Dynamics of Personal Responses to Terror Attacks: A Temporal Network Analysis Perspective

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Abstract: In this paper, we analyze responses to terror attacks through the lens of the Terror Management Theory. We focus on the temporal evolution of Twitter messages that convey death anxiety, emotional pain, as well as positivity. We model the responses to terror attacks as personal reactions that include the use of a first person singular pronoun along with cues of affect and personal concerns. In order to detect these textual features, we used the Linguistic Inquiry and Word Count (LIWC) tool. Our data-set includes tweets related to three terror attacks: the 2017 Manchester terror attack, the 2019 Christchurch terror attack, and the 2020 Vienna terror attack. Our analysis is based on 3.8 million tweets that have been sent by 1.6 million users. The results indicate that positive messages associated with the use of religious words (e.g., messages of prayers and hope) dominate over those that convey emotional pain and fear of death. This points to a tendency to spread hope and empathy in the aftermath of a terror attack. We found that the acute phase of a terror attack exhibits a high volume of messages that sharply decline in the immediate aftermath. In contrast, positive messages exhibit smaller peaks even one week after a terror attack happened.

1 INTRODUCTION

People who face immediate threats to their own life, their family members, or friends, tend to respond with elevated emotions of fear, anxiety, anger, and grief (Hardy and Miller, 2022; Kušen and Strembeck, 2021). Such reactions to crises have long been in focus of behavioral scientists who found that people universally respond with an initial disbelief, followed by a wide spread of information and rumors, venting of intense emotions, as well as various collective reactions (incl. collective panic, organized help and rescue efforts). Other studies also showed that expressions of solidarity, togetherness, as well as blame commonly occur before people can return to their normal routine (Flynn, 1997; Smelser and Mitchell, 2002).

Terror attacks are a specific type of crisis that happen unexpectedly and without a prior warning. Moreover, terror attacks pose an immediate threat to the well-being and life of those directly affected, aim to destabilize our world-view (Miller and Landau, 2005), and give rise to an intense anxiety. The latter is strongly related to the reminder of our own mortality which is a focal point of Terror Management The-

ory (TMT) (Greenberg et al., 1986; Rosenblatt et al., 1989). In general human beings are not only aware of their own mortality but also have a desire for self-preservation. In this light, a positive worldview serves as an effective barrier to death anxiety (Kastenbaum, 2007).

Death anxiety related to terror attacks is universal (Greenberg et al., 1986) and not only concerns those who are directly affected, but also those who are reminded of past experiences of terror. (Rosenblatt et al., 1989) further showed that people are often reminded of their own mortality simply by reading newspapers or watching the news on TV. Thereby, such studies confirm that the fear of death caused by terror attacks is one of the strongest psychological threats (Becker, 1997).

As in any type of crisis, Online Social Networks play an important role during terror attacks. They serve an informational purpose during the acute phase of a terror attack (Steensen, 2018; Simon et al., 2014) and facilitate the organization of crisis relief efforts as well as expressions of togetherness in the aftermath of a terror attack (Merrill et al., 2020). While multiple studies focused on the types of messages and the vol-

ume of messages sent in each phase of a terror attack, it has rarely been studied how specific types of social media messages are exchanged and which temporal communication patterns emerge during terror attacks.

In this paper, we investigate the temporal patterns resulting from messages that convey death anxiety, emotional pain, as well as positive perspectives about an otherwise bleak future (associated with one's faith). We model these responses as personal stories told from a person's individual perspective (indicated by the use of the first singular personal pronoun) in order to make sense out of a terror attack. According to (Hermans and Hermans-Jansen, 1995), self-narratives serve as a good indicator of situations that have a high personal meaning during an episode in the speaker's life.

Our findings bring forth a couple of valuable insights into the psychological underpinnings of terror attacks. We extend the existing literature on human responses to terror attacks by showing that positive messages associated with the use of religious words (e.g., messages of prayers and hope) play a special role in the acute phase of the terror attack as well as in its aftermath.

The remainder of this paper is organized as follows. In Section 2 we provide a summary of related work. Section 3 describes our research method. Results are presented in Section 4 and discussed in Section 5. We conclude the paper in Section 6 and provide directions for future research.

2 RELATED WORK

Informational Role of Twitter. (Simon et al., 2014) studied the role of Twitter during the 2013 Westgate mall terror attack in Kenya and found that initially an uncontrolled surge of messages occurred. Though there are obvious positive effects of such a high rate of message sharing (e.g., social bonding with the community, stress relief), the authors found that the terrorists also monitored Twitter to acquire information about the actions of the police and armed forces. Along these lines, a study by (Oh et al., 2011) found the same phenomenon during the 2008 Mumbai terrorist attack. As a result of the uncontrolled surge of messages, sensitive situational information about the officials' operational activities were revealed to the terrorists.

Another study on the 2013 Westgate mall in Kenya analyzed narratives formed by a terrorist group (Mair, 2017). This study found that the terrorists took control of their own narrative by not providing any links to external websites or engaging with other Twitter users. Their sole purpose was to spread their ideology and justify their actions.

