [98], or simply accessed technical training material through online means [230, 231]. An examination of a number of militant cases from Indonesia ($n = 36$) and Saudi Arabia ($n = 240$) showed that many of the individuals were both veterans of training camps and armed jihad [135, 232]. Jihadist leadership figures, in particular, tend to exhibit substantial battlefield experience ($n = 66$) [233]. Interviews conducted with members from al-Jama'a al-Islamiyya (GI), EIJ ($n = 5$), JI, MK ($n = 23$), and MB ($n = 5$), all identified with violence in a number of their decision-making processes [87, 139]. The same association and presence of violence were made by researchers who examined cases of terrorism offenders in the US ($n = 600$) inspired by AQ, HA, or HE in their actions [99]. Interviews with convicted jihadists linked to ISIS ($n = 58$) found that a significant minority of those examined remained welded to a militant mindset and were likely to reoffend upon release [234]. A number of studies identified abuse suffered by individuals [174, 184, 235] and traumatic events [97, 163, 164] as contributory factors in their respective radicalisation processes.

Studies that reviewed cases of suicide bombers ($n = 462$) associated with AQ, as well

as Chechen, Kurdish, and Tamilian movements, found increased levels of popular support for suicide attacks [93], and a questionnaire of Muslim populations in Lebanon ($n = 553$) and Palestine ($n = 342$) supported this finding when an attachment to political Islam was present [236]. Similarly, a political calculus was found to explain support for appeals from al-Qa'ida Central (AQC) leadership, in the case of Muslims in Indonesia ($n = 1,008$) and Pakistan ($n = 2,008$) [237]. Support for suicide bombings against civilians and foreigners in Iraq was found among those surveyed in six countries in the Middle East, North Africa, and South Asia ($n = 5,668$) [238]. Interviews with organisers of suicide attacks for FA ($n = 4$), HA ($n = 5$), and PIJ ($n = 5$), as well as would-be suicide attackers ($n = 15$) in Palestine showed that these individuals were motivated to conduct suicide operations based on the interests of their community and religion, despite the presence of suicidal tendencies in a number of potential suicide attackers [110]. Reminders of death (i.e., mortality salience) were also found to increase Islamic fundamentalism [239], politically and religiously extreme views [240], and martyrdom activities [241], in a number of Muslim youth samples in Australia ($n = 63$), Indonesia ($n = 308$), and Iran ($n = 40$). The presence of violence and death in the cognitive domains of EFIJ individuals are potential first-order identifiers for support of violence and violent action in conflicts, but also capture destructive actions directed at individuals outside of conflicts, such as abuse and trauma. Therefore, it follows that:

PROPOSITION 5 An EFIJ construct taxonomy should include a dimension to capture actions in or reactions to a fight, battle, or struggle.

2.4.6 Oppositional Evocations (OE)

The visceral separation of the world into opposing parts was manifested in the actions and thoughts of many EFIJ individuals. A number of studies concluded that an oppositional identity formed in individuals who became radicalised [242, 243], which may provide some explanation for the finding that many of these individuals were absolutist in orientation [203]. Indoctrination of individuals was found to use ideas and images of a bipolar struggle between Islam and the West [112], where the world was divided into 'us' and 'them' experiences [146, 244], and relied on the use of Islamic religious vocabulary [161]. Experimental research that explored the psychology of Islamism found a positive association between Islamist affinities and a preoccupation with dominance (strength) and submission (weakness) dichotomies in a sample of Muslim youth in the UK [245]. Others found that radical individuals attempted to distinguish between 'true' and 'false' Islam in their interpretations of the world [155]. Interestingly, interviews with disengaged AS militants ($n = 32$) found that while dichotomous thinking played a role in why they joined the group, the same separation of true and false Islam contributed toward their ultimate disillusionment with the

group [106]. A study of individual jihadist cases from Australia ($n = 8$), Canada ($n = 6$), the Netherlands ($n = 4$), Spain ($n = 7$), and the UK ($n = 4$) [246], as well as online cases ($n = 367$) [247], found that the excommunication practice of takfir was used by jihadists to dichotomise their world view and denounce other Muslims as kuffar, or unbelievers, in order to justify acts against them. A negative view of those who offend Islam was a significant predictor in support for violence in a study of a Muslim population in Italy ($n = 440$) [248]. Evidence for a dichotomous cognitive process was also found at the neurocognitive level in the form of diminished activity in the dorsolateral prefrontal cortex, inferior frontal gyrus, and parietal cortex (regions implicated in calculating costs and consequences), when supporters of LeT ($n = 30$) conveyed their willingness to fight and die for ‘sacred’ relative to ‘non-sacred’ values [142]. Although difficult to capture, omnipresent evocations used by individuals that attempt to divide perceptions of the world through dichotomous relationships to its ideas and representations, may provide meaningful first-order identifiers closely linked to the aforementioned dimensions in EFIJ written content. These degrees of bipolarity could present as, for example, constructs linked to TK in the form of purity and impurity, constructs associated with CB through victory and defeat, SR constructs that make references to us and them, and so on. As such:

PROPOSITION 6 An EFIJ construct taxonomy should include a dimension to capture acts or rhetoric that elicit feelings, memories, or images in the conscious mind that are dichotomous in nature.

2.4.7 Affective Experiences (AE)

Various conscious experiences were identified in the study of EFIJ individuals that depended on their own thoughts, feelings, and actions, or those of others with whom they interacted or sought to interact. A study of global Islamic suicide terrorist cases ($n = 12$) concluded in part that these individuals experienced fear of an approaching enemy [249]. Fear and hesitation were also experienced in would-be suicide attackers prior to the execution of their mission [110]. Interviews with Muslims that were arrested in the process of trying to carry out a suicide attack for FA ($n = 4$), HA ($n = 5$), and PIJ ($n = 5$) highlighted that these individuals suffered from anxiety [109]. The experience of humiliation was found to be a common occurrence among those cases of individuals who committed suicide attacks for a wide range of groups: al-Qa’ida in the Arabian Peninsula (AQAP), the Islamic Movement of Uzbekistan (IMU), the Moroccan Islamic Combatant Group (GICM), AQIM, AS, JI ($n = 77$), AQ, Lashkar-e-Jhangvi (LeJ), the Taliban (TAL) ($n = 608$), al-Qa’ida in Iraq (AQI), Jamaat Ansar al-Sunnah (JAS) ($n = 1,404$), HE ($n = 48$), and LTTE ($n = 131$) [101]. Stress from significant hardship was also identified as contributory in the acts of homegrown Islamist terror plots perpetrated by individuals ($n = 60$) or interrupted

by law enforcement in the US [158]. Feelings of anger and aggression that could be directed were identified in cases of persons linked to jihadist-related crime in the US ($n = 125$) [250], as well as in the cases of foreign fighters from Denmark ($n = 22$) [146]. A broad questionnaire research study of the relationship between culture and terrorism across 38 countries ($n = 1,000 \times 38$) found that populations that were angry, hopeless, and experienced suffering, showed more tolerance of terrorism and incidents of terrorism [251]. Analysis of the members of two EOF ($n = 33,881$) found that many of these experiences were represented in the communication found on the fora and were accompanied by high levels of hate [252].

Interviews conducted with religious extremists across five countries in Asia, South Asia, and in refugee camps in the Middle East, found that individuals felt a deep sense of moral dissatisfaction based on the perceived decadence of modern institutions [253]. General dissatisfaction with life [155] and religious dissatisfaction [254] were also found in Western samples of Muslims. Other socially complex motivations and experiences such as needs for commitment [192] were identified in the cases of Muslim youth who were arrested at the border in attempts to join ISIS ($n = 809$) [125, 126]. Interviews with the close relatives of several close members and friends of Chechen suicide bombers ($n = 51$) reported that the deceased experienced a profound sense of duty to enact revenge [163]. Whilst negative affective experiences featured prominently from a wide spectrum of anger (e.g., frustration [255], hatred [83], outrage [164]), sadness (e.g., humiliation [256], neglect [127], shame [148], sympathy [257]), and fear (e.g., anxiety [222], distress [191]), positive affective experiences such as ideological passion that underlie political or religious commitment [258] and excitement [94] were also present in the findings of studies. An analysis of several extremist online samples, composed of ISIS affiliates ($n = 112$) and sympathisers ($n = 142$), found statistical evidence that these individuals were more likely to express negative affects in the form of emotions tied to perceived discrimination and criticism of Western society, and positive affects in support of jihad, than average users of these publicly accessible social media [259].

A large number of interviews conducted with captured AQ and associated foreign fighters identified a complex web of experiences that sought status in the form of recognition and esteem from others, thrill in the form of glory, and outlets for endured experiences [94]. Suicide bombing, for example, was perceived as noble [140]. Similarly, others reported a belief that support and acts awarded recognition and a special status [213], enhanced their social status [217] and self-esteem [118], and served egoistic and altruistic goals [101]. The wide and contrasting range of basic emotions present in the experiences of EFIJ individuals allow for the inclusion of extant categorisation schemes to identify emotions as first-order identifiers, which are closely linked to more complex forms of moral or personal affections [260, 261, 262, 263]:

PROPOSITION 7 An EFIJ construct taxonomy should include a dimension to capture instances of observing, encountering, or undergoing emotions or feelings.

2.4.8 Persuasion Processes (PP)

A number of studies discovered particular ways in which information was created and transmitted to and from individuals in order to influence their beliefs, attitudes, intentions, motivations, and behaviours. Studies noted that radical ideology influenced individuals through persuasion [84, 217]. Individuals who possessed vast knowledge of Islam were attractive to recruits in a study that examined cases of radicalised Muslims in the US ($n = 83$) [211]. Research showed that such authority could be used to successfully manipulate normative beliefs [264] about aggression toward others [171]. Another study found that messages exchanged in the radicalisation process were amplified and combined with jihadist interpretations of verses from the Quran [161]. Others in turn were found to develop a desire to spread the word given to them, known as da'wah, either in-person or online [89, 97]. Among those in a sample who sought interpretations of the Quran and sunnah, second and third generation Muslims were found to seek more literal interpretations of narratives [265]. In population samples, support for scriptural literalism coincided with support for religious violence, as was found in a study of Muslims in Cameroon ($n = 245$), Ghana ($n = 339$), Guinea Bissau ($n = 373$), and Liberia ($n = 279$) [266]. A literalist religious outlook also generated positive views of a specific violent group, such as AQ, which was found in a questionnaire study of Muslim populations in Egypt ($n = 899$), Jordan ($n = 894$), Tunisia ($n = 906$), and Turkey ($n = 836$) [267]. Experimental research ($n = 164$) that investigated the relationship between persuasive narratives and costly actions, such as suicide missions or martyrdom operations, found that those who were high-perspective takers and experienced more physiological arousal from the narrative were more likely to engage in the costly behaviour [268].

Narratives such as those found in the online environment often included tales of exploits by foreign fighters and individuals who joined extremist groups as a means to enhance the persuasiveness of the narrative and project onto themselves a romanticised version of Islamic history, as was found by a study that examined individuals who joined ISIS in Syria from Australia, Europe, and the US [269]. Studies that examined the role of the Internet in radicalisation processes of extremists in the UK ($n = 15$) and individuals charged with ISIS-related activities in the US ($n = 71$) concluded that these individuals used the Internet as an echo chamber to find support for their ideas that were echoed by like-minded individuals in their communication with each other [122, 270]. A study of a youth sample in Kyrgyzstan ($n = 108$), deemed likely targets for radicalisation by ISIS, found that exposure to the group's online propaganda elicited support for and trust in the messaging, as well as a desire to exchange information and seek further interaction to get answers to their

questions [121]. Given that the processes of persuasion and interpretation rely on both the effective construction and communication of ideas, useful first-order identification would be alerted to content that includes the specific means and modes of information processes:

PROPOSITION 8 An EFIJ construct taxonomy should include a dimension to capture actions of communication or reception of knowledge that influence convictions or beliefs.

2.4.9 Existential Validation (EV)

The relationship between individual and sensemaking was prevalent in a range of studies that examined, in some form, the inherently social journeys individuals experienced in pre- and post-radicalisation pathways [271, 272]. Research that examined individual cases of terrorist or separatist activity consistently found evidence of adverse life events [84], identity issues, and crises [96] in the backgrounds and trajectories of ranks in al-Aqsa Martyrs Brigade (AMB), Tanzim (TAN), HA, PIJ ($n = 9$), AQ ($n = 163$), LTTE ($n = 4$), and Chechen groups ($n = 9$). Identity issues and crises were also associated with individuals who were convicted under anti-terrorism laws in Australia ($n = 21$) [273], were radicalised prisoners in France ($n = 112$) [274], committed crimes motivated by Islamic beliefs in Germany ($n = 29$) [275], or were involved in Islamist terrorism in the West and spent their formative years there ($n = 228$) [276]. Questionnaire research on Muslim youth in Canada ($n = 111$) and the Netherlands ($n = 131$) found that personal uncertainty was an important determinant of a radical belief system [190], and that obsessive ideological passion was anchored in a strong, but insecure sense of identity [258]. Interviews conducted with radicalised individuals in France ($n = 6$), Spain ($n = 6$), and the UK ($n = 6$), as well as members ($n = 95$) and relatives of members ($n = 46$) of AS in Kenya, found evidence of identity exploitation as a means of influence to control and guide individuals [103, 277].

Searches for meaning [192, 278], identity [279], and significance [280] were present in interviews with individuals who were in the direct environment of others who became foreign fighters in Syria ($n = 18$), interviews with informants in asylum and detention centres in the Netherlands ($n = 21$), as well as posthumous case examinations of suicide attackers from various regions on the world ($n = 219$). Studies identified the presence of environments of support and encouragement for the actions of individuals, both morally and intellectually [91, 281], as was found in the case of pro-ISIS online aggregates that grew through nuanced mechanisms of homophily [282], and supported the trajectories of individual followers with information, who passed through numerous groups [283], from relatively small networks on Twitter ($n = 727$) [284] to very large networks on VKontakte ($n = 108,086$) [285]. A sample of individuals who became radicalised and joined ISIS as foreign fighters ($n = 22$) reported in interviews that they attempted to close the gap

between an ‘un-Islamic’ past and a better, redeemed future [123]. Other studies found evidence that these supportive environments rely on existing cultural schemata built into the popular imagination of how Islamic combatants engaged enemies of faith, in the case of Muslim youth in Morocco ($n = 148$) [286], and that such environments acted to normalise and socialise jihad [287], as demonstrated in interviews with foreign fighters from Sweden ($n = 8$). Different drivers were observed and noted in a number of samples where individuals attempted to address issues that stemmed from a lack of existential meaning [146] and the perceived misrecognition of Muslim identity in society [242]. Such actions included empowerment and displays of power [209], overt rebellion [97], displays of difference and resistance [265], and attempts to strengthen [186, 225] and defend a newfound sense of identity as ‘true’ Muslims [116, 288]. Recruitment actions capitalised on the interplay between individual and environment [92], and the facilitation of various drives in a number of studies that examined cases of radicalisation [102, 204]. The interaction between human identity as social beings and the various unwritten rules that govern behaviour in EFIJ communities provide first-order areas of content identification, as this interaction sheds light on behaviour by individuals that attempts to fulfil the normative social requirements of association [289]:

PROPOSITION 9 An EFIJ construct taxonomy should include a dimension to capture acts of assertion or recognition grounded in experiences or the affirmation of experiences.

2.5 Discussion

The present study proposed nine dimensions, defined through first-order identifiers, for the identification of unit level constructs in the content written by EFIJ in communities such as EOF. These dimensions were developed from the empirical findings of a systematic review of literature that produced a limited number of studies at the local individual EFIJ level and utilised cases, questionnaires, and interviews. Notably, various parts of individual factors such as those within a person’s sociodemographic characteristics, criminal history, work and education, personal experiences, attitudes and beliefs, relationships, and mental health cannot easily be identified in their linguistic expressions [290]. The full complexity of an individual’s psychopathological and psychological context is therefore near impossible to capture in written content. As such the dimensions introduced in this work, whilst broad, cannot capture every factor that motivates the engagement of EFIJ.

Studies on the psychopathology of individuals who engaged in terrorist acts found very little empirical support that these individuals as a group espouse a greater propensity for clinically diagnosable mental disorders when compared with others [200, 291, 292, 293, 294].

Some cases showed schizophrenic and dissocial psychosis [275], particularly cases that involved suicide terrorist acts [295]. Individuals who engaged in lone wolf terrorist acts, however, were found to exhibit higher rates of mental illness [191, 296] and psychological disturbance [297] such as paranoid schizophrenia, personality disorders, and unidentified psychological disorders involving uncontrollable violent behaviour [158, 211]. Studies found that individuals with vulnerable personalities [245] were drawn to extremist ideology for a wide range of reasons linked to a desire to reverse psychological resource loss [298], a lack of empathy [299] and integrative complexity [104], authoritarianism [83], conformity [300], low self-esteem [299] and social dominance orientation [301], narcissism [302], neuroticism [174], and paranoia [303]. Individuals in these cases also experienced social exclusion, isolation [304], and ultimately a failure to cope [275]. Notably, an empirical distinction does appear to exist between radicalised youth and adults, where the former exhibit comparatively higher levels of psychological vulnerability [130]. Differences also exist within youth samples, such as former child soldiers who showed significantly higher prevalence of post-traumatic stress disorder, depressive disorders, anxiety disorders, and somatic disturbances, when compared with children who had not been child soldiers [128]. Despite the difficulty of identifying these more complex phenomena in the content produced by EFIJ individuals, their existence is worthy of note.

