Learning from stress: Transforming trauma into sustainable risk reduction

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Abstract

This study explores the collective learning process that evolved in the cities, towns, and districts damaged in the February 6, 2023, Kahramanmaraş earthquakes in Türkiye. Employing a multi-methods approach and a dataset comprising a review of relevant documents, semi-structured interviews, and field observations, we examine four fundamental stages of collective learning – knowledge acquisition, information distribution, interpretation, and organizational memory – in assessing the learning process in communities exposed to the devastation and trauma of the earthquakes. The study highlights the importance of adaptation, change, and collective growth as communities struggle to cope with the demands incurred by the disaster, and identifies factors that inhibit such growth in practice. In the aftermath of the Kahramanmaraş earthquakes, individuals and organizations sought to adapt their existing knowledge and practices to meet the challenges posed by recovery from this disaster and to build a consensual understanding of changes needed to achieve sustainable reduction of continuing seismic risk. The study underscores the vital Importance of timely and accurate Information In enabling Individuals and organizations to make informed decisions during and after the chaos engendered by the earthquakes. It highlights the pivotal role of technology in bridging communication gaps and facilitating the flow of critical information. The study concludes by identifying inaccurate information as the most harmful characteristic inhibiting collective learning, and by emphasizing the importance of aligning collective learning processes simultaneously among diverse groups within the community and across jurisdictional levels of operation. This study offers valuable insights into how to translate collective learning from traumatic events into sustained measures to reduce the risk of future disasters, going beyond resilience to achieve sustainable risk reduction. By understanding the factors that drive collective learning and the challenges that can arise, policymakers and practitioners can develop more effective strategies for supporting collective learning in the aftermath of extreme events.

Keywords: collective learning, knowledge acquisition, resilience, sustainable risk education, transforming trauma

1. Introduction

The extraordinary escalation in extreme events over the last decades reveals a serious gap in understanding how residents of heavily damaged communities cope with such events and rebuild their lives, presumably learning from the experience to enact changes that will prevent such

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destruction in the future. Nowhere is this gap more vividly apparent than in the response to the 6 February 2023 Kahramanmaraş Earthquakes that devastated a wide region of 11 provinces, 10 cities, multiple districts, and smaller villages, affecting 13 million residents in southern Türkiye, with the destruction spilling across the border into Syria (Çetin, Ilgaç, Can, & Çaker, 2023). Losses incurred from this event tallied more than 50,783 lives and 115,353 individuals injured in Türkiye, more than 8,000 lives in Syria (AFAD, 2023), and an estimated $103.6 billion in total costs for Türkiye alone (Turkey Presidential Strategy and Budget Directorate, 2023). Ironically, these events occurred only 24 years after the sobering sequence of earthquakes in 1999, August 17 in the Marmara Region and November 12 in Duzce. These events triggered an extensive revision of building codes, and led to the development of the Turkish National Disaster Plan (TAMP) and the Turkish Catastrophe Insurance Pool (TCIP) that was intended to protect Turkish citizens from losses in future events (Gülkan, 2001; Basbug Erkan & Yilmaz, 2015).

Presumably, the substantive steps implemented after the 1999 earthquakes demonstrated societal learning and informed actions taken to prevent future catastrophes in a nation of known seismic risk. Regrettably, those carefully constructed changes in building codes and policy following the 1999 earthquakes did not translate uniformly into practice, as in 2023, a total of 37,984 buildings collapsed completely, and more than 240,000 buildings were rendered unusable following the Kahramanmaraş earthquake sequence and aftershocks (AFAD, 2023; Çetin et al., 2023). Millions of residents in damaged cities, towns, and villages affected by the earthquakes were huddled into temporary rescue sites with inadequate facilities in housing, sanitation, access to clean water, and medical care, while an estimated 3.5 million people left the region (OCHA, 2023).

As the number, frequency, and severity of extreme events increases, the challenges to learning from such events and translating those insights into effective action become ever more difficult as the social, economic, physical, and technical systems that enable a community to function are increasingly interconnected and interdependent. In disaster-degraded conditions, as one system falters, it triggers failure in the next and the next, rippling dysfunction throughout the whole community and creating further stress for the residents. Stress is defined as the sense of being overwhelmed by external events, and loss of agency to manage the situation without support (Lindau, Almkvist, & Mohammed, 2016). For communities exposed to multiple hazards, the sequence of failure is compounded by cascading events, deepening the initial losses and weakening the communities' capacity for full recovery. This pattern is vividly illustrated in the chaotic response operations in the immediate days following, and the struggle for recovery from, the Kahramanmaraş Earthquakes that is still ongoing in southern Türkiye and northern Syria. *The question is whether, and if so, how, communities can learn collectively from the stress of extreme events and transform their communities through sustainable measures to reduce known risk.*