Twitter as a Channel for Collective Sharing of Emotions. (Bruns and Hanusch, 2017) focused on the dissemination of audiovisual content during the 2015 Paris terror attack and the 2016 Brussels terror attack. This study found that the intent of audiovisual content was predominantly of an affective nature (e.g., photos of landmarks lit up in French national colors, images with text "Pray for Paris") and informational nature (eyewitness photos). The study pointed to the importance of affective intent in the audiovisual content as it reveals how a collective responds to an attack. Another study on collective emotions is presented in (Steensen, 2018), who found that the narratives of empathy associated with the #PrayForOslo and #PrayForNorway hashtags emerged about two and a half hours since the 2011 attack in Oslo and on the island of Utøya in Norway. One week after the terror attack, tweets of grief and love (#oslove, #showyourhearts) dominated the Norwegian Twitter discourse.

The 2013 Woolwich/London terror attack was studied by (Burnap et al., 2014). They found that affects conveyed in tweets are directly associated with message diffusion rates. In particular, the authors found that tweets that convey a high level of tension and antagonism circulated for a shorter amount of time compared to those with a low level of these two sentiments. Several important implications were reported in this study, one of them being the role of positive messages which were shown to propagate longer than the negative messages.

Twitter as a Channel for Sense-making. In terms of message creation, (Kwon et al., 2017) found that tweets sent during terror attacks predominantly focus on present (rather than past or future) and included detailed and concrete descriptions of the event rather than an abstract account of the event. (Eriksson, 2016) analyzed post-attack responses to the 2011 terror attacks in Oslo and on the island of Utøya, Norway. The results revealed that people dealt with the collective trauma by expressing solidarity and collectively tried to make sense of what had happened by searching for the underlying causes for the attack. The latter discussion especially focused on the political ideology of the perpetrator and those sharing a similar ideological viewpoint. Interestingly, the study found that people try to compare and reference different violent incidents to construct a narrative of a growing trend of violence.

Twitter as a Channel for Pro-social Behavior. During the acute phase of a terror attack, a collective solidarity towards those who seek shelter may emerge. One such example was studied in (Reilly and Vicari,

2021) during the 2015 Paris terror attack where the hashtag #PorteOuverte (open door) was highly shared on Twitter as means of offering a safe place to hide from the terrorists roaming the streets of Paris. This inspired a series of similar initiatives (Tikka, 2019), such as #openhouse during the 2016 attack in Brussels, #offenetür during the 2016 attack in Munich, #opendoors during the 2016 attack in Nice, #roomformanchester during the 2017 attack in Manchester, #openstockholm during the 2017 attack in Stockholm, or #bedinbarcelona during the 2017 attack in Barcelona.

In addition to offering shelter, another form of pro-social behavior during terror attacks is the expression of togetherness and unity. While studying the responses to two terror attacks (Ezzati, 2021) found that people are united through common values, such as tolerance, co-existence, love, justice, peace, and fraternity. The author pointed out that the purpose of such value-conveying messages is to dissociate religious groups and members of a certain ethnicity from the perpetrator(s).

3 METHOD

In this paper we analyze temporal characteristics of emotional human reactions to terror attacks through the lens of TMT. Our paper is guided by the following main research question:

- How do responses to terror attacks evolve over time?

To further elaborate on this question, we explore the following types of human responses to terror attacks: 1) emotional pain, 2) death anxiety, and 3) messages of positivity associated with a use of religious words, and define the following sub-questions:

- How does the expression of emotional pain by those affected evolve over time?

- How does the expression of anxiety related to own mortality by those affected evolve over time?

- How does the expression of positivity related to the use of religious words evolve over time?

In order to answer to these questions, our research method follows three phases, as outlined below.

Data Extraction. We extracted the data by using Twitter's Search API and a list of predefined hashtags and key terms for each terror attack[1]. The data extrac-

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[1]Christchurch terror attack: #NewZealandTerroristAttack, #Christchurch, #ChristchurchMosqueShootings, #ChristchurchMosqueAttack, #ChristchurchTerrorAttack;

tion started on the day of the terror attack and continued for another two weeks. After removing duplicate entries, our data-set comprised 3,854,670 tweets authored by 1,643,939 Twitter users. Details are presented in Table 1.

Data Pre-processing. In our analysis, we used the Linguistic Inquiry and Word Count (LIWC) tool (Pennebaker et al., 2015) to identify psycholinguistic features in Twitter messages. LIWC's internal lexicon is organized into a set of categories, each designating a specific psycholinguistic phenomenon. For example, a category called "Personal Concerns" includes variables "religion", "death", "money", and "home" along with their corresponding internal lexica, while the category "Affective Processes" includes anxiety, fear, anger, positive emotions, and negative emotions, (see (Pennebaker et al., 2015) for details).

