

Role of Cultural Scripts in Public Mass Killings: Empirical Observations & Simulations of two School Shooting and a White Supremacy Terror Contagions

Timothy Clancy*, K.J. Oviatt, Valeria Stephens

*Corresponding Author: tmc@dialecticsims.com or 678-576-4786

Abstract:

In this paper, we continue the study of the terror contagion hypothesis, which proposes that violent radicalization leading to public mass killings operates as a social contagion spread through the transmission of cultural scripts through a high-risk population. Cultural scripts determine not only what content is spread (found in template ideology and template method), but also the extent to which they spread based on how well-suited a contagion is to reaching a high-risk population (template attractiveness). We combine the preliminary collection of records for public mass killings suspected to be contagion incidents with computer simulation to study three terror contagions: Columbine style school shootings, Virginia Polytechnical Institute style shootings, and Great White Replacement Theory attacks. We demonstrate our computer simulation can accurately reproduce the historical behavior of these contagions from initial conditions. Our findings include empirical evidence of cultural script transmission as well as experimentation through the simulation of counterfactual scenarios to demonstrate how changes to these cultural scripts change the outcomes of the contagion. These experimental findings connect theory to empirical data, introduce the utilization of a systems sciences perspective relying on computer simulations and calculus to the challenge of studying public mass violence, and set a foundation for the exploration of novel pathways for potential intervention in terror contagions by targeting the cultural scripts that spread them.

1 Introduction

Mass killings are a form of terrorism resulting in four or more fatalities, excluding the perpetrator, regardless of location, circumstance, or weapon used. In the United States, public mass killings, including acts of terrorism, school shootings, bombings and vehicular ramming, represent 19% of all mass killings between 2006-2022[1] but are the most lethal of all mass killings and drive public fears on violence. Given their very public settings, apparently unpredictable nature, and both catastrophic and lasting consequences, they often gain extensive media attention and spark fierce public debate [2, p. 31]. This has resulted in over half of Americans expressing worry about falling victim to a mass shooting [3], and at least a third reporting avoidance of public spaces out of fear of being attacked [4]. Similar concerns have occurred in the aftermath of public mass killings in countries as far apart as Brazil, Germany, Norway and New Zealand also grapple with public mass killings.

Our evidence suggests between 62-72% of all public mass killing fatalities in the United States from 2006-2022, as listed in both the Mass Killing[2] and Violence Project databases[5], were caused by so-called "terror contagions." Terror contagions, described more fully in Section 2, are a form of social contagion that spreads a particular template ideology, such as xenophobia or misogynistic beliefs, and template method describing how to conduct public mass killings such as school shootings, or attacks on centers of worship. Between 2006-2022, 135 suspected terror contagion incidents accounted for 610 fatalities and 1748 injuries across both completed and thwarted attempts[1]. Although massive in impact, these were caused by only a handful of contagions. Thus, correctly identifying specific terror contagions and the dynamics by which they spread provides a crucial means to target interventions and have meaningful impact in violence reduction efforts.

In our previous work on the terror contagion hypothesis, we used a simulation to identify some of those dynamics in a generic, abstracted, terror contagion. In this paper, we advance that work by focusing on cultural

scripts that help spread a contagion through template attractiveness as well as determine what is spread through template ideology and template method. We shift from theoretical to empirical collecting data on suspected terror contagion incidents in the historical record from around the globe. We begin by providing background on both the terror contagion hypothesis and our terror contagion simulation (TCS). We then describe our method of data collection and how that informs the initial settings for our contagion simulation. Next, we demonstrate the ability of the TCS to accurately reproduce the behaviors of Columbine Style Shooting, Virginia Polytechnic style shooting, and the Great White Replacement Theory style attack contagions. We accomplish this first by building confidence in these simulated historical recreations, sharing forecast accuracy, measures including MAE, MSE, and Thiel's Inequality Statistics decomposing MSE. This examination of our ability to simulate the historical record builds confidence for when we conduct simulated counterfactual experiments in the next sections of counterfactuals. Our findings follow – one section per contagion. In each contagion findings, we present the historical quantitative summary of the terror contagion, qualitative descriptions of each contagions seed event, template ideology, template method, and how it conveyed template attractiveness through self-similarity, notoriety, and coherence. We also present selected evidence of cultural script transmission from each contagion. We conclude each findings section with a simulated experiment, exploring counterfactuals related to cultural script transmission of template attractiveness, method, and ideology. After the findings, we present a discussion on their implications toward reducing violence and on the use of simulation science to study terror contagions and public mass killings before presenting our conclusion.

2 Terror Contagion Hypothesis

There is strong disagreement in the literature over whether evidence of replicated elements in public mass killings incidents are motivated by a perpetrator's desire to pay tribute to past perpetrators through imitation or if they suggest the spread of violent social contagions arising from the transmission of ideologically grounded cultural ideas, which we call cultural scripts. These differences can be distilled into three types: First, the imitation-centric perspective argues that there is no contagion, or that any contagion influence is minimal. Alternatively, there is a traditional, contagion-centric perspective to studying public mass killings, does so through the lens of existing research on social contagions. Both of these rely on the traditional tools of sociology, criminology, and statistics, and have struggled to find evidence of contagion effects [6], [7] in mass killings. Our perspective, the third, arising from a systems science approach, and relying on computer simulations and calculus, suggests a complex, dynamic system of violent radicalization where, under certain conditions, a terror contagion as a specific form of public mass killing emerges [8],[9]. Not only are these terror contagions are both a distinct type of public mass killings but different among one another. Possessing characteristics that are difficult to identify using the imitation-centric or traditional contagion-centric methods. Both the second and third perspectives utilize contagion theory, enabling the inclusion of well-established forms of social contagion theory into their construction, such as the well-accepted research centered on the media reporting of celebrity suicides and how it can increase the risk of copycat suicides (the Werther effect) or decrease it (the Papageno effect)[10, p. 34].

2.1 Dynamics of a Terror Contagion

Terror contagions begin with a seed event. This seed event is a public mass killing with high enough media coverage to spawn a contagion. This publicity is usually generated by the high number of fatalities (often 10+), or the particular optics of the attack, but often both[6]. This strong public attention sparks a contagion as depicted in a simplified system-structure form, Figure 1.

For the contagion to spread past the initial seed event, cultural scripts must convey both a template method and a template ideology suitable for social contagion (Figure 1, A). This combined template exploits an existing set of circumstances consisting of grievances; moral outrage; and social cultural factors (Figure 1, B) creating a high-risk population (Figure 1, C).

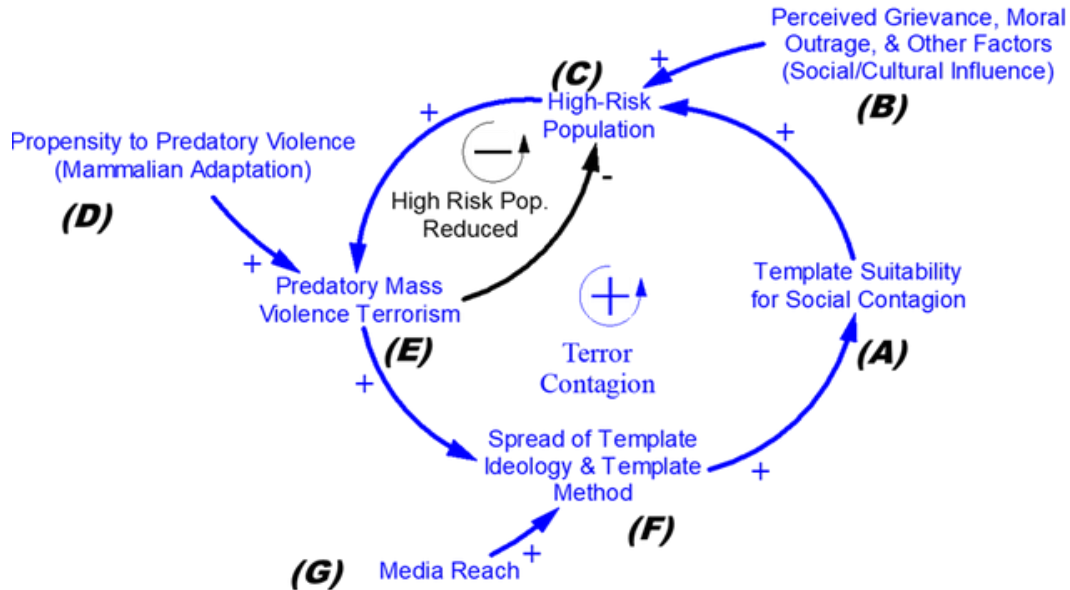


Figure 1: Terror Contagion Hypothesis

The high-risk population possesses a prevalence of risk factors indicating they are at higher risk of committing mass violence. Suitability for contagion within this high-risk population is determined by similarity bias, notoriety bias, and coherence of templates. Similarity bias means that members of the high-risk population see themselves in the perpetrator, including (but not limited to) sharing physical markings of age, race, gender, social, or circumstantial characteristics, or even a shared grievance. Notoriety bias is the opposite of celebrity bias – it is the degree of infamy the high-risk population views the perpetrator with. Coherence describes the clarity of the cultural scripts spreading the template ideology and method. The templates initiate a radicalization process, activating an existing mammalian adaptation for predatory violence (Figure 1, D). Predatory violence is an evolutionary adaptation for sustained, cognitively intensive violence, such as endurance hunting[7]. Perpetrators following template methods conduct public mass killings in specific ways with target location, equipment, and means of attack determined largely by the received template (Figure 1, E). If a replication of the template method generates enough fatalities, resulting public attention, this will further disseminate cultural scripts re-communicating the template ideology and methods (Figure 1, E) to the extent of media reach (Figure 1, G). Media here is a broad designation including traditional news media as well as dissemination through individuals interacting across the internet through social media, content platforms, messaging services and online gaming spaces. The spread of cultural scripts sets the conditions for subsequent replication by individuals adopting the template ideology and pursuing the template method, allowing the terror contagion to become self-perpetuating (Figure 1, A)[6].

From our past research using computer simulations and system structure analysis, we identified a set of contingencies necessary for a contagion to form and sustain itself [6] as well as characteristics of contagions [8]

summarized in Table 1. These contingencies are the factors that determine the strength and sustainability of a specific terror contagion; and characteristics are common across all terror contagions.

Table 1: Contingencies and Characteristics of the Terror Contagion Hypothesis

Contingencies Determining whether a Contagion will form and its Strength	Characteristics
Seed events require broadcast of both template ideology AND template method.	Terror contagions are global in nature.
High-risk populations can be small: 360-3000 is sufficient.	Terror contagions have coherent, identifiable profiles that define them, consisting of template ideologies and template methods.
Seed event fatality rates must be 10+.	Contagions form on received cultural scripts rather than intended ones.
Average fatality rates: 10-12+ fatalities	Among the high-risk population perceived self-similarity, the notoriety of the seed event's perpetrators, and the coherence of their communications regarding template ideology and template method are more important for contagion than a template's practical lethality.
Pathway to Violence Success Rates: >40%	A template method must be sufficiently simple to replicate.
Out the Door Success Rates: >60%	Methods cross-over from one template to the next may occur due to temporal proximity.