2. Theoretical Context

Learning from stress is not a new concept. The oft-cited maxim, '*That which does not kill me makes me stronger,*' attributed to Friedrich Nietzsche in 1888, has been touted as an antidote to the sense of loss and grief that overwhelms people affected by extreme events. Previous researchers have sought to explore the validity of this widely repeated maxim, but the studies have focused on individual response to stress. Findings, largely from psychologists, suggest that approximately 50% of those who experienced trauma reported positive learning outcomes (Tedeschi & Calhoun, 2004; Lindau, Almkvist, & Mohammed, 2016). Other researchers, in business, emergency response, and neuroscience, report that cognitive capacity drops under stress (Nelson & Winter, 1982; Klein, 1993; Arnsten, 2009). While this concept has been studied extensively, researchers report mixed findings regarding the capacity of individuals to function in stressful conditions or to recover from traumatic events, conditional upon previous experience and resources available for support (Calvo & Gutiérrez Garcia, 2016; Fink, 2016).

More difficult and little studied is whether communities that have collectively experienced major trauma can transform the mental, emotional, physical, and economic stress from the event

into a collective learning process that yields positive outcomes. There are many cases that document the negative impact of stress on cognitive performance when whole communities experience a traumatic event. For example, the Town of Paradise, California, USA was overwhelmed by wildfire in 2018 (Comfort et al., 2021); the cities of Golbasi, Antakya, and Samandagi, Türkiye were devastated by earthquakes in 2023 (Comfort, Celik, & Erkan, 2023); and the town of Lahaina, Maui, Hawaii, USA was destroyed by wildfire in August, 2023 (Bogel-Burroughs, Kovaleski, Huber, & Mellen, 2023). These events and the struggle to recover from them demonstrate that the impact of an extreme event escalates when the whole community experiences the trauma. The consequences of an extreme event fall differently on individuals, but collectively on the whole community. The challenge is to determine what strategies and conditions allow communities to transform trauma into a positive learning experience and act collectively to reduce future risk.

There are few known instances when collective learning has led to sustainable change after traumatic events. One example is the Helsinki Peace Agreement signed on August 15, 2005, after the deadly Indian Ocean Tsunami of 26 December 2004 to end the long-running conflict between the Indonesian Government and the Free Aceh Movement, approximately eight months after the earthquake and tsunami claimed more than 125,000 lives in Indonesia alone (Aspinall, 2005). A major rationale for the agreement, brokered by then-president of Finland, Martii Ahtisaari, was that both sides were exhausted from 30+ years of conflict and acknowledged that their shared experience of the heavy losses from the 2004 tsunami demonstrated that they had more substantive goals in common than differences that divided them (Comfort, 2019). A second instance was the end of apartheid in South Africa in 1994 after decades of internal conflict, loss, and trauma (Finnan, 2022). Rare as these cases are, they offer glimpses of successful transformation of trauma into collective learning processes that demonstrate the capacity for whole communities to recover from severely damaging events.

Yet, collective learning from stress is never certain. Other communities that experienced major trauma lose their resolve, resources, and capacity to envision constructive change, and spiral downward into ever greater dysfunction. For example, Haiti, after the devastating earthquake on January 12, 2010, has never fully recovered from that painful event and has slipped increasingly into social, economic, and political chaos in the following years (Comfort, 2019; Merino & Ware, 2021). Given the possibility of positive outcomes from traumatic events on a community-wide scale, but often deadly failure, this study explores three research questions. First, what conditions and characteristics of communities that have suffered collective trauma lead to collective learning, positive outcomes, and near-full recovery? Second, what conditions and characteristics inhibit collective learning and impair recovery after traumatic events, deepening dysfunction in the community? Third, how does collective learning from stress vary in dynamic contexts across jurisdictional scales? Exploring the consequences of stress and trauma on collective learning and increasing the capacity to act to reduce risk of future catastrophe are fundamental to creating sustainable communities in zones of recurring risk.

Multiple concepts and strategies have been advanced to suggest methods of coping with stress. Most depend on prior knowledge and recognition of risk from previous experience.

First, there is the classic assertion by Herbert Simon (1962), distinguished scholar of organizations and decision making, that 'we can only create what we already know.' With this statement, Simon acknowledged the essential role of information in framing strategies of action in uncertain contexts.

Second, Gary Klein (1993) and his colleagues built on Simon's insight and developed a conceptual framework for decision making in urgent conditions termed 'recognition-primed decision making.' This framework held that actors facing novel, urgent conditions drew on previous experience to forge new strategies of action to fit immediate demands, but the framework applied more specifically to individual managers in urgent operations, not necessarily to a whole community.