Many studies cautioned against the search for personality traits common to EFIJ individuals, as these traits may only point to decisions to involve themselves in acts, as opposed to being a unified framework of traits shared by all such individuals, which to date has not been shown to exist [305, 306, 307]. A number of factors may also be in flux and act as drivers for behaviour that depend on the individual's needs or circumstances, which further complicates explicit identification of specific factors involved [308]. Given the complex interplay between these factors at a number of levels and the difficulty in the capture of their manifestations in content written by EFIJ individuals, the proposed outline for an ECT on the basis of what can be reasonably identified is a step toward a principled arrangement method for the empirical study of EFIJ interactions at behavioural, cognitive, and emotive levels. Regardless of the application, consideration of the context within which specific terms are mentioned in interactions needs to be treated with care, so as to ensure conflicts that arise in their assignment to overlapping dimensions of the ECT are resolved using the meaning given to terms through the context of their linguistic use. A developed ECT is useful for a number of applications in descriptive, exploratory, and confirmatory data analysis. One such application is text mining, an area relatively underrepresented in EFIJ research, which allows for the application of statistical, linguistic, and structural techniques to extract and classify information from unstructured data found on the Internet in communities and documents produced by EFIJ individuals and groups.

The work in section 3 will develop the content of the ECT through identified constructs

from a large number of temporal conversations between EFIJ individuals across a collection of EOF, and empirically explore engagement with and influence of ECT dimensions in these EOF.

3.1 Abstract

Background: Few empirical insights exist into the content of communication in EOF¹² and how individuals interact with such content over time. The present study sought to classify content through the systematic extraction of constructs used by a spectrum of EFIJ¹³ individuals in these communities. Exploratory analysis of the dimensions of an ECT¹⁴ is presented through analysis of engagement and interaction with identified constructs.

Methods: A mixed methods approach was applied to independent EOF ($n = 13$) and sampled sentences ($n = 10,000$) from a large number of dyadic communication interactions between EFIJ individuals, where identified constructs in sentences were coded according to the dimensions of the ECT. A novel change point detection methodology was applied to the lifespan of constructs ($n = 5,784$) to empirically measure engagement, which was estimated across EOF through random/mixed and fixed effects meta-analyses. An adaptation of the methodology was used to identify clusters of construct subdimensions that exercised influence in discussions from these EOF through testing of multiple community detection methods ($n = 9$).

Results: A small proportion (5.07%) of constructs experienced significant engagement over time, the majority of which were concentrated in the TK¹⁵ (32.41%) and SR¹⁶ (30.56%) dimensions, out of a total of nine dimensions. Both TK (incidence, .21; 95% confidence interval (CI), .17–.26) and SR (incidence, .1; 95% CI, .07–.14) were found to attract high engagement in all EOF analysed, where SR had smaller effects than TK across EOF. Clusters discovered in the subdimension influence network of content showed high normalised mutual information ($\mu = .9$) and significant modularity ($p < .01$), which found that SR subdimensions accounted for a near majority (40%) of all influential subdimensions.

Conclusions: The nature of EOF and EFIJ discourse makes the finding of engagement with and influence of TK a reasonable expectation, but similar results produced by SR were surprising in the context of other dimensions. The comparative dominance of SR influence

¹²Extremist online fora ¹³Extremist, fundamentalist, Islamist, and jihadist ¹⁴EFIJ construct taxonomy
¹⁵Theological knowledge ¹⁶Social relations

in particular serves as a beacon for future research to pay special attention to the presence of social connections or associations and the roles they signify in EFIJ content, as their importance seemingly extends beyond the behavioural domains of these individuals and also permeates their written interactions with each other.

3.2 Background

A number of research reviews on extremism, radicalisation, and terrorism have concluded that the broader field lacks systemic empirical and scientific research [309, 310]. Works on these topics are critiqued for findings that draw on research that are predominantly conceptual in nature [311], exhibit an over-reliance on conventional wisdom [312], and lack a foundation built on extensive primary data [313, 314, 315]. Stronger empirical research has emerged at the macro-level [316], due to the increased accessibility of open-source incident databases [317], but research is comparatively lacking at the individual level of analysis [318, 319]. A recent study found that only 219 (3.6%) out of 6,085 studies reviewed presented findings based on primary research and original data on individuals. Despite significant policy interest, the many mechanisms and processes put forward as theories to explain radicalisation remain untested and are not domain-specific [320] (for a review of cognitive, psychological, sociological, and psychoanalytical theories, see [321]). The field faces a number of challenges as knowledge about the behavioural, cognitive, and emotive domains of individuals who are radicalised or at risk of radicalisation remains relatively weak with respect to individual level empirical work in these domains [322, 323, 324, 325, 326, 327].

A systematic review of empirical studies in the field identified individual level factors associated with EFIJ [64]. Individuals who were attracted to or showed support for EFIJ ideologies, were at risk of radicalisation or were radicalised, or engaged in terrorism, can be viewed as different points on a spectrum of EFIJ. The same study used the findings to inform the outline of an ECT by developing dimensions at the individual level that may translate into groups of constructs that can be systematically identified in content written by EFIJ individuals. Despite these findings from a limited pool of empirical work, the relationship between the specificity of communication and engagement with and influence of such content in EFIJ communities remains an open question. The systematic classification of constructs used in the content of communication between individuals is useful for the modelling of these phenomena in order to understand the nature of its engagement and influence in communities. Such study of EFIJ individuals in their communities is a tenable step in a direction that may develop our understanding of how the internal community dynamics of individuals and their communication with each other shape them, which is an area of social psychology that is particularly lacking with respect to the study of EFIJ phenomena [328, 329]. In consideration of these conditions, a prospective path to the empirical

study of EFIJ individuals is the online environment [28], as the Internet provides extensive access to the communities that these individuals use to communicate freely and form social ties.

3.2.1 Definitions

A total of nine dimensions were developed from the aforementioned systematic review of empirical findings at the individual level. The dimensions were defined on the basis of being first-order identifiers of content as their aim is to capture the simplest or most fundamental level of organisation, experience, and analysis in the content written by EFIJ individuals on Internet communication platforms like EOF. The nine dimensions identified are as follows, and may include subdimensions depending on the nature of constructs (see table 3.1 for definitions):

- Geopolitical perspectives (GP)
- Collective dynamics (CD)
- Social relations (SR)
- Theological knowledge (TK)
- Conflict behaviour (CB)
- Oppositional evocations (OE)
- Affective experiences (AE)
- Persuasion processes (PP)
- Existential validation (EV)

As EOF can be mirrored to store identical replications of their original state, they represented excellent candidates for observation of the large-scale and temporal order of communication between individuals, and thus are the environments used to analyse engagement with and influence of content. For the purposes of this study, engagement with ECT dimensions can be defined as the observable semantic shifts [330] in written content over time relative to surrounding content at the word and phrase level of communication between individuals, due to the notion that significant enough shifts represent a high degree of fine-grained participation in conversations attributed to a dimension in a community, as opposed to larger cultural shifts studied in diachronic semantics [331]. Since these semantic shifts are relational, a content network of communication [332] can be used to show the influence of ECT subdimensions in conversations, which builds on the methodological notion of engagement and defines the sets of constructs that move in and out of the centre

Table 3.1: ECT dimensions and definitions

Code	Definition
GP	Views of geographic or political factors that influence or characterise a country or region.
CD	Mechanisms that deal with any assemblage or collection of persons or parts that form a complex or unitary whole.
SR	Connections or associations that involve two or more persons who occupy different social roles.
TK	Awareness of religious faith, practice, and experience.
CB	Actions in or reactions to a fight, battle, or struggle.
OE	Acts or rhetoric that elicit feelings, memories, or images in the conscious mind that are dichotomous in nature.
AE	Instances of observing, encountering, or undergoing emotions or feelings.
PP	Actions of communication or reception of knowledge that influence convictions or beliefs.
EV	Acts of assertion or recognition grounded in experiences or the affirmation of experiences.

[333] of changing conversations over time, to reflect the nature of communication as a dynamic process, but remain part of the main group [334] of subdimensions in the content of such communication.

3.2.2 Objectives

The objective of the present study is to build a foundation for the empirical study of local level interactions between individuals in online environments where EFIJ content exists. It aims to contribute an ECT built on the aforementioned dimensions and analyse the constructs observed in the content of these interactions between individuals. To satisfy this objective, the study will:

1. Analyse a large number of temporal conversations between individuals in EOF in order to identify constructs that meet the definitions outlined in the ECT structure. This will develop the content of each ECT dimension, and subdimension where applicable, to advance an understanding of the nature of content in the space of interaction between individuals.
2. Without a priori knowledge on engagement with content in EOF by EFIJ individuals, empirically test for and compare engagement with dimensions of such content over time in independent fora. Thus, the study hypothesises that:

HYPOTHESIS 1A — ECT dimensions experience different levels of engagement in EOF.

3. On the assumption of significant engagement with ECT dimensions in EOF and without a priori knowledge on influence of such content, empirically test for and extract subdimensions that are influential in conversations:

HYPOTHESIS 1B — ECT subdimensions exert different levels of influence in EOF.

In light of the absence of empirical work at the local level of interaction between individuals in these fora, the study utilised a data-driven approach to the objectives and brought

together a number of novel methodologies to develop the contribution through direct observation of communication between individuals as viewed from archived and complete EOF in their natural state. Without these advances in interdisciplinary methods, the study of EFIJ phenomena in this field would not have been possible, and are thus cited in detail for the benefit of future researchers.

3.3 Methods

3.3.1 Sample

Conversational text data were collected from a total of 13 separate EOF that were centred on religious extremist Islamic ideology, operated through online discussion board infrastructure, and attracted a wide spectrum of EFIJ content. Each dataset spanned a number of years ($\wedge = 2000$, $\vee = 2014$, $\mu = 7.31$, $\sigma = 3.15$), varied in the number of conversations or threads ($\wedge = 822$, $\vee = 172,543$, $\mu = 36,262.62$, $\sigma = 60,845.99$), and consisted of hundreds to tens of thousands of unique contributing members or individuals ($\wedge = 112$, $\vee = 74,206$, $\mu = 10,691.69$, $\sigma = 22,650.23$) who engaged in conversations on the EOF. Arabic EOF were selected over this timespan as their English-language EOF counterparts were far less active [37].

3.3.2 Word and Phrase Tokenisation

Each conversation existed on a separate web page in the form of a thread that was dyadic, interactive, and dialogue in nature. Each EOF was interrogated to extract the conversational text data from raw and unstructured data by removing the HTML from each file, as is common in text mining when preprocessing web text [335, 336]. Threads that contained single posts were not included in the sample, as these were not considered conversational. Specifically, the `Beautiful Soup` [337], `Bleach` [338], `ftfy` [339], `HTMLParser` [340], `Markdown` [341], and `postmarkup` [342] modules from the Python programming language were used for this purpose.

Because the majority of sentences in the conversations between users on the forums were written in Arabic (72.26%) regardless of the geographical focus of the forum, analysis was limited to the Arabic language to capture an individual's meaning in their most probable native language. Special care was taken to preserve the proper representation of Modern Standard Arabic (MSA) text as the characters were written by their individual authors by directly working with the language in Unicode through the `Unidecode` [343] module and utility functions provided by the `Gensim` [344] module. The conversations were tokenised into sentences using the `TextBlob` [345] and `Natural Language Toolkit` [346] modules, through which an unsupervised multilingual sentence boundary detection algorithm trained

on large MSA corpora was used [347]. Each dataset was thus represented in sentence form as a diverse collection of sentences ($\wedge = 7,577$, $\vee = 3,462,803$, $\mu = 646,531.77$, $\sigma = 1,055,654.89$), derived from conversations between individuals who were members of the observed EOF.

To arrive at a more comprehensive unit of analysis that extended beyond single words or unigrams, phrases, or multiword expressions, were identified as frequently co-occurring tokens in the text through a data-driven approach where phrases were formed based on unigram (e.g., مجاهدة – fight or battle) and bigram (e.g., قنبلة صاروخية – rocket bomb or guided missile) counts [348]:

$$\text{score}(w_i, w_j) = \frac{\text{count}(w_i w_j) - \delta}{\text{count}(w_i) \times \text{count}(w_j)}, \quad (3.1)$$

where δ was used as a discounting coefficient and prevented too many phrases ($w_i w_j$) that consisted of very infrequent words to be formed. $\text{score}(w_i, w_j)$ was a value given to each bigram and used as a threshold of what constituted a phrase in the corpus, or the collection of all text data in the observed EOF. In order to collect as many phrases as possible without any prior empirical knowledge of the corpus, δ was set to 1 and a threshold score of 5 was chosen in each respective corpus, which identified a large number of unique words and potential phrases across the EOF for further analysis ($\wedge = 17,563$, $\vee = 3,737,833$, $\mu = 989,204.62$, $\sigma = 1,294,576.62$).

3.3.3 Content Identification and Classification

To identify sentences that had potential ‘extremist’ properties in the tokenised corpora of the EOF, a sentiment classification model was developed to assign a negative and positive polarity score to each sentence, thereby providing a semi-supervised means to filter content in corpora to a size fit for human evaluation and restrict analysis to statements that carried a specified threshold of highly positive or negative sentiment, as evaluated by the classifier. Unfortunately, few resources existed publicly for the analysis of sentiment in MSA. However, some works made efforts to make available to researchers MSA corpora annotated for sentiment that were sourced from various microblogs [349, 350, 351, 352, 353] and reviews [354, 355, 356, 357]. A balanced two-class corpus was constructed from these mixed resources (32,000 positive and 32,000 negative statements) and the importance of the features (i.e., words and phrases) were vectorised through the term frequency inverse document frequency (TF-IDF) algorithm [358, 359, 360, 361, 362, 363]. Specifically, the hyperparameters chosen for the TF-IDF algorithm were L2 normalisation, IDF reweighting, smoothed IDF weights, and sublinear TF scaling [364].

To classify unseen data based on sentiment, a linear support vector machine (SVM) learning algorithm was trained on the constructed corpus through the `scikit-learn` [365] and `lightning` [366] Python modules to build a sentiment classifier [367, 368, 369, 370]. The hyperparameters chosen for the linear support vector classifier (SVC) algorithm were L2 normalisation used for penalisation, the liblinear solver used for optimisation [371], and a maximum of 1,000 iterations [364]. To test the accuracy of the method, the constructed corpus was randomly partitioned into ten equal sized subsamples, a classifier was trained on nine subsamples and tested on the remaining one, and the process was repeated ten times to produce a mean accuracy of negative or positive prediction across the ten folds (i.e., ten-fold cross-validation) [372, 373, 374, 375]. The accuracy achieved by the classifier was 82.1%. Through this model, each sentence of the text data of each EOF was given a positive and negative polarity score by the trained classifier. Given the size of the text corpora, the identification of potentially extremist content was restricted to those sentences that scored .8 or higher on either positive or negative polarity as evaluated by the classifier, which amounted to a total of 69,549 sentences for human analysis across the corpora of the EOF collection.

Finally, a random sample of 10,000 sentences were selected from the aforementioned sentences for manual inspection and a qualitative extraction commenced in order to assign words and phrases to any identifiable constructs, which were coded into dimensions and subdimensions of the ECT structure, either through association or direct reference. All 13 EOF were approximately equally represented in the random sample. Coding was performed independently by the author and a colleague with the ECT structure as guidance, followed by calculation of Cohen's kappa coefficient (κ) [376, 377] using the `irr` R package [378] as a measure of inter-rater reliability for the qualitative phase of the study.

3.3.4 Semantic Shift

Levels of engagement with ECT dimensions in EOF were measured through a computational approach that tracked and detected statistically significant semantic shifts in the meaning and usage of words and phrases (i.e., tokens) over time (hypothesis 1a) [330]. Specifically, the approach ① constructed a time series for each token in order to model the temporal evolution of natural language, ② inferred contextual cues from token co-occurrence statistics to construct distributional time series, and ③ incorporated a change point detection algorithm to establish the statistical significance of token changes over time, indicative of individual engagement with the specific content.

Previous work on semantic shifts over time analysed frequency patterns [379], compared language from different time periods to quantify the change [380], or used topic modelling and distributional semantics [381, 382, 383, 384, 385], but suffer from restrictions on the

number of required language snapshots taken over time, do not include statistical change point detection, do not allow for efficient scaling required to analyse larger corpora [386], or require linguistic knowledge of the data [387]. The approach selected was attractive as it applied equally to all languages and domains, placed no requirement on time scales of equal sizes across datasets, and allowed for efficient parallelisation of model training on larger corpora [330], which fulfilled the analysis conditions of the EOF collection. Specifically, the `langchange-track` [388] Python module was used to implement ①-③ (subsections 3.3.5-3.3.6).

3.3.5 Time Series and Distributional Method

The dataset of each EOF was converted into a temporal corpus (\mathcal{C}) over a time span (\mathcal{S}) and divided into n snapshots (\mathcal{C}_t) with a period length of three months each (P). Tokens in the ECT (\mathcal{E}) were used to construct a time series ($\mathcal{T}(wp)$) for each word and phrase ($wp \in \mathcal{E}$), where each point in the time series ($\mathcal{T}_t(wp)$) corresponded to statistical information extracted from a corpus (\mathcal{C}_t) snapshot that reflected the use of wp .

$\mathcal{T}_t(wp)$ was calculated through a distributional method that used statistical information on the context of wp , which learned a semantic space that mapped each word and phrase in the corpus snapshot ($wp \in \mathcal{C}_t$) to continuous vector space (\mathbb{R}^d), where d was the dimension of the vector space [389]. In this way, vector representations of tokens, or word embeddings [390], that appeared in similar contexts were close to each other in vector space. This representation reflected the notion of the distributional hypothesis in linguistics, which argues that words (and phrases) that occur in the same contexts tend to have similar meanings (i.e., are semantically similar) [391, 392, 393]. Several works improved word embedding computations to the point where distributional methods can now efficiently scale to large corpora [394, 395, 396, 397].

The method learned a temporal word embedding ($\phi_t \mathcal{E}, \mathcal{C}_t \mapsto \mathbb{R}^d$) of a specific token for each corpus snapshot, and changes of the representation were tracked across the embedding space to quantify the meaning shift of the token. Thus, semantic shift was captured from the construction of the distributional time series through the following calculation of $\mathcal{T}_t(wp)$:

$$\mathcal{T}_t(wp) = 1 - \frac{(\phi_t(wp) \mathbf{WP}_{t \rightarrow 0}(wp))^T \phi_0(wp)}{\|\phi_t(wp) \mathbf{WP}_{t \rightarrow 0}(wp)\|_2 \|\phi_0(wp)\|_2}, \quad (3.2)$$

where the distance in the embedding space between $\phi_t(w) \mathbf{WP}_{t \rightarrow 0}(w)$ and $\phi_0(w)$ was calculated.