3 Terror Contagion Simulation (TCS)

Our method of studying the impact of cultural scripts involves an existing peer-reviewed model, the terror contagion simulation (TCS). This simulation was designed to study the terror contagion hypothesis and meets DIME-PMESII military standards for simulations[9, p. 8]. The original publications includes complete model documentation and discussion[6],[10]. In overview, the terror contagion simulation models a single high-risk population and its internal network dynamics within larger societal dynamics. At the beginning of the simulation, this high-risk population supports no violent ideology nor does it employ a template method of public mass killing. If they commit violence, it is indistinguishable from normal homicidal crime and results in 1 fatality. The simulation initiates with a seed event. The seed event is a single contagion incident – a terrorist attack communicating template ideology and a template method. Each terror contagion has its own specific seed event that sparks the replication which follows.

The simulation runs for ten years to explore the terror contagions that can spawn from this seed event. Each simulation imports a file of contagion settings to initialize key values. Contagion settings consists of the initial stock and parameter values of either a generic or researched violent ideology, including success rates and average fatality rates of template methods, factors related to the high-risk population, and the extent to which this violent ideology is or is not supported by non-state actors operating in a safe haven. Contagion settings also contain policy response options activated as switches to test policy responses against a specific violent ideology. In this paper, we limit the contagion settings to the following elements: 1) Seed Event Time; 2)Seed Event Fatalities; 3)Out the Door Success Rate; 4) After Seed Event Average Template Fatalities; 5)After Seed Event Standard Deviation of Template Fatalities; 6) After Seed Event Minimum Fatalities of a Completed Event; 7)After Seed Event Maximum Fatalities of a Completed Event; 8)Pathway to Violence Success Rate.

On the final item, Pathway to Violence, this is the success rate with which a perpetrator conducts their planning and preparations to the point they can start an incident by going “out the door”, at which point the OTD success rate is used. In prior research we identified four common behavior modes reflective of a pathway to violence success rate described as follows. Equilibrium (EQ) = NA as there is no Seed Event and thus no Contagion. Failure to Grow (F2G) = 10%. Struggle to Grow (S2G) = 20%. Contagion (CONT) = 50%. Strong Contagion (CONT+) = 100%.

Figure 2 depicts an aggregate view of the Terror Contagion Simulation “core model,” which contains five systems levels: Incidents (1), Agents (2), Networks & Actors (3), System of Spaces (4), and System of Systems (5). Each level represents one layer of the system's structure within which key dynamics occur. The arrows in Figure 2 represent the upwards and downwards causation of these causal influences crossing between system layers. Excluded from this depiction for clarity are modules containing model documentation, model values, and testing structure.

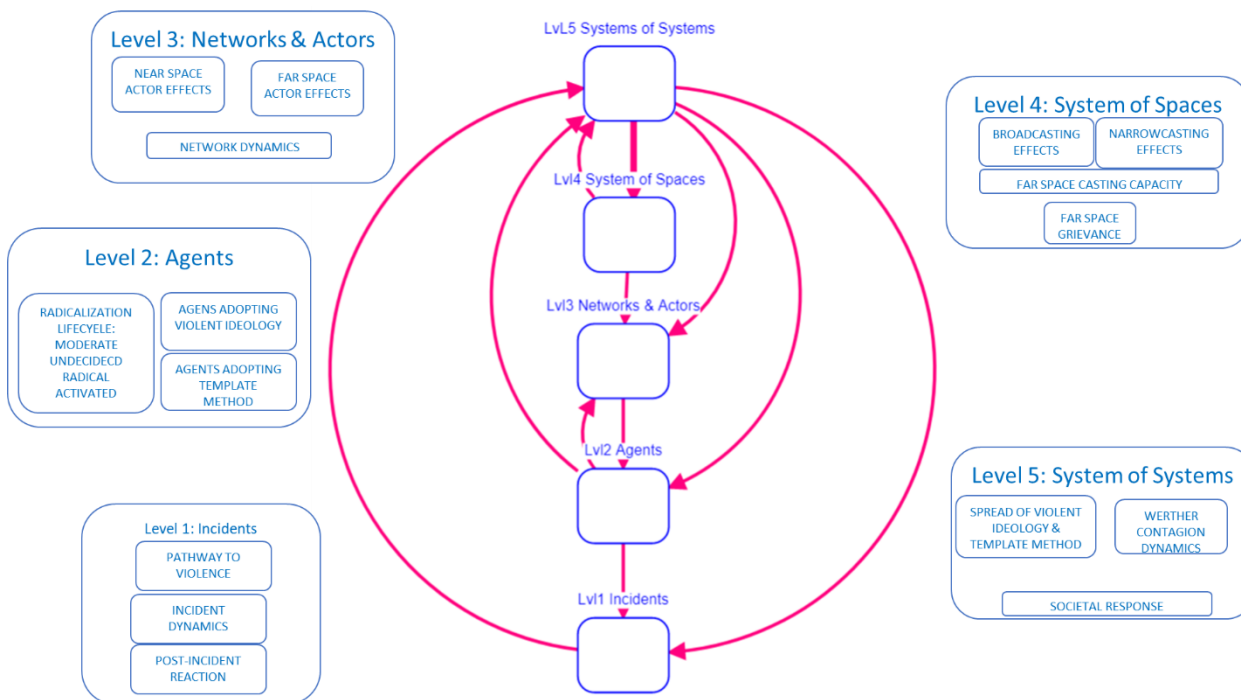


Figure 2 Overview System Structure Levels & Sectors of Terror Contagion Hypothesis Model

The four baseline runs of the simulation include equilibrium (EQ), failure to grow (F2G), struggle to grow (S2G), contagion (CONT), and strong contagion (CONT+) manifestations.

The simulation continuously calculates changes in radicalization at the individual and societal levels. We model terror incidents within the simulation as discrete events using five stochastic random number generators (RNG). To ensure any results we see are not the outcome of a particular RNG sequence, we vary the RNGs of terror incidents to create 1,000 permutations of each baseline run. (See Volume II: Terror Contagion Hypothesis & Simulation Supplementary Materials for more discussion on this stochastically discrete formulation.)

Table 2 displays the statistical means and ranges of base runs numbered contagion incidents from our initial research using generic contagion settings[6]. Although any incident can broadcast a template ideology or employ a template method, only when they occur together is that counted as a contagion incident.

Table 2. Contagion Incidents in Base Runs across 1,000 Permutations

Policy #	Parameter Tested	Baseline Tested	# of Runs	Behavior Mode-->	EQ	F2G (Failure to Grow)	S2G (Struggle to Grow)	CONT (Contagion)	CONT+ (Strong Contagion)
0	BASELINE	CONT	1,000	Mean		3.2	27.7	259.8	704.8
				Range	0	0-32	0-105	57-372	469-806

The table reads left to right, demonstrating the mean range of terror contagion incidents in each baseline behavior mode from smallest to largest.

In Equilibrium (EQ), there is no seed event. No violent ideology or template method spreads across the high-risk population. Although there may be normal crime levels, there are no terror incidents.

In the Failure to Grow (F2G), there is a range of zero to 32 incidents with an average of 3.2. F2G reflects terror contagions with a seed event that failed to provoke a strong contagion. Reasons may include a small susceptible high-risk population with self-similarity to the perpetrator. Alternatively, cultural scripts of the ideology and template may be too hard to understand to replicate indicating low coherence[6].

In Struggle to Grow (S2G), there is a range of zero to 105 incidents and, on average, 27.7 over the 10-year simulation. An S2G is the abstracted representation of a brief terror contagion that fails to sustain over time, such as the wave of vehicular terrorism by ISIS supporters in Europe in 2017[11].

In the contagion baseline (CONT), contagion incidents jump to a range of 57-372, with an average of 259.8 incidents over ten years. The CONT represents an abstracted recognizable terror contagions initiated by singular seed events that have served as patterns for replication.

A strong contagion (CONT+) is the baseline behavior when conditions are ideal for a terror contagion. CONT+ is significantly worse than CONT, with a range of 469-806 incidents and an average of 704. Incidents. Over time, these levels of sustained violence indicate mass instability and may represent a nascent insurgency or violent separatist movement.

Visual inspection of Template Ideology and Method adoption rates also distinguish behavior modes, such as F2G versus EQ or certain S2G versus CONT cases. The steeper the rate of adoption, the more severe a contagion. CONT+ has a hockey-stick adoption rate to reach the limit of the population, while CONT and S2G both have an S-shaped growth. CONT and S2G are distinguishable by the time delay to complete the s-curve pattern. F2G shows an increasing concave behavior but never materializes into an S-Shaped pattern before the end of the simulation[6, p. 14].

3.1 Level 5 System of Systems Overview

Of particular focus in this paper is TCS Level 5: System of Systems, depicted in Figure 3, within which the abstracted level of dynamics occurring at macro levels on cultural scripts occurs. This is where the Terror Contagion dynamics occur, and individual cultural scripts are coarse-grained into coherent Template Method and Template Ideology which the high-risk population can then adopt in Level 2

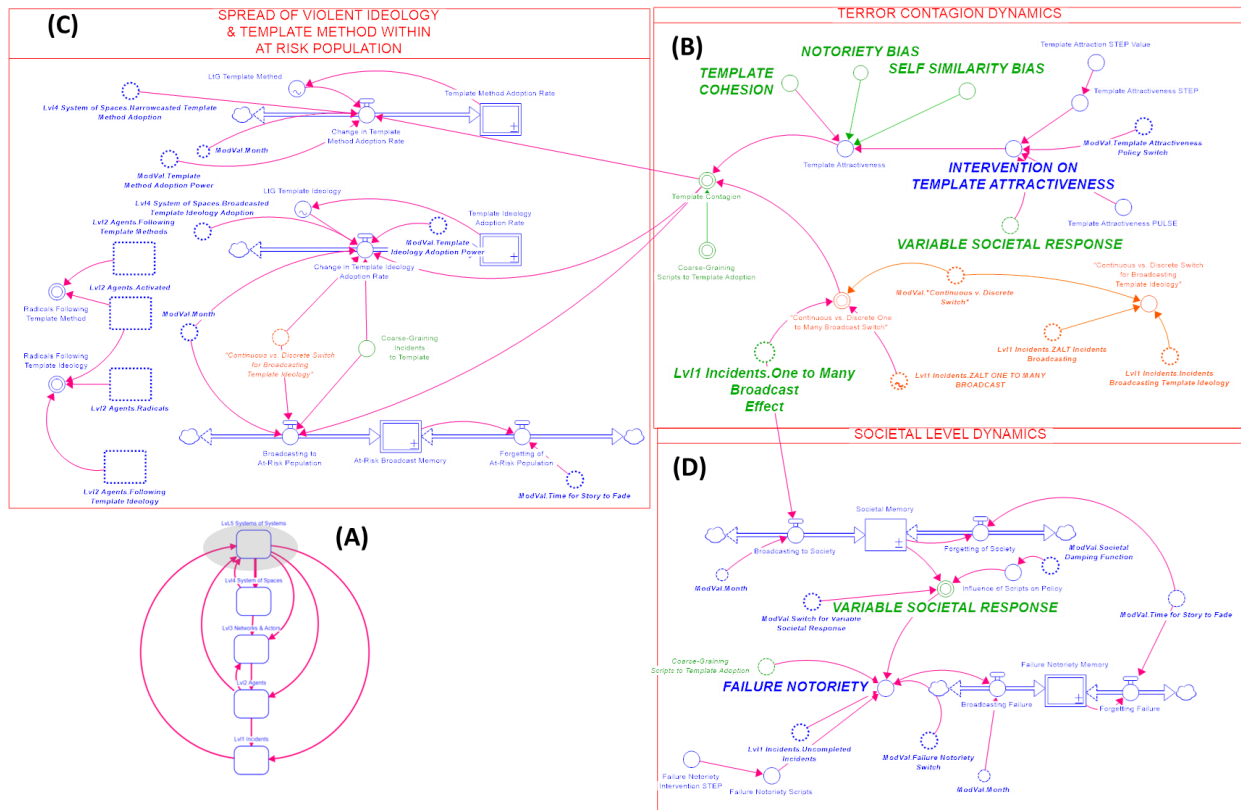


Figure 3: TCS Level 5 System of Systems Overview. (A) Location of Module in TCS; (B) Contagion Dynamics Sector; (C) Spread of Contagion Sector; (D) Societal Dynamics Sector.