We first defined a rule to capture a narrative (main theme) conveyed in each tweet. The rule was as follows:

$$f(x,y) = \begin{cases} x+y, & \text{if } x > 0 \wedge y > 0 \\ 0, & \text{otherwise} \end{cases}$$

where x and y represent a variable in the category "Personal Concerns" and "Affective Processes" respectively. If both values were positive, we multiplied their sum with the LIWC score of the first person singular personal pronoun. The LIWC variables used in this paper are outlined in Table 2 along with a note on the rationale behind the choice and application of LIWC variables.

Network Construction. Upon inferring the scores for emotional pain, death anxiety, and religion (in this context associated with positivity), we measured the daily intensities of the three personal responses. For each of the three types of personal responses, we constructed temporal direct messaging (DM) networks for each type of a narrative by tracing the @-mentions in the text[2] of a tweet. Users mentioned via the @-mechanism are considered target nodes in our net-

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Manchester terror attack: #ManchesterArena, #manchesterstrong, "terror manchester", "manchester ariana grande"; Vienna terror attack: "vienna terror", "terrorist attack #Vienna", "#ViennaAttack"", "#Viennashooting", "#prayforvienna", "#wienATTACK", "angriff vienna"", "#terrorwien", "#PrayforWien", "#viennaattacks", "#ViennaTerrorAttack", "#austriaAttack", "sorgen Wien", "#Viennaterror", "#ViennaTerroristAttack", "#viennapolice", "#austriashooting", "terror wien", "wien Hintergrund", "vienna background", "#Schwedenplatz", "wien #staysafe", "vienna #staysafe", "#StayStrongAustria", "#zibspezial", "#Nehammer", "#0211w", "@ORFBreakingNews", "#Synagoge", "#Schießerei", "#terroranschlag wien", "#terroranschlag vienna", "#schleichdiduoaschloch".

[2]Note that we removed the retweets prior to a network construction.

Table 1: Basic information about the data-set.

Event	Time period	Tweets	Retweets	Usernames	Language
Christchurch	15 – 28 March, 2019	1,775,901	1,567,946 (88%)	846,858	en
Manchester	22 May – 4 June, 2017	1,582,586	1,232,085 (77.8%)	675,183	en
Vienna	2 – 15 Nov, 2020	496,183	378,171 (76%)	202,719	en, de

Table 2: The choice of LIWC variables.

LIWC variables	Explanation
Emotional pain "I" × (sadness + anger)	(Junghaenel et al., 2017; Rude et al., 2004; Tausczik and Pennebaker, 2010) indicated that those who experience emotional and physical pain tend to draw attention to themselves (via a first person singular pronoun) and use words that indicate their emotions, especially sadness and anger. Example: *"I'm sorry I'm sorry I'm sorry I send my love if I could come hold all the families #ManchesterArena"*, *"I didn't sleep a second. I am tired. My head hurts. My heart hurts. #PrayforVienna"*, *"I f**ing hate humanity man #ChristchurchMosqueAttack"*
Death anxiety "I" × (death + anxiety)	(Greenberg et al., 1986) indicated that threat to one's mortality is reflected through anxiety over death, either an own death or death of someone else. Example: *"Every time I see the confirmation picture of another death in Manchester attack I feel so much pain... #manchester #terror"*, *"#PrayforVienna I swear I've never been so scared of death"*, *"I just learned about #Christchurch terrorist massacre... I'm just...appalled. Speechless. I just can't..."*
Religion "I" × (religion + positive affect)	(Flynn, 1997) found that religious beliefs provide hope for the otherwise bleak future. Example: *"I pray for the victims. I pray for the families of the victims. I pray for #Manchester. I pray for Ariana Grande. I pray for the world."*, *"My heart is sore for my other hometown tonight. God bless Vienna #viennaterrorattack"*, *"I hope the victims find paradise #NewZealandTerroristAttack"*

work, while the author of a corresponding tweet is considered a source node. Basic information about our networks is presented in Table 3.

Data Analysis. We analyzed our networks with respect to their underlying temporal dynamics that emerge due to direct message exchanges among the Twitter users. Subsequently, we analyzed the temporal networks with respect to their momentary structure (edge formation patterns and dyad density). To construct and analyze the temporal networks, we used *tsna* (Bender-deMoll and Morris, 2021) R package. Our analysis was conducted on a quad-core machine with Intel(R) Core(TM) i7-5600U CPU @2.60GHz.

4 RESULTS

The results revealed distinctive temporal patterns among the three personal responses analyzed in this paper. As shown in Figure 1, all three emotional re-

Table 3: Basic information about each network.