A third approach, as researchers sought to comprehend the varied responses of communities to adverse events, is the effort to define and develop resilience. This concept, first articulated by Mary Douglas and Aaron Wildavsky (1982), acknowledged the impact of adverse events on both individuals and communities, but also noted the capacity of the actors to withstand harm and recover to their previous level of function. The concept of resilience has been widely adopted and refined by many researchers and organizations (Comfort et al., 2010; National Research Council, 2012; Davis, Mostafavi, & Wang, 2019). The basic approach is to build capacity to recover from adverse events generated by known risk through preparedness, planning, and modeling alternative strategies, so when a hazardous event occurs, the community is not surprised and can act to reduce risk, minimize losses, and recover quickly. While many efforts have been made to identify workable strategies to build resilience in communities exposed to risk (Davis, Mostafavi, & Wang, 2019; Ayyub, 2021), these concepts and methods do not always lead to action or change in fundamental behaviors to reduce risk.

A fourth approach, antifragility (Taleb, 2012), is likely the most relevant to the conditions of the Turkish communities affected by the 6 February 2023 earthquake sequence. This approach reflects a community that is aware of the risk to which it is exposed, and creates its social, physical, and economic institutions to anticipate uncertainty and build the resources to detect and reduce risk. It relies on new technologies to search and exchange information regarding risk and to develop agency for action among the residents of the community through simulations and 'serious games.' This approach includes the concept of post-traumatic growth (Tedeschi & Calhoun, 2004); that is, the positive outcome for people who have lived through traumatic experiences but have learned from those experiences how to transform risk into informed action to reduce the likelihood of future damaging events. This approach is being adapted in a current research project on wildfire risk reduction in northern California, USA, funded by the U.S. National Science Foundation's program on Smart and Connected Communities (Soga, 2022).

Translating any framework into action in the dynamic context of recovery from a major seismic event is difficult. Recovery operations involve multiple jurisdictions, organizations, and disciplines, each with different backgrounds, specific interests, goals, and capabilities. In practice, the actors cooperate at some times, other times not. Further, residents as well as public, private, and nonprofit agencies are operating in a degraded disaster environment without their usual means of support. Consequently, dynamic conditions create unique tensions for decision processes. As conditions change, actors need to remain *open* to incoming information and update their understanding of the operational context, but mobilizing response to changing conditions requires *control* over information critical to the operation and a clear logic of action (Hautz, Seidl, & Whittington, 2017). The degree of tension varies with the intensity of the event, severity of destruction, and capacity of the actors to adapt to the fluctuating rate of change in the operational context. Balancing openness with control to achieve an effective outcome depends on the flow of information within the larger complex, adaptive system that envelopes those organizations, agents, and community residents most directly involved in implementing the recovery processes. Information, then, becomes a primary resource for managing the continuing tension between the government agencies seeking to execute the recovery process and the residents of the community whose interests are most at stake.

In his review of learning from traumatic events, Huber (1991) identified four basic activities that characterize the learning process in individuals and organizations. These activities include knowledge acquisition, information distribution, information interpretation, and encoding new information into organizational memory. Would these same processes characterize a collective learning process for whole communities, and if so, could they be structured to enhance the possibility of positive outcomes for groups and communities that have experienced major trauma? This study will examine this question in reference to communities affected by the 6 February Kahramanmaraş Earthquakes in southern Türkiye.

3. Research Design Methods and Data

The research design for this study is an exploratory case study (Yin, 2016) of the potential for collective learning by communities that experienced the trauma of the 6 February Kahramanmaraş Earthquakes and, further, the possible effort to translate an emerging consensual understanding of seismic risk into sustainable measures to reduce the threat of future earthquakes. The study seeks to characterize the potential for collective learning from actual traumatic events and to create a sufficiently rigorous understanding of the process to serve as the basis for future systematic investigation. It included a field visit to Türkiye, March 4 – 12, 2023 for L. Comfort, with site visits in collaboration with Turkish colleagues, Suleyman Celik and Burcak Basbug Erkan, in Ankara, March 6-7, and with Suleyman Celik in the disaster-degraded region, March 8-10. On March 11, L. Comfort met with policy and engineering experts in Istanbul. In early May, 5-6, Burcak Basbug Erkan made a field visit to Sanliurfa.