There are three sectors in this model. Terror contagion dynamics (Figure 3, B); the spread of the contagion through a specific high-risk population (Figure 3, C); and societal level dynamics in response to the contagion outside that high-risk population (Figure 3, C). The modules as depicted include policy intervention structure, model testing structure, and links to other parts of the model. (See Supplementary Materials for full descriptions.)

3.2 Cultural Scripts: Template Attractiveness (How Spread) and Template Ideology & Template Method (What is Spread)

Focusing in on the relevant structure and hiding the rest results in the simplified two sectors displayed in Figure 4. The terror contagion sector Figure 4(right) receives the One-to-Many Broadcast effect of Level 1 and transmits the cultural scripts broadcasted to the high-risk population. Note that the more fatalities a terrorist incident generates, the greater the power of the One-to-Many Broadcast will be in this sector; expressed in units of cultural scripts.

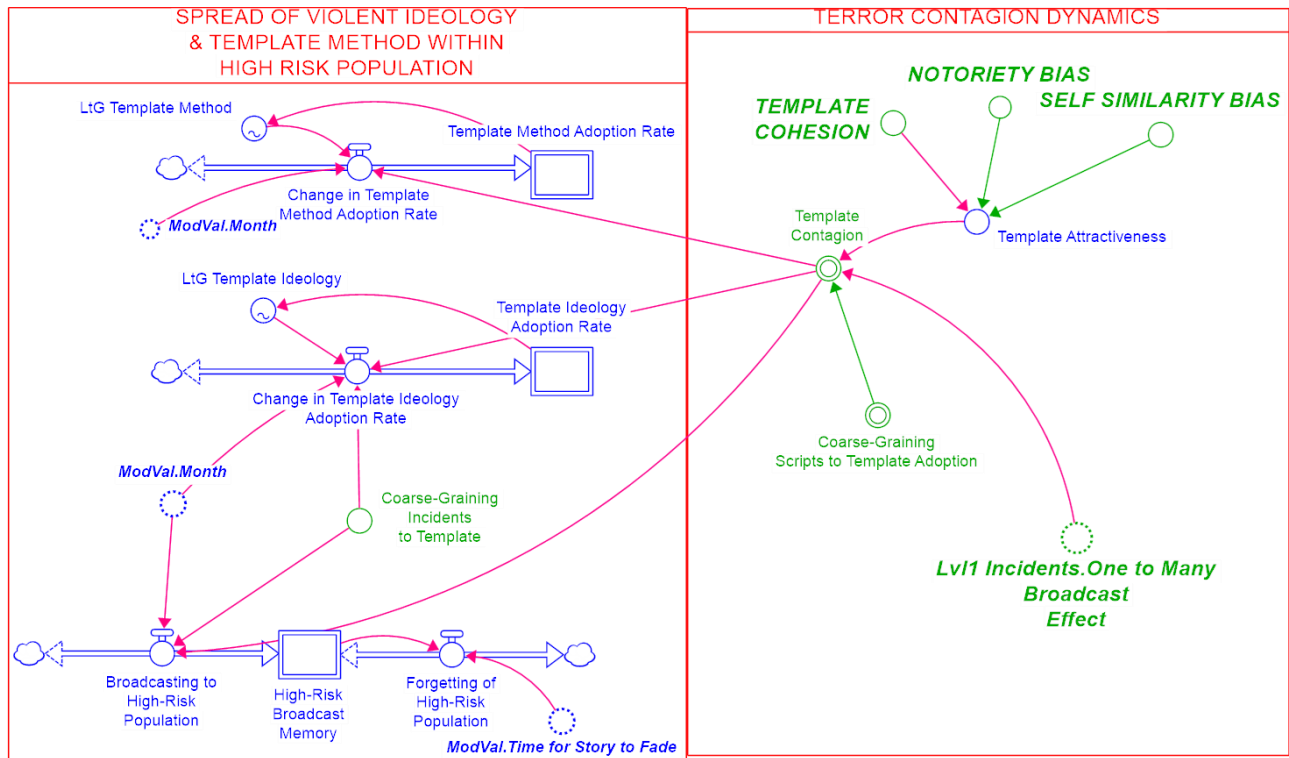


Figure 4: Focus on Terror Contagion Dynamics (Right) and Spread of Contagion through High-Risk Population (Left) Sectors.

The One-to-Many Broadcast is filtered by the Template Attractiveness which is a multiplicative function of Notoriety Bias, Self-Similarity Bias, and Template Cohesion[8] resulting in a range of 0-1. A Template Attractiveness value of 1 indicates that 100% of the high-risk population will find the Template attractive. This determines how much of the power of the media broadcast filters through and is received to the high-risk populations Broadcast Memory in the next sector.

In the spread of contagion through high-risk population sector Figure 4(left) broadcast memory represents the stored media dissemination of these aggregated of cultural scripts from a mass-violent incident received by the high-risk population with a natural rate of forgetting. Broadcast Memory is crucial for fueling Perceived Grievance & Moral Outrage in Level 3 by sensationalizing what may be a fringe grievance into a mass-media story. Such coverage magnifies the Urge to Radicalize within the high-risk population, drawing more Moderates and Undecided into the Radicalized population stock in Level 2, within which some will adopt the Template Method and Template Ideology. The rates of those adoptions are also determined in Level 5. Based on its attractiveness, Template Contagion fuel Template Method Adoption and Template Ideology Adoption rates that range between 0 and 100%. Template Ideology Adoption Rate determines how many people of the high-risk population who become generally radicalized in Level 2 adopt the specific violent ideology of the contagion. Template Method Adoption Rate determines of those radical who become activated, beginning on the pathway to violence, what % will adopt a specific Template Method. Note that activated individuals when they commit their acts of violence may or may not be following a Template Ideology or Template Method individually, combined, or neither. This is important because those using the Template Method will generate enough fatalities to power the mass-media dissemination, but it's only receivable if it also broadcasts a Template ideology. The requirement that a contagion incident must involve both a template method and template ideology

was a crucial finding of earlier research[6]. Using the template method generates the high fatalities that gain media coverage and what they broadcast are the cultural scripts of the violent ideology to the high-risk population. This broadcast then returns to Level 5, spreading anew the cultural scripts of the terror contagion in Broadcast Memory. Because Broadcast Memory has a natural rate of forgetting, a terror contagion needs repeated incidents to sustain itself over time.

Note that coarse-graining occurs at two places. Coarse-graining is an accepted practice in physics and other fields of aggregating detailed discrete values into a single aggregate value, such as averaging the speed of molecules to determine temperature. The first coarse-graining occurs as the individual cultural scripts disseminated in the One-to-Many Broadcast are aggregated into a dimensionless percentage of attractiveness for any given incident. The second coarse-graining is on the stream of those incident-denominated attractiveness into an accumulation of Broadcast Memory. This method of coarse-graining discrete to aggregated meets Flack's criteria of effective causation in that the aggregated dimensionless properties are predictive of the future state of the system; robust to small changes; system information is not 'lost' in the coarse-graining[12, p. 2].

First order control is maintained on Template Method Adoption Rate and Template Ideology Adoption Rate through the use of simplified decreasing concave graphical functions, which are included in the Supplementary Materials. Equations for the selected stock & flow diagrams above are also included in the supplementary materials. Readers interested in additional detail to this are directed to the full model documentation of TCS which includes over 200 pages of model setting, structural overviews, detailed equations, confidence building measures and a sourced glossary of terms[10].

3.2.1 *Realism versus Precision in TCS Analysis*

We intend the analysis generated from this simulation to be *realistic* even if it is not always *precise*. By *realistic*, we mean that the causal interactions within the model generate behavior modes similar to those observed historically and under plausible counterfactuals. Parameter values represent what we know from sources, modeler judgment on plausible values, or increasingly researched values from empirical data. All sectors dynamically interact, allowing for propagation of 2nd and 3rd -order effects. Not being *precise* means that the parameter values are left as they were found in evidence or estimated by prudent means. We did not attempt 'fitting' the simulation with exogenous factors that may produce slightly more accurate results but at the cost of creating inaccurate or implausible structural interactions. The goal for the model is to represent known or suspected real-world phenomena and minimize mathematical fitting which, though it may produce a more accurate result, lacks a connection between the mathematical parameter adjustment and a corresponding real-world representation of that parameter. We believe, however, that the behavior of the Terror Contagion Simulation, though an early-stage model for exploration and understanding, can realistically and plausibly behave under a wide variety of circumstances and that its utility increases as we improve our data sets.

We must also be clear on the limitations of our data, however. Although public mass killing datasets are becoming more common, this area of data collection has only begun to develop in the last 20 years. We know of no existing terror contagion data set. Likewise, terrorism is statistically rare, and data collection suffers from collection bias where incidents that completed with high fatalities are more likely to be readily accessible in the data streams of reporting than less lethal or failed incidents. With the exception of CSS, all terror contagions in our data set contain fewer than 20 identified incidents.

The only data available to assess behavior reproduction are the incidents themselves and the reported fatalities. The actual size of the high-risk population and the success rates either in the pathway to violence or the out the

door execution of an attack are impossible to discern at this moment given the survivorship bias of studying only completed attacks and the ambiguous nature of the populations supporting each contagion.

4 Method

4.1 Data Collection

We opened our process with the collection of data. In order to facilitate the exploratory nature of this series of simulations, we restricted our search to contagion incidents predominantly seeded or occurring in the United States or Western Europe (USWE), regions with which we have prior familiarity in researching radicalization and terrorism[5]. However, in keeping with the hypothesis that terror contagions are global in nature, we searched for public mass killing events containing the cultural scripts for USWE seeded events in non-USWE countries as well. Beginning with established databases such as The Violence Project[3] and The Global Terrorism Database[4], and later expanding our search more broadly to include less well-known databases and data reporting sites, we collected reported public mass killing incidents that fit our criteria for a public mass killing as defined above. We additionally sought out records of *averted*, *thwarted*, or *failed* incidents reported to have intended to kill at least 4 people. We then employed the Terror Contagion Hypothesis contingencies to identify potential terror contagion incidents, resulting in a data set of over two hundred potential terror contagion incidents (n=237) occurring between 1995-2022. These we coded into our own database, associating each with a suspected contagion by abbreviation: CSS for Columbine style shootings, VA-Tech for Virginia Polytechnic style shootings, and GWRT for The Great White Replacement Theory attacks. Incidents were numbered sequentially, beginning with zero for the seed event. Thus, CSS-0 represents the Columbine attack in 1999, while GWRT-0 represents the attack on Oslo and Utoya in Norway, 2011. Since incidents can be a member of more than one contagion, we coded some incidents in more than two records, resulting in over 250 records (n=253) in our dataset.

4.2 Initial Contagion Settings for Historical Contagions

In this paper, we used the TCS as published in prior peer review [6] with everything held constant, but the parameters discussed above in Section 3, which we initialized based on the historical data shown in Table 3.