3.3.6 Change Point Detection

Upon construction of a time series of a token $\mathcal{T}(wp)$, quantification of significant change detection through estimation of change points became attainable, which may indicate the occurrence of shifts in the meaning and usage of wp . Change detection thus attempted to identify times when the probability distribution of a stochastic process or time series changed, which involved both the detection of whether or not a change had occurred and identification of the times of any such changes [398, 399, 400, 401].

The time series of each token $\mathcal{T}(wp)$ was first normalised to account for general stochastic drift exhibited in language through calculation of the mean ($\mu_i = \frac{1}{|\mathcal{E}|} \sum_{wp \in \mathcal{E}} \mathcal{T}_i(wp)$) and standard deviation ($\sigma_i = \frac{1}{|\mathcal{E}|} \sum_{wp \in \mathcal{E}} (\mathcal{T}_i(wp) - \mu_i)^2$) across all tokens, followed by a transformation of the time series into a z -score series:

$$\mathcal{Z}_i(wp) = \frac{\mathcal{T}_i(wp) - \mu_i}{\sigma_i}, \quad (3.3)$$

where $\mathcal{Z}_i(wp)$ was the z -score of the time series for the word or phrase (wp) at a time snapshot (i). The time series points were shuffled to produce a permuted set ($\pi(\mathcal{Z}(wp))$). A mean shift transformation (\mathcal{K}) was applied to the original normalised time series ($\mathcal{Z}(wp)$) and the permuted set:

$$\mathcal{K}(S) = \frac{1}{l-j} \sum_{k=j+1}^l S_k - \frac{1}{j} \sum_{k=1}^j S_k, \quad (3.4)$$

which corresponded to calculation of the shift in mean between two parts of the time series (S) pivoted at a time point (j), that allowed for the identification of change points through significant shifts in the mean [402]. Bootstrapping was used to estimate the statistical significance of a mean shift observation at a time point (j), under the null hypothesis that there was no change in the mean [403]. This probability distribution of possible mean shifts was calculated given a specific time over 1,000 bootstrapped samples.

Finally, a comparison was made between the observed value in $\mathcal{K}(\mathcal{Z}(wp))$ and the probability distribution of possible values to calculate the p -value which determined the statistical significance of the observed time series shift. As noted in the work that pioneered the method, the approach was also extended to obtain tokens that changed significantly compared to other tokens through consideration of only those time points where the z -score exceeded a defined threshold ($\gamma = 1.75$). The significant estimated change point(s) (ECP)s in a temporal EOF were therefore those time points with the minimum p -value as outlined before, where each ECP represented a significant deviation in the way members of an EOF engaged with ECT content at the individual token level of analysis.

3.3.7 Meta-analysis Models

The number of ECT tokens per dimension observed in each EOF (n_i) and the number of these tokens that had significant ($p < .05$) ECPs (x_i) were calculated to produce a proportional measure for comparison. Before differences between dimension proportions were analysed (hypothesis 1a), the Shapiro-Wilk test of normality was used to establish the possibility that the proportions came from a normal distribution ($W = .77, p < .001$) [404]. In addition, Bartlett's test was used to test if the proportions were from populations of equal variances ($\chi^2 = 20.24, p < .01$) [405]. Both tests indicated that the proportion data did not meet the parametric assumptions of analysis of variance (ANOVA), and as such, nonparametric approaches were used to analyse differences between dimension proportions. Specifically, an omnibus Kruskal-Wallis test was used to determine whether dimension proportions differed [406], followed by post-hoc comparisons in the form of Wilcoxon rank-sum tests to compare dimension proportions two at a time [407], where p -values were adjusted through the Holm-Bonferroni method to take multiple testing into account and strongly control the family-wise error rate [408]. The `nparrcomp` R package was used to perform these methods [409].

A number of meta-analyses of these proportions, grouped by dimension, were conducted to calculate the average engagement incidence across EOF, where x_i and n_i represented the most prominent proportion of token ECPs per dimension. A binomial-normal (BN) generalised linear mixed model (GLMM), or more specifically, a random intercept logistic regression model, was used. In the case of a meta-analysis of event data, such as the present study, this type of model has been shown to outperform the normal-normal (NN) model on bias and coverage of confidence intervals [410]. The NN model was traditionally used to meta-analyse independent studies ($i = 1, \dots, N$) where a parameter of interest (θ_i) was estimated, particularly when the proportions studied were close to one or zero and events were relatively rare [411]. Each meta-analysis used logit transformed proportions (i.e., log odds) [412].

To compare the estimates of these independent group-based random/mixed effects meta-analyses and to test whether their estimates were different from each other, a Wald-type test was used, which is conceptually similar to a single meta-regression model that would include all EOF using a dichotomous moderator to distinguish the sets [413]. A fixed effects model was used for this purpose, as the residual heterogeneity within each subset of meta-analyses had already been accounted for through the random/mixed effects models. The `metafor` R package was used to fit the random/mixed effects and fixed effects model(s) [414, 415].

3.3.8 Edge Betweenness Centrality

A content network of relationships between ECT subdimensions was constructed where nodes in the network were subdimensions and edges represented the strength, or weight, between nodes as a count of the number of times tokens from any two respective subdimensions occurred together in the same sentence across all the polarity-filtered sentences, which added heterogeneity within the network beyond topological effects. An influential edge between two subdimensions in the network was defined as an edge with ① a betweenness centrality that ranked among the highest of all other edges in the network, ② experienced significant fluctuations in betweenness centrality over time, and ③ formed part of the main core of edges that satisfied ① and ② (hypothesis 1b). The betweenness centrality of an edge (e) was formally defined as the sum of the fraction of all-pairs shortest paths that passed through e :

$$\mathcal{C}_B(e) = \sum_{s,t \in N} \frac{\sigma(s,t|e)}{\sigma(s,t)}, \quad (3.5)$$

where N was the set of nodes, $\sigma(s,t)$ was the number of shortest (s,t) -paths and $\sigma(s,t|e)$ was the number of those paths that passed through edge e [416]. Normalised $\mathcal{C}_B(e)$ was calculated with the edge betweenness centrality algorithm [417] in the `NetworkX` [418, 419] Python package for each weighted edge in each of the three-month snapshot networks that spanned the life of each EOF. The subsequent edge betweenness centrality scores were ranked according to natural clusters found by the `Ckmeans.1d.dp` algorithm [420] to identify those edges that had the highest scores relative to all other edges, as a measure of difference [421]. `Ckmeans.1d.dp` is a dynamic programming algorithm implemented in R for one-dimensional k -means clustering and guarantees an optimal solution to the k -means problem, which aims to partition data into k groups based on some property, in this case edge betweenness centrality scores, so that the sum of Euclidean distances to each group mean is minimised [422, 423]. It allows for the discovery of ‘natural’ clusters when a range of clusters is provided, where the actual number of clusters is determined by the Bayesian information criterion (BIC) [424, 425], which was set to 1 and count (e) (the total number of edges).

Finally, a time series was constructed for each edge and the change point detection method outlined in subsection 3.3.6 was followed to identify significant ($p < .05$) ECPs in edge betweenness centrality scores. The main core, or maximal subgraph that contained nodes of the largest degree [334], which represented the most influential ECT subdimensions (and dimensions) in the content of the EOF collection, was extracted from the identified edges through the k -core decomposition algorithm [426].

3.3.9 Cluster Detection

To understand the structure of the main core network and extract useful information from the relationships between ECT subdimensions, a number of popular modularity optimisation community detection algorithms were applied to the network in an attempt to discover underlying clusters of subdimensions in the ECT. Modularity (Q) is based on the idea that a random network is not expected to have a cluster structure, which means the possible existence of clusters can be revealed by the comparison between the actual density of edges in a subgraph of the network and the density expected in the subgraph if the nodes of the graphs were attached regardless of cluster structure [427]. The underlying assumption of modularity optimisation algorithms is that high values of Q indicate good partitions of the network, and because an exhaustive optimisation of Q is impossible even in the case of small networks, different algorithms deploy different strategies in attempts to find the modularity maximum of the network. The methods performed included (in chronological order): Sobolevsky's combination [428], Newman's edge betweenness [429], Ovelgönne's ensemble learning algorithm [430], Blondel's multi-level [431], Duch's extremal optimisation [432], Brandes's optimal [433], Guimerà's simulated annealing [434], Reichardt's spin-glass [435], and Pons's walktrap [436] algorithm. The methods were compiled from source code provided by the authors or existing library implementations were used, such as the `igraph` R package [437].

The clusters produced by the algorithms were compared through the normalised mutual information (NMI) measure, which was extended to evaluate the similarity between network clusters [438, 439], where 0 meant no mutual information between clusters and 1 meant the clusters were identical. A mean NMI of .9 was observed across the network clusters identified by the modularity optimisation methods ($\wedge = .8$, $\vee = 1$, $\mu = .9$, $\sigma = .1$), which produced an overall mean Q of .4 ($\wedge = .39$, $\vee = .41$, $\mu = .4$, $\sigma = .01$). The consensus among these clusters was used to produce the final set of ECT subdimensions at the centre of conversations across EOF [440]. It is recommended that the modularity of the empirical network be compared to the null case of a random graph to establish the statistical significance of the modularity found in the network [434]. Following this procedure, Q was compared to the Q of 1,000 random scale-free graphs generated with the same number of nodes as the network on which clusters were defined [441].

3.4 Results

3.4.1 Dimension Constructs

The qualitative evaluation of tokens from the sampled sentences, each sentence with a defined positive or negative polarity ($\geq .8$), produced a total of 5,784 tokens coded for ECT

dimensions. Tokens were assigned to dimensions as follows (in decreasing size as a percentage of total ECT tokens - see \mathcal{E} in table 3.2; $\kappa = .8$, $p < .001$): TK (20.34%), SR (17.96%), AE (12.75%), CD (11.75%), OE (9.59%), EV (9.42%), PP (6.87%), CB (6.37%), and GP (4.99%). A strong positive correlation ($r_s = .84$, $p < .001$) was found between \mathcal{E} and the usage or frequency counts of \mathcal{E} across EOF (as a percentage of total ECT token counts - see $C(\mathcal{E})$ in table 3.2), which suggests a monotonic relationship between the proportion a dimension represents in the overall ECT and the extent to which tokens in that dimension were used in the overall discourse across the EOF collection. The sections below present the content of each dimension and subdimension, followed by the results of ECT engagement and influence analysis across EOF.

3.4.1.1 Geopolitic Perspectives (GP)

GP refer to views of geographic or political factors that influence or characterise a country or region. Tokens that referred to a nation or territory construct, recognised by regional classification schemes as an organised political community under a government, were coded into a subdimension (GP_1). Such instances included nations or states in the general sense and in a specific or demonym sense (4.27%), such as states in the Americas, Arab world, Asia and the Pacific, and Europe. Constructs of established communities within nations or territories, such as cities, towns, and villages, were also identified and included under a subdimension (GP_2). A number of general collective terms and specific cities, towns, and villages (.72%) were found, but fewer than constructs at the nation level.

3.4.1.2 Collective Dynamics (CD)

CD ascribe mechanisms that deal with any assemblage or collection of persons or parts that form a complex or unitary whole. References to people who were grouped or considered together, specifically by name, of an ideological or political and military nature, or generally as collectives (3.44%) were coded into a subdimension (CD_1). Also found in the content, to a lesser extent, were ethnic and religious groups (1.33%), and were classed under a subdimension (CD_2). Separate from groups were tokens that formed part of a set of principles or procedures according to which judiciary and legislative branches of governance systems (4.38%) work, as well as a smaller number of constructs from economic and education systems (2.61%), which were grouped together as subdimensions (CD_3 , CD_4).

3.4.1.3 Social Relations (SR)

SR designate connections or associations that involve two or more persons who occupy different social roles. Tokens that mentioned a human being or individual by name were coded into a number of subdimensions. Persons were identified in the content, directly by name, and were categorised as such (2.77%) (SR_1). The names of a number of lesser-known

Table 3.2: ECT dimensions, subdimensions, and example constructs

#	Dimension [Subdimension]	\mathcal{E}	$C(\mathcal{E})$	$C(\mathcal{E}_{ECP})$	Example Construct
<i>GP Geopolitical Perspectives</i>					
1	Countries and demonyms	4.27	4.41	5.56	[Americas]: United States (of America)/American — [Arab States]: (al-)Iraq(i) — [Asia & the Pacific]: Pakistan(i) — [Europe]: German(y) — [nation]: homeland
2	Cities and villages	.72	.78	2.31	[cities]: Basra — [villages]: Halaleh-ye Manzel
<i>CD Collective Dynamics</i>					
1	Ideological/political and military groups	3.44	2.44	2.31	[ideological/political] ②: al-Qaeda — [military]: al-Qassam
2	Ethnic and religious groups	1.33	1.22	3.24	[ethnic]: Jew — [religious]: Ummah
3	Governance systems	4.38	3.64	5.09	[judiciary] ①: imprisonment — [legislative]: doctrine
4	Economic and education systems	2.61	2.39	2.31	[economic]: financial support — [education]: Umm al-Qura
<i>SR Social Relations</i>					
1	Named persons	2.77	3.9	8.33	[leader]: Mahmoud Ahmadinejad — [scholar] ③: Muhammad Saalih al-Munajjid — [militant]: Abu Musab al-Zarqawi — [historical figure]: Malik ibn Anas — [lesser-known]: —
2	Familial and friendship roles	5.21	3.98	6.48	[familial] ①: mother — [friendship] ②: companion — [fraternal/sororal] ③: brother
3	Ideological/religious roles	3.44	4.43	6.94	[factionist]: Zionist — [forebearer] ②: prophet — [faithful(+)]: hadji — [faithful(-)]: infidel
4	Adversarial roles	3.1	1.71	3.7	[enemy]: occupier — [fighter]: mujahid — [captive]: detainee
5	Leadership roles	3.44	9.76	6.94	[government] ③: sheikh — [scholarly]: imam — [military]: lieutenant
<i>TK Theological Knowledge</i>					
1	Concepts	14.25	23.68	20.83	[faith] ①: reverence — [god] ①: Allah — [jihad] — [paradise] — [prayer]: worship — [transgression]: blasphemy
2	Customs, laws, and texts	4.32	5.78	8.33	[customs]: suhur — [laws]: fatwa — [texts]: al-Kursi
3	Events and places	1.77	1.47	1.39	[events]: Rajab — [places]: al-Marwah
<i>CB Conflict Behaviour</i>					
1	Conflict and weaponry	2.61	2.33	1.85	[conflict]: battle — [weaponry]: missile
2	Death and harm	3.77	5.27	1.85	[death] ③: massacre — [harm]: injury
<i>OE Oppositional Evocations</i>					
1	–	9.59	4.46	2.78	good/evil — purity/impurity ② — us/them — victory/defeat
<i>AE Affective Experiences</i>					
1	Basic emotions	7.87	4.37	3.7	[anger] ②: hatred — [excitement]: passion — [fear]: anxiety — [sadness]: humiliation
2	Moral affections	1.72	.73	–	[commitment]: duty — [dissatisfaction]: condemnation — [individual status]: nobility
3	Personal affections	1.27	.56	–	[individual status]: glory
4	Sympathetic affections	1.88	.91	–	[benevolence]: generosity — [forgiveness]: conciliation
<i>PP Persuasion Processes</i>					
1	[Formation of knowledge] ③	2.99	1.05	.46	discoveries, learnings, narratives, opinions, readings, writings
2	[Communication of knowledge]	3.88	2.37	.93	advice, answers, discussions, explanations, questions, teaching
<i>EV Existential Validation</i>					
1	Individual volition	4.55	4.84	2.31	[defence]: bulwark — [personal empowerment]: recruitment
2	Intersocial volition	4.88	3.51	2.31	[control] ①: obedience — [dissent]: resistance — [collective empowerment]: support — [justice]: forbiddance

①-③: Influential cluster

persons were also observed and included without identification as a subdimension. Lesser-known persons were defined as the names of individuals who appear in EFIJ content, but cannot be reliably identified as being a named leader, scholar, militant, or historical figure through open-source intelligence (OSINT) data [442, 443]. If no name was present, but instead tokens described functions assumed or parts played by people in social situations, the constructs were coded into subdimensions. These constructs represented a number of different roles individuals occupied in the form of familial and friendship roles (5.21%) (SR₂), which represented most references, followed by ideological or religious (3.44%) (SR₃), adversarial (3.1%) (SR₄), and leadership (3.44%) (SR₅) roles.

3.4.1.4 Theological Knowledge (TK)

TK exemplifies awareness of religious faith, practice, and experience. A subdimension was created for a large number of constructs in the content that referenced religious concepts (14.25%) (TK₁). A smaller number of general and specific references to customs, laws, and texts (4.32%) (TK₂) were also observed, as well as specific events and places (1.77%) (TK₃) of religious significance, which formed their own respective subdimensions.

3.4.1.5 Conflict Behaviour (CB)

CB comprises actions in or reactions to a fight, battle, or struggle. Tokens that indicated a behaviour which involved physical force intended to hurt, damage, or kill someone or something, as well as various states of conflict between and within different individuals or groups were coded into separate subdimensions. These behaviours encompassed a wide range of constructs that spanned conflict, weaponry (2.61%) (CB₁), and to a larger extent, forms of death and harm (3.77%) (CB₂).

3.4.1.6 Oppositional Evocations (OE)

OE involve acts or rhetoric that elicit feelings, memories, or images in the conscious mind that are dichotomous in nature. This dimension included tokens that explicitly contrasted two constructs as being opposed through a direct dichotomous relationship in the content. The majority of these constructs (9.59%) were used in the contexts of theological knowledge and conflict behaviour. Such references included comparative concepts like purity or impurity, light or darkness, good or evil, and victory or defeat, that conceptualised a particular issue from these perspectives.