We used three methods of data collection in conducting the study, First, we reviewed the relevant documents regarding the context of seismic risk in Türkiye, previous policies and changes in law and building codes made following the 1999 earthquakes, and current updates to policies and practices that were in force during the 6 February 2023 earthquakes. Second, we conducted 23 semi-structured interviews with experts in Türkiye from a range of disciplines – earthquake engineering, public administration and policy, psychology, urban planning, business management, and disaster management. Third, L. Comfort and S. Celik visited cities and towns in the heavily damaged provinces of Kahramanmaraş, Hatay, and Adiyaman, and observed directly the actual conditions of people who remained in these cities and towns approximately one month following the earthquakes, as they were struggling with recovery operations. We visited the provinces of Gaziantep, center and districts of Islahiye and Nurdagi; Kahramanmaraş center and Pazarcik district; Adiyaman and Golbasi district; and Hatay with the districts of Kirikhan, Defne, Antakya, and Samandagi. A later field site visit in May by B. Basbug Erkan included observations and interviews from Sanliurfa.

In preparation for the study, we developed an interview protocol for planned semi-structured interviews and submitted our research design and protocol to the University of California, Berkeley's Institutional Review Board, requesting an exempt review. We specified the unit of analysis for the study as the organization, and the unit of observation as individual experts and managers who had specific knowledge of the conditions, regulations, and context of seismic risk in Türkiye. The Berkeley IRB granted exempt review status for the study, which allowed us to create informal relationships with our interviewees so they could speak candidly about their operations, as no personal, identifying data were collected.

During these site visits, we conducted interviews with field personnel who were managing operations in these locations. We used a purposive sample, seeking managers of site operations and local officials, but also in Antakya, a local resident who served as the organizing leader for his neighborhood. We had remarkable access to local leaders, including governors and mayors, gained through academic contacts and professional relationships. The field visits often included tours of the facilities being used and observation of service delivery under disaster conditions.

In terms of analytical procedures, we transcribed the 23 interviews and coded them systematically, checking and cross-checking the content to identify major themes that were shared among the 23 respondents, and conversely, differences that were observed among managers representing different levels of government or between managers in public agencies and local community leaders. The analysis included an identification of areas for future study of social and policy issues.

4. Context of Recovery Operations

Briefly, the context in which the earthquakes occurred shaped the organizational response and the initial reactions of the affected communities. Two major earthquakes, $M_w = 7.7$ and $M_w = 7.6$,

occurred approximately six hours apart on the same day, February 6, 2023 in Kahramanmaraş, a province astride the East Anatolian Fault in southern Türkiye. The policies and practices designed to reduce earthquake risk following the 1999 earthquakes were presumably in practice. Yet, the destruction of homes, businesses, roads, communications, water, and electrical power infrastructure shattered the sense of safety in the region.

Given Türkiye's high seismicity, with 95% of the land area exposed to some degree of seismic risk, developing sustainable methods of managing risk is imperative for the country (Erdik et al., 2023). Fig. 1 below shows the extent of seismic risk throughout the whole country. Other characteristics were important in shaping the response to this traumatic event in 2023. Türkiye is a middle-income country, but high rates of inflation had been buffeting the economy for years, and citizens were uneasy about the falling value of the lira. The country was still reeling from the consequences of the July 2016 attempted coup and effort to take over the presidency, followed by the Administration's harsh measures to punish and jail anyone suspected of supporting the effort. Consequently, the society was fragmented with deep mistrust among different groups, lack of communication within and between organizations, and institutions hollowed out by loyalty tests to
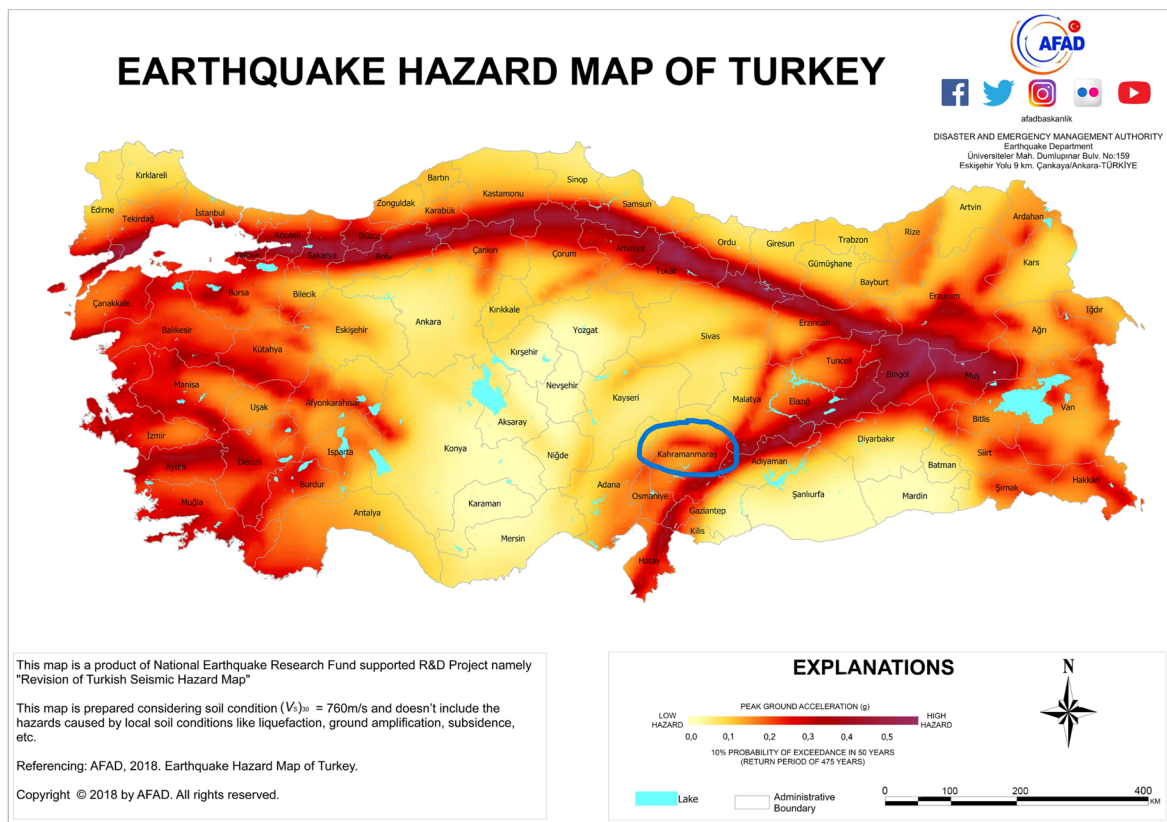