Table 3: Simulation Contagion Settings for Initial Values

Simulation Run	ModVal. Seed Time (Month)	ModVal.Template Method Success Rate (OTD)	Seed Event Fatalities	Mean After Seed Fatalities	SD After Seed Fatalities	Random Seed	After Seed Min	After Seed Max	ModVal.Pathway to Violence Success Rate
CSS Historical	4	1	13.0	5.1	7.0	7.0	0.0	33.0	S2G 20%
VA-Tech Historical	4	100%	33.0	13.8	13.9	7.0	0.0	34.0	CONT 50%
GWRT Historical	7	84%	77.0	11.3	13.4	7.0	0.0	51.0	F2G 10%

Arrests during the pathway to violence, before any attack has even begun, do not gain much media attention and are very difficult to identify in the historical record. To account for this, we tested all four values (F2G, S2G, CONT and CONT+) and used the one wherein the simulated record of completed incidents most closely replicated the historical record, listed in Table 3. Additional settings involved setting the Template Attractiveness values as indicated in Table 4.

Table 4: Template Attractiveness Settings

Contagion	Self-Similarity	Notoriety	Coherence
CSS Historical	1	1	1
VA-Tech Historical	.5	.5	.5
GWRT Historical	1	1	1

As discussed above, these include perceived Self-Similarity, Notoriety, and Coherence. The values range from 0 to 1, representing a percentage of the high-risk population that will respond to that aspect of template attractiveness. In our exploratory model and with most contagions, these are set to 1 across the board, meaning that the entirety of the high-risk population will receive, recognize, and understand the cultural scripts. However due to the nature of the VA-Tech contagion (described in Section 6.1) these were set at .5.

4.3 Building Confidence: Historical vs. Simulated Behavior Reproduction

As part of our work involves exploring simulated counterfactual experiments, we first wished to build confidence that the simulations are capable of accurately reproducing historical behaviors. These results are presented in Table 5 by comparing the 10-year historical record of completed incidents and fatalities vs. simulated results for the three contagions. Completed incidents in the historical data are any incident where 1 or more people was injured or killed. We only compare fatalities however because our simulation does not track injuries as it does not appear to be a driving measure of media attention [6], Since simulation runs are for 10 years, the “historical record” compared against is only the first 10 years of a contagion. This is immaterial for most contagions. But for Columbine, which has a current duration of 24 years, the “historical record” only includes the 25 incidents identified in the data through 2009. The full 24-year duration of the contagion has over 75 incidents in our dataset.

Table 5: Behavior Reproduction & Forecasting Accuracy Measurements

	CSS		VA-Tech		GWRT	
	Incidents	Fatalities	Incidents	Fatalities	Incidents	Fatalities
10yr Historical Record	25.0	109.0	6.0	79.0	17.0	237.0
Simulated	19.0	155.3	6.0	112.1	19.0	344.7
MAE	0.1	0.8	0.0	0.5	0.2	2.0
MSE	0.0	1.1	0.0	1.0	0.1	6.6
U^m	0.1	0.1	0.1	0.0	0.0	0.1
U^s	0.0	0.0	0.0	0.2	0.0	0.0
U^c	0.9	0.9	0.9	0.8	1.0	0.9

For forecasting accuracy measurements our data is reported in 1-month increments over 10 years, or 120 months. Because our focus is on the long-term behavior of contagions over time we are not concerned with point-to-point accuracy month-to-month and instead used a rolling 12month average beginning in the first month of the 2nd year of the simulation. This phrases the question of confidence as: “Within a given 12month period how accurate is our simulation compared to the historical record?” From this we calculated Mean Average Error (MAE) and Means Squared Error (MSE). We then further decomposed MSE using Theil’s Inequality statistics. A prevalence of MSE attributable to U^c indicates covariance, meaning the model captures the means and the trends well, but data may different point by point[13, pp. 875–880]. Our supplemental materials include further information on these forecasting accuracy measurements.

4.4 Counterfactual Experiments

With the simulation able to reproduce historical behavior, we can run counterfactual experiments. These experiments involve holding all other parameters constant to the historical reproduction except for specifically listed parameters. By changing these parameters in isolation and comparing the resulting runs to the historical reproduction, we can demonstrate the influence of particular aspects of cultural scripts in template attractiveness, template method, or template ideology to the dynamics of a contagion. In addition to providing insights into the dynamics that drive contagions, these experiments can help identify cultural script elements that strengthen contagions, known as Werther effects, and those that dampen contagions, known as Papageno effects[14]. Computer simulation also adheres to the principle of harm-reduction in researching violence and instability. Simulated counterfactual experiments allow us to explore dangerous phenomena in realistic and plausible ways without subjecting research participants or other parties to unethical practices or potential harm either directly or indirectly.

4.5 Limitations

Our data analysis is preliminary, thus the simulations (both historical and counterfactual) that follow from it are as well. More work is needed to build confidence in our observations, including the incorporation of averted predatory mass violence incidents (i.e., those prevented by some form of intervention before a perpetrator could begin causing harm), the incorporation of incident reports from the continents currently not represented in our dataset, the development of robust inclusion and exclusion criteria for what constitutes a contagion replication, and more rigorous statistical analysis on numerically quantified contagion characteristics in a systemic way of the observations we have made above.

5 Columbine Style School Shooting (CSS) Contagion Findings

The Columbine Style School Shooting (CSS) contagion is the most well-known and frequent contagion we examined, with over 75 suspected incidents identified to date, accounting for nearly a thousand killed and wounded within it, as summarized in Table 6.

Table 6: Columbine-style School Shooting (CSS) Contagion Summary

Seed Event	# of Incidents after Seed	Casualties to Date	Time to 1st Replication Attempt	Time to 1st Intl Replication Attempt	Time to 1st Completed Attempt	Latest Suspected Contagion Incident
Columbine, CO USA April 20th, 1999 (13K 24W)	>75	395K 683W	8 Days Taber, AB, Canada	8 Days Taber, AB, Canada (5K 7W)	195 days Bad Reichenhall, BY, Germany	Izhevsk, UR, Russia (19K 23W)
Countries with Suspected Contagion Incidents (# of Suspected Incidents)						
Brazil (3), Canada (6), Finland (2), France (1), Germany (5), Mexico (1), Netherlands (1), Poland (2), Portugal (1), Russia (8), Sweden (1), UK (1), USA (44)						

The CSS contagion also popularized the popular understanding of what a public mass killing is, especially through mass-shootings targeting schools. The plot of the actual historically observed seed event and subsequent incidents in our data set against the simulated run is included in the supplementary materials.

5.1 CSS Contagion Profile

Seed Event: The seed event for this contagion was the Columbine Highschool public mass killing in Littleton, CO United States on April 20th, 1999. Two perpetrators attacked a single target, their own high school, killing 13 and wounding 24. The attack lasted less than an hour and ended when the perpetrators committed suicide with their own weapons.

Received Template Attractiveness In terms of self-similarity, the perpetrators were two monoracial (White) males aged 17 and 18 native of the United States. From a notoriety aspect media broadcasts at the time portrayed them as bullied loners who wore trench-coats associated with a gothic clique known as the “trench coat mafia,” listened to Marilyn Manson, and were the outsiders, rebels and outcasts of the school. Although the connection with Hitler’s death on April 20th was noted at the time, media reporting was limited on their fascination with Hitler and Nazis. Coherence was high. They prepared for the attack over the course of a year documenting their progress. Template ideology and template methods were communicated through these legacy tokens[5] including diary entries, a manifesto, and self-made films of their preparation, all of which became public after the attack. In addition numerous media documentaries focused on aspects of their motivation (template ideology) and the public mass killing itself (template method).

Actual Template Attractiveness In contrast to the received template attractiveness, the actual profile of the perpetrators was that they were often the aggressors, bullying others at school. Although both had mental health issues, they were well connected with social groups and at least one of the two performed well academically. The perpetrators did not make a habit of wearing trench coats, but only wore them during the first few minutes of the attack to conceal their weapon. Likewise there is no evidence they listened to Marilyn Manson while there is extensive evidence they idolized Hitler and the Nazis.

Template Ideology The primary grievance of the perpetrators appears to be racism, homophobia, and religious hatred and their primary motivation appears to be fame-seeking and generalized anger[5].

Template Method The received template method is of a public mass killing by way of mass-shooting at a school. This was propagated by media emphasis. However, the perpetrators planned method was to detonate the explosives in the school cafeteria and then shoot or stab any survivors fleeing. The perpetrators armed themselves with improvised explosive devices and each carried four weapons: a shotgun, an assault rifle, a combat tactical knife; and a smaller boot or belt knife blade. When the bombs failed to detonate, the perpetrators entered the school facilities and improvised an active shooting event. Clothing was specifically worn for effect and became a key element of template method for subsequent replication. The perpetrators wore trench coats to begin the attack in order to conceal their weapons, underneath the trench coats were t-shirts selected to heighten fear. One perpetrator, Harris, wore an all-white shirt with the words “Natural Selection” in black letters and the other, Klebold wore an all black shirt with the word “Hatred” in red letters. The two split a single pair of black gloves with Klebold wearing one black glove on his left hand and Harris a black glove on his right. Both trench coats were abandoned after the attack began. The attack concluded with the suicide of both perpetrators using the weapons they carried. Harris with a shotgun, Klebold with a machine pistol[15],.

5.2 Cultural Scripts Findings

5.2.1 Convey Template Ideology and Template Method.

Template method replication is strong in Columbine, especially among single-target selection (schools); equipment selection (shotguns and assault rifles); and scripts for how to conduct (enter school grounds and proceed to a mass-shooting) and conclude the attack (suicide of perpetrator) are well-documented. However we

have discovered other template method replication markers in less reported areas, including clothing choice and attribution-through-artifact on the equipment used in the attack. These findings indicate the extent to which replication is occurring in detail in a contagion, and not just in aggregate.

5.2.2 *Material Cultural Scripts: Clothing & Markings*

Demonstrating such detailed replication over time and space, we compare the seed event with a public mass killing in Russian-occupied Crimea in 2018. This incident demonstrates the reach and duration of CSS, especially through the adoption of a template method. The perpetrator, Roslyakov, was born after the seed event in May of 2000 and does not appear to have been fluent in English. His public mass killing took place over 6,000 miles away from and 19 years later than the CSS seed event. In Figure 5, we see (from left to right) the only well circulated image of the 1999 Columbine seed event perpetrators Klebold and Harris; a still from an unofficial music video set to the 2010 song, "Pumped Up Kicks," responding to the event in song and image; and a still image taken from the 2018 incident



Figure 5: Comparison of depictions. (Left) Columbine actual footage 1999; (Center) Columbine Music Video 1999; (Right) Kerch actual footage 2018.

Note the starkness of the clothing in all three pictures, and how the figures in the music video and the Crimea still both closely resemble Harris, the figure to the left in the Columbine image. We know that Harris's shirt read "NATURAL SELECTION" while Klebold's shirt read "WRATH" - these facts are not visible in the grainy footage still taken from the 1999 seed event. The video, however, provides the viewer with a clear, cinematically refined interpretation of the Columbine events. In addition to depicting the shooting in motion, the video provides details later replicated in Kerch. The level of detail in copied cultural specifics is distinct in clothing choices. For instance, he wears a white shirt written with "ненависть," the Russian word for hatred, black pants, and significantly a single black glove on the right hand the same as Harris in Columbine[16, p. 3].