Event	Nodes	Edges
EMOTIONAL PAIN		
Christchurch	241	133
Manchester	324	264
Vienna	2344	2675
DEATH ANXIETY		
Christchurch	140	78
Manchester	282	246
Vienna	1555	1728
RELIGION		
Christchurch	1101	690
Manchester	648	540
Vienna	3498	4106

sponses are present throughout the 14-day extraction period in all data-sets. We observed a higher level of death anxiety during the acute phase of each ter-

ror attack and its gradual decrease over time. Positive messages (associated with the use of religious words) are dominant throughout the entire extraction period, while emotional pain peaks in the immediate aftermath and afterwards decreases over time.
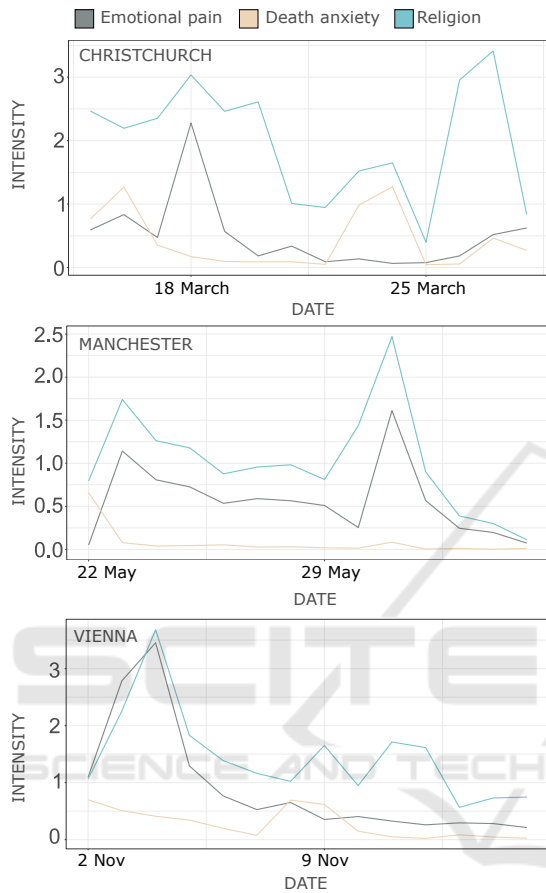

Figure 1: Intensities of emotional pain, death anxiety, and religion in each data-set.

Table 4 shows reactions to the tweets that convey death anxiety, emotional pain, and religious words. The results point to a tendency to highly retweet messages that convey emotional pain ($\mu(Christchurch) = 873.72 \pm 788.76$, $\widetilde{x}(Christchurch) = 571$; $\mu(Manchester) = 27303.87 \pm 11746.99$, $\widetilde{x}(Manchester) = 32373$; $\mu(Vienna) = 7560.01 \pm 6182.08$, $\widetilde{x}(Vienna) = 4620$) while those that convey death anxiety received substantially smaller number of retweets ($\mu(Manchester) = 28.13 \pm 39.54$, $\widetilde{x}(Manchester) = 5$; $\mu(Vienna) = 561.15 \pm 773.70$, $\widetilde{x}(Vienna) = 186$; with an exception of the Christchurch terror attack data-set). In terms of "likes", the results are inconclusive.

Next, we turn to the analysis of temporal commu-

nication networks. Three examples of daily message-exchange networks shown in Figure 2 reveal that the networks substantially change their structure over time (note that, in our analysis, once an edge is formed, it does not cease to exist but a new edge is added in each time step).[3] In order to describe the evolution of each network, we first report on the measures of momentary structure.

Figure 3 illustrates daily edge formations for each network and shows that a great majority of edges are formed in the first two days of the terror attacks we analyzed. The edge formation count sharply decreases during the immediate aftermath and only occasionally new edges are formed. This is illustrated via small spikes in Figure 3 (we point the attention to "religion" for the Christchurch and Vienna terror attacks). We also observed a substantially higher volume of edges formed in the religion-related networks throughout the data-extraction period for all terror attacks in our study. For example, the Manchester terror attack counts between 130 and 160 edges for the exchange of emotional pain and death anxiety and over 340 edges for messages that convey positivity and religious words (which corresponds to an increase of approx. 100%).

We also measured dyad density. The results indicate that for all possible dyads, the fraction of time they are tied is relatively low in all networks (see Figure 4). For example, if we randomly select a pair of nodes from the network representing emotional pain (Vienna), there is only about 5 in 10,000 chance that the pair will be connected by an active edge. However, one pattern still emerges across all terror attacks we analyzed – the dyad duration of all networks representing religion (positivity) is higher than the dyad duration in emotional pain and death anxiety networks.

5 DISCUSSION

Our study on the evolution of messages expressing emotional pain, death anxiety, and positivity brings forth some interesting insights into human (online) behavior during terror attacks. While our focus was on the personal reactions to the terror attacks, we observed a high dominance of positive messages related to the use of religious words throughout the data extraction period. We found that all personal narratives initially show a sudden surge in a message volume, which is in line with the findings presented in (Simon

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[3]Our animated networks are available at https://nm.wu.ac.at/nm/Complexis22-supplemental.

Table 4: User reactions to tweets conveying emotional pain, death anxiety, and religion.