Figure 1 Revised Seismic Hazard Map of Turkey in use since 2018. The East Anatolian Fault is the dark red area slanting diagonally at the right, and the blue circle indicates the epicenters of the 6 February 2023 earthquakes. Source: (AFAD, https://www.afad.gov.tr/turkiye-deprem-tehlike-haritasi)

the current government (N. Karanci, personal communication, March 6, 2023). Further, 2023 was an election year in Türkiye, with the president, Recep Tayyip Erdogan, running for re-election, amid deep suspicion between the ruling party and the opposition party. This national event colored the response and recovery operations, as tensions were already high among citizens who were deeply polarized. In this context, recovery operations were initiated in the damaged communities with badly traumatized individuals sharing their grief and despair in collective trauma that affected whole communities.

5. Findings

Returning to the main research question of *whether communities can learn collectively from the stress of extreme events and transform their communities through sustainable measures to reduce known risk,* we find that this question breaks into two parts. First, clearly communities came together in substantive ways to help one another and adapted remarkably to survive in very difficult, harsh conditions, so the potential for collective learning is evident. The news media were filled with stories of residents from Istanbul, Ankara, and Erzincan mobilizing resources to support families needing assistance in the earthquake-damaged region. Nonprofit organizations reported a remarkable increase in volunteers from all over the country to support outreach efforts to traumatized communities (ANDA, personal communication, March 7, 2023).

The more difficult task is to transform this traumatic experience into sustainable measures to reduce known risk. In reviewing the findings from our field study, we used the four suggested categories in Huber's (1991) concept of post-traumatic growth in organizations as an analytical framework to examine this collective process for whole communities. Although our study was limited in both time and resources, we find some evidence relevant to the emergence of positive growth toward collaboration among different groups in rebuilding communities, but also barriers to this process.

5.1. Knowledge Acquisition

The first step toward developing a consensual understanding of seismic risk is gaining access to valid information about the seismicity of the region and of ongoing steps to reduce that risk. In this instance, the seismicity of the region was well-known among the scientists (Lund, 2023; Erdik et al., 2023), but the communication of that risk to residents of the community was not well developed. The shock of the earthquakes was documented and relayed via television and news accounts to the entire country, but the detailed assessment of how the risk affected the built infrastructure, why the buildings collapsed, and what measures residents could take to ensure safe reconstruction was not.

Further, it was difficult to determine which reports were valid and which were not. The government's control over information about the earthquakes and the recovery process was nearly complete. Independent journalists were not granted direct access to damaged earthquake sites, nor were their stories published in the widely circulated national newspapers. The massive destruction from the earthquakes was visible and documented extensively by research teams of national and international experts (Çetin, K. Ö., Bray, J. D., Frost, J. D et al., 2023; Çetin, K. Ö., Ilgaç, M., Can, G., & Çaker, E., 2023), but the actual account of how and why the scale of damage was so severe, given the measures taken after the 1999 earthquakes, was fractured among different groups in the society.