In Kerch, the perpetrator fused the clothing styles of Klebold and Harris wearing a white shirt with the Russian word for "Hatred." Other incidents with clothing styles copied from Columbine seed event include:

- Wearing of trench coats: Taber, AB, Canada 1999; Red Lake, AZ, USA, 2005; and Santa Fe, TX, USA 2018; Kerch, Russian-occupied Crimea 2018
- Backwards baseball caps: Blacksburg, VA, USA 2007
- T-Shirt with Slogans: "Humanity is Overrated" Tuusla, Finland, 2007; Kerch, Russian-occupied Crimea, 2018; Nazi symbology, Izhevsk, UR, Russia 2022

5.2.3 *Suicide as a Cultural Script and Material Markers*

In the Kerch incident the perpetrator carried a shotgun similar to Harris and like Harris, used it to kill himself in a school library. In cases like this questions may linger as to whether such an act was intentional replication or operational contingency (e.g. as it was for Harris.) Roslyakov died in the attack so was unable to provide testimony and like many perpetrators did not leave a clear manifesto. However, his wearing of a single black glove on his right hand, a distinctive feature unique to Harris among the Columbine pair is strongly indicative that the location and manner of suicide was intentional. Numerous other perpetrators in the CSS contagion also committed, or planned to commit suicide as an end to their attack.

5.2.4 *Cultural Script Artifact Markings*

Another incident in Izhevsk, Russia in September of 2022 shows how non-textual materials can convey contagion spread. In this case artifact markings were used as a form of legacy tokens. The perpetrator of that public mass killing at a school braided the names of the two CSS seed event perpetrators into the tassels of his pistols, along with other references on his magazine cartridges as shown below in Figure 6[17].



Figure 6: Artifact Markings of Attribution & Slogans Izhevsk, UR, Russia SEP 2022

5.3 **What if the bombs had gone off? Intended vs. received cultural scripts on template method.**

To demonstrate the power of cultural scripts in spreading specific template methods we return to the received vs. intended template methods of the CSS event. As mentioned above, the plan of Klebold and Harris was to detonate two large 20lb propane bombs in the cafeteria and shoot or stab survivors fleeing the building. It was only when those bombs failed to detonate that the mass-shooting method for which CSS has become known through media coverage was begun as an improvised approach. The Kerch 2018 incident is a rarity in the contagion for a perpetrator who replicated the planned template method vs. the template method received by cultural scripts. Successfully detonating explosives in the dining room and then shooting survivors.

But what if the bombs had gone off? Experts later used computer modeling and the actual count of 488 students present in the cafeteria at that time to estimate what might have happened had the bombs gone off. They found that the resulting explosion would not only have killed many of the students in the cafeteria, but likely collapsed the cafeteria and library above it[15]. As there has been confirmation of 488 students in the cafeteria at the time we can simulate a counter-factual to the observed historical seed event. At a conservative estimate of 25% fatalities 122 students would've been killed, still making it the deadliest school massacre in US history and one of the most lethal bombings.

Of course we can't know how successful a template method on bombing would have been as compared to a mass-shooting but we can approximate based on earlier data analysis[18]. Using data from the Global Terrorism

Dataset[19] between 1995-2018 there were 121 attempted explosive terrorist attacks in the United States of which 71 completed resulting in an OTD success rate of 61.98%, lower than the CSS contagion OTD success rate. Of events which caused fatalities, the average fatality was 7.91 fatalities, the minimum 0, the maximum 168, and the standard deviation of fatalities among these attacks 34.21. However this includes the catastrophic Oklahoma City Bombing which killed 168. Excluding OKC bombing as an outlier there was an average of .95 fatalities, the minimum 0, the maximum, 14, and a standard deviation of 2.89. There are valid reasons to use both estimate ranges. Bombings are harder to complete than mass-shootings because of required technical proficiency and size of explosions. Oklahoma City involved a Ryder truck full of explosives. However, that being said, had the CSS attempted bombing been successful it would've accomplished devastation at or near that of Oklahoma City because of it's placement in a full cafeteria. So in the experiment we use a "Less Lethal Bombing Stats" and "More Lethal Bombing Stats" for the template fatalities parameters in the simulation settings. With all else being held constant, we then compare these two counterfactuals against a simulated "Historical" run in summary in Table 7.

Table 7: CSS Counterfactual Experiment Results Summary

Simulation Run (Template Method)	Attempted Incidents	Contagion Incidents	Contagion Fatalities
CSS Equilibrium (No Template)	29	0	0
CSS Historical (Mass Shooting Template)	61	19	155
CSS Counterfactual (Less Lethal Bombing Template)	61	33	216
CSS Counterfactual (More Lethal Bombing Template)	73	44	1557

Although the Attempted Incidents for all three non-equilibrium runs remain close, the completed contagion incidents broadcasting a combined template ideology and template method vary significantly between the historical and counterfactual settings. This is because of the increased spread of template ideology and template method in the aftermath of a catastrophic bombing attack killing 122 people, as observed in Figure 7 below.

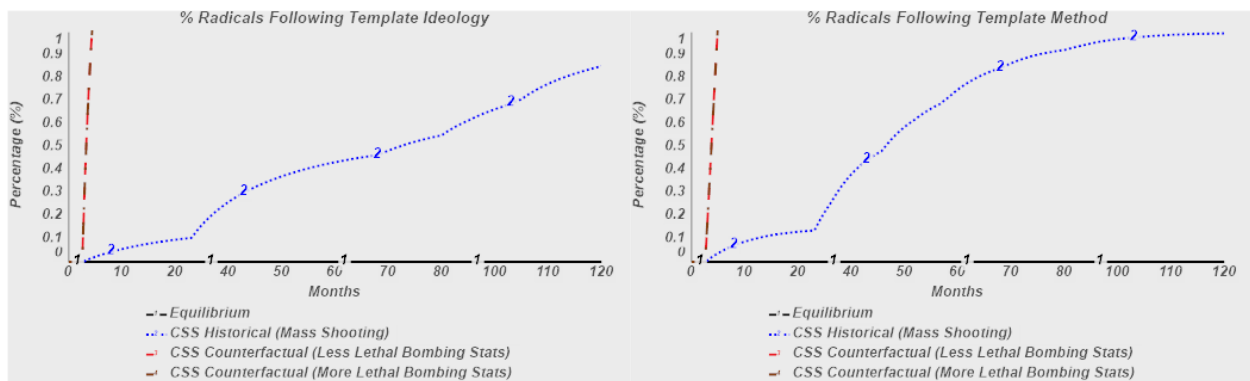


Figure 7: Comparing Template Ideology & Template Method Adoption in CSS Experiment.

The historical adoption rates Figure 7(2) of template ideology and template method following the seed event show a F2G or S2G pattern, concave and struggling to reach the limit of the population. However both counterfactual examples Figure 7(3&4) both demonstrate CONT+ hockey-stick exponential increase in adoption rate increases following the seed events. This is because, as much as the CSS seed event was broadcast, a lethality level nearly 10x as bad, would have saturated the high-risk population with the cultural scripts conveying template ideology and the bombing template method. This is evidenced by looking at the stock of high-risk broadcast memory displayed in Figure 8.

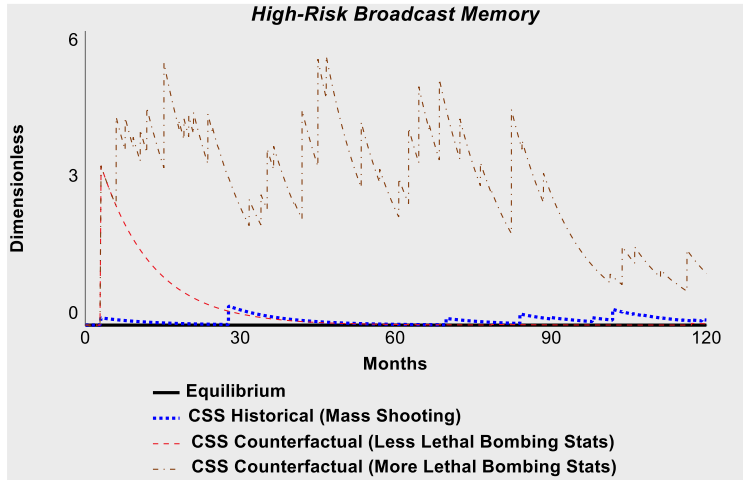


Figure 8: CSS High-Risk Broadcast Memory

Although the broadcast memory of less and more lethal counterfactual simulations differ in absolute value, Figure 8 (3&4), both dwarf the historical high-risk broadcast memory after the initial seed event. Less lethal and more lethal counterfactuals diverge sharply in the high-risk broadcast memory however. The increased difficulty of completing any bombing, as well as the reduced average template fatalities of any subsequent less lethal contagion incident Figure 8(3) causes the broadcast memory in the high-risk population to decline until it is lower than the CSS Historical Figure 8(2). Much like Oklahoma City, such a counterfactual may have been most remembered for its singular seed event, rather than a repetition. The more lethal template however, by producing more average fatalities, replenishes the high-risk broadcast memory with new cultural scripts at each completion Figure 8(4). This is why, over the 10-year run, the less lethal counterfactual only has marginally more fatalities attributable to contagion incidents than the historical (216 vs. 155). But the more lethal bombing template counterfactual has nearly 10x the fatalities (1557 x 155).

6 Virginia Tech (VA-Tech) Contagion Findings

The VA-Tech contagion began as an offshoot of the CSS Contagion. Despite a seed event employing a more sophisticated template method of attack that caused far more casualties than Columbine, it failed to replicate extensively as summarized in Table 8 making it a useful contagion to study to understand why.

Table 8: Virginia Tech-style (VATech) Contagion Summary

Seed Event	# of Incidents after Seed Event	Casualties to Date in Contagion	Time to 1 st Replication Attempt	Time to 1 st Intl Attempt	Time to 1 st Completed Event	Latest Suspected Contagion Incident
Blacksburg, VA April 16 th , 2007	5	79K 86W	718 Days Binghamton, NY April 3 rd , 2009 (13K 4W)	1452 Days Rio de Janeiro, Brazil April 7 th , 2011 (12K 22W)	718 Days Binghamton, NY April 3 rd , 2009 (13K 4W)	Munich, Germany July 22 nd , 2016 (9K 34W)
Countries with Suspected Contagion Incidents (# of Suspected Incidents)						
Brazil (1), Germany (1), USA (4)						

The plot of the actual historically observed seed event and subsequent incidents in our data set against the simulated run is included in the supplementary materials.

6.1 VA-Tech Contagion Profile

Seed Event The seed event for this contagion was Virginia Tech University public mass killing in Blacksburg, VA United States on April 16th, 2007. A single perpetrator conducted a complex shooting attack at multiple locations on the campus killing 33 and wounding 17. The attack lasted several hours and ended when the perpetrator committed suicide with their own weapons.

Received Template Attractiveness: As a 23-year-old monoracial minority (Asian) male immigrant to the United States the perpetrator had reduced self-similarity to the CSS high-risk population. Likewise, early media reports focusing on prior bullying due to a speech difficulty, failed romantic advances with the perpetrators first victim, and extensive mental health difficulties reduced perceived notoriety. Finally, although the perpetrator prepared a manifesto and a release mechanism, the rambling lack of coherence made it hard to understand and communicate his grievance, intentions, and motivations.

Actual Template Attractiveness: Despite the early reports, on subsequent investigation no evidence was found of prior bullying or of any contact, romantic or otherwise, between the perpetrator and his first victim. However, the mental health difficulties were confirmed and became a primary focus of broadcast coverage, ensuring reduced notoriety perception.

Template Ideology: Like Columbine, the incorrect early media reporting resulted in a split template ideology. The received template ideology spread by cultural scripts was of an outsider immigrant bullied by their school peers and unable to form romantic connections. The perpetrators own manifesto and videos, sent as legacy tokens, reveals a template ideology of aggression, generalized anger, misogyny, hatred, and a god-complex very similar to the Columbine perpetrators who he idolized.