Event	RETWEETS			LIKES		
	Mean	Median	Max	Mean	Median	Max
EMOTIONAL PAIN						
Christchurch	873.72±788.76	571	1918	3.35±119.2	0	9590
Manchester	27303.87±11746.99	32373	32373	1.22±140.55	0	23247
Vienna	7560.01±6182.08	4620	13752	7.50087±745.73	0	114013
DEATH ANXIETY						
Christchurch	1839.74±1804.45	1770	4654	2.28±83.91	0	6842
Manchester	28.13±39.54	5	127	2.14±20.84	0	614
Vienna	561.15±773.70	186	2008	4.67±81.20	0	3918
RELIGION						
Christchurch	1123.84±1617.37	314	4731	3.57±183.00	0	31906
Manchester	24729.12±13621.65	32373	32373	1.17±133.70	0	23247
Vienna	1092.27±1836.44	120	4636	5.97±312.28	0	40771

a) Emotional pain (Christchurch)

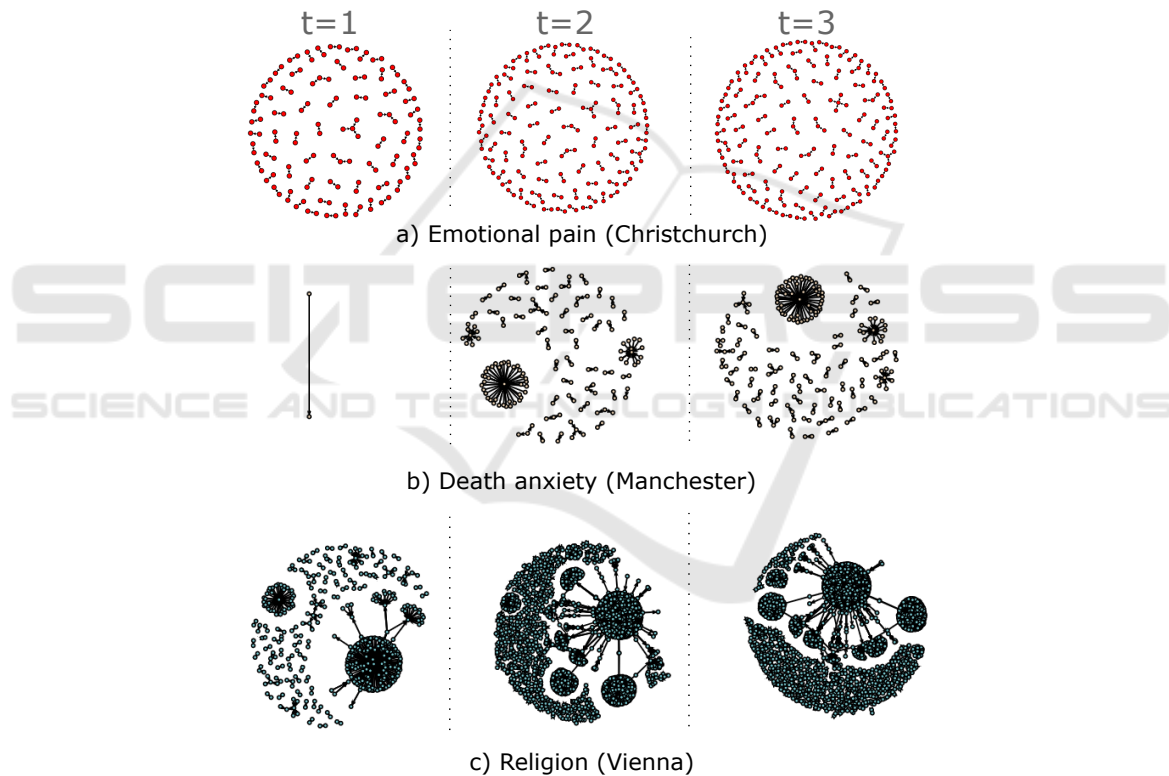b) Death anxiety (Manchester)

c) Religion (Vienna)

Figure 2: Examples of daily message exchange networks that convey emotional pain, death anxiety, and religion sent during the first three days of the Christchurch terror attack, Manchester terror attack, and Vienna terror attack, respectively.