3.4.1.7 Affective Experiences (AE)

AE are instances of observing, encountering, or undergoing emotions or feelings. A subdimension was formed for tokens that referred to constructs that included a wide range of basic

emotions and more complex affections that involved moral, personal, and sympathetic factors. Basic emotion constructs (7.87%) (AE_1) represented the largest subdimension among these and included tokens that referred to the primary emotions of anger, excitement, fear, and sadness. These primary emotions included references to a number of secondary and tertiary emotion types [444, 445]. Moral affections (1.72%) (AE_2) included references to commitment, dissatisfaction, and individual status constructs. Similar in size to moral affections were personal affections (1.27%) (AE_3), which also included individual status constructs. The second largest subdimension consisted of sympathetic affections (1.88%) (AE_4) and included benevolence and forgiveness constructs.

3.4.1.8 Persuasion Processes (PP)

PP capture actions of communication or reception of knowledge that influence convictions or beliefs. A subdimension was created for the formation of knowledge (2.99%) (PP_1) as a number of constructs were found that signified the development of new knowledge through scholarly interpretation of sources, either directly by internal EOF members, or indirectly in reference to the works of external learned individuals. A larger subdimension formed on the basis of knowledge communication (3.88%) (PP_2), as many constructs within this dimension referred to the diffusion means of developed knowledge through the communication actions of EOF members and the actions of others.

3.4.1.9 Existential Validation (EV)

EV denotes acts of assertion or recognition grounded in experiences or the affirmation of experiences. These tokens emerged broadly as two separate subdimensions that referenced individual and intersocial volitions. Individual volition (4.55%) (EV_1) included actions that referred to defence and personal empowerment, which were contained to instances where individuals signified the use of their own will or faculty in the real or imaginative service of acts. The similarly sized intersocial volition (4.88%) (EV_2) subdimension included relational constructs that referred to control, dissent, collective empowerment, and justice, which meant these constructs involved the assistance or approval of others.

3.4.2 H_{1a} : Dimension Engagement

Hypothesis 1a states that *ECT dimensions experience different levels of engagement in EOF*. A relatively small proportion of tokens (5.07%) demonstrated observable and significant engagement over time ($p < .05$), as a percentage of total tokens with significant ECPs (see $C(\mathcal{E}_{ECP})$ in table 3.2). Of all the tokens with significant ECPs, the largest proportions were identified in the SR (32.41%) and TK (30.56%) dimensions, followed by tokens from the CD (12.96%), GP (7.87%), EV (4.63%), CB (3.7%), AE (3.7%), OE (2.78%), and

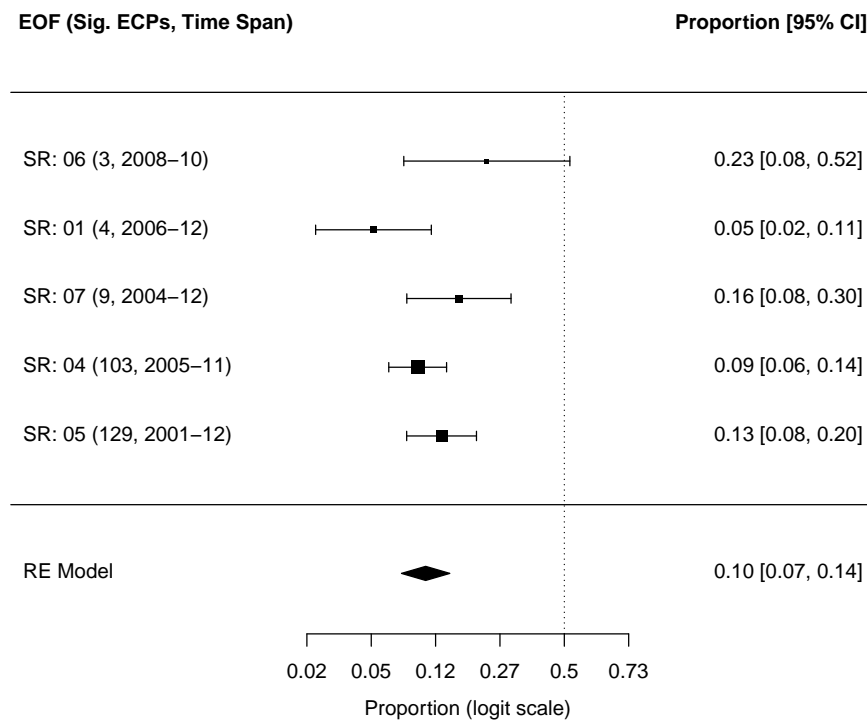
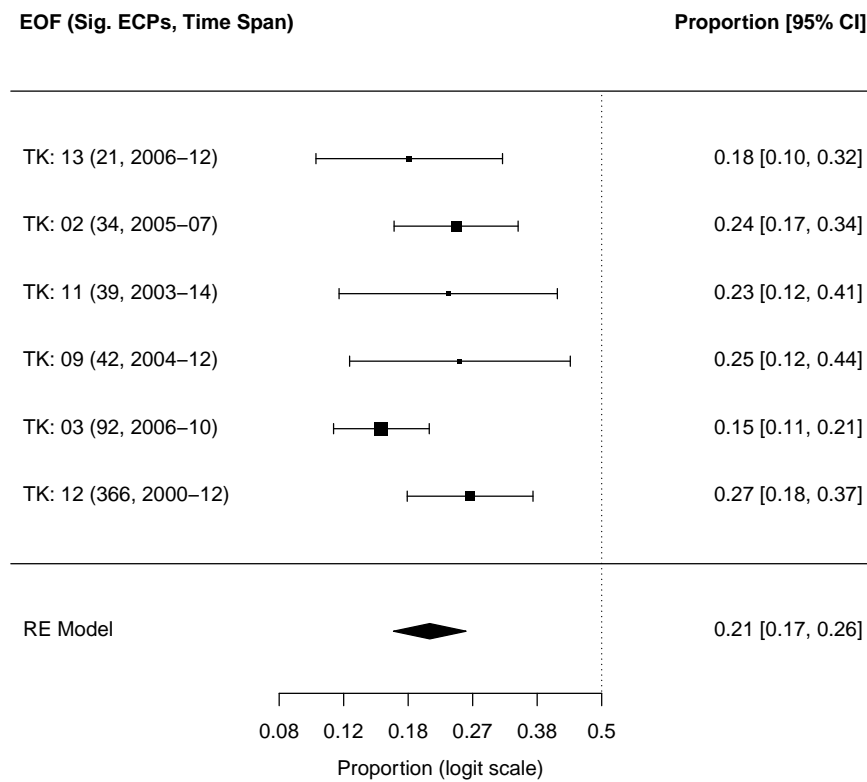


FIGURE 3.1: Random/mixed effects models of TK (top) and SR (bottom) ECT dimensions

PP (1.39%) dimensions. Analysis of tokens in the ECT showed significant engagement over time across EOF for a small proportion of tokens. A positive correlation ($r_s = .53$, $p < .01$), but weaker than the observed \mathcal{E} and $C(\mathcal{E})$ correlation, was found between \mathcal{E} and $C(\mathcal{E}_{ECP})$, which is indicative of a monotonic relationship between the proportion a dimension represents in the overall ECT and the significant engagement tokens in that dimension experienced in the overall discourse that occurred over time across the EOF.

An overall Kruskal-Wallis test ($\chi^2 = 37.68$, $p < .001$) suggested there were differences between ECT dimensions in terms of the number of tokens in a dimension with significant ECPs, as a proportion of the total tokens from that dimension observed in each respective EOF. This measure of proportional significant engagement per dimension showed that in all EOF, either TK (\mathcal{E}_{TK}) or SR (\mathcal{E}_{SR}) emerged as the dimension with the largest significant engagement, compared to other dimensions. Both \mathcal{E}_{SR} and \mathcal{E}_{TK} had similar levels of significant engagement and variability (median: $\mathcal{E}_{SR} = .15$, $\mathcal{E}_{TK} = .15$; variability: $\mathcal{E}_{SR} = .09$, $\mathcal{E}_{TK} = .11$). To identify where the differences lie, a Wilcoxon rank-sum test was used to perform pairwise comparisons and found statistically significant differences in the levels of significant engagement between both \mathcal{E}_{SR} and \mathcal{E}_{TK} and *PP* ($\mathcal{E}_{SR} = .02$, $\mathcal{E}_{TK} = .03$), *OE* ($\mathcal{E}_{SR} = .01$, $\mathcal{E}_{TK} = .03$), *AE* ($\mathcal{E}_{SR} = .01$, $\mathcal{E}_{TK} = .02$), and *EV* ($\mathcal{E}_{SR} = .02$, $\mathcal{E}_{TK} = .05$), but no statistically significant differences were found for \mathcal{E}_{CD} , \mathcal{E}_{GP} , and \mathcal{E}_{CB} .

A meta-analysis of six EOF with TK as the ECT dimension with the most prominent proportion of ECPs (high engagement) showed a statistically significant random effects average engagement incidence of 21% across these EOF (95% CI 17 to 26%), without statistically significant heterogeneity ($p = .24$) (see column \mathcal{E}_{TK} in table 3.2). The other five EOF with SR as a high engagement dimension demonstrated a statistically significant random effects average engagement incidence of 10% (95% CI 7 to 14%), also without statistically significant heterogeneity ($p = .10$) (see column \mathcal{E}_{SR} in table 3.2). Comparison of these estimates using a fixed effects model found that EOFs with high engagement SR dimensions had smaller (less negative) effects than EOFs with high engagement TK dimensions ($b_1 = .82$, $SE = .24$), and that the difference between the two estimates was significant ($z = 3.43$, $p < .001$). Figure 3.1 presents a forest plot to illustrate the dichotomous split between the TK and SR high engagement dimensions across EOF, and shows the results of the random effects models [446]. The forest plot is used to show the amount of variation between independent EOF, and for each EOF, a horizontal line runs through a square to show its CI (95%). An overall estimate of the result per high engagement dimension from the meta-analysis is displayed at the bottom as a diamond alongside its CI. Significance is achieved if the diamond is clear of the dotted vertical line of no effect. As can be seen from these results, hypothesis 1a was supported.

3.4.3 H_{1b}: Subdimension Influence

Hypothesis 1b states that *ECT subdimensions exert different levels of influence in EOF*. Cluster detection performed on the main core of influence in the content network identified three clusters among a total of 16 ECT subdimensions that met conditions ①-③ outlined in section 3.3.8 and were dispersed among these clusters. The modularity of the network was statistically significant ($p < .01$) across all applied algorithms ($\wedge = .39$, $\vee = .41$, $\mu = .40$, $\sigma = .01$) when compared to similar random networks for values of Q (95% CI): combination (.276 to .28), edge betweenness (.244 to .25), ensemble learning (.246 to .253), multi-level (.271 to .275), extremal optimisation (.271 to .274), optimal (.279 to .283), simulated annealing (.279 to .283), spin-glass (.276 to .28), and walktrap (.247 to .252) algorithm.

The clusters identified across EOF included a cluster of discussion (①) that was influenced by familial (SR₂), control (EV₂), judiciary (CD₃), faith, and god (TK₁) constructs. Another cluster in the content of communication (②) formed through discussions that were composed of friendship (SR₂), ideological or political groups (CD₁), anger (AE₁), purity or impurity (OE), and forebearer (SR₃) constructs. Finally, a cluster (③) was made up of discussions that included death (CB₂), scholar (SR₁), government (SR₅), and fraternal/sororal (SR₂) constructs.

The SR dimension accounted for close to half of all influential subdimensions (40%) and its constructs were present across all three clusters, making it the most diverse dimension among dimensions, compared to a small proportion of influence exerted by TK subdimensions (13.3%) limited to a single cluster. All other dimensions that produced influential subdimensions contributed one to two (6.67-13.3%) of these to the clusters identified. The most central subdimensions in each cluster, however, did not come from SR and instead were represented by CB, EV, and CD as follows: death (.58), control (.21), and ideological or political groups (.23). As such, support was found for hypothesis 1b.

3.5 Discussion

The present study developed the content of a construct taxonomy at the word and phrase, or token, level of analysis through representative samples collected from online fora with EFIJ content. The composition of tokens identified in highly polarised sentences of such content showed that a majority of tokens sampled referred to either TK, SR, or AE, out of a total of nine dimensions in the ECT.

Only a small proportion of tokens experienced significant engagement over time in the way individuals communicated through such constructs on EOF, where the vast majority

of these engagements were attributable to discussion of TK and SR. This may indicate that individuals engaged with these dimensions more intensely than other dimensions in their local level communication with each other, as constructs from these dimensions experienced notable contextual changes. As shown by the findings of hypothesis 1a, significant differences existed between ECT dimensions in terms of the engagement they experienced over time, and that most of the differences were concentrated on a per-EOF basis in either discussion of TK or SR, which indicates that these dimensions consistently emerged as high engagement dimensions of discussion across EOF, as opposed to other dimensions that were analysed. The nature of the 13 separate EOF met a reasonable expectation of individuals' high engagement with constructs that spanned the TK dimension, given that evidence exists for the interest of some EFIJ individuals in rigoristic religious beliefs [213, 214], Islamic moral principles [113], and the presence of madrasa or religious seminary attendance in their life histories [131, 136, 137], which explains high engagement with theological type constructs.

However, the near adequation of high engagement with the SR dimension came as a surprise, especially in the context of the broad scope of coverage offered by the ECT structure and other dimensions. Further investigation of the influence carried by subdimensions over time, identified within each ECT dimension, found that a near majority of these subdimensions belonged to the SR dimension, whilst only a small number of subdimensions from other dimensions enjoyed the same level of influence in the content of EFIJ individuals. This suggests that the SR dimension not only attracts high engagement and features alongside many other subdimensions in discussion, but also occupies a central space in such communication between individuals across EOF. The findings of this study thus infer that discussion of social entities, particularly those identified through names or roles, are of special importance to EFIJ individuals. Discussion of these constructs attract both high engagement from individuals in EOF environments and carry high influence in their discussions with each other. Prior work established the existence of diverse sets of roles that delineated EFIJ individuals in the way they sought to join groups [94], as well as differences in intra-group roles played by members upon acceptance, such as gender-based roles [43, 95, 193]. The mechanisms of these roles and the networks within which they exist are not well-understood, but are generally seen as behavioural phenomena that operate through processes rooted in reciprocal [97, 118, 209], kinship [200, 206, 207], and leadership [145, 166, 211] social structures. The importance of the SR dimension in the content of EFIJ individuals can be seen to show that this dimension holds a remarkable cognitive presence in the communication between these individuals when one considers the nature of content to which attention is given across EOF. It is the opinion of this study that the findings should extend thinking around SR of EFIJ individuals beyond behavioural domains to also carefully consider the cognitive significance of these phenomena in the study of EFIJ in

online environments where individuals are free to develop large histories of written content.

The text mining of EOF content explored in this study resulted in the identification of a large number of constructs and paved the way for further fine-grained analysis of EFIJ phenomena. The work in section 4 will assess the viability of the SR dimension to predictively separate the behaviour of individuals in the communication networks found within EOF. Such analysis is not limited to the study of individuals and can also be applied to the study of group-based content, as these documents were likely written by singular individuals at the direction of others, or a number of individuals who collaborated together. To learn from these data, large amounts of content are required, to which EOF and document collections represent prime opportunities to advance the study of EFIJ phenomena, which will be adequately explored in subsequent studies with application of the ECT as a developed auxiliary content identification method.

4.1 Abstract

Background: Little is known about the differences and similarities in EFIJ groups and individual roles, such as those found in EOF¹⁷, with respect to their ideology and behaviour. The present study seeks to explore whether SR¹⁸ as a dimension of constructs can be utilised to reliably identify different types of EFIJ¹⁹ groups and individuals through their written content.

Methods: Two independent corpora were developed to differentiate the classes (group and role attribution) in EFIJ content: the extremist group attribution corpus (EGAC) and extremist role attribution corpus (ERAC). Statistical keyword extraction was used to identify significant words and phrases ($p < .05$) in each corpora document and tokens (or features) from the SR dimension were identified as a means of unique differentiation for groups in EGAC ($n = 376$) and roles in ERAC ($n = 525$). Multinomial logistic regression was chosen as a classification method with ten-fold cross-validation and control for type I and type II errors. Weighted rank aggregation and clustering were applied to the regression results of the estimated models to isolate high-ranking SR subdimensions. To compare subdimension ranks, the rank-biased overlap test was used and significance of the observations was tested through multiple permutation testing ($n = 10,000$) with family-wise error rate control. Pairwise post-hoc tests were used to find the number of times a subdimension formed part of the highest ranking feature group capable of predicting a class in the E(G/R)AC.

Results: SR features produced high levels of accuracy across classification experiments in identifying documents based on group and role attribution (groups 95% CI, .95–.98; roles 95% CI, .92–.98). Fighter adversarial, factionist ideological or religious, and named militant subdimensions of SR were more important in the determining individual roles than they were to the classification of groups, which placed greater importance on the named lesser-known person and friendship subdimensions. Overall, the majority of significant differentiation ability for individual level content was found in the named and familial and friendship subdimensions (71.43%), which focused on societal roles, whereas group level

¹⁷Extremist online fora ¹⁸Social relations ¹⁹Extremist, fundamentalist, Islamist, and jihadist

content was found to be separated primarily through the ideological or religious subdimension (57.89%), which focused on theistic roles.

Conclusions: Subdimensions captured within the overarching SR dimension possess versatile differentiation abilities insofar as they can accurately distinguish the stated affiliations and perceptible behaviours of EFIJ authors, based on identifiable nuances present in the content of their communications and writings. The predictive qualities of different subdimensions are varied in their abilities to capture the cognitive attention of EFIJ communities, which represent unique opportunities to identify and map the unexplored social dynamics present in these communities at the micro- and meso-levels.