Template Method: The perpetrator, inspired by the CSS contagion mass-shooting template method improved upon it in a planned public mass killing on his own University campus. While the CSS contagion template method involves a mix of shotguns, assault rifles, and pistols and a roaming improvised method based on the seed event; the VA-Tech contagion seed event employed a distinctive two-pistol template method with specific actions to maximize fatalities. The perpetrator armed himself with two pistols, a hunting knife similar to the CSS knives, a hammer, and rope. The incident began with an attack in a dorm room on a female student resulting in two deaths. At this point the perpetrator paused to physically mail multi-media package of legacy tokens including directly to reporters. The attack continued when the perpetrator entered a classroom building, using the chain to lock the doors and prevent them from opening. He then proceeded to the upper floor, scouted which classrooms had the most students in them, and began his attack. The incident lasted over 2.5hours and resulted in 32 deaths and 22 injuries and ended when the perpetrator committed suicide with weapons he brought.

6.2 Cultural script findings

6.2.1 Role of Template Attractiveness

The VA-Tech contagion provides strong evidence that contagion replication is filtered through template attractiveness mechanisms of self-similarity, notoriety, and coherence within a given high-risk population more

than template method lethality. In Table 9 below we compare Template Attractiveness factor differences all as we seed event fatalities.

Table 9: Comparing CSS and VA-Tech Seed Event Template Attractiveness Factors

Template Attractiveness Factor	CSS Seed Event Perpetrators	VA-Tech Seed Event Perpetrator
Self-Similarity	Monoracial (White) native to the United States teenage (17 & 18) males.	Monoracial (Asian) immigrant to the United States older (23) male.
Notoriety	High – media portrayed as outcast, rebels, violent “natural born killers”	Low – media portrayed as “loser” spurned by woman with severe mental health problems
Coherence	High – own legacy tokens and subsequent reporting provided clear coherence of both ideology and method.	Low – manifesto was rambling and hard to understand, videos were unclear.
Seed Event Casualties	13K 24W	33K 17W

6.3 What if Cho were white? Altering self-similarity, notoriety, and coherence in VA-Tech Counterfactual

But what if Cho had been a younger white male, was depicted with more notoriety and his legacy tokens held greater coherence? We can simulate a counterfactual increase in the seed events Template Attractiveness, by increasing self-similarity, notoriety, and coherence to 1 from their initial .5 values. This changes the net Template Attractiveness from 12.5% in the historical case to 100% in the counterfactual, showing how much of an impact this change alone has in the summary results of Table 10.

Table 10: VA-Tech Counterfactual Experiment Results Summary

Simulation Run (Template Attractiveness Level)	Attempted Incidents	Contagion Incidents	Contagion Fatalities
VA-Tech Equilibrium (N/A)	29	0	0
VA-Tech Historical (Low)	148	6	112
VA-Tech Counterfactual (High)	188	159	2669

The counterfactual contagion shows the highest completed incidents and overall fatalities of any contagion modeled in our experiments, even higher than the more lethal bombing CSS counterfactual discussed above. This is because the template method of VA-Tech was sophisticated, and when replicated, has resulted in historically more fatalities on average than CSS or even GWRT and higher completion rates than GWRT with its simpler method to achieve.

The question of why this replication hasn’t happened to such frequency is therefore crucial to understanding the terror contagion hypothesis and the role template method plays. We present again the high-risk broadcast memory Figure 9 comparing all runs (left) with the historical and equilibrium (right).

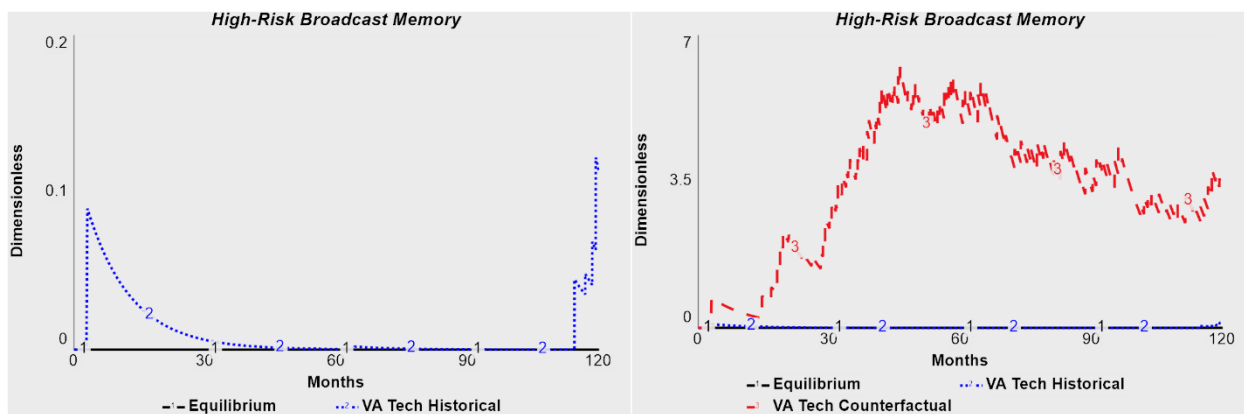


Figure 9: High-Risk Broadcast Memory for VA-Tech equilibrium and historical (left) and adding counterfactual experiment (right).

Comparing the historical high-risk broadcast memory to the equilibrium case in the left-hand Figure 9(1&2) shows that it's value is not zero, and over the course of the contagion it rises and falls periodically in relation to completed incidents. But when we add the counterfactual experiment in the right-hand Figure 9(3) it makes the historical look like zero. This is the difference between a Template Attractiveness of 12.5% (historical) and 100% (counterfactual) which were the only factors changed. Even though there are VA-Tech contagion replications occurring in the historical case, the low template attractiveness is acting as a filter preventing it from reaching the high-risk population. They don't see themselves in or find the perpetrator notorious and they don't understand the template methodology and ideology.

The historical record confirms this filtering process. In none of the five replicated VA-Tech incidents was a perpetrator monoracially White. Additionally, most were as old or older than the VA-Tech perpetrator and also struggled with severe mental health issues. One (Binghamton, NY, US 2009) was a 41-year-old monoracial Asian immigrant male with severe mental health issues. One was a 26-year-old majority-minority (White-Black) 23-year-old with severe mental health issues (Roseburg, OR, US 2015). Another was an 18-year-old monoracial (Persian) native German with dual German-Iranian nationality who's motivation was bullying, mental illness, and romantic rejection (Munich, Germany, 2016). The final was a 23-year-old monoracial (Portuguese) native of Brazil motivated by bullying and mental illness (Rio De Janeiro, Brazil 2011).

Notably, of five subsequent replications we have identified – all of them match Cho's template method using only pistols. Three incidents used two pistols, one incident used one pistol, and one incident used four pistols. Assault rifles were never used in a subsequent VA-Tech replication despite the increasing popularity of those weapons from the CSS Contagion Template Method. There is additional evidence of copying photographic poses in pictures perpetrators took of themselves prior to the public mass killings as shown in Figure 10.

In this example we compare the posing of Cho (left) and de Oliveria (right) who conducted a public mass killing in Rio De Janeiro in Brazil killing 12 and wounding 22. De Oliveria, a 23-year-old monoracially Latino male used a template method distinctively similar to Cho. In addition to the similar photographic posing as indicated above de Oliveria used two pistols, targeted a school he had formerly attended, and killed himself with a gunshot to the head at the conclusion of the incident.



Figure 10: Replicated Posing (LEFT) Blacksburg, VA 2007; (RIGHT) Rio De Janeiro, Brazil 2011

7 Great White Replacement Theory (GWRT) Contagion Findings

The Great White Replacement Theory (GWRT) contagion, summarized in Table 11, is less well known than CSS but more lethal. GWRT Contagion incidents account for nearly the same fatalities on less than a 1/3rd of the incidents as CSS. This is perhaps because GWRT from the beginning appears to be a contagion-by-design.

Table 11: Great White Replacement Theory (GWRT) Contagion Summary

Seed Event	# of Incidents after Seed Event	Casualties to Date in Contagion	Time to 1 st Replication Attempt	Time to 1 st Intl Attempt	Time to 1 st Completed Event	Latest Suspected Contagion Incident
Oslo & Utoya, Norway July 22 nd , 2011 (77K 319W)	18	247K 447W	474 Days Moscow, CFD, Russia (6K 1W)	474 Days Moscow, CFD, Russia (6K 1W)	474 Days Moscow, CFD, Russia (6K 1W)	Buffalo, NY, USA May 14 th , 2022 (10K 3W)
Countries with Suspected Contagion Incidents (# of Suspected Incidents)						
Canada (1), Germany (3), New Zealand (1), Norway (2), Russia (1), Sweden (2), USA (9)						

The plot of the actual historically observed seed event and subsequent incidents in our data set against the simulated run is included in the supplementary materials.

7.1 Contagion Profile

Seed Event: The seed event for this contagion was public mass killings targeting government buildings and a youth camp in Oslo and Utoya, Norway on July 22nd, 2011. A single perpetrator conducted a complex attack against multiple locations selected for ideological reasons. The attack began with a car bomb detonated in Oslo and continued 1.5 hours later with a mass-shooting on Utoya island where a youth camp was being held. The combined attacks killed 77 and wounded 319 lasting slightly over three hours.

Template Attractiveness: In terms of self-similarity the perpetrator was an adult monoracial (White) male native of Norway, 32 years old at the time of the attack. As an avowed fascist, white supremacist and identifying himself as a “knight” in the vein of historical military orders of the Crusades he maximized notoriety bias within the targeted high-risk population. In terms of coherence both template ideology and template method were communicated through a manifesto legacy token consisting of a sophisticated manifesto

over 1,500 pages in length distributed to a wide variety of social media accounts in the hours preceding the attack. Subsequent attacks have also replicated the use of media-ready manifestos and other communication techniques to ensure wide spread of template ideology and template method with strong coherence. This contagion-by-design approach of high coherence leaves little room between actual and received template attractiveness than was there in either the CSS and VA-Tech templates.

Template Ideology: The primary grievance of GWRT perpetrators is grounded in the so-called “Great White Replacement Theory” conspiracy. This conspiracy mixes xenophobia, racism, anti-Semitism, anti-Muslim, anti-Feminism and fears of “Multicultural Marxism” to assert that a declining “white” fertility rate means the “white race” will be replaced by foreigners, specifically foreign Muslims and Blacks. The “replacement” is facilitated by Jews, Feminists, and “Multicultural Marxists.” This is often presented in a clash-of-civilization concepts with the “white race” associated with asserted historical European and North American supremacy over non-white areas of the world.

Template Method: The template method of the GWRT Contagion is often mistaken with CSS because they both involve mass-shootings, however some differences are noteworthy. GWRT Contagion attacks tend to target multiple locations, rather than a single location. These attacks focus on Mosques, Synagogues, or other places of worship as well as grocery stores, clubs, or locations were perceived enemies (e.g. Jews, Blacks, Muslims, or Multi-Cultural Marxists) are believed to congregate. Unlike the CSS legacy token which was haphazard and perhaps even unintended evidence; the GWRT legacy token manifestos are intentionally designed for subsequent spread and replication. They contain both template ideological materials as well as detailed planning and preparation guidance on how to conduct an attack. The Norway perpetrator spent years preparing for the attack, and documented this in a journal form in his manifesto. The template method planned in Norway was successfully completed involving a detonation in one location to draw law enforcement and then a mass-shooting in another location where most of the casualties occurred. The perpetrator armed himself with an assault rifle and pistol. The perpetrator disguised himself as a police officer. The perpetrator then surrendered to police, planning on perpetuating further media coverage through his detention, trial, and imprisonment.