et al., 2014). While the majority of previous studies focused on the informative role of Twitter during terror attacks, we focused on the personal emotional responses to the terror attack. In contrast to our prior assumption that death anxiety and emotional pain will be dominant in the acute phase of the terror attack, our data points to an immediate surge in messages that convey positivity. To explain this observation, we refer to (Steensen, 2018) who showed that the messages of prayer emerge already a few hours after the news of a terror attack have reached the audience. These messages often contain a #prayfor hashtag (followed by a name of a country or a city affected by a terror attack, e.g., #prayforparis). This clearly points to a human tendency to show resilience against the otherwise disruptive effects of a terror attack and engage in a pro-social behavior while expressing empathy, hope, and well-wishes.
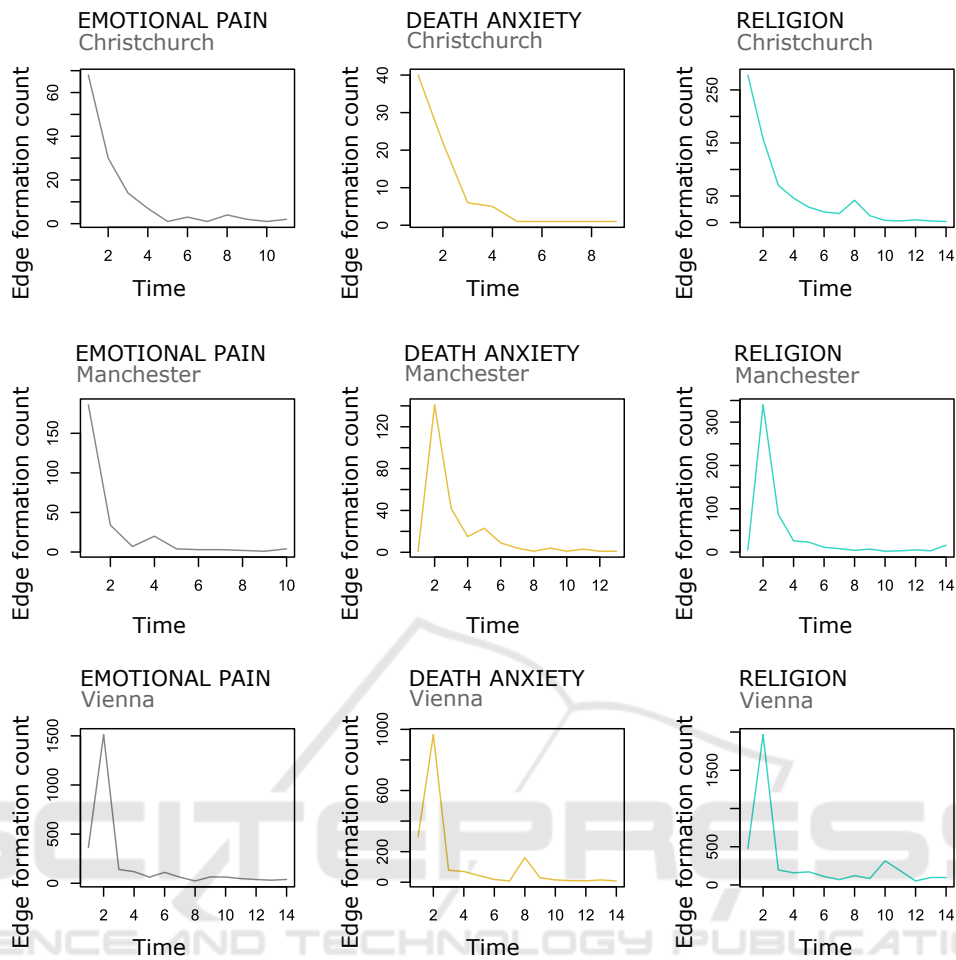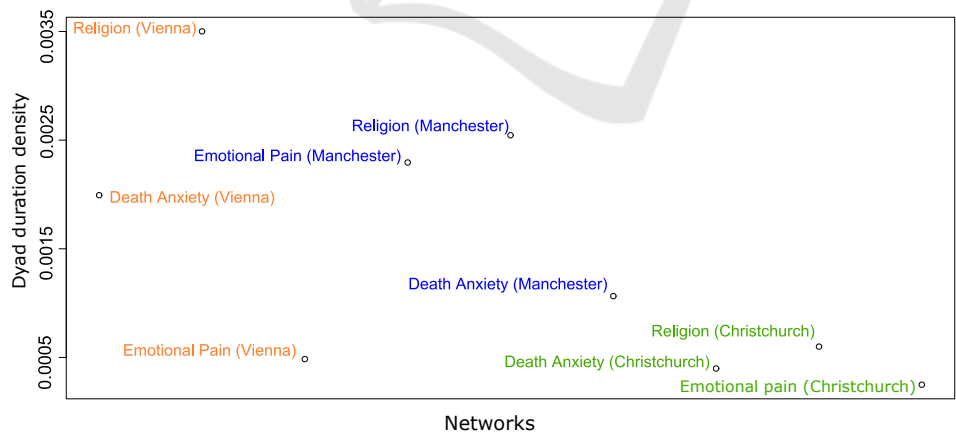
Figure 3: Edge formation.

Figure 4: Dyad duration. The networks are grouped according to the event of study (Vienna terror attack in orange, Manchester terror attack in blue, Christchurch terror attack in green alongside x-axis).

These findings are in line with the Terror Management Theory's basic premise, which points to a human tendency to focus on a positive worldview as a shield against the fear of death (Greenberg et al., 1986). We examined a 3% random sample of tweets (excluding retweets) for each personal response and each terror attack[4] to get further insights into the

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[4]In total, we manually inspected 261 messages related

content associated with emotional pain, death anxiety, and positivity associated with the use of religious words.