4.2 Background

Which specific facets of ideology separate extremist groups from each other? Can these facets be used to reliably differentiate the behaviour of individuals in extremist online communities? Methodological issues and a general lack of empirical research in the study of extremism at the local level are well-known barriers to answering such questions [447]. In an effort to provide tools for further exploration, previous work identified the structure of a construct taxonomy for the study of EFIJ content. Study of such communication between EFIJ individuals found that constructs which signified theological knowledge received significant engagement in these communities, as did constructs which denoted social relations, but the latter also exercised influence in the content produced by individuals in that these constructs occupied a central position in their written content [65].

The present study aims to determine what is known about EFIJ content at the group and individual level, how these findings relate to an EFIJ construct taxonomy, and whether social relations as a dimension of constructs can be used to identify different types of groups and individuals on the basis of their ideology in written form. An understanding of EFIJ content has practical relevance for the study of terrorism; as previous work has outlined, the formal study of relationships between individuals, groups, and their content broadly lacks systematic empirical and scientific research [64].

4.2.1 Previous Work on EFIJ Content

While a previous systematic literature review was conducted to identify individual level factors associated with susceptibility to and participation in radicalisation, terrorism, and violent extremism (see section 2), the current review aimed to find studies specific to EFIJ content at the group and individual levels. This was done to ascertain what is known about a wide spectrum of such content and to capture communication thereof in egoistic or dyadic, static or interactive, and monologue or dialogue form.

Data sources included the *ProQuest*, *Scopus*, and *Web of Science* bibliographic databases and documents were limited to scholarly journal articles, books, technical reports, and proceedings. The preliminary search was restricted to the following search terms: (extremi* OR radicali* OR terrori*) AND (islam* OR jihad* OR muslim* OR salafi* OR wahhabi*). After duplicates were filtered from the search results, a total of 6,085 documents were obtained for further evaluation. The full-text of each document was examined and the final set of literature was restricted to studies that presented findings based on primary research and original data on EFIJ content at the aforementioned levels.

A total of 78 (1.28%) studies met these criteria and were included in the final review. The sample sizes of the content analysed in these works were of particular interest to the present study and are indicated where possible, due to the notion that differentiation between potential group and individual attributions would require larger document collections to reliably identify which facets of ideology explain such differences.

4.2.1.1 Group Level

Studies at the group level included samples of content published by groups in the form of magazines, communiqués such as statements and farewell letters, and works that either included texts without specifying the nature of the content but included the origin of the collection obtained, or texts that focused on fine-grained elements of jihadist culture such as the content of anashids, nasheeds, and taranas in the form of vocals to be performed.

A number of studies conducted content analyses of samples that included a range of issues from magazines produced by fundamentalist, Islamist, and jihadist groups ($\wedge = 1$, $\vee = 32$, $\mu = 16.24$, $\sigma = 8.75$). The dominant groups in these samples were AQAP²⁰, ISIS²¹, and the TAL²², who published Inspire [448, 449, 450, 451, 452, 453, 454], Dabiq [455, 456, 457, 458, 459, 460, 461, 462, 463], Rumiya [464, 465, 466], and Azan [467], through their media affiliates, respectively. Other studies relied on mixed samples of these publications in their analyses, which included lesser-known magazines such as Ansar al-Sunna by JAS²³, Biographies of Eminent Martyrs by AQI²⁴, and Fursan by the Islamic Army in Iraq (IAI) [468, 469, 470, 471, 472].

Various samples of communiqués were identified and studied as these texts were periodically released by groups in the form of statements from their leadership figures ($\wedge = 7$, $\vee = 290$, $\mu = 65.57$, $\sigma = 93.31$) [70, 473, 474, 475, 476, 477, 478], and to a lesser extent, direct communiqués such as farewell letters from the individuals of groups who were to execute martyrdom operations (e.g., suicide bombing) ($\wedge = 60$, $\vee = 300$, $\mu = 190.33$,

²⁰al-Qa'ida in the Arabian Peninsula ²¹Islamic State of Iraq and Syria ²²Taliban ²³Jamaat Ansar al-Sunnah ²⁴al-Qa'ida in Iraq

$\sigma = 99.06$) [73, 479, 480]. Statements were from Boko Haram (BH), AQIC²⁵, AQI, and ISIS, whereas samples that included farewell letters were primarily from Palestinian nationalist groups.

Unspecified collections of texts included material from groups in studies that did not provide specific information to identify the nature of the sample ($\wedge = 24$, $\vee = 571$, $\mu = 227.9$, $\sigma = 167.83$). These samples included texts from AQAP [481], AQIM²⁶ [482, 483, 484], IDQ²⁷ [485], and ISIS [486], and mixed document samples from violent (AQAP, AQIC) and non-violent (Movement for Islamic Reform in Arabia (MIRA), HT²⁸) groups [487, 488, 489, 490, 491]. The content of jihadist cultural tools were also studied [492] ($\wedge = 14$, $\vee = 93$, $\mu = 37.25$, $\sigma = 32.44$), such as anashids, nasheeds, and taranas, which are songs, chants, and hymns used by ISIS [493, 494] and the TAL [495].

4.2.1.2 Individual Level

While the majority of content studies at the group level were qualitative, only a minority of studies at the individual level examined content from a qualitative perspective. Most of the works at this level included samples extracted from EOF and were focused on the introduction and evaluation of advanced methods, as opposed to more detailed subject matter analyses, as was found at the group level of content.

Content analyses of EOF were the norm among those individual level studies that performed descriptive [496, 497] and qualitative analyses ($\wedge = 6$, $\vee = 1,498$, $\mu = 689$, $\sigma = 538.67$) [498, 499, 500, 501, 502], but also included the study of samples from a growing body of individual jihadist scholarship [72, 503], who did not exhibit explicit group affiliation, but carry influence in these communities. Quantitative studies of EOF focused on link analyses [504, 505], affect and sentiment analyses [252, 506, 507, 508, 509, 510, 511, 512], topic modelling [513, 514, 515, 516], frequency and time series analyses [517, 518, 519], authorship identification [520, 521], and dynamical system modelling [522, 523].

4.2.1.3 Review Findings

Findings from studies at the group and individual levels of analyses can be abridged through a number of dimensions. Geopolitical perspectives view the West as an aggressor [472, 475] and conspirator [473, 483] engaged in a clash of civilisations [473] that require various forms of local and global borderless jihad as responses [473, 478, 483]. Collective dynamics are framed as in-group/Other narratives [458, 485] through different value sets [487, 491] that try and force an identity choice on the reader. The actions of favourable groups and individuals are required, justified, and legitimised by Quranic/historical reinterpretation of theo-

²⁵al-Qa'ida Central ²⁶al-Qa'ida in the Islamic Maghreb ²⁷Izz ad-Din al-Qassam Brigades ²⁸Hizb ut-Tahrir

logical knowledge [473, 481] (e.g., Jahiliyyah or ignorance of divine law [459], weakness of the Ummah or whole community of Muslims bound together [493]). Persistent themes of conflict behaviour in EFIJ content prime readers for engagement [467], enforce the attraction of death on the basis of afterlife rewards [475], and normalise war and brutality against unbelief by suicide and killing of Muslims and non-Muslims [468]. The underlying thread of such content utilises binary oppositional evocations in different capacities to attempt persuasive moral proof arguments [485]. Condemnations of this nature are often ideologically motivated [477], which in turn serve to reinforce themes of cultural polarisation [458] between the embraced ‘true’ believers and the rejected ‘false’ unbelievers [467, 464].

Encouragement of affective experiences is enforced through emotional connotations and language [455, 488] built on highly positively or negatively skewed information [456] that draw on an array of themes, such as grievance narratives [481] and examples of humiliation and tragedy endured by Muslims [483, 493]. Persuasion processes can involve the gamification of objectives to the reader [469, 470], use Islam/Sharia as a messaging vehicle [476], and the inclusion of culturally relevant symbology [495] and positive archaic language (e.g., haqq, hizabr, taghut, zulm) [492] to differentiate content and attract readership. In part, the purpose of the content is the development or deepening of a defined identity distanced from Western social/political concepts [492], who embraces the view that martyrs are moral exemplars [474], and acts on the urges of existential validation to rectify a perception of dishonour and indignity caused to the identity [490].

Embedded within the content identified by the literature and written by EFIJ groups and individuals is a web of social relations that connect their ideas to physical dimensions of the world and its events. Subdimensions within social relations as an overall dimension can be useful markers or identifiers of constructs in content, such as scholars linked to ideas expressed in debates that involve theological knowledge, leaders mentioned in discussions on various geopolitical perspectives, militants involved in conflict behaviour, and so on. Therefore, social relations can be used as a means to cover the breadth of EFIJ content as indicated by the findings of literature, due to the notion that these relations typically encompass and possess the ability to link various different forms of other dimensions expressed in written text as well as its importance and influence as a dimension in EFIJ content found in previous work [65].

4.2.2 Objectives

1. The objective of the present study is to extract constructs that identify SR in EFIJ content and use these subdimensions of constructs to differentiate types of groups ideologically and individual roles behaviourally from each other. To satisfy this objective, the study hypothesises that:

HYPOTHESIS 2 — SR subdimensions of EFIJ content predict group and role attribution.

2. In the absence of a priori knowledge on which SR subdimensions of constructs are important to the identification of different group and role attributions, explore subdimension similarities and differences between and within attributions. As such, hypotheses are that:

HYPOTHESIS 3A — Overlap exists between important SR subdimensions of EFIJ content that predict group and role attribution.

HYPOTHESIS 3B — Differences exist between groups and between roles on important SR subdimensions of EFIJ content that predict their attribution.

The study also aims to contribute two original group and individual level text corpora constructed from primary sources in the form of EFIJ magazines and communiqués for group content and EOF for individual content.

4.3 Methods

4.3.1 Sample and Corpora Construction

Two independent samples of text data were collected, preprocessed, and used to construct EFIJ corpora at the individual and group level. Content data published by EFIJ groups were collected from a range of primary Internet sources. A total of 5,045 documents were collected in this way, which were filtered to remove duplicates and those documents that did not contain at least 250 words and 50 unique words. The set of text data in the corpus amounted to 4,236 documents of varying word counts ($\wedge = 251$, $\vee = 574,870$, $\mu = 6,434.28$, $\sigma = 20,964.06$) and spanned 31 separate EFIJ groups. At the individual level, conversational text data were collected from a total of 27 separate Arabic EOF that were centred on religious extremist Islamic ideology, operated through online discussion board infrastructure, and attracted a wide spectrum of EFIJ content. Each dataset spanned a number of years ($\wedge = 2000$, $\vee = 2014$, $\mu = 6.89$, $\sigma = 3.25$), varied in the number of conversations or threads ($\wedge = 392$, $\vee = 252,952$, $\mu = 43,816.56$, $\sigma = 64,327.54$), and consisted of a large range of unique contributing members or individuals ($\wedge = 58$, $\vee = 115,089$, $\mu = 11,386.30$, $\sigma = 26,150.84$) who engaged in conversations on these EOF.

4.3.1.1 Word and Phrase Tokenisation

Each web document that contained raw and unstructured data in both corpora was interrogated to extract text data by removing HTML²⁹, as is common in text mining when preprocessing web text [335, 336]. Specifically, the `Beautiful Soup` [337], `Bleach` [338], `ftfy` [339], `HTMLParser` [340], `Markdown` [341], and `postmarkup` [342] modules from the Python programming language were used for this purpose. Special care was taken to preserve the proper representation of Modern Standard Arabic (MSA) text as the characters were written by their authors to directly work with the language in Unicode through the `Unidecode` [343] module and utility functions provided by the `Gensim` [344] module. The text data were tokenised into sentences using the `TextBlob` [345] and `Natural Language Toolkit` [346] modules, through which an unsupervised multilingual sentence boundary detection algorithm trained on large MSA corpora was used [347]. Each corpus was thus represented in sentence form as a diverse collection of sentences.

To arrive at a more comprehensive unit of analysis that extended beyond single words or unigrams; phrases, or multiword expressions, were identified as frequently co-occurring tokens in the text through a data-driven approach where phrases were formed based on unigram (e.g., القاعدة – al-Qa’ida) and bigram (e.g., الدولة الإسلامية – Islamic State of Iraq and Syria in short form) counts [348]:

$$\text{score}(w_i, w_j) = \frac{\text{count}(w_i w_j) - \delta}{\text{count}(w_i) \times \text{count}(w_j)}, \quad (4.1)$$

where δ was used as a discounting coefficient and prevented too many phrases ($w_i w_j$) that consisted of very infrequent words to be formed. $\text{score}(w_i, w_j)$ was a value given to each bigram and used as a threshold of what constituted a phrase in each corpus. In order to collect as many phrases as possible without any prior empirical knowledge of the corpus, δ was set to 1 and a threshold score of 5 was chosen in each respective corpus, which identified a large number of unique words and potential phrases across the corpora for further analysis.

4.3.1.2 EGAC Group Attribution

It was discovered that not all documents in the EFIJ group corpus provided clear group attribution through surface level metadata that accompanied each source. An exploratory method was devised to conduct pairwise comparisons of semantic similarity between known and unknown documents to find a potential secondary set of documents for human evaluation and subsequent attribution to known groups where applicable. In order to reduce lexical sparsity and simplify syntactic analysis, the clitics attached to unigrams for each document

²⁹Hypertext Markup Language

Table 4.1: EGAC groups, proportions, and definitions

Code	Group Attribution	Abbreviation	EGAC	Ideological Definition
G ₁	al-Nusrah Front	ANF	.321	Salafi jihadism
G ₂	al-Qa'ida Central	AQC	.159	Salafi jihadism
G ₃	al-Qa'ida in the Arabian Peninsula	AQAP	.098	Salafi jihadism
G ₄	Hamas	HA	.105	Palestinian nationalism
G ₅	Islamic State of Iraq and Syria	ISIS	.227	Salafi jihadism
G ₆	Taliban	TAL	.090	Deobandi fundamentalism

were segmented [524] in accordance with the Penn Arabic Treebank (ATB) standard [525]. Orthographic normalisation was also performed to change alif forms to bare alif, map ya to alif maqsura, and remove diacritic and tatweel elongation characters. Parts of speech were assigned to unigrams [526, 527] and were represented as stems through the IRSI Arabic stemmer [528], which does not require a root dictionary. The NLTK [346] Python module, Stanford Arabic Word Segmenter [529] and Part of Speech Tagger [530] software were used for these tasks.

Latent semantic analysis (LSA) [531] was performed on the corpus using singular value decomposition (SVD) [532] to represent relationships between the set of documents and the unigrams they contained. The number of latent dimensions was set to 300, as this number performed well with moderate-sized document collections in a number of studies [533]. Other LSA hyperparameters included the use of a stochastic two-pass algorithm with a high number of power iterations (3) and extra samples (400), in accordance with experiments that demonstrated the relative boost in accuracy of setting these values compared to other algorithms available for LSA training [534]. To measure semantic similarity, two weighting functions were used to transform the word-document co-occurrence matrix into locally and globally weighted matrices in the form of TF-IDF³⁰ [358, 359] and logarithmic entropy [535, 536] models. The Gensim [344] Python module was used to conduct the LSA. As is standard with LSA, cosine similarity was used as a measure between documents to determine the similarity of two vectors, which ranged from 0 to 1. Unknown documents that obtained a high cosine similarity score ($.7 \leq \cos(\theta) < 1$) were investigated to qualitatively determine the group attribution of the document.

The final set of documents in the corpus used for this study totalled 1,861, where 150 or more documents could be assigned to each group, and comprised documents directly attributable to four Salafi jihadist groups, a Palestinian nationalist group, and a Deobandi fundamentalist group. These groups were ANF³¹, AQAP, AQC, HA³², ISIS, and the TAL (see table 4.1 for corpus proportions). Henceforth, this corpus is referred to as the EGAC.

³⁰Term frequency inverse document frequency ³¹al-Nusrah Front ³²Hamas

4.3.1.3 ERAC Role Attribution

The roles that individuals in EOF occupy are a useful means to characterise various types of individuals in a community on the basis of their position and behaviour relative to others. Each EOF was thus represented in relational form as interactions where each communication instance or edge occurred between two individuals or nodes when they posted content to the same thread. Threads that contained single posts were therefore filtered out of the sample, as these were not considered dialogue in form. The separate EOF in network form ranged in unique counts of nodes ($\wedge = 33, \vee = 13, 135, \mu = 2, 421.78, \sigma = 2, 977.34$) and edges ($\wedge = 41, \vee = 2, 403, 720, \mu = 238, 147.41, \sigma = 486, 855.32$), reflective of differences in community size. A relational representation of EOF is useful for the differentiation of individuals on their behaviour as previous work showed nodes in complex networks can be classified into system-independent universal roles according to their inter- and intra-module connections [537]. Such a method is of particular interest to social systems where no a priori knowledge existed about the defined roles individuals occupied relative to each other. Unknown roles can be determined on the notion that the same roles should have similar topological properties in a network, once the modules or clusters of the network are known [538].

Modularity (Q) is based on the idea that a random network is not expected to have a modular structure, which means the possible existence of modules can be revealed by comparison of the actual density of edges in a subgraph of the network and the density expected in the subgraph if the nodes of the graphs were attached regardless of modular structure [427]. The underlying assumption of modularity optimisation algorithms is that high values of Q indicate good partitions of the network, which becomes difficult to optimise in large networks, and because an exhaustive optimisation of Q is impossible even in the case of small networks, different algorithms deploy different strategies in attempts to find the modularity maximum of the network. A novel approach to these problems is an ensemble learning scheme that uses weak classifiers, with respect to the objective function Q , to search for a strong classifier, which outperformed all previously published heuristics in terms of optimisation quality, and scaled efficiently to large networks [539]. The modular structure of each EOF was determined through this methodology and identified values of Q in the range 0 to 1 ($\wedge = .08, \vee = .94, \mu = .65, \sigma = .19$).