7.2 Cultural Script Findings: Contagion by Design

7.2.1 Ensuring Coherence by Attribution in Manifestos

As mentioned in above, a distinguishing feature of GWRT is the intentional use of legacy tokens, especially manifestos, in a planned attempt to further replication through high coherence. Manifestos often attribute inspiration, by name, to previous attackers the perpetrator believes are linked to GWRT incidents. These are sophisticated efforts, as indicated in Table 12 [20].

Table 12: Citation Frequency in GWRT Manifestos by Perpetrator

	Breivik	Roof	Bowers	Tarrant	Earnest	Crusius	Manshaus	Balliet	Jackson	Gendron
Breivik										
Roof										
Bowers										
Tarrant	3	2								
Earnest			5	11						
Crusius				2						
Manshaus				2	1	1				
Balliet				1						
Jackson				1						
Gendron	2	2	1	6	2	2	1			

Reading vertically down the left is a timeline of subsequent GWRT perpetrators, while reading across each row indicates how much they cited in their manifesto past GWRT perpetrators. The authors note that at times this citation analysis by terrorist perpetrators is more sophisticated than current research, often identifying GWRT incidents that had been misclassified in peer-review studies. Using this kind of citation analysis is a future research effort intended by the authors as we collect manifestos, similar to previous research that grouped Salafi-takfirist terrorists into ideological strands based on who they cited in their writings. [21]

7.2.2 Coherence in Idiomatic Replication in Template Ideology

In addition to direct attribution, GWRT manifestos frequently share idiomatic replication. This is demonstrated by comparing passages, with key idiomatic phrasings marked in red, from three GWRT manifesto quotations from Norway 2011, Christ Church 2018, and Buffalo 2022

If you compare *white Americans to white Europeans, the American birth* rate is somewhat higher than those of the Scandinavian nanny states, but still lower than replacement level...In recent years, though, it has hovered at an all-time low of roughly 1.5 children per woman (we need 2.1 if we're going to replace ourselves). (p364) Oslo & Utoya, Norway JUL 2011

To maintain a population the people must achieve a birthrate that reaches replacement fertility levels. In the Western world this is roughly 2.06 births per woman. (p4) Christ Church, New Zealand MAR 2019

If there's one thing I want you to get from these writings, it's that *White birth rates must change*. Everyday the White population becomes fewer in number. *To maintain a population the people must achieve a birth rate that reaches replacement fertility levels, in the western world that is about 2.06 births per woman.* (p1) Buffalo, NY 2022

The Christ Church perpetrator in in 2018 took the longer 1,500 page manifesto of the Norway 2011 perpetrator and shortened it 68 pages. In doing so he summarized dense text into more accessible media-ready themes and added a significant digit to the fertility rate. A subsequent GWRT attacker in Buffalo, NY 2022 copied the Christ Church idiom almost verbatim, including the extra significant digit.

7.2.3 Coherence in Structural Replication in the Template Ideology

In addition to idiomatic copying, the GWRT manifestos demonstrate structural replication. In Table 13 we compare select passages from the manifesto of the 2019 Christ Church, New Zealand attack and the subsequent released manifesto of the Buffalo, NY USA 2022 attack. All of these extracts are taken from a self-interview written in the style of a Frequently Asked Questions (FAQ) found in the Christ Church manifesto and copied in structure in the Buffalo manifesto[20].

Table 13: Structural Replication in GWRT Contagion Manifestos

Christ Church, New Zealand 2019	Buffalo, NY, USA 2022
Why did you choose this time to attack? <i>The best time to attack was yesterday, the next best time is today.</i> (p14)	•Why did you choose this particular moment in time to attack? <i>The best time to attack was yesterday, the next best time is today.</i> (p5)
•By living in <i>New Zealand</i> , weren't you an immigrant yourself? (p22)	•By living in the <i>United States</i> , weren't you an immigrant yourself? (p8)
•Did/do you personally hate <i>muslims</i> ? A <i>muslim</i> man or woman living in their homelands? No. (p16)	•Did, or do you personally hate <i>blacks</i> ? A <i>black</i> man or woman living in their homelands? No. (p6)

The red text in Table 13 indicates where the Buffalo perpetrator has copied the exact structure of the Christ Church perpetrators manifesto, only swapping out relevant terms for his particular aspect of GWRT contagion grievance.

7.2.4 Coherence in Artifact Markings

Similar to the CSS contagion, we also see GWRT perpetrators use markings on their equipment, gear and other artifacts as opportunities for distinctive replication. But the level of detail and transmitted coherence is higher. In Figure 11 we place evidence photos of select weapons and gear used in the Christ Church, New Zealand public mass killing of 2019 (left), compared with the photographs of select weapons and gear used in the Buffalo, NY 2022 public mass killing (center) and a memetic cultural script (right) attack[22].

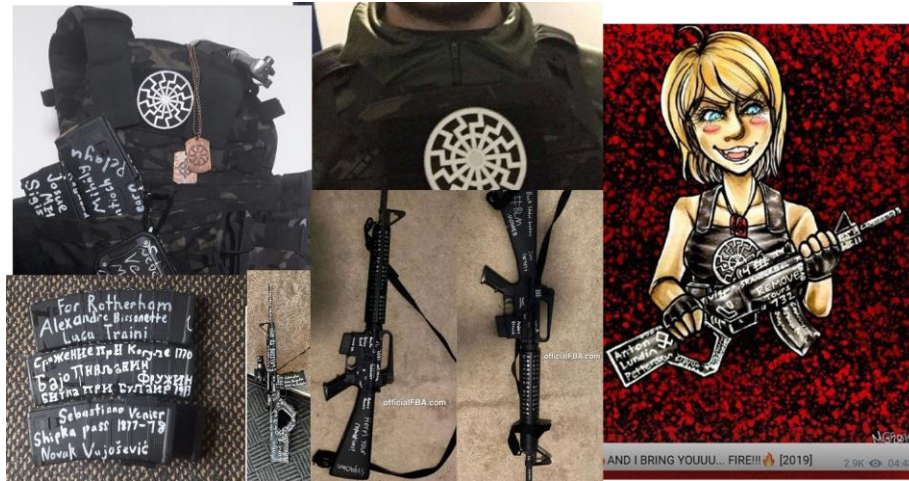


Figure 11: Replicated weapon markings in GWRT Contagion; (LEFT) Christ Church, New Zealand 2019, (MIDDLE) Buffalo, NY (RIGHT) Contagion cultural script example.

Not only are the perpetrators using a similar distinctive style of white lettering on rifles – but the phraseology is similar as well. On the left the Christ Church perpetrator listed historical and recent incidents of perceived racial conflict in Europe and past GWRT shooters, in the middle the Buffalo perpetrator listed historical and recent perceived racial conflict in the United States as well as reference to prior GWRT shooters. Likewise the image centered on the body armor of both perpetrators is known as the *sonnerad* or *sun wheel* or *black wheel* and is one of many Norse symbols that the Nazi’s appropriated (indeed the swastika is a form of the *sonnerad*). It has subsequently become a common symbol in white supremacy movements and links with Breivik’s stated Odinism. The image on the right shows a cultural script, or “meme”, circulated in extremist blogs showing this fusion of white lettering on rifles, the same specific phrases, and the *sonnerad* on the chest.

7.3 What if Breivik’s manifesto had been incoherent? Reducing coherence in GWRT Counterfactual

We ran a counterfactual experiment to ask if this contagion-by-design element had not been present, how widely replicated would GWRT have become? Assuming Breivik’s original manifesto was as rambling and incoherent as Cho’s in VA-Tech. We return to modifying Template Attractiveness as we did in VA-Tech above. In that experiment we increased all three elements of Template Attractiveness, in the GWRT counterfactual we reduce coherence to 2.5 resulting in a corresponding Template Attractiveness of 25% to the high-risk population. The results of this experiment in comparison to equilibrium and historical are summarized in Table 14.

Table 14: GWRT Counterfactual Experiment Results Summary

Simulation Run (Template Attractiveness – Coherence Level)	Attempted Incidents	Contagion Incidents	Contagion Fatalities
GWRT Equilibrium (N/A)	29	0	0
GWRT Historical (High Coherence of Template Attractiveness)	32	19	345
GWRT Counterfactual (Low Coherence of Template Attractiveness)	30	12	258

Both completed contagion incidents fatalities drop significantly. The filtering process we examined in VA-Tech applies here. When cultural scripts are not coherent, it is hard for the high-risk population to receive the template signals. We can see this filtering effect of reduced coherence in the reception of the cultural scripts into the high-risk broadcast memory in Figure 12.

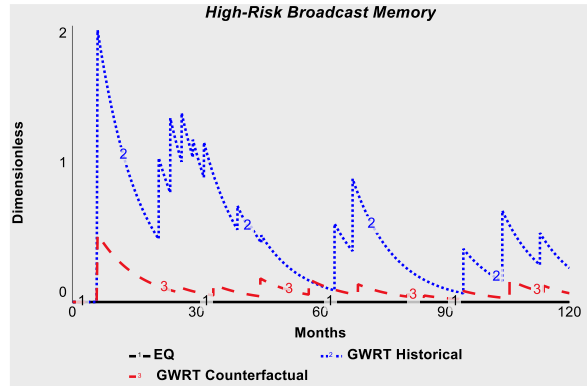


Figure 12: High Risk Broadcast Memory GWRT Experiments.

The targeted high-risk population of GWRT is narrower than CSS, focusing on white supremacy and xenophobia. When that high-risk population cannot recognize the cultural scripts of GWRT because of lowered template attractiveness as seen when comparing the historical vs. counterfactual Figure 12 (2&3) it reduces the adoption of template ideology and method within the high-risk population as well as reduced radicalization overall. The first of these effects is seen comparing template adoption rates, shifting them from CONT+ behavior modes to F2G or S2G as shown in Figure 13.

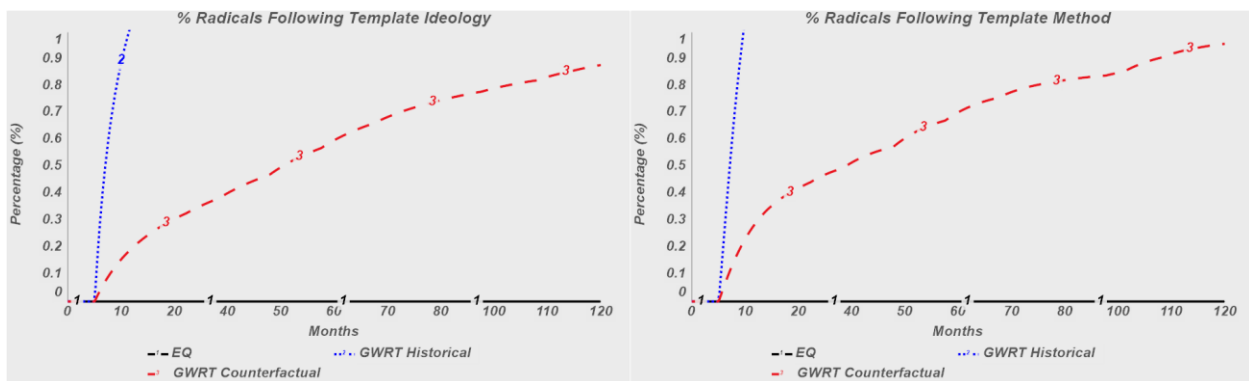


Figure 13: Template Adoption Rates GWRT Experiments

The adoption rates have shifted from CONT+ with high coherence in the historical to F2G; a concave adoption without ever reaching the limit in the counter-factual Figure 13 (2&3). This has implications in the broader radicalization of the high-risk population. Because the GWRT is spreading a very specific white supremacy

ideology, the filtration that occurs due to lower coherence mean less of the high-risk population become radicalized to that strand of ideology as shown in Figure 14.