The **emotional pain** category predominantly included messages of condolences (92%). This category also conveyed a smaller amount of messages of intense anger (2.5%), e.g., *"I'm BREWING OVER with anger at THIS evil loser. #ManchesterArena"*, *"What a cruel and evil cu*t this Brenton Tarrant is hope you rot in hell you vile evil cunt"*, *"Jesus fu**ing christ, I'm so unbearably fu**ing sad and angry."*, *"I hope the perpetrators are caught alive, these deranged scum disgust me. #PrayforVienna #fu*kterrorism"* and annoyance (1%), e.g., *"I think by equating #Brexit and #Christchurch attack you have reached a new low"* and *"Anyone who sends private videos of terror, suffering and death to [magazine name] to grab a few euros should be struck by lightning"*.

To a lesser amount (1.5%), values such as the role of "love" to "silence hate" or describing terror as a "cowardly act" that destroys lives and "violates our human values", were also a theme of the messages in the emotional pain category. Such messages that convey values indirectly also communicate a messages of togetherness. (Ezzati, 2021) showed that values serve as means to unite those affected by the terror attack. While the purpose of such messages is to dissociate religious groups from the perpetrator, we found that our examples do not explicitly refer to any specific religious group or ethnicity but rather generally refer to human values as means for hoping for a better future – *"War may be loud and strong - I hope we can be louder and stronger. For the peace. Together - no matter who and from where."*

However, distancing oneself from the perpetrators was conveyed in responses to islamophobic tweets. We label such tweets as messages of counter-bigotry (1%), e.g., *"As a Muslim I feel double pain, (1) for the lose of innocent people, (2) coz terrorists kill using the name of Islam. #ManchesterArena"*.

In total, 2% of the messages in the emotional pain category were misclassified, for example: *"#ManchesterStrong I would hope that politicians have respect enough to not use the tragic events to launch scatching attacks at each other."*, *"The obnoxious [anonymized] has made a glorifying video about the Islamist attack in Vienna. I ask everyone to report the video on YouTube and rate it negatively! #vienna #terror #islam #attack"*.

Our second type of a personal response to terror attacks, **death anxiety**, was largely conveyed in

to religion, 101 related to death anxiety, and 299 related to emotional pain, equally distributed over each terror attack.

messages of condemnation and detestation against the perpetrators followed by well-wishing to those affected (78%), e.g.:

- *"Unhuman act of terror(IS)m hits Manchester, my thoughts and feelings go out to the ones who died #manchester"*
- *"Another senseless tragedy for a pointless 'war'. My heart hurts too much to sleep."*
- *"This is one of the most disgustingly disturbing mass shooting footage I've ever seen. Sick. Burning him alive would do him no justice. #prayforchristchurch"*

However, we also found messages that express concern for the lives of the ones directly affected by a terror attack (9%), e.g.:

- *"I can only think of #Paris #Nice #Kabul #Vienna all the victims of the #terrorist attack."*
- *"I hope that no one else has to die out there from these terrorists who are still walking around freely."*

Death anxiety was also associated with a reminder of previous terror attacks (8%), e.g., *"I am reminded today of the awful feeling when I learned that a terrorist had killed dozens of my people at night"*, and *"Horrifying visuals and chilling reminder of Mumbai"*. Such a reference to other acts of violence is commonly found in various reports on human responses to terror attacks and, as pointed in (Eriksson, 2016), is used to put the current terror attack in a context of a growing trend of violence. Moreover, we also found that the three terror attacks studied in this paper brought memories of other terror attacks which further points to the universal fear of death regardless of one's temporal, social, or geographical proximity to the event.

In the category "death anxiety", we also found instances of islamophobic tweets (3.5%) that convey anger and convey a lack of tolerance towards specific religious groups. For example, *"When I think of Vienna I see architecture and culture. When Muslims think of Vienna they see murder and terrorism. Islam is a cancer on Europe. Outlaw it now. Banish them all. Their teachings tell them to kill us. Their books guide them into terror #islamiscancer"*, *"One after another terror attacks r happening in world I don't know when will dis sought of mentality will end these radicalised islamics r still living in previous centuries they r not getting that dis is 21st century u can't get power by killing people #ViennaTerrorAttack"*. Islamophobic tweets were shown to be a common narrative in the aftermath of terror attacks, especially when the perpetrator(s) were identified as members of the Islamic religion (see, e.g., (Awan, 2014;

Hardy and Miller, 2022)). Islamophobia is seen as a prejudice against Muslims with a goal to cause hostility and provoke feelings of intolerance (Awan, 2014). As pointed out in (Hardy and Miller, 2022), islamophobic tweets can be regarded as a form of blaming, which commonly emerges in the aftermath of terror attacks and serves as a mechanism to regain a psychological control over the highly emotional situation (Flynn, 1997).

The remaining messages (1.5%) conveyed disbelief and a shift in one's worldview. Messages such as *"I never thought that this would happen. Vienna is one of the best places in the world. I always felt so good there - far away from all the war and terror. Now it's over. Wtf is wrong with this world."* are in line with the goal of terrorists to destabilize our worldview (see (Miller and Landau, 2005)) and an expected reaction to the terror attack by those affected.