It is recommended that the modularity of the empirical network be compared to the null case of a random graph to establish the statistical significance of the modularity found in the network [434]. Following this procedure, Q was compared to the Q of 1,000 random scale-free graphs generated with the same number of nodes as the network on which modules were defined [441]. If the null hypothesis was rejected, modularity of the observed network was considered statistically significant and the network was included in the study. For an

Table 4.2: ERAC roles, proportions, and definitions

Code	Role Attribution	Abbreviation	ERAC	Behavioural Definition
R ₁	Ultra-peripheral	UPI	.437	$P \leq .05$
R ₂	Peripheral	PI	.387	$.05 < P \leq .62$
R ₃	Non-hub connector	NCI	.140	$.62 < P \leq .8$
R ₄	Non-hub kinless	NKI	.007	$P > .8$
R ₅	Provincial hub	PHI	.009	$P \leq .3$
R ₆	Connector hub	CHI	.015	$.3 < P \leq .75$
R ₇	Kinless hub	KHI	.004	$P > .75$

$z < 2.5$: R₁₋₄ — $z \geq 2.5$: R₅₋₇

overall meta-analysis of modularity significance, Stouffer’s weighted Z -score method was used ($Z = 17.52, p < .001$) [540, 541, 542], where weights were proportional to the square root of sample sizes [543]. The modular structure of three smaller networks were rejected when compared to random networks and were excluded from corpus construction. Once nodes from EOF networks were assigned to modules, each node’s within-module degree z -score was calculated to measure how well-connected a node was to other nodes in the module:

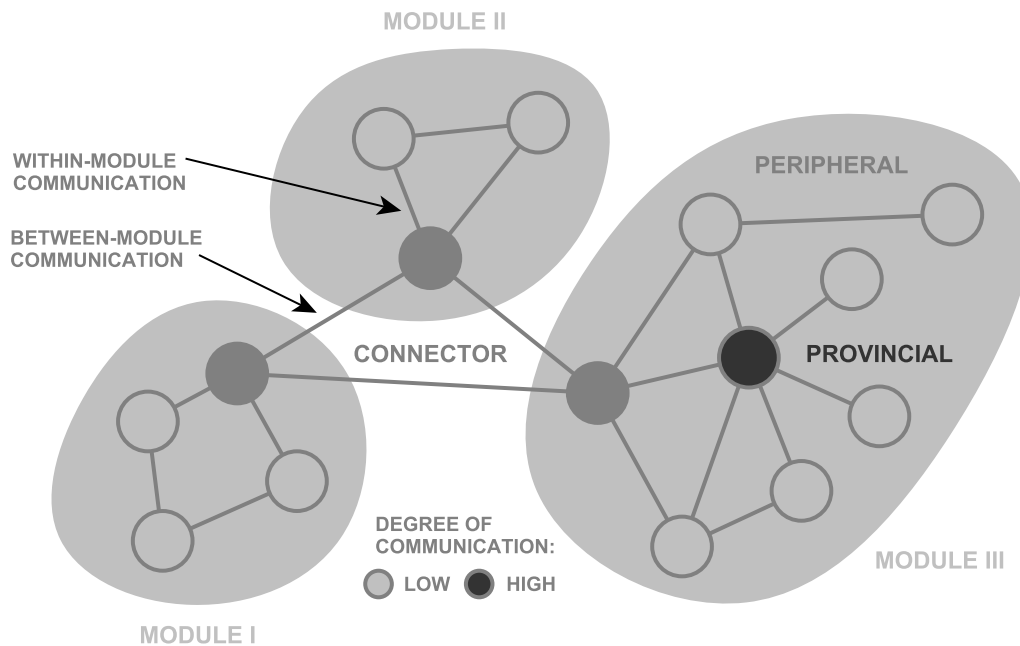
$$z_i = \frac{K_i - \bar{K}_{s_i}}{\sigma_{K_{s_i}}}, \quad (4.2)$$

where K_i was the number of edges from node i to other nodes in its module s_i , \bar{K}_{s_i} was the average of K over all nodes in s_i , and $\sigma_{K_{s_i}}$ was the standard deviation of K in s_i . Similarly, the participation coefficient P of each node was calculated to measure how well-distributed the edges of a node were among different modules:

$$P_i = 1 - \sum_{s=1}^{n_M} \left(\frac{K_{is}}{k_i} \right)^2, \quad (4.3)$$

where K_{is} was the number of edges from node i to nodes in module s , and k_i was the total degree of node i . High values of z_i thus indicated high within-module degrees while P_i ranged from 0 to 1, so as to represent a node’s uniformly distributed edges among all modules if P_i was close to 1 and 0 if all of a node’s edges were within its own module [544]. Both measures were calculated using the `brainGraph` R package [545]. Upon calculation of the z - P parameter space, a heuristic definition of seven different universal roles was followed, where each role occupied a different region of the space. Although the empirical determination behind these universal roles is beyond the scope of this work, the same behavioural definitions were followed in the present study as those presented in the work that discovered them and should subsequently be consulted for a detailed examination [537, 538, 544].

FIGURE 4.1: Roles in Extremist Online Fora (Adapted from van den Heuvel and Sporns [1])



For non-hub roles ($z < 2.5$), these definitions were: (1) ultra-peripheral, if a node had all of its edges within its module; (2) peripheral, if a node had at least 60% of its edges within-module; (3) non-hub connector, if a node with $k < 4$ had half of its links (or at least two links, whichever was larger) within-module; and (4) non-hub kinless, if a node had fewer than 35% of its links within-module. Similarly, hub roles ($z \geq 2.5$) were assigned definitions as follows: (5) provincial hub, if a node with a large degree, $k \geq 1$, had at least 80% of its edges within-module; (6) connector hub, if a node with a large degree had at least half of its links within-module; and (7) kinless hub, if a node had fewer than half of its links within-module. These behavioural definitions were applied to users in the EOF and associated with the subsequent content written by each user (see table 4.2 for corpus proportions). From this point forward, this corpus is referred to as the ERAC.

To illustrate how the roles function, figure 4.1 depicts three modules joined by connector roles who can have degrees of communication that are high (as hubs) or low (as non-hubs) depending on the number of posts they make across forum conversations. Connectors ensure communication flows between different modules in the forum. Embedded deeper in the communication of a module is the provincial hub role with high degrees of communication, who may have connections to other modules, but not as many as connectors. Located near the outside of the module due to lower degrees of communication are peripheral roles who have no or very limited communication with the other modules. Finally, kinless roles are rarer and can have high or low degrees of communication, but

cannot easily be placed in a specific module due to their posting patterns in the forum being across all modules (not shown in the example).

4.3.2 Subdimension Keywords

To identify potential words and phrases, or tokens, that may explain differentiation between group and role attributions, a statistical keyword extraction methodology was applied to the EGAC and ERAC. Previous work on this method showed that the spatial distribution of relevant tokens in texts were different from the distributions of irrelevant tokens [546]. The method applied did not require a reference corpus or a priori knowledge about documents and considered both the frequencies of tokens in each document and their spatial distribution, which found that relevant tokens were statistically significantly clustered (i.e., not due to statistical fluctuations) while irrelevant tokens were distributed randomly in texts [547, 548]. Tokens in each document were represented as a geometric Poisson distribution of nearest-neighbor spacing, or a normalised histogram of the sets of distances (or spacings) between consecutive occurrences of a token. A z -score measure C was applied to each token in the corpora to quantify and rank its relevance to the document:

$$C(\sigma_{nor}, n) = \frac{\sigma_{nor} - \langle \sigma_{nor} \rangle(n)}{sd(\sigma_{nor})(n)}, \quad (4.4)$$

where C measured the deviation of the measured clustering of a token σ_{nor} of frequency count n with respect to the expected value in a random text ($\langle \sigma_{nor} \rangle(n)$) in units of the expected standard deviation ($sd(\sigma_{nor})(n)$) [549]. Keywords in each document were limited to significant tokens in the calculated C distribution ($p < .05$). Previous work on the ECT³³ identified a number of SR subdimensions in EFIJ content, which served as a diverse set of perspectives to identify a large collection of tokens in the EGAC and ERAC. These were defined as tokens that denoted relations with respect to named persons (SR₁), familial and friendship (SR₂), ideological or religious (SR₃), adversarial (SR₄), and leadership (SR₅) roles. Significant keywords from each document in both corpora were qualitatively examined to determine their relevance in identifying a social relation, which meant each SR₁₋₅ consisted of multiple groups of identifiers found in the corpora. The top 250 most frequently occurring significant tokens from these subdimensions for each group and role attribution were retained. This resulted in 376 and 525 unique SR identifiers from the EGAC and ERAC, respectively. Finally, the Shapiro-Wilk test of normality was used to establish the possibility that subdimension token proportions came from a normal distribu-

³³EFIJ construct taxonomy

Table 4.3: SR subdimension proportions and identifier examples

SR	Social Relations	EGAC	ERAC	Identifiers
1	Named	.283	.206	[1.1 leader]: <i>Bashar al-Assad, Abdel el-Sisi, ...</i> — [1.2 scholar]: — [1.3 militant]: <i>Abu al-Baghdadi, Ayman al-Zawabiri, ...</i> — [1.4 historical figure]: <i>Abu al-Khudri, Umm Salama, ...</i> — [1.5 lesser-known person]: <i>Majid, Yasin, ...</i>
2	Familial and friendship	.144	.185	[2.1 familial]: <i>mother, uncle, ...</i> — [2.2 friendship]: <i>companion, friend, ...</i> — [2.3 fraternal/sororal]: <i>brother, sister, ...</i>
3	Ideological or religious	.261	.225	[3.1 factionist]: <i>Madkhalist, Zionist, ...</i> — [3.2 forebearer]: <i>messenger of Allah, prophet of Islam, ...</i> — [3.3 faithful(+)]: <i>hajji, servant of Allah, ...</i> — [3.4 faithful(-)]: <i>apostate, kafir, ...</i>
4	Adversarial	.181	.255	[4.1 enemy]: <i>occupier, crusader, ...</i> — [4.2 fighter]: <i>jihadist, mujahid, ...</i> — [4.3 captive]: <i>detainee, slave, ...</i>
5	Leadership	.131	.130	[5.1 government]: <i>prime minister, ruler, ...</i> — [5.2 scholarly]: <i>faqih, mullah, ...</i> — [5.3 military]: <i>commander, leader of jihad, ...</i>

tion for further comparative analysis ($W = .95$, $p = .146$) (see table 4.3 for proportions and identifiers) [404].

4.3.3 Multinomial Logistic Regression

Multinomial logistic regression was chosen as a classification method to predict the probabilities of different possible outcomes of a categorically distributed dependent variable (group or role attribution of a document), given a set of independent variables (SR subdimension tokens or features) (hypothesis 2) [550]. 150 random documents were taken from each attribution class of group and role to create a balanced corpus for the classification experiment of 900 and 1,050 documents for the EGAC and ERAC, respectively. The experiment was repeated 1,000 times for each of the EGAC and ERAC random sampled corpora, where a classifier was trained on a random sample of 20% of the SR dimension features in table 4.3. To test the accuracy of the method for each experiment, the constructed corpus was randomly partitioned into ten equal sized subsamples, a classifier was trained on nine subsamples and tested on the remaining one, and the process was repeated ten times to produce a mean accuracy of class prediction across the ten folds (i.e., ten-fold cross-validation) [372, 373, 374, 375]. Measures of precision p and recall r were calculated for each class in each classification experiment, which together explained the performance of the method in terms of true (T) and false (F) negatives (N) and positives (P) (i.e., hits or TP, correct rejections or TN, type I errors or FP, and type II errors or FN) [551]. p or confidence is the proportion of predicted positive documents that were correctly real positives ($\frac{TP}{TP+FP}$) [552], while r or sensitivity is the proportion of real positive documents that were correctly predicted positives ($\frac{TP}{TP+FN}$). Accuracy was measured from 0 to 1 through the balanced F -score or F_1 as the harmonic mean of p and r [553].

4.3.4 Aggregation and Clustering

Since multinomial logistic regression is a linear method each feature is given a beta weight β by the estimated model, the exponential of which represents the change in the odds of the dependent variable or document being in a particular class with respect to the reference class. Features in each class were sorted in decreasing order of their odds ratios to identify ranked lists of subdimension importance to their assigned class [554]. Aggregation of these weighted ranked lists across classification experiments was conceptualised as an optimisation problem where an objective function was minimised to find a ‘super-list’ as close as possible to all individual ranked lists simultaneously [555]. Two algorithms were used to solve the combinatorial problem and aggregate class-based subdimension ranks: a cross-entropy Monte Carlo [556, 557] and genetic [558] algorithm.

Given the sensitivity of algorithm performance to parameter tuning, a number of variations for each algorithm were explored and the lowest objective function score was used to select the optimal solution achieved by the algorithm and its variation [559]. Specifically, the parameters that were varied for the cross-entropy algorithm were based on list size k and included the number of samples generated by the Markov chain Monte Carlo (MCMC) procedure and the population size in each generation of the genetic algorithm. Both algorithms converged after each was allowed a maximum of 10,000 iterations and the stopping criterion was defined as no change in the best solution across 30 iterations. Once a solution was found, the process was repeated with higher samples or population size and stricter stopping criteria (50 iterations) to ensure the same final solution was produced 10 times from separate runs. The `RankAggreg` R package was used to perform weighted rank aggregation for both algorithms [560].

In contrast to aggregation, another data-driven approach was taken to determine natural groups of high-ranking subdimensions relative to each class in each classification experiment. A dynamic programming algorithm `Ckmeans.1d.dp` [421] was used for one-dimensional k -means clustering of the odds ratios of class-based features and guaranteed an optimal solution to the k -means problem, which aims to partition data into k groups based on some property, in this case odds ratios, so that the sum of Euclidean distances to each group mean is minimised [422, 423]. The method allows for the discovery of ‘natural’ clusters when a range of clusters is provided, where the actual number of clusters is determined by the BIC [424, 425], which was set to 1, and the total number of class-based features. The `Ckmeans.1d.dp` R package was used to solve the k -means problem on a per class-experiment basis and identified a descending order of high-ranking feature groups for analysis [420].

4.3.5 Rank Overlap Tests

Comparisons of aggregated subdimension ranks on the degree of overlap between groups G_{1-6} and between roles R_{1-7} were performed by calculation of their agreement through the rank-biased overlap (RBO) measure (hypothesis 3a), which ensures numerical convergence regardless of list length [561]. RBO weights high ranks more heavily than low ranks through a parameter p which determines the strength of the weighting to top ranks and returns values that range from 0 (disjoint lists) to 1 (identical lists). p was set to .9, which meant the first 10 subdimension ranks (out of 18) carried 86% of the weight of the evaluation, so as to reflect the top-weighted nature of subdimension importance in determining a specific class of group or role. The significance of overlap was calculated through a test of the hypothesis that ordering of subdimensions was arbitrary, where the approach counted the number of common subdimensions in the first $i \times \text{stepsize}$ and $j \times \text{stepsize}$ subdimensions of the first and second list of ranks ($\text{stepsize} = 1$) [562]. Because the count of common subdimensions could be driven by chance, the significance of the observed count was calculated on the assumption of completely random orderings. As this was done for all $i \times \text{stepsize}$ and $j \times \text{stepsize}$, correction for multiple comparisons was performed through family-wise error rate (FWER) control using permutation testing (10,000 iterations) [563]. The `RRHO` R package [564] was used for the significant overlap test.

4.3.6 Rank Difference Tests

The number of times a subdimension formed part of the highest ranking feature group for a class was counted for each experiment, followed by an assessment using the Friedman [565, 566] and Nemenyi [567] tests to detect differences in groups G_{1-6} and in roles R_{1-7} for every subdimension (hypothesis 3b). The Friedman test is a non-parametric equivalent of the repeated-measured ANOVA and ranked the class for each experiment separately, with the best group (in terms of subdimension count) receiving the rank of 1, the second best getting rank 2, and so on. Specifically, the Friedman test compared the average ranks of classes. Under the null hypothesis, which states that all the classes are equivalent and so their ranks should be equal, the Friedman statistic is distributed according to χ_F^2 with $k - 1$ degrees of freedom, when N and k are big enough ($N = 1,000$ experiments, $k_G = 6$ groups, $k_R = 7$ roles).

A Nemenyi post-hoc test was performed for each subdimension if the null hypothesis was rejected to find the classes that differed through pairwise comparisons which calculated the critical distance (between average ranks) required in order for two classes to be considered significantly different. Both tests were performed using the `PMCMR` R package [568].

4.4 Results

The method of the present study sought to construct two independent corpora from large collections of content written by EFIJ individuals and groups. In the case of the EGAC, documents were labelled as originating from a particular group. Similarly, in the ERAC, documents were associated with the behavioural characteristics of their author in the EOF, relative to all other authors, where the content was written. Keywords, or tokens, were empirically extracted from documents and a set of frequently occurring tokens was selected based on whether they identified subdimensions of SR as outlined in the ECT. Multinomial logistic regression was used to test how accurately random samples of these tokens could identify the role and group attribution of documents. Finally, SR subdimensions were ranked based on their importance in the prediction of a document's classification, followed by rank overlap and difference tests to discern which subdimensions were important to the predictions.

Following the aforementioned procedure, results showed that the set of unique SR identifiers, or tokens, selected for attribution differentiation showed a high level of coverage for both the EGAC and ERAC, and were present in .981 and .962 of the respective corpora documents. A moderate positive correlation ($r_p = .53, p < .05$) [569, 570] was found between subdimension proportions of EGAC and ERAC SR tokens.

4.4.1 H₂: EFIJ Content Classification

Hypothesis 2 states that *SR subdimensions of EFIJ content predict group and role attribution*. High rates of accuracy F_1 were found across classification experiments for attribution of groups G_{1-6} ($\wedge = .896, \vee = 1, \mu = .971, \sigma = .016$) and roles R_{1-7} ($\wedge = .836, \vee = 1, \mu = .958, \sigma = .026$) to documents using SR identifiers as features for model training (see table 4.4 for F_1 , precision p , and recall r scores; 95% CI). Thus, hypothesis 2 was supported.