5.2. Information Distribution

Technologies to support communications were being rapidly adopted, and although statistics vary, cell phone penetration was estimated at 101% of households in Türkiye. Even in rural communities, cell phone use was high. Importantly, the use of WhatsApp groups became the dominant form of exchanging information about the earthquakes and the processes of recovery. For example, in Golbasi, as the school administrators were preparing to reopen the schools, they formed a WhatsApp group for the teachers and school administrators, a second WhatsApp group for the students and parents, and a third WhatsApp group for school administrators in different cities who were going through the same process of re-establishing their schools' operations and returning to functioning school buildings (School administrator, Golbasi, TR, March 10, 2023) . Many school buildings survived the earthquake as they were built relatively recently, but were still nonfunctional as they lacked electrical power, water, and sanitation.

Disaster managers also used WhatsApp as a main form of communication, as the groups could easily include personnel from government agencies at different jurisdictional levels – international, national, provincial, municipal, and district – as well as nonprofit organizations, large and small, and business organizations. WhatsApp groups became an easy and simple mode of connecting people around specific issues but did not connect people from different groups effectively.   While these WA groups could build a shared understanding of the problem for specific issues, they did not easily translate the groups' perspective into an operational view of the whole system. The practice of forming WhatsApp groups for easy communication, commonly used, illustrates the impact of 'complex time. Different groups were often acting on their own assessment of needs without considering the impact of their actions on other groups in the same system, leading to misalignment in action among the set of groups in the communities, despite their common goal.

Other modes of information distribution, such as television, web pages, radio, and satellite phones, were available, but none encompassed the entire profile of the event, with updates at specific levels of detail. It became difficult for even the most dedicated community resident to follow the news regarding all aspects of the recovery process, and especially for those in towns, villages, and cities that were operating on different time scales. The distribution of information among the different groups, especially for a society of more than 85 million people, each of whom was affected, directly or indirectly, by this event, was complex. While key to the development of a consensual understanding of seismic risk, so essential to building commitment to reducing future seismic hazards, the modes of distribution and communication of information varied widely. This variation in modes of distributing information led to variation in practice at different scales of operation and misalignment in action among the scales of operations as local households, community groups, and public agencies sought recovery within the wider Turkish society. Fig. 2, below illustrates this misalignment as 'complex time' (Krakauer, 2020); that is, actions that are shaped by different perceptions of time at different levels of operation in a shared endeavor, such as disaster recovery.

<div align="center">

Complex Time

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Classic conception of time: the 'arrow of time' moves only forward, never back.
In complex adaptive systems, time is perceived differently in different contexts.
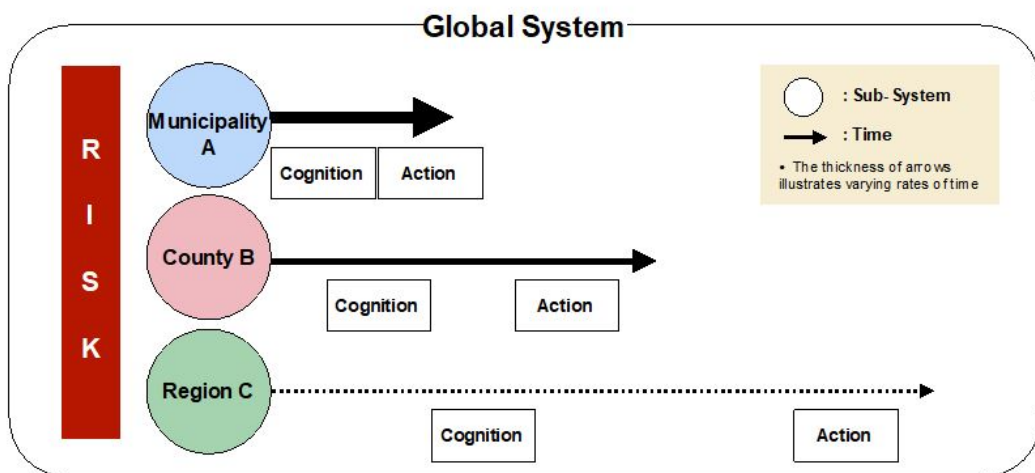

Figure by Sae Mi Chang

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Figure 2 Complex Time

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The concept of complex time illustrates the integral relationship between cognition and action and the essential role of information in enabling cognition in novel, stressful conditions (Comfort & Rhodes, 2022). For example, in the chaotic first three days following the earthquake, when communications were urgently needed to coordinate search and rescue operations, it took days for

the communications companies to bring mobile vans with equipment and technicians to the damaged areas to repair the shattered infrastructure to enable coordination among the multiple teams. The cell towers for communications transmission had been located on the roofs of buildings in cities and towns, so when the buildings collapsed under seismic shaking, the communications system also collapsed (Disaster operations director, personal communication, Kahramanmaraş, March 8, 2023). Ironically, the delay was caused in part because the communications infrastructure was destroyed by the earthquakes, and communications technicians outside the region had no way of knowing immediately the extent of destruction in the damaged communities (Disaster operations director, personal communication, Samandagi, March 9, 2023).