Other tweets in the sub-category of "death anxiety" included feelings of pain as a result of hearing about people dying (*"each massacre and terrorist attack kills a tiny piece of me... maybe all of us?... no words are adequate."*, *"I cannot begin to image how one deals with ones child being killed by a terrorist. #ManchesterBombing #ManchesterArena"*), as well as glorification of human values (*"Whoever kills an innocent life it is as if he has killed all of humanity.."*), and a critique to human behavior during the acute phase of the terror attack (*"With all the videos of the #terrorist attack in #Vienna, I wonder how people manage to keep their smartphones steady while people are being shot in front of their eyes."*).

We found that a great majority of tweets related to **positivity** were messages that convey prayers that express well-wishing and sympathies (86.59%), e.g, *"I'm praying for everyone in Manchester! #staystrongmanchester"*, *"All my prayers and sympathies are with those who have lost their precious lives and are in the hospitals. #newzealandterroristattack"*.

Some of the prayers conveyed calls for peace, togetherness, and unity, e.g.:

- '*I pray for the victims and their families. Enough violence! Let us together strengthen peace and fraternity. Only love can silence hate. #viennaterrorrattack"*,

- *"Whether you agree with people religious beliefs or not, we should love them equally. My heart goes out to the victims' families. #christchurch"*,

- *"Murdering people - and supposedly in the name of God: unbearable. Terrorism knows no religion. Together we are stronger than hate and terror. #viennaATTACK"*.

These findings are in line with (Steensen, 2018), who found that the messages of empathy and love dominated a discourse even two weeks since the 2011 Norway terror attack occurred.

Among the remaining 13.41% tweets in this category, some instances called for (symbolic) action, e.g., *"Let our memory of the victims remind us of the dignity of every human being, which we will defend together. I invite you to attend a nationwide minute of silence at 12 p.m. #viennaterrorattack"*, while some tweets glorified diversity and acceptance towards those of a different culture or religion, e.g., "*Edinburgh Central Mosque. Crowds gathering in solidarity with #christchurch. So glad I came. Such diversity here.*", "*I hugged my neighbors this morning! They are Muslim, and the best family I've ever met!*".

Other messages expressed counter-bigotry, e.g.:

- *"I'm beyond proud of my lil sis and her friends at their first protest against islamophobia! The youth are so powerful."*

- "*I will forever fight against antisemitism, any kinda of segregation isn't okay, we all should be against hate crime. violence is never the answer, today i sadly came across some ppl being extremely racist and islamophobic under the #ViennaAttack hashtag*"

Approximately 3% of tweets were misclassified. For example, messages such as "*I hope you rot in hell*", "*No innocent person deserves to die from a flawed ideology.*", and "*You going to the gig to enjoy yourself and create beautiful memories. Not to die.*" were classified as messages that predominantly convey positivity, but instead they are of a predominantly negative affect.

Limitations. Even though we conducted a focused data extraction and monitored Twitter to select appropriate key terms and hashtags to fetch tweets, we cannot exclude the possibility that we missed some relevant tweets. Moreover, social bots and their role in social networks is still of a great concern among the researchers. While our data-set on the Vienna terror attack excludes bots (based on Botometer score ≥ 0.8), we did not process the remaining two terror attacks data-sets to identify and exclude social bots due to the large number of screennames. We acknowledge this as a limitation as our results might be affected by the influence of bots to a certain degree. Finally, our computational method to detect death anxiety, emotional pain, and positive messages associated with the use of religious words is solely based on LIWC and its internal lexicon. Though we manually inspected a random sample of tweets and their corresponding scores

assigned by LIWC during the pre-processing phase of our research method, we still identified tweets that were misclassified.

6 CONCLUSION

In this paper, we analyzed a data-set consisting over 3.8 million tweets related to three terror attacks (the 2017 Manchester terror attack, the 2019 Christchurch terror attack, and the 2020 Vienna terror attack). Our goal was to examine the temporal evolution of three types of personal responses to the terror attacks – death anxiety, emotional pain, and words of positivity associated with the use of religious words. To analyze our tweets and detect the level of emotional pain, fear of death, and positivity, we used the Linguistic Inquiry and Word Count (LIWC) tool for English and German language.

Our findings clearly indicate the prominent role of positive religion-related messages that convey empathy and well-wishing. We showed that not only do such messages dominate over the messages of death anxiety and emotional pain, but they are disseminated with a higher frequency over Twitter (via retweeting), and discussed in a substantially higher rate than their counterparts. Given such a difference in the underlying communication networks, we subsequently examined the measures of momentary structure and showed that a duration of dyads in the religion/positivity-related networks is comparatively higher than the remaining networks in all terror attacks that we analyzed.

In our future work we plan to further investigate the temporal dynamics of specific narratives that emerge during different types of crisis events. Moreover, in our previous studies we showed that the networks resulting from the exchange of messages that convey basic emotions, exhibited substantial differences in their underlying structures. Along these lines, it would be interesting to expand our work to the underlying structure and a dynamic evolution of narratives.

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