4.4.2 H_{3a}: Subdimension Overlap

Hypothesis 3a states that *overlap exists between important SR subdimensions of EFIJ content that predict group and role attribution*. Pairwise comparisons of aggregated subdimension ranks showed high degrees of RBO for both group ($\wedge = .876, \vee = .996, \mu = .954, \sigma = .039$) and role ($\wedge = .970, \vee = 1, \mu = .986, \sigma = .010$) attribution. All role attribution comparisons showed significant overlap ($p < .001$), whereas group attribution comparisons found less but significant overlap ($p < .05$) in subdimension ranks that determined attribution. Specifically, ANF (G_1) and HA (G_4) ($p = .074$) and ISIS (G_5) and HA (G_4) ($p = .073$) did not share significant overlap. Given the high degree and significance of overlap among intra-attribution comparisons of group and role attribution, the

Table 4.4: Group and role attribution precision, recall, and accuracy scores

Measure	Group Attribution						
	G_1	G_2	G_3	G_4	G_5	G_6	
Precision p	[.931, .936]	[.958, .962]	[.984, .986]	[.993, .994]	[.979, .982]	[.978, .981]	
Recall r	[.978, .980]	[.978, .981]	[.952, .954]	[.975, .976]	[.958, .961]	[.976, .978]	
F -score	[.954, .956]	[.968, .970]	[.968, .969]	[.984, .985]	[.969, .970]	[.977, .979]	
Measure	Role Attribution						
	R_1	R_2	R_3	R_4	R_5	R_6	R_7
Precision p	[.930, .938]	[.873, .882]	[.969, .974]	[.961, .965]	[.995, .996]	[.997, .998]	[.996, .997]
Recall r	[.967, .970]	[.981, .984]	[.945, .948]	[.955, .958]	[.941, .944]	[.933, .935]	[.970, .972]
F -score	[.947, .951]	[.923, .927]	[.957, .959]	[.958, .960]	[.967, .969]	[.964, .965]	[.983, .984]

2,000 experiments; 95% CI

F -score = Accuracy F_1

same analysis was applied to the aggregated subdimension ranks of group and role attribution to determine whether similar subdimensions accounted for overlap between groups and roles. The analysis showed a lower degree of overlap than intra-attribution comparisons (RBO = .564), and no significance was found ($p = .076$), which suggests a different set of subdimension ranks account for group and role attribution, respectively.

The majority of identical overlap in ranks between group and role attribution was found in subdimensions that did not form part of the top-weighted section of important subdimensions in determining class in the classification experiments. Both groups and roles ranked named historical figure (SR_{1,4}), captive adversarial (SR_{4,3}), and military leadership (SR_{5,3}) subdimensions identically. The comparatively low RBO score between aggregated group and role attribution was primarily driven by a lack of overlap between the comparative top-weighted sections. Fighter adversarial (SR_{4,2}), factionist ideological or religious (SR_{3,1}), and named militant (SR_{1,3}) subdimensions were more important in determining individual roles than they were to the classification of groups, as these subdimensions formed part of the top-weighted section (3rd, 4th, and 5th) of roles, but not for groups (11th, 15th, and 12th). Similarly, group classification placed greater importance on named lesser-known person (SR_{1,5}) and friendship (SR_{2,2}) subdimensions in its top-weighted section (2nd and 7th) than did role classification, where the subdimensions were placed in positions of lower importance to attribution (14th and 13th).

These subdimension ranks represent the most extreme differences between group and role attribution, where comparison is the result of rank aggregation, and more subtle differences warrant caution (see table 4.5 for SR identifier attribution ranks). As such, hypothesis 3a was supported (for intra-attribution comparisons).

4.4.3 H_{3b}: Attribution Differences

Hypothesis 3b states that *differences exist between groups and between roles on important SR subdimensions of EFIJ content that predict their attribution*. Significant differences were discovered between individuals who occupy hub and non-hub roles on their use of fraternal/sororal (SR_{2,1}), named lesser-known person (SR_{1,5}), factionist ideological or religious (SR_{3,1}), and militant (SR_{1,3}) subdimensions, where the presence of these subdimensions in discussions were consistently more important to the determination of non-hubs than they were to hubs ($R_2 > \{R_6, R_7\}$, $R_3 > R_7$, $R_4 > R_5$, $p < .05$, and $R_4 > R_5$, $p < .001$). Differences within hubs were also found to be significant and again included the named lesser-known person (SR_{1,5}) subdimension as well as the fighter adversarial (SR_{4,2}) subdimension, where they held greater importance in the classification of hubs with lower participation than those with higher participation in the network ($R_5 > R_7$, $p < .05$ and $R_6 > R_7$, $p < .01$). Similarly, a significant difference between the lowest and highest participation non-hubs was also found for the named militant (SR_{1,3}) subdimension, as it was more important in identifying the former than it was for the latter ($R_4 > R_1$, $p < .01$).

At the group attribution level, significant differences were found between some of the Salafi jihadist groups and the Deobandi fundamentalist group for the familial (SR_{2,1}) and fighter adversarial (SR_{4,2}) subdimensions. SR_{2,1} and SR_{4,2} were of greater importance to ANF and AQAP in identifying their attribution than these subdimensions were to the TAL in their documents ($G_1 > G_6$, $p < .05$ and $G_3 > G_6$, $p < .01$). Another significant difference was observed between the Salafi jihadist group ISIS and the Palestinian nationalist group HA on the importance of the named lesser-known person (SR_{1,5}) subdimension in distinguishing its documents from other groups, as ISIS ranked higher on its use of this subdimension than Hamas did ($G_5 > G_4$, $p < .01$). Interestingly, differences in the use of the faithful(+) (SR_{3,3}) and faithful(-) (SR_{3,4}) ideological or religious subdimension played significant parts in identifying different groups from each other. As is expected from conventional wisdom on the specific geopolitical focus of HA's ideology compared to that of the other Salafi jihadist groups [571, 572, 573], the nationalist group ranked lower on its use of the faithful(+) subdimension than ANF, AQAP, and AQC did ($G_4 < \{G_1, G_2\}$, $p < .01$ and $G_4 < G_3$, $p < .05$). The use of references to faithful(-) identifiers were significantly more important to the TAL in distinguishing its documents from those of the majority of jihadist groups and the nationalist group that utilised this subdimension ($G_6 > \{G_1, G_5\}$, $p < .001$ and $G_6 > \{G_3, G_4\}$, $p < .01$). Notably, as was the case with roles, significant intra-group attribution differences were also found between jihadist groups. AQC's use of the faithful(-) subdimension in its documents was significantly more important in separating it from other groups than ISIS's use of the same subdimension in their content, whereas ISIS's reliance on references to named lesser-known person identifiers ranked highly enough to distinguish it from both ANF and AQAP content ($G_5 > G_3$, $p < .001$, $G_5 > G_1$, and

Table 4.5: SR identifier attribution ranks and differences

SR	Identifier	G_r	R_r	$G\chi_F^2$	$R\chi_F^2$	Significant Differences
<i>Named</i>						
1.1	Leader	8	8	11.39	7.67	–
1.2	Scholar	6	7	3.01	5.59	–
1.3	Militant	12	5	6.65	28.53***	$R_4 > \{R_1^{**}, R_5^{***}\}$
1.4	Historical figure	16	16	8.78	3.86	–
1.5	Lesser-known person	2	14	25.41***	19.31**	$G_5 > \{G_1^{**}, G_3^{***}, G_4^{**}\}$ $R_7 < \{R_3, R_5, R_6\}^*$
<i>Familial and friendship</i>						
2.1	Familial	1	6	16.27**	8.7	$G_3 > G_6^{**}$
2.2	Friendship	7	13	3.83	11.67	–
2.3	Fraternal/sororal	3	1	12.06*	19.4**	$R_2 > \{R_6, R_7\}^*$
<i>Ideological or religious</i>						
3.1	Factionist	15	4	8.53	17.9**	$R_4 > R_5^*$
3.2	Forebearer	9	11	10.24	11.46	–
3.3	Faithful(+)	14	15	22.57***	5.92	$G_4 < \{G_1^{**}, G_2^{**}, G_3^*\}$
3.4	Faithful(–)	13	12	41.87***	10.02	$G_6 > \{G_1^{***}, G_3^{**}, G_4^{**}, G_5^{***}\}$ $G_2 > G_5^{**}$
<i>Adversarial</i>						
4.1	Enemy	4	2	3.73	7.87	–
4.2	Fighter	11	3	13.73*	13.17*	$G_1 > G_6^*$ $R_6 > R_7^{**}$
4.3	Captive	17	17	7.44	3.92	–
<i>Leadership</i>						
5.1	Government	10	9	4.59	4.65	–
5.2	Scholarly	5	10	13.3*	5.38	–
5.3	Military	18	18	6.64	3.08	–

* $p < .05$; ** $p < .01$; *** $p < .001$

$G_2 > G_5, p < .01$).

In summary, an array of significant differences that spanned eight SR subdimensions were found to separate different roles and different groups, respectively. The remaining 10 subdimensions (55.56%) were not found to possess any differentiation ability. Differences among roles were primarily concentrated in the named and familial and friendship subdimensions (71.43%), whereas the majority differences among groups were found in the ideological or religious subdimension (57.89%) (see table 4.5 for SR identifier attribution differences). Thus, sufficient support was found for hypothesis 3b.

4.5 Discussion

The present study provided a brief review of EFIJ content at the group and individual levels. SR as a dimension in EFIJ content were proposed as useful potential identifiers, or tokens, that could be utilised to differentiate groups ideologically and individuals behaviourally from each other. Given the lack of adequately sized corpora at the group level and reliable access to data at the individual level, two new corpora were developed for this study: the

Table 4.6: SR identifier predictive usefulness summary

SR	Identifier	Inter- <i>i</i>	Intra- <i>j</i>	Inter- <i>b</i>	Intra- <i>b</i>	Predictive Usefulness
<i>Single differentiation</i>						
3.3	Faithful(+)	•				Simple ideological
2.1	Familial	•				Simple ideological
3.4	Faithful(-)	•	•			Complex ideological
3.1	Factionist			•		Simple behavioural
2.3	Fraternal/sororal			•		Simple behavioural
1.3	Militant			•	•	Complex behavioural
<i>Dual differentiation</i>						
4.2	Fighter	•			•	Simple behavioural, simple ideological
1.5	Lesser-known person	•	•	•	•	Complex ideological, complex behavioural

i = ideology; *j* = Salafi jihadism; *b* = behaviour

EGAC and ERAC. A relatively small but frequently occurring set of SR tokens that were determined to be significant keywords to singular documents were found across nearly all documents in both corpora. Furthermore, these SR tokens were able to accurately differentiate group and role attributions of documents, which suggests that the SR dimension of EFIJ content may be utilised in the characterisation of different behavioural and ideological authorship types expressed in written form.

At the individual level, previous work employed sets of tokens for the development of useful technical methods [519, 522], but did not explore in-depth the nature of content that characterises differences and similarities between and among sample subjects. In this study, such characterisation was defined and subsequently observed through the formation of clusters of individuals within EOF, which provided an avenue for insight into the empirical disaggregation of roles individuals play in these communities. Very little is known about EFIJ culture and its internal dynamics, both on- and offline [329]. Though previous work has suggested complex social mechanisms such as peer influence [209, 210], embeddedness [118, 146], and immersion [97] operate within the networks of EFIJ communities, these works lacked formal network analysis of the phenomena. A single other study utilised a similar classification approach to differentiate documents at the group level between AQ³⁴, HA, HE³⁵, and MB³⁶, which also achieved high levels of accuracy [574]. However, the authors only explored the performance of frequent and function word unigrams, did not use a categorisation scheme, and did not specify transnational differences between documents from groups such as AQ (e.g., al-Qa'ida in the Indian Subcontinent (AQIS), AQAP, AQC, AQIM), as was done in this study.

Comparatively, the named lesser-known person and militant subdimensions held interesting properties in their ability to differentiate individuals in EOF. Both emerged as inter-behavioural subdimensions that could separate types of individuals with varying levels

³⁴al-Qa'ida (unspecified) ³⁵Hizballah ³⁶Muslim Brotherhood

of communication from different clusters of other individuals in these communities (hubs versus non-hubs; see column *Inter-b* in table 4.6). In addition, each possessed an intra-behavioural property that could identify types of individuals where each type exhibited different behavioural characteristics within their clusters of communication as well (hubs versus hubs or non-hubs versus non-hubs; see column *Intra-b* in table 4.6). Social relations denoted by the fraternal/sororal, factionist ideological or religious, and fighter adversarial subdimensions each possessed either an inter- or intra-behavioural differentiation ability (hubs versus non-hubs or hubs versus hubs), but not both. This is noteworthy since previous evidence found at the individual level of analysis suggested that familial [141, 184, 204] and friendship [200, 206, 207] bonds, identity salience anchored in ideology [116, 273, 275], and the influence of veteran fighters and martyrs [166, 497] were all observed factors in the formation and development of EFIJ individuals. Granted, such evidence did not originate from the analysis of content written by EFIJ individuals in the EOF context, but a reasonable expectation follows that the importance of these subdimensions would manifest some empirical differences observable in discussions between individuals, insofar as content identifiers can capture the presence of such social relations in-text.

At the group level, a similar inter- and intra-ideological differentiation ability was found for lesser-known persons among Salafi jihadist groups (ANF, AQAP, ISIS) and between ISIS and a Palestinian nationalist group (HA) (see columns *Inter-i* and *Intra-j* in table 4.6), which suggests the subdimension may apply more broadly to EFIJ content and not just individual or group content. The intra-ideological finding was limited to Salafi jihadism since the composition of the EGAC shows this ideology is the only one represented by multiple groups in the corpus. This is due to the dominance of Salafi jihadist groups in the production of EFIJ content and their diffusion of such content when compared to fundamentalist, nationalist, and Shia jihadist groups. Unlike the individual level, however, the majority of inter-ideological differentiation ability was concentrated among faithful ideological or religious subdimensions, which denoted social relations in clearly defined positive and negative terms. Separation among groups along these subdimensions supports evidence from previous work that found a core thread of binary oppositional themes [475, 493] composed of highly positively and negatively skewed information [456, 487] in EFIJ group content. Negative faithful terms did carry greater complexity than positive terms, insofar as they were found to differentiate on both the inter- and intra-levels and could accurately delineate all ideologies in the EGAC (more than any other significant subdimension could).

In summary, the finding in this study is that many identifiable nuances exist when expressed as social relations and that these identifiers possess the ability to separate the content of different groups through inter- and intra-ideological comparisons. The majority of significant differentiation ability for individual level content was concentrated in the named and

familial and friendship subdimensions, which focused on societal roles, whereas group level content was separated primarily through the ideological or religious subdimension, which focused on theistic roles. For the majority of subdimensions, a single differentiation ability emerged as either delineating ideology or behaviour in the corpora on an inter- or intra-level, but not both, which can be conceptualised in usefulness terms as simple ideological or simple behavioural predictive potential. The fact that the fighter adversarial subdimension showed capacity for dual differentiation on both inter- and intra-levels, but in a simple behavioural and ideological manner, is interesting, but not surprising given the nature of EFIJ content. However, it is interesting to note that despite being an expected theme, the way in which such communication occurs was found to be unique enough to delineate particular types of EFIJ ideologies and roles in EOF communication networks. The complex dual differentiation ability of the named lesser-known person subdimension is a finding of special note as it signifies that differences in communication about these relatively unknown people are significant enough to separate both the ideology of groups and behaviour of individuals at both the inter- and intra-levels. In other words, lesser-known people capture the cognitive attention of EFIJ communities many years before OSINT sources can identify them. In most cases these individuals never make it into such sources for identification, hence the development of the subdimension, which strongly points to the existence of a communication layer hidden inside the observable communication, and represents a window into the hitherto largely unexplored social dynamics that underpin these communities.

These findings can be seen to show that the observed subdimensions hold particular importance for practitioners in the digital forensics field who wish to examine or study EFIJ content for difference insofar as surface level ideology can reasonably distinguish the stated affiliation and perceptible behaviour of their authors. Future work will explore the social dynamics of EFIJ communities to see if similar adoption patterns exist across independent EOF in the use of other subdimensions from the overall ECT, beyond the SR subdimension, and whether such identifiers may be utilised in the explanation of behavioural ties formed between individuals in their communication with each other.

This thesis set out to develop a better understanding of the content and structure of on-line communities identified as subscribing to EFIJ³⁷ ideologies. In particular, the thesis examines the nature of the content (specifically language) produced and exchanged in these communities and how this changes over time and, further, the relationship between the type of content exchanged and the formation of ties between actors in the community as well as the relationship between content and an individual's position in the community overall.

In the absence of formal structures and hierarchies or pre-defined roles for individuals, online communities organise around the content that individuals share with one another. In the EFIJ context, some recent work has examined the monologues or other static (e.g., written) work of influential individuals such as jihadist scholars and suicide bombers [72, 73, 74]. However, very little research has been undertaken on the dynamic interaction of EFIJ individuals, specifically in communities that develop in environments with high degrees of internal control and moderation. Examining dynamic interactions of and between EFIJ individuals is critical to understanding how ideas develop, evolve, and are shared in these communities, and how these ideas and their communication relate to an individual's influence and role in the communication network of the community. Therefore the first paper of this thesis, *First-order Identifiable Dimensions of Extremist Content at the Individual Level* [64] (see section 2), reviews the existing literature to identify constructs that are commonly observed in studies at the individual level and categorise the constructs, such that they become useful first-order identifiers of EFIJ content. First-order identifiers are useful and necessary due to the volume of communication exchanged via these communities. In simple terms, these first-order identifiers (categories of content) may be used to identify a given corpus of communication as EFIJ.