5.3. Interpretation

The third phase in Huber's framework for collective learning is likely the most difficult and most complex. To achieve a consensual model of a complex problem, such as recovery from a major disaster, the first two phases need to be sufficiently established to have a reasonably coherent profile of the whole operating system and its components, with sufficient understanding of the component parts and their respective roles. That is, the actors need to recognize their membership within the operating system and their specific roles in achieving the overall system's goal, sustainable recovery from the current disaster event in ways that reduce risk of future disaster events.

It is not clear that the interpretation of the events of the 6 February 2023 earthquakes has sufficiently reached a degree of consensus within the Turkish society to meet this standard. There is still discussion and disagreement about aspects of the recovery, with different views being reported at different scales of operation while the recovery process is still underway. Commentary from the Kahramanmaraş region reports that one casualty was found almost 10 months after the earthquake. Further, people still living in temporary shelters suffer from seasonal conditions such as heavy rainstorms, high winds, flash floods, and snow. A major issue in the area is the serious risk from asbestos. As the necessary precautions were not taken when removing the rubble at the initial stages of reconstruction, the Turkish Medical Association declared that the level of the asbestos in the region is three times higher than the level that is considered safe by the World Health Organization, likely leading to an increase in cancer cases in the future (Turkish Medical Association, 2023).

In the damaged cities, construction of new housing is proceeding, but are the building codes, revised again in 2018 (Turkish Building Earthquake Regulation, 2018), being followed? Is there sufficient knowledge and agreement among the building owners, contractors, and government agencies overseeing the construction process to ensure that not only the buildings will be built according to current codes, in force since 2019, but the supervision process specified under Law No. 4708 (Law on Construction Supervision, 2001) will also be followed? There is little information publicly available to document the construction process, but these are practical tests of a shared understanding of what is required to achieve sustainable recovery from a major disaster event.

In Huber's (1991: 102) discussion of achieving a common interpretation of new information about a shared event, he notes that an important factor is the degree of uniformity in the prior cognitive maps of participating groups or organizations. This factor relates directly to the vital effort to collect timely, valid information about the new event and to distribute that information broadly to all participating members. If the differences in cognitive maps are significant, it is likely necessary for some members or groups to "unlearn" existing beliefs that have blocked their acceptance and understanding of new information. For example, in a public statement made while on tour of the devastated earthquake region three days after the event, President Erdogan reportedly stated that it is "not possible to be prepared for such a disaster" (Druker, 2023). Such a statement, uttered by the President, would need to be unlearned by the millions who may have heard or seen it before they can accept agency for changing their existing practices to achieve sustainable risk reduction in zones prone to seismic risk. Creating a valid interpretation of the actual events is a vital but ongoing

process in a dynamic society, as leaders change, external conditions change, and new information supersedes previous accounts of actual events.

5.4. Organizational Memory

The fourth phase of Huber's framework for post-traumatic growth is encoding the new knowledge gained from the traumatic experience into organizational memory. Huber, in contrast to other researchers (Arnsten, 2009), does not assume that learning from trauma necessarily leads to change in behavior, but holds that it does lead to change in perspective about extreme events and understanding of the organization's role in relation to other actors. Applying this concept to the larger social construct of a community becomes a harder task. Communities vary in size, for example, Golbasi municipality and district, pre-earthquake, had approximately 150,000 residents; Antakya, pre-earthquake, was a municipality of approximately 400,000. Cities develop identities and do so in numerous ways. Some cities construct museums or memorials following extreme events to honor the dead and to acknowledge the sacrifices made that day so that others may live. The City of Kobe, Japan has created a museum to house artifacts from the Great Hanshin Earthquake of January 17, 1995, and grade school children make regular pilgrimages to the museum so they 'will never forget.' New York City has created a memorial to honor those who died in the tragedy of the 9/11 terrorist attack in September, 2001 to serve as a public reminder of the city's grief that day, but also of the collective response of the city and nation to recover from that shattering event.

Collective learning, however, is more than building a museum or a monument. In terms of achieving an actual shift in perception or, indeed, a change in behavior; the information held collectively in people's minds about a threat needs to change. This step can be facilitated by digital technologies that create archives of records and store visual artifacts that document the consequences of buildings constructed not according to code or inadequate siting of major facilities, like hospitals or schools, where they may be vulnerable to seismic movement.