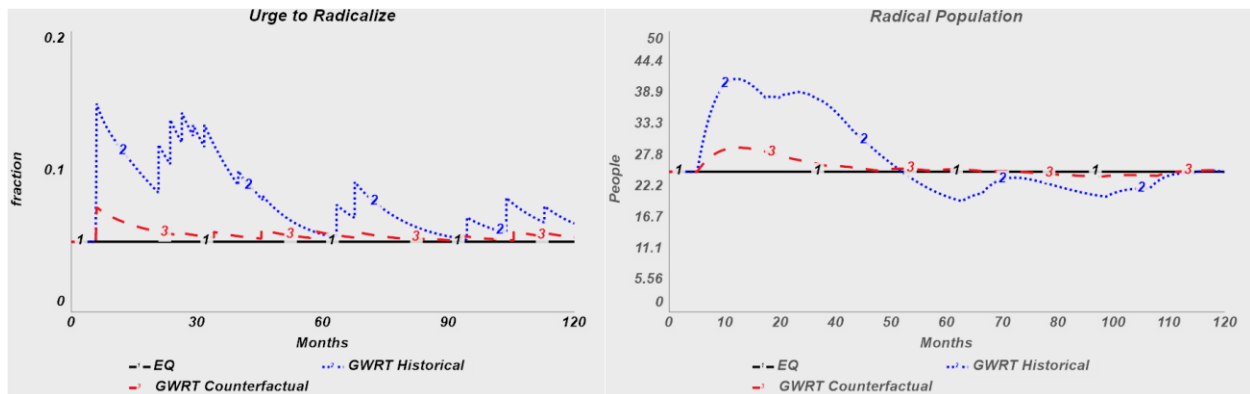


Figure 14: Urge to Radicalize (left) and Radical Population within the High-Risk Population of GWRT.

This finding is intuitive, lower coherence means less urge to radicalize resulting in less actual numbers of the radical population in the historical vs. counterfactual scenarios Figure 14 (2&3). But key to note is the effect is cumulative. Contagions operate on positive reinforcing feedback loops, the subsequent incidents replicating prior ones. Absent an innovation of coherence, a low coherence seed event leads to similarly low coherence replicated incidents. The effect of a lower template attractiveness is accumulated across the entire simulation run of 10 years.

8 Discussion

As we organized our data, we observed two striking findings regarding contagion replication through cultural scripts. First, how cultural scripts communicated template ideology and template method through the creation of legacy artifacts. Second, how this communication became more or less accessible when filtered through template attractiveness.

Each contagion contains evidence of template ideology and template methodology transmission in the form of legacy tokens, such as manifestos, journals, and how-to or progress videos. We find the most overt evidence of this in the GWRT catalogue of manifestos, wherein direct, approaching-academic degrees of citation occur. Within this contagion, perpetrators reference previous perpetrators in their manifestos. They quote them. They refer to them by name. They copy the specific text of previous perpetrators. In the case of Tarrant, we see him refining his predecessor's arguments, both making them more precise and accessible to those that follow him, resulting in a chain of subsequent manifestos that cite him specifically. The CSS and VA-Tech contagions do not exhibit this exact degree of replication. They do, however, contain other elements indicative of replication, as does GWRT. Some are idiomatically emblematic, such as in the braiding of Klebold and Harris's names into the gun tassels in Izhevsk, Russia, or the decoration of weapons and ammunition magazines with names and slogans also found in Izhevsk but also found and in multiple GWRT incidents. Less overt yet still conspicuous visual repetitions occur as well. These may serve to identify a perpetrator visually, and potentially ideologically or socially, with seed event perpetrators, as we suspect in the close replication of Columbine clothing artifacts by Roslyakov in Kerch; or with a broader extremist movement, as the incorporation of the *sonnerad* into GWRT incident gear. In the less coherent VA-Tech contagion, these kinds of repetition have not occurred. Yet,

a noteworthy similarity exists between the posed photos taken by Cho before the VA-Tech seed event and, later, by the Rio De Janeiro perpetrator, suggesting yet another potential form of legacy artifact – posed photography.

This ability to discover and discern template ideology and template method details over time and space matches a previous theorized element of the radicalization cycle. Occurring in parallel with activation, ‘fixation’ involves a radicalizing person’s almost pathological [23, p. 2] obsession with finding all material related to the template ideology and template method [8]. This fixation drives the perpetrator to seek out and uncover cultural scripts conveying template ideology and template method, furthering their activation and progression onto the pathway to violence, and then to building on the template method. At times, perpetrator fixation distinguishes between intended and received template method, as we see in the case of the Kerch public mass killing in the CSS contagion. Most CSS contagion incidents emulate Klebold and Harris’s media-depicted mass-shooting template method involving guns and knives. Yet, in Kerch, where Roslyakov appears to have meticulously replicated the CSS template method down to precise detail, including very specific clothing artifacts, we also see him replicating Klebold and Harris’s intended template method – the bombing the cafeteria. This suggests that the intensity of fixation exhibited by a member of the high-risk population may influence how faithfully they replicate template method details and impact the severity of completed incidents.

The Kerch incident provides additional insight into the specificity of contagion transmission as well. We know that Roslyakov’s fixation period involved the study of the Oslo and Utoyo GWRT seed event, a methodologically much more lethal incident than the CSS seed event[16]. Yet the details of his attack remain strictly tied to the CSS template methodology. This observation elevates the significance identifying cultural and legacy artifacts displayed in a given incident as it suggests that, despite the potential for “idea sharing” across contagion methodologies (as evidenced by the similar use of idiomatic emblems in both the CSS contagion and the GWRT), identification with a specific contagion remains important.

Turning our attention to our simulation results, our most noteworthy observations involve the impact of template attractiveness and coherence in the efficacy of its transmission, and the impact of accessibility of methods on the implementation of contagion incidents.

We found that increasing template attractiveness (VA-Tech) or decreasing it (GWRT) either expanded or reduced the spread of the contagion. If Cho had been a white teenage male with the same media propagated notoriety as Klebold and Harris, the Virginia-Tech shooting may have been the source of dozens of replications rather its suspected five; none those five suspected incidents involved a white teenage male, nor did they occur in the United States. Had the contagion-by-design coherence of the GWRT seed event and subsequent replications not been so high, incidents may have been reduced by nearly 40% with fatalities potentially falling by 25%. This suggests that the clarity and understandability of the cultural scripts are as important to contagion spread as the violence of the template method.

Similarly, contagion proliferation requires cultural scripts conveying a method that is both sufficiently accessible and lethal to sustain a contagion. This became evident in the CSS experiment. Both counterfactuals, Less Lethal and More Lethal, began from the same starting point. The far higher fatalities in the counterfactual seed event (122) compared to the historical seed event (13) both result in a rapid adoption of the template method across the entire high-risk population. The Less Lethal and More Lethal counterfactual contagion behaviors diverge, however. Both templates experience the same implementation difficulty – explosive materials are harder to acquire, proficiency at explosive construction is more difficult to develop, and explosives are harder to successfully use than firearms. This reduces subsequent completed incidents capable of

producing fatalities, and the CSS Less Lethal Template cannot produce enough fatalities per completed incident to generate media interest. Without subsequent infusions of media attention to bolster the spread of cultural scripts, the contagion fades. In the CSS More Lethal Bombing Template, however, the high average fatalities of each subsequent incident maintain the contagion, resulting in over 1,500 fatalities over a 10-year period. This reinforces prior findings that to sustain itself, regardless of seed event, the transmitted cultural scripts of a template method must reliably generate, on average, 10 or more fatalities per completed incident.

The complexity, or difficulty, of the transmitted method and its lethality have a further impact on its replication. As an example of this, continuing with the template method of bombings, the Oklahoma City Bombing of 1995 (see Section 5.35.3) generated no contagion despite high fatalities, high template attractiveness, and a large high-risk population identifying with the template ideology – it is too difficult a template method to replicate. Likewise, though high-risk individuals fixating on the CSS template method can access information about the intended bombing, few attempt to replicate it. We attribute this to the greater accessibility to and ease of practice with firearms that are less likely to draw attention preparation efforts than the gathering of the materials and performance of the trial runs necessary for bombings. As a result, the reception of Klebold and Harris's improvised mass-shooting template method has anchored the contagion to this template method, and become the dominant approach consistently generate enough fatalities with each completed incident to sustain itself globally for twenty-two years

9 Conclusion

In this paper, we studied a subset of public mass killings through the lens of the terror contagion hypothesis. We used preliminary data collection of suspected contagion incidents to initialize an exploratory computer simulation with initial conditions of the Columbine-style School Shooting (CSS), Virginia-Tech style shooting (VA-Tech), and Great White Replacement Theory attack (GWRT) terror contagions. Using the data from these contagions to set initial conditions, we were able to suitably recreate the historical behavior of each contagion over a 10-year period. We then examined each contagion through a qualitative approach, presenting a descriptive profile for each including seed event, template attractiveness, template ideology, and template method. We then examined select evidence of the cultural script transmission within each contagion involving elements of template attractiveness (self-similarity, notoriety, coherence), template method, and template ideology. We found confirmation of earlier predictions produced from a generic computer simulation in previous work – that contagions are global, they are transmitted through template attractiveness conveying template ideology and template method, that this transmission goes far beyond a simple target location and method of public mass killing. We found compelling evidence of the existence of cultural scripts in legacy and artifact replication, from idiomatic repetition in manifestos and emblematic modification of equipment to detailed specificity involving clothing, notably including which hand wore a single glove. We found that when template attractiveness was low, a more lethal template method was ignored in favor of a lower lethal method with higher attractiveness. We tested these assumptions with computer simulation counterfactual experiments. These involved holding everything constant to the initial settings of a historical contagion, then changing template attractiveness, template ideology, or template method. We found that altering these factors representing cultural scripts had meaningful effects increasing or dampening, the spread of a terror contagion.

We recognize the preliminary nature of our findings, both in data collection and the exploratory nature of the simulations. While we believe our findings contain important contributions to the academic dialogue on public mass killings as well as the development of the terror contagion hypothesis, the amount of work lying before us to build confidence in them is significant. It involves foremost the maturing of our data set by creating stronger

inclusion and exclusion criteria for what constitutes a potential contagion incident in general, as well as what cultural scripts should specifically be used to identify a given contagion. It will also necessarily involve continued simulation experimentation and the building of confidence in both the data set and simulation. In order to accomplish this, we intend to develop robust criteria for numerically evaluating the elements of a contagion, then subject our contagion profiles to more rigorous statistical analysis. This may pull from existing methods such as forensic linguistics [23], and existing statistical measures used in recent research [20]. Finally, we will continue to refine the terror contagion simulation through ongoing confidence building measures, including structural calibration, to identify missing structure in the simulation that can allow better replication of a variety of historical cases as well as more rigorous confidence building measures.

Approaching public mass killings through the terror contagion hypothesis provides two opportunities. First, to study public mass killings using systems science and simulations to gain new perspective. Second, from these perspectives, to suggest novel policy options to reduce contagion-generated public mass killings, which our research suggests account for 62-72% of deaths in all public mass killings 2006-2023. Reducing the impact of these few contagions could have significant benefits in reducing levels of violence. We have tested some of these policy options in a generic computer simulation in the past[24]. We look forward to continuing to refine both our data set and the terror contagion simulation to contribute to the work of reducing public mass killings.

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