This paper's comprehensive review finds nine dimensions (themes) that appear prominently in studies of EFIJ individuals globally: GP³⁸, CD³⁹, SR⁴⁰, TK⁴¹, CB⁴², OE⁴³, AE⁴⁴, PP⁴⁵, and EV⁴⁶. The GP dimension is comprised of references to relationships between countries and grievances that individuals and groups have with particular countries. Many references of GP, across a range of different recognised EFIJ groups, mentioned grievances and perceived incompatibilities with the West, and interviews with militants found that

³⁷Extremist, fundamentalist, Islamist, and jihadist ³⁸Geopolitical perspectives ³⁹Collective dynamics
⁴⁰Social relations ⁴¹Theological knowledge ⁴²Conflict behaviour ⁴³Oppositional evocations ⁴⁴Affective experiences
⁴⁵Persuasion processes ⁴⁶Existential validation

grievances with foreign and domestic forces compelled them to fight. The CD dimension referred to shared, often negative experiences such as perceived discrimination, injustice, threat, as well as shared beliefs around ideology and in-group superiority. Social relations in the EFIJ literature place a strong emphasis on marriage and family, such that many men fight while many women support this effort by assuming active and caring roles so as to advance the ideology. Another major component of the SR dimension is the role and emphasis on leaders, particularly in recruiting and encouraging militants - in addition to existing friend and peer networks exerting influence.

TK refers to the understanding that EFIJ individuals have of scripture, influential works by past and present scholars, holy places, beliefs, and practices. CB is about training for or executing acts of violence, as well as support for these acts of violence. OE, that is, the belief of a bipolar struggle between Islam and the West, were also prominent in studies of EFIJ individuals. This belief was reflected in references to 'us' versus 'them', denouncement of non-believers, and promotion of a particular type of Islam as 'correct'. AE included negative emotions such as fear, anger, and stress experienced by militants or would-be militants in the lead up to their attacks. These negative emotions, when experienced by a radicalised population, are related to greater acceptance of terrorist acts. Positive and more complex forms of moral and personal affections that sought status were also included. PP refer to the methods found to influence members of EFIJ communities. These include the strategic use of individuals with expert knowledge of Islam, encouragement of literal interpretations of scripture, and blurring interpretations of verses with jihadist views. The use of dramatised narratives of fighters and those who join the cause is also common in persuasion processes. EV, that is, the search for identity and meaning, was very common in studies of EFIJ individuals and closely linked to more radical belief systems.

Perhaps what is most relevant about these dimensions is that they present across samples of EFIJ individuals that differ in terms of geography, ideological community membership, age, and nationality. Also of note is that these dimensions are often associated with the decision to take violent action and, amongst civilian populations, including populations of Muslims living in Western countries, are associated with support of violent acts. While the paper does not suggest that these categories represent the only content domains in which EFIJ individuals' communication can be categorised, nor that communication in any of these categories is an indication of violent acts or tendencies, the prominence of content in these categories across samples does indicate that the dimensions put forward form a taxonomy which may be useful for identifying, organising, and analysing EFIJ content.

To empirically explore the proposition that the nine dimensions presented in the taxonomy in the first paper are a useful means of organising EFIJ content, the second paper of the thesis, *Taxonomic Classification and Analysis of Communication in Extremist Online Fora* [65]

(see section 3), analyses extremist content from 13 EOF⁴⁷. The aim of this paper is to understand how engagement with content in different dimensions changes over time and how the influence of content attributable to particular dimensions differs between dimensions. Changes in engagement are observed through semantic shifts in written content relative to surrounding words and phrases, while influence refers to the centrality of a given category to the communication network. To identify a word or phrase as 'extremist' in context, semantic analysis was undertaken and words and phrases that had a polarity (positive or negative) score greater than .8 were qualitatively evaluated and categorised into the dimensions of the taxonomy. The TK dimension accounted for 20.3% of the words and phrases in the EOF, followed by SR (18%), AE (12.7%), then CD (11.8%). Words and phrases in the OE and EV dimensions accounted for 9.6% and 9.4% of content, respectively; PP and CB accounted for 6.9% and 6.4% and, finally, 5% of the words and phrases examined were categorised into the GP dimension.

Subdimensions were then identified within the nine dimensions. References to specific countries or their people accounted for most content within the GP dimension, with a smaller proportion referring to particular cities and villages. The groups mentioned in the CD dimension could be further categorised into the subdimensions of ideological or political and military groups, ethnic and religious groups, governance systems such as judiciary and legislative systems, and economic and educational systems. A proportion of content in the SR dimension specifically referred to named persons, while the remainder could be classified into familial and friendship roles, leadership roles, ideological or religious roles, and adversarial roles. The TK dimension referred mostly to concepts, such as afterlife, faith, and sin, but the additional subdimensions of customs, laws and texts, and events and places, also emerged. The CB dimension could be further broken down into two subdimensions of conflict and weaponry, and death and harm. OE remained one overarching dimension, while the AE dimension was disaggregated into four subdimensions: basic emotions (e.g., anger, fear, excitement), moral affections (e.g., commitment, dissatisfaction), personal affections (e.g., individual status), and sympathetic affections (e.g., benevolence, forgiveness). Formation and communication of knowledge were the two subdimensions that emerged within the PP dimension, and individual and intersocial volition emerged from the EV dimension.

Examination of whether engagement with the dimensions changes within the EOF revealed that a small proportion (5%) of words and phrases experienced statistically significant changes over time. Words in the TK and SR dimensions accounted for the majority (63%) of the words and phrases that experienced significant changes in engagement over time. Given the nature of the fora (i.e., that they are Islamic), the prominence of the TK dimension is not terribly surprising, especially since prior empirical work at both qualitative

⁴⁷Extremist online fora

[575] and quantitative [518] levels found that the TK dimension is deeply embedded in communication that occurs on such EOF. However, the almost equal level of engagement with the SR dimension is a surprising finding that reveals important information regarding the dynamics of EOF. While earlier work has noted the presence of sociological references in forum messages [499], the few works that considered social entities mentioned in discourse relied on descriptive analyses and did not analyse the impact of these references on engagement with content on EOF. Another study found that while the TK dimension was the major source of identification for discussions on EOF, as is supported by this work's findings, communication also included references to another element of the SR dimension in the form of authority figures (although significantly fewer references compared to TK) [502]. The analysis of this thesis found that the SR dimension was more significant for some fora, while TK was more significant for others (i.e., a between-groups difference in the importance of particular dimensions). Cluster analysis was undertaken to evaluate whether certain dimensions and subdimensions exercised significant influence over the communication networks of the EOF. Three clusters of influential subdimensions were identified, and 40% of the subdimensions in the clusters were from the SR dimension.

In sum, the second paper of the thesis found that content identified as extremist, that is, quantitatively having a positive or negative semantic polarity score of .8 or more in the EOF context, can be qualitatively categorised into the nine dimensions of the ECT⁴⁸ presented in paper one. In addition, the qualitative evaluation revealed that content could be further disaggregated into 24 subdimensions within the nine dimensions. Significant engagement with terms changed over time for only a very small proportion of the words and phrases examined, and the majority of those words and phrases were in the TK and SR dimensions. Finally, three clusters of subdimensions were found to be influential in the communication network; subdimensions within the SR dimension were present in all three clusters, and words and phrases in the SR dimension accounted for close to half of the influential content. Therefore, the second paper provides support for the proposition that the ECT is a useful means of categorising extremist content in EOF, such that the taxonomy dimensions capture the content discussed, experience different levels of (changing) engagement over time, and exert differential influence over the communication network of EOF communities.

The third paper, *Predicting Group and Role Attribution using a Relational Dimension of Extremism* [66] (see section 4), further investigates the importance of the SR dimension. A sample of over 4,000 EFIJ documents, such as magazines and communiqués published by groups, along with a corpus of text conversations between individuals on 27 EOF were analysed. The groups from which many of the documents in the document corpus originated

⁴⁸EFIJ construct taxonomy

were identifiable through surface-level metadata. For those documents that did not have a clear origin in terms of ideological group, semantic analysis was undertaken to categorise them into the most accurate group. Six groups, representing three ideological stances (Salafi jihadism, Palestinian nationalism and Deobandi fundamentalism), were identified, with at least 150 documents attributable to each group.

The EOF data were represented as relational networks of interactions between individuals, with each individual representing a node in its respective network. The modularity of the communication network, that is, the degree to which the network can be partitioned into smaller modules was analysed. The statistical significance of modularity scores of the communication networks were tested by comparing them to 1,000 random networks comprised of the same number of nodes. Networks with statistically insignificant modularity scores ($n = 3$) were removed from further analysis.

To examine the roles that individuals play within their network, the connectedness of nodes relative to other nodes in the network was analysed. Connectedness was operationalised as both the number of edges (connections) a node has to other nodes, and the extent to which these edges connect them to different modules in the network. Per previous work [537], seven network roles emerged: ultra-peripheral, peripheral, non-hub connector, non-hub kinless, provincial hub, connector hub, and kinless hub. An ultra-peripheral node has relatively few edges that are only located within one module of the network, while a peripheral node has relatively few edges, of which at least 60% are located in one module. A non-hub connector node has relatively few edges, around half of which are located in one module, while a non-hub kinless node has relatively few edges that are more distributed across the modules of the network (less than 35% of edges in the same module). A provincial hub is a node with a relatively large number of edges, 5/6 of which are in a single module. A connector hub has a relatively large number of edges, at least half of which are located in a single module. Finally, a kinless hub is a highly connected node that has less than half of its edges located in the same module.

Over 80% of the nodes in the EOF network occupied peripheral or ultra-peripheral roles, while 14% acted as non-hub connectors. Only 1.4% occupied roles as connector hubs, and .9% were provincial hubs, indicating that a small proportion of nodes control a large amount of influence in these networks. To understand how the SR domain affects ideological group and network role attribution, significant keywords were extracted from the document and EOF corpora and categorised into the SR subdimensions of named persons, familial and friendship, ideological or religious, adversarial, and leadership. Multinomial logistic regression was then used to establish the probability of communication in a given SR subdimension predicting group and role attribution. The named persons and familial and friendship subdimensions held the greatest ability to differentiate individuals, while

the ideological or religious subdimension differentiated groups. The findings elucidated the emergence of a spectrum of predictive usefulness for the application of subdimensions as identifiers in the analysis of EFIJ content that spanned permutations of simple and complex ideological and behavioural application potential unique to these subdimensions.

Therefore, this thesis presents three papers examining the nature of EFIJ content and its communication through EFIJ individuals and groups. The first paper reviews the literature to develop a taxonomy of constructs that are commonly observed in studies of EFIJ individuals. These studies span multiple geographic locations (including the West), a range of ideological groups, and present evidence at the individual level of analysis, indicating the salience of the constructs revealed. The second paper explores the usefulness of the taxonomy presented in the first paper for categorising and analysing EFIJ content, finding that a substantial proportion of communication can be categorised into the dimensions identified, and that the SR and TK dimensions significantly affected communication in EFIJ networks, such that words attributable to these dimensions experienced significant changes in engagement over time, and were present in influential clusters of the communication network. Finally, the third paper examines the ability of subdimensions of the SR domain to predict group and individual role attribution, finding that the named persons and familial and friendship subdimensions held the greatest ability to differentiate individuals, while the ideological or religious subdimension differentiated groups, and the existence of an underlying spectrum of predictive usefulness for the subdimensions.

5.1 Academic Implications

The introduction of this thesis put forward that its significance could be categorised into four categories: further exploration of the dynamics of online communication, examination of EFIJ communication at the individual level, the use of comparably objective data, and the utilisation and combination of complex linguistic, network, and statistical methods.

As communication is central to all interactions as human beings, the role of language in communication - its ability to garner social influence, direct social events - is extremely well studied [576]. However, up until relatively recently most dynamic communication, that is, dyadic communication in which parties can respond with reasonable speed (as opposed to, say, sending a letter or telegram), occurred verbally. Consequently, most studies of the influence of language on communication dynamics have focused on verbal communication [577]. Without the verbal and physical cues of communication such as tone and inflection, body language, physical attractiveness, and/or charisma of the communicator, it can be reasonably hypothesised that the use of language plays an even greater role in the dynamics of online communication than verbal. Previous studies have identified that speed of adoption of an

online community's language predicted tenure in the community [15], and that the volume and variety of words selected predicted influence [16]. This study, therefore, builds on these findings by discovering that the content of communication predicts structural influence in a communication network, such that utilisation of words in particular content domains (in this context, SR and TK) is positively related to an individual occupying a network role that has greater influence over the communication network.

The second area of academic contribution is examining EFIJ communication at the individual level. A relatively small proportion of the literature is undertaken at the individual level, which leaves us with gaps in understanding the nature and structure of individual EFIJ communication [25]. Unpacking the content and how it affects communication networks is critical to further research on these individuals and, indeed, groups, as dyadic communication is the base from which a communication network grows. Interestingly, as mentioned in the previous section, this thesis finds that the categories of content that predict network role are consistent across communication networks that represent different ideological communities, geographies, and nationalities. This provides support for the development and use of content taxonomies to organise large volumes of communication where the nature of the content is broadly similar (e.g., in this case the content is EFIJ in nature, but not restricted to a particular Islamic-based ideology of an individual, group, or community). In the EFIJ context, it also refines the scope of content categories that are likely to be influential, providing a potential point from which future research can build.

The use of comparably objective data provides greater insight into the dynamics of EFIJ communication networks. The lack of reliance on self-report data that is subject to social desirability bias and failures of memory arguably presents a more 'natural' view of communication between EFIJ individuals. The problem, up until reasonably recently, is that communication data of this nature is typically quite large - as there is not an interviewer or survey instrument to point to the key themes or findings, the full data must be considered in order to derive meaning from it. This is a rather impossible task for a human to do manually, which brings us to the fourth academic contribution of this thesis - the utilisation of novel and complex methods to analyse this data. Having the tools available to understand how communication networks form in these communities without intervention opens up significant possibilities for academic research. For instance, the types and amounts of data that can be analysed expand, the facets of the data that can be explored similarly expand, be it the content (language, references) and structure (who talks to whom, how much and when, how networks evolve over time) of the communication, or metadata analysis (how does posting frequency or time relate to influence in the network?).

In sum, the methodology and findings of this thesis have several academic implications. They suggest that the study of content and structure of large-scale EFIJ communication

networks is not only possible, but can effectively and efficiently narrow the scope of the content that is important to a given network.

5.2 Practical Implications

This thesis has identified a useful methodology for identifying content that determines the influence of particular individuals in online EFIJ communities. Further, as demonstrated, this methodology can be used to predict and attribute ideological group membership using the content communicated by its authorship. Though this thesis does not seek to demonstrate a relationship between online communication and offline behaviour, the spread of extremist ideology online is a known concern of scholars and practitioners alike [24]. Consequently, the methodology and findings of this thesis have several practical implications and applications for those tasked with identifying and addressing people and threats in the EFIJ context.

The ways in which individuals organise at local levels have been shown to be critical to the development of major impact events [578]. Thus, identifying influential individuals in a network and the factors that facilitate their garnering of said influence means that, if someone was seeking to interfere with the network (e.g., to thwart the spread of ideology), they are able to strategically target the actors whose removal would most disrupt the flow of communication. Similarly, if someone sought to infiltrate the communication network, for example to shape the rhetoric within it or to gather information that is not posted publicly from actors in the network, they would know what they should communicate about in order to gain the influence required to do so.

The ability to reliably attribute group membership based on content alone means that, if a terrorist plot or dangerous rhetoric of unknown or unspecified origin were to appear, the methodology outlined in this thesis could be used to attribute an ideological group. This may, in turn, provide insights into the geographic location of the actors, other means of communication they are likely to employ which can then be intercepted and investigated, and perhaps (triangulating with other sources of intelligence), who may be involved.

Therefore, the methodology developed in this thesis has several practical implications and may serve as a useful complement to other sources of intelligence.

5.3 Limitations

Though this thesis makes several contributions to academic and practical knowledge about content and communication in the EFIJ context, it is not without limitations. The first, as mentioned above, is that this thesis and its methodology are not trying to predict 'real

world' behaviour or suggest that an individual communicating about these content domains is at risk of committing violent acts. As such, any findings are limited only to content, communication, and influence in the online context.

A second limitation of the thesis is that, without talking to the individuals responsible for the content, we cannot definitively ascribe meaning to said content. Consequently, the manual categorisation of communication undertaken may not reflect the meaning intended by the writer of those words. This limitation is somewhat mitigated through the checking of categories by a colleague, resulting in greater consistency to the categorisation. However, to understand at a more micro-level why individuals spoke about certain things or what they meant by certain things would require methodological approaches beyond those used in this thesis.

Another limitation is that one cannot precisely identify individuals on online fora as people may be posting across fora and/or posting multiple times under different usernames. This is a relatively minor limitation, as constraints to individuals' time, technology, and simple interest in an issue or community mean that only a very small proportion of people would consider 'double posting' or assuming multiple identities, meaning that the fora are authentic representations of online communities and their communication.

To summarise, the findings of this thesis must be interpreted with consideration to certain limitations. The findings cannot be used to predict real world behaviour, they do not shed light on what an individual meant by particular words or why they spoke to certain people about certain things, and some content that appears to be from different users may be produced by the same user.

5.4 Directions for Future Research

There are several directions for future research that arise from this thesis. One is the application of these methods to communication outside of online fora, such as communication transcripts between known terrorist actors, to investigate whether the same categories of content feature and influence the communication, as well as examining the relationship between communication and violent action. Another is deeper longitudinal examination of these communication networks: why is there change in the way that certain words and phrases are used within a network? How does the network itself change over time? Is there commonality in how communication networks evolve? Are there differences? What drives these commonalities and differences? Are they common across a range of online fora, or only EOF?

There are also avenues for experimental design, for instance, inserting actors into active communication networks and observing the effects of communicating about particular

content or with certain individuals. It is important to note that a robust ethical framework would need to be developed for this type of research design.

Another direction for future research is to continue to use advanced and emerging methods to explore EOF. The scale of the data from EOF in terms of volume precludes purely manual analysis, and emerging methods such as exponential random graph modelling can be used to address some of the limitations of this thesis. For example, how do actors' relations with one another affect what they post (content) and how they post (frequency, replies versus initiations, and so forth).

These represent just a few directions for future research that will address some of the limitations of this thesis. Given the ever-increasing use of the online medium across all human functions, along with the ever-present threat of terrorism, future research in these domains can and will continue.

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