Again, the concept of 'complex time' factors into the encoding of knowledge into collective memory. For the cities and districts that were most severely damaged, the events may be vividly encoded in digital archives and made accessible to public schools, universities, community organizations, and nonprofit organizations to serve as a continuing record of the event. The archives can then be freely accessible to members of the community, scientific and arts organizations that can review the records and develop innovative strategies to counter seismic risk. The archives essentially create 'time machines' that enable users to align their perspectives across jurisdictions and organizations to build a consensual understanding of risk that serves as the basis for sustainable change in managing a long-term hazard like seismic risk.

6. Conclusions

Returning to the major question posed for this study, "*can communities learn collectively from the stress of extreme events and transform their communities through sustainable measures to reduce known risk,*" findings from this preliminary field study of the 6 February 2023 Kahmaranmaraş Earthquakes are mixed. There is evidence of collective response, both in the damaged cities and villages and in the regions of the country outside the earthquake-stricken area, in which people spontaneously rallied to assist residents in the disaster-degraded areas and contributed their time and resources to provide support in the immediate post-earthquake period. But the review of actions taken for the recovery process are still underway in the earthquake-shattered provinces of southern Turkey, and it may be too soon to determine the eventual outcome of this process.

Reviewing the three sub-questions regarding collective learning from trauma in the specific context of the Kahramanmaraş Earthquakes, preliminary insights can be gained from this field study that indicate the potential for shaping collective learning from trauma. They are summarized below.

6.1. Characteristics that Lead to Collective Learning

An important insight underscored in the study is that learning relies on timely, valid information, and constructing a shared knowledge base of accurate information about the extreme event and ensuing trauma is the first step in developing a consensual understanding of the event, what happened and why. The second step is distributing this information widely over a reliable platform to build trust among the diverse audience of participants in the community. These steps may be done most effectively at the local level, with trusted leaders verifying the information and translating it into local terms. To engage in both steps, innovative but practical uses of information technology are critical. The adaptive use of WhatsApp to form communication groups after the earthquakes, as organizations and groups sought to re-establish connections and develop strategies for action to cope with the demands of recovery, illustrates the potential for enhancing learning processes. It demonstrates, again, that learning is social, and engaging people in shared communication processes contributes to an emerging consensus for the group.

6.2. Characteristics that Inhibit Collective Learning

The most damaging characteristic that inhibits collective learning is distorted information that is discovered to be false. This discovery destroys trust in not only the purveyor of that information but, more seriously, the whole public information collection and distribution process. The lack of trust leads to withdrawal from community activities, isolation, and angry denial of responsible action to support community goals.

This characteristic, regrettably, was evident in some communities where the residents believed they had been misled regarding the reliable construction of their buildings. Other factors that inhibit collective learning are lack of access to valid information and the resources that allow people to search for information while they are under stress from other needs.

6.3. Variance in Collective Learning in Dynamic Contexts

One of the most interesting but difficult aspects of collective learning is that learning occurs at different rates for different groups of residents in a community and at different rates at different jurisdictional levels of operation. This is a factor of complex perceptions of time. The discrepancies can be managed, but to do so, requires a small group of community leaders to articulate the goals for the whole system in ways that every participant can understand. Advances in information technology, appropriately developed for different regions and different levels of jurisdictional operation can be adapted to facilitate this vital process.

6.4. Toward Sustainable Risk Reduction

Based on these observations, we conclude that transformation of trauma into a learning process to reduce risk is a collective effort. No community can do it alone. Rather, it depends on the support, understanding, and guidelines set by the wider social and institutional context of the traumatic event. This means that investing additional resources -- financial, organizational, technical, intelligence, emotional -- is instrumental to enhancing the learning process and essential for holistic recovery of damaged communities. Further, collective learning will proceed at different rates for different groups within the traumatized community, so aligning the learning process among these groups is fundamental to achieving a consensual goal in a dynamic social environment.

In this critical task of building a consensual commitment to sustainable risk reduction, information technologies offer an important tool to accelerate learning and provide greater access, openness, and engagement for participation at different jurisdictional levels of operation. Greater investment in technologies that allow rapid, easy access to valid knowledge will facilitate the collective learning process essential to the transformation of trauma into positive outcomes. Investing in community outreach and building local social networks can reinforce the confidence that people working together can reimagine the built infrastructure in their communities to withstand seismic shaking. Innovative uses of simulations and modeling, enhanced by scientific

expertise, could present information about seismic risk to community residents in ways they can easily understand.

The Turkish society faces a critical set of choices in the cities, towns, and villages damaged by the Kahramanmaraş earthquake sequence of 6 February 2023. Recovery means not just reconstruction of buildings and bridges, but also creating the social connections and collective confidence to act that enable communities to transform trauma into sustainable risk reduction